STUDIES ON THE BIOLOGY OF SILVER CATFISH (*CHRYSICHTHYS NIGRODIGITATUS* LACÈPÈDE 1803) IN JEBBA LAKE, NIGERIA

BY

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DECLARATION

I declare that this work in this dissertation entitled **"Studies on the biology of silver catfish, *Chrysichthys nigrodigitatus* (Lacèpède, 1803) in Jebba Lake, Nigeria"** has been performed by me in the Department of Biological Sciences. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

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CERTIFICATION

This dissertation entitled **"STUDIES ON THE BIOLOGY OF SILVER CATFISH, *CHRYSICHTHYS NIGRODIGITATUS* (LACÈPÈDE, 1803) IN JEBBA LAKE, NIGERIA"** by Innocent Yakubu YEM meets the regulations governing the award of the degree of Doctor of Philosophy of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

Studies on the biology of silver catfish *Chrysichthys nigrodigitatus* (Lacèpède, 1803) in Jebba Lake, Nigeria was carried out between January 2009 and December 2010. Samples collected using fleets of experimental gillnets were used for the study. There was fluctuations in the physico-chemical parameters measured; mean electrical conductivity (66.41±13.89µs/cm), and mean phosphate (0.20±0.15mg/l), which was significantly different ($p<0.05$) at the zones. The males and females showed allometric (2.49) and isometric (3.18) growth pattern respectively, with strong relationship and direct proportionality between length-length for males (0.93) and females (0.83). The condition factor for males (K=1.74) and females (K=1.83) showed that the lake was conducive for the survival of the fish because it was greater than 1. The positive correlations in the morphometric parameters, and the meristic counts confirmed the presence of the species in the lake. The age structure was between 0+ and 3+ with bulk of the samples within ranges of 2 and 2+, males being bigger than females. Size distribution ranged from small to adult, with few adults in the population. *Chrysichthys nigrodigitatus* has the tendency to grow bigger based on the growth performance index. Nine (9) major items ingested by *C. nigrodigitatus* ranged from plant materials (21.75%) to animal components (55.65%), which vary in abundance across months and seasons. Juveniles and sub-adult fed predominantly on insects (36.72% and 28.69), while adults on fry (27.86%). There was a direct relationship between the size of fish and ingested food items. Prey importance index showed insects (57.61%), insects (53.70%) and fry (39.65%) as the most important items ingested by juveniles, sub-adults and adults, respectively. There was high feeding intensity due to few number of fish stomachs without food. *Chrysichthys nigrodigitatus* is an omnivore with moderate gut length. There were more males than females (1.77:1) in the population. More gravid females were recorded in August and September, which coincide with the period of spawning. Gonad maturity showed stages I-VI, males attained first maturity than females. Female *C. nigrodigitatus* had higher gonado-somatic index (9.73) than males (1.32) especially during the wet season. Mean fecundity ranged between 1,670-3,375 eggs, which increase with increased in fish size. *Chrysichthys nigrodigitatus* was the most abundant species both within the family Claroteidae (13.06%) and in the overall catch (8.95%) during wet than dry seasons, dominant in zones I and II during the wet season, and commonly found at the bottom of the lake. It is recommended that morphometric and meristic parameters be used to identify the fish, study on population structure to reveal more class sizes be done, culture trials should also be done, and the feed components to be plant and animals materials.

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Abbreviations, Definitions and Symbols

Abbreviations

Condition factor: K

Growth performance index: GPI

Length-weight relationship: LWR

Length-length relationship: LLR

Definitions

Detritus: Decompose plant or animal materials

Omnivore: Animal that feed on both plant and animal materials

Symbols

^{o}C: Degree Celsius/Centigrade

S/m: Siemens per meter

µS/cm: microsiemens per centimeter

mg/l: Milligram per litre

Kg: Kilogram

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Fish is a resource mostly exploited by man and is basically linked to the trophic chain in the entire environment where they are commonly found (Craig *et al*., 2004). Inland waters of Nigeria consist of water bodies that support a wide array of aquatic organisms, which includes phytoplankton, zooplanktons, crustaceans, and vertebrates such as fish, crocodile, and aquatic mammals (Atobatele and Ugwumba, 2008).

Fishes found in the tropics and tropical water bodies experience changes in their biological parameters and activities due to fluctuations in factors such as food composition and availability, spawning rate, and other environmental factors. Welcomme (2001) reported that factors such as fishing, pollution and eutrophication among others could bring about series of changes in fish size, species composition and abundance in the aquatic environment. Similarly, Bisht *et al*. (2009) and Soyinka *et al*. (2010) reported that changes in environmental factors such as water quality, depth, water current, availability of food and substratum influence the occurrence of fish fauna, abundance and distribution.

Despite massive world-wide development efforts, in terms of many laudable programmes and ways to reduce poverty and improve livelihoods in fisheries and other sectors of the economy, poverty remains a nightmare for millions of Africans. In West Africa alone, seven million people are involved in fishing, aquaculture and related activities, such as processing and trading because it is a major source of livelihoods in many coastal communities, both inland and on the Atlantic coast. In addition to providing employmentand income, fisheries play a very important role in local and national economies (Komolafe and Arawomo, 2011). Nigeria is the largest consumer of fish in Africa with an approximately 1.2 million tonnes of fish needed annually to satisfy the demand of the ever increasing population. FAO (2000) estimated fish demand for Nigeria from 1997 - 2025, based on projected population and gave an average of 1.11 million tonnes for a decade (2000 - 2010). The country is highly blessed and endowed with vast expanse of inland freshwater and brackish ecosystems with abundant fish species, which have potentials for culture. These water bodies also play an important role in the provision of protein to Nigerians, especially now that imported fish is becoming expensive to the common man (Komolafe and Arawomo, 2011).

Freshwater is a very important natural resource crucial for the survival of all living beings. UNESCO (2003)reported that water is the most vital resource for all kinds of life on earth and essential for sustainability of the earth’s crust ecosystem. The quality of life depends on the quality of water. Physico - chemical factors are important in estimating the constituents of water and concentration of pollutants or contaminants. These factors are interrelated and interdependent with biological factors (plants and animals). Similarly, these factors immensely influenced the uses as well as the distribution and richness of biota (Unanam and Akpan, 2006). Physical parameters of water bodes include water movement, depth, turbidity, transparency, temperature and suspended solids. Chemical parameters include pH, dissolved oxygen, carbonates, bicarbonates, nitrate, phosphate, carbon dioxide, cations and anions and dissolved organic matters (Mustapha and Omotosho, 2005).

Growth is simply defined as change in size (length, weight and bulk) with time and can also be change in numbers with time in the case of population (Abowei and Ezekiel, 2013). Factors that influence growth of fish, according to Welcomme (2001), can either be endogenous or exogenous. Endogenous factors include genetic components of fish, which limits the maximum size of a given species, while exogenous factors include food availability, feeding rate and the nature of food ingested. Length and weight are two key components in the study of fish growth be it at individual or population level. The length of a fish is often measured easily than the weight; it is therefore, possible to determine weight where only length is known. The relationship between length and weight is important in this regard because it can be used to assess the effect of factors such as growth and condition factor in fishes. There are basically two patterns of growth in fish, which relates the length, be it standard or total, to the weight. Isometric growth pattern shows that the body weight and length of fish grows at a constant proportion that is, if the coefficient of the relationship (often denoted as b) is equal to 3. Allometric growth pattern shows that the body weight and length of fish do not grow at a constant proportion, that is when the value of b is less than or greater than 3. It is negative allometric growth if the value of b is less than 3, when the fish becomes slender as it grows, and positive allometric growth if b value is greater than 3, when the fish becomes robust as it grows. Growth fluctuations are more frequent in fishes of tropical and subtropical water bodies due to several factors such as environmental variations, multiple spawning, physiological changes and dynamics of food composition (Adeyemi *et al*., 2009).

Condition Factor (K) is another key parameter that describes the well - being or survival of fish in the aquatic environment. It has been used along with age and growth studies to indicate the suitability of an environment for fish species (Adeyemi *et al*., 2009). If this value is either equal to one or above one, the environment is good or better for fish survival and not suitable if the value is less than one. Factors such as non-availability of food, predation, competition, fishing intensity, change in water physico-chemical parameters, spawning and pollution can influence the well-being of fish in the aquatic environment (Abowei, 2009).

Morphological characters such as morphometric and meristic have been commonly used to identify stocks of fish (Turan *et al*., 2005) and the differences between fish populations (Buj *et al*., 2008; Torres *et al*., 2010). These parameters or characters include standard length, snout length, body depth, head length, pre dorsal distance, pre pelvic distance, and pelvic length, and anal base length, depth of the caudal peduncle, eye diameter and suborbital width. Meristic (counts) parameters include numbers of rays (spines or soft rays), gill rakers, scales and total number of vertebrae. The use of chromosome numbers and genetic parameters such as DNA sequences (requiring sophisticated measuring techniques) are the newest methods for identification of fish stocks (Akin-Oriola *et al.*,2005).

Age determination in fish is important for the assessment of life history, maturity, spawning times, growth rate, growth at different age groups and mortality rates of a given population (Gocer and Ekingen, 2005). Similarly, it is an essential component in understanding the dynamic changes of fishery in any water body. Accurate age determination is essential to both fisheries biology and management as it provides information pertaining to stock age structure, age-at-first maturity, spawning frequency, individual and stock responses to changes in the habitat, recruitment success and determination of population changes due to exploitation. Information on age also enables determination of growth and mortality, which form the basic input parameters for population dynamics models used in fishery analysis (Welcomme, 2001).

Many methods have been used to determine the age of fish, of which three methods predominates. The first is the mark and recapture method, second is Petersen method, which involves the comparisons of length - frequency distribution of fish population samples. Lengths of a large number of fish in a population need to be measured. The third method is to count growth marks that develop periodically in various hard parts of fishes (Adeyemi *et al*., 2009). Those that are considered to be formed on annual basis are called year marks, annual marks, annual rings or annuli. Methods for estimation of fish age are reliable especially if these structures possess patterns related to the annual growth. These structures include vertebrae, otoliths, scales, fin rays, opercular bones and some other body parts. The suitability and usage of any of these methods differ from species to species (Gocer and Ekingen, 2005).

Food is a fundamental element in the life of all living organisms including fish, being the source of energy and nutrients for growth, reproduction, movement that are vital activities for survival in the aquatic environment. Qualitative and quantitative compositions of fish diets are important to the growth, maturity and fecundity changes in fish. Food study reveals the status of foraging, growth rate and seasonal life history changes in fish, which are useful for rational exploitation of the species (Ugwumba and Ugwumba, 2007). In addition, the study of food and feeding habits of fish based on stomach content analysis is commonly used in fishery ecology to show the position of fish within a food web and to provide information on the contribution of different prey items to the diets. Information about food habits of fish is also useful in defining predator-prey relationships, estimating trophic level and in the creation of trophic models as a tool to understanding complex ecosystem.

Different kinds of items, ranging from plant to animal materials, be it micro or macro in nature, are eaten as food by fish. These items are of great diversity in the aquatic environment and differ in size and kind (Olojo *et al*., 2003). Most of this food base either change or fluctuates in terms of biomass, relative species and other population responses. Examples of food items eaten by fish include phytoplankton, zooplankton, zoobenthos, bacterioplankton and fish amongst others. Those that feed on a single type of item are termed ‘Monophagic’; those that combined plant and animal materials as food are termed ‘Euryphagic’, while those that eat plant or animal materials are termed ‘Stenophagic’(Welcomme, 2001). Fish may be classified on the basis of food habits as carnivores, herbivores and omnivores. The carnivores are flesh eaters, and are divided into two based on specialization. Those that rely solely on insects as their food are called insectivores and those that dwell entirely on fish are called piscivores. The herbivores exploits a wide range of plant materials that include plankton, diatoms, algae and large plants especially rooted aquatic plants. The third category, omnivore, are those that feed on wide variety of food items that range from animal to plant materials. Most of fish species in this category eat almost anything they come across. (Welcomme, 2001).

The diet of fishes, just like in many other vertebrates, also relates to the length of the gut or intestine. The structure, length and conformation of the intestine are closely related to the diet of the fish (Miller and Harley, 2002). Therefore, understanding this relationship is important to predict the diet of fishes, how fishes feed and the mechanism of feeding (Malami *et al*., 2007). Herbivores have longer and coiled digestive tract, carnivores have short digestive tract and omnivores have intermediate length of digestive tract. According to German and Horn (2006), all vertebrates on the category of herbivores have longer digestive tracts than do carnivores and that the pattern is consistent among mammals.

Reproduction in fishes is one of the fundamental biological processes that enable survival and continuity of species in the aquatic environment. Reproductive patterns of fish, according to Paugy (2002), differ when factors such as habitats, geographical zone and species are considered, which are influenced by environmental and biotic factors. These reproductive parameters include sex ratio, stage of maturity, gonad index (GI), gonadosomatic index (GSI),and fecundity. Knowledge on the reproductive patterns of fishes as well as growth and mortality characteristics will define the regenerative capacity of a population. Gonad maturation stages have become increasingly important in fish production, especially in induced spawning and hybridization in addition to determine the stock that is, mature, and the size or age at first maturity. Similarly, it can be used to determine the reproductive potential of fish populations and monitoring of changes in biological characteristics of exploited fish stock (Williams, 2007). It is also used to establish reproduction period and length of time it takes the gonads to mature (Goncalves *et al*. 2006). It has been shown that fecundity is influenced by a number of factors such as size of fish, the kind of species, season and reproductive behavior. Marked differences in fecundity among fish often reflected different reproductive strategies (Murua and Saborido-Rey, 2003). The eggs of most species of fish vary in size and chemical composition, which determine the quality of the offspring. There is also relationship between the fat content of female parent and the egg size and quality of yolk. There may also be differences in the amount of eggs deposited in individual species and in population from different water bodies or different parts of the same body of water (Murua and Saborido-Rey, 2003).

Fish abundance refers to the total catch in number or biomass of the species in that particular water body, while fish distribution is an indication of where fish species occur, located or are commonly found in the aquatic environment. This consists of the vertical aspect, that is, surface, mid water and bottom and the horizontal component such as convex, central and the concave sections across the water body. Species distribution thus, provides information on whether the fish species is pelagic or demersal. Such information are vital for fisheries development and management. Fish abundance and distribution also have influence on the abundance and distribution of other aquatic organisms in the water (Olopade, 2001). There are several factors that affect fish distribution and abundance in any water body. These includes availability of food, spawning rates, breeding grounds plus shelter, vegetation, water depth, breeding habits, presence of current, migration and vegetation. At a large - scale, abiotic factors influenced fish assemblages in temperate and tropical regions (Tejerina-Garro *et al*., 2005).

Catfishes generally are important fish species in inland water bodies of Africa because of their high commercial value. *Chrysichthys* species are among other species that have been reclassified to the family Claroteidae (Paugy *et al*., 2003; Olaosebikan and Raji, 2004). *Chrysichthys nigrodigitatus*, commonly known as ″silver catfish″, grows up to 3kg and even above, which can be found both in fresh and brackish waters. It is known as Warushe in Hausa, Obokun in Yoruba and Okpo Ocha in Igbo. It is very tasty with tough flesh and good keeping quality.

Chrysichthys nigrodigitatus commonly known as silver catfish is an important commercial fish species found in both fresh and brackish waters. It has been thought not to spawn in captivity and experimental fish or broodstock had been difficult to obtain except from the wild, which is unreliable. There was breakthrough in spawning of the fish in captivity when more than one hundred spawns were obtained under controlled condition at Layo in Cote'Ivoire (Ekanem, 2003). Since then, there has been growing interest in the culture of *C. nigrodigitatus* and in the past two decades scientists have worked to provide the necessary information on the biology and ecology of this valuable fish species, so as to enhance its successful culture. The species is important, highly valued and common in inland waters of Nigeria and sought for due to its flavour and chemical composition (Akinsanya *et al*., 2007; Saliu, 2008; Olarinmoye *et al*., 2009).

1.2 Research Problems

Physico-chemical parameters influence the biological productivity of water bodies. These include species abundance, composition, productivity and physiological conditions of aquatic organisms (Idowu *et al*., 2004). There is no current information on the state of physico-chemical parameters of Jebba Lake, and changes in these parameters adversely affects aquatic life.

Nigeria is a country blessed with abundant of inland water bodies with diverse fish species most of which their biology is yet to be fully studied. Catfishes are the commonly cultivated species of fish in Nigeria. *Chrysichthys*, a genus of the family Claroteidae, which is among the important commercial fish species has not been given due attention since the creation of Jebba Lake. It has been reported as a dominant fish species in the lake (Abiodun and Odunze, 2011). The silver catfish *Chrysichthys nigrodigitatus* with promising aquaculture potential has not been successfully domesticated, which could be due to improper understanding of the biology. Offem *et* *al*. (2008) reported that there is still dearth of information on the biology of *C. nigrodigitatus* in some water bodies of Nigeria.

Preliminary report on the abundance and distribution of fish species (including *Chrysichthys* species) in Jebba Lake, has been documented for over two decades now but, no information on other aspects of the biology of the species, such as, morphometric and meristic, reproductive, age and growth, food and feeding habit parameters, which makes the management and sustainable utilization of this economically important fish unrealistic. There has also been reduction in the abundance of *C. nigrodigitatus* in Nigerian water bodies, because of over-exploitation and destruction of habitat (Offem *et al*., 2008). This has affected the sizes been caught. Over the years, it has been observed that majority of the sizes caught from Jebba Lake range from small to medium, even though the fish grows up to 3 kg and even above.

Dearth of scientifically sound management of fish resources based on basic knowledge of the biology of the species, including information on the population structure, influence the development of strategies for conserving *C. nigrodigitatus* in the lake.

1.3 Justification of the Study

Catfishes are economically important groups of fresh and brackish water fishes worldwide because they form a significant part of the inland fisheries in many countries; Several specieshave been cultured while others are of great interest to the aquarium industry (Ekamen, 2003). Fishes in this family, which include *Chrysichthys nigrodigitatus*, *Chrysichthys auratus longifilis* (now *Chrysichthys auratus*(Paugy *et al*., 2003) and *Chrysichthys walker*, are valued food fish with high demand in the whole of West Africa especially *Chrysichthys nigrodigitatus* (Ekanem, 2003). *Chrysichthys* species have commercial value, which if carefully studied could add to the existing culturable fish species in the country.

The rearing or culturing of any living organism including fish in a controlled environment begins with the understanding of aspects of the biology such as age and growth, reproduction, food and feeding, and abundance. Considering *C. nigrodigitatus* for culture and conservation, have resulted in several biological studies on growth and fecundity (Akinsanya *et al*., 2007). Studies on *C. nigrodigitatus* in Nigerian water bodies include the works of Inyang and Ezenwaji (2004) on size, length-weight relationship, reproduction and trophic biology in Anambra River, Nigeria; Yem *et al*. (2005) on length-weight relationship and condition factor of *C. nigrodigitatus* in Kainji Lake, Nigeria; Offem *et al*. (2008) on reproductive aspects of *C. nigrodigitatus* in Cross River, Nigeria; Yem *et al*. (2009) on food composition and feeding pattern of *C. nigrodigitatus* in Kainji Lake, Nigeria; Lawal *et al*. (2010) on morphometry and diets of *C. nigrodigitatus* in Epe Lagoon, Nigeria and Atobatele and Ugwumba (2011) on condition factor and diet of *Chrysichthys nigrodigitatus* and *Chrysichthys auratus* from Aiba Reservior, Iwo, Nigeria. This study is quite auspicious, so that proper management plans or strategies to sustain this valuable fish in the lake will be established.

1.4 Aim and Objectives of the Study

The aim of the study is to investigate the biology of *Chrysichthys nigrodigitatus* in Jebba Lake with the following specific objectives:

a. Determine the physico-chemical parameters of Jebba Lake
b. Determine the morphometric and meristic parameters of *Chrysichthys nigrodigitatus* in JebbaLake
c. Determine age and growth parameters of *Chrysichthys nigrodigitatus* in Jebba

Lake

d. Determine food and feeding habit of *Chrysichthys nigrodigitatus* in Jebba Lake

e. Determine reproductive parameters of *Chrysichthys nigrodigitatus* in Jebba Lake

f. Determine the abundance and distribution of *Chrysichthys nigrodigitatus* in Jebba Lake

1.5 Hypotheses

a. There is no significant difference in physico-chemical parameters at the various sampling zones and between seasons in Jebba Lake

b. Morphometric and meristic parameters cannot be used to identify *Chrysichthysnigrodigitatus* in Jebba Lake

c. Age and growth between sexes of *Chrysichthys nigrodigitatus* did not show any difference

d. *Chrysichthys nigrodigitatus*does not consume a variety of food items in Jebba Lake

e. There is no difference in reproductive parameters between sexes of *Chrysichthys nigrodigitatus*

f. There is no difference in abundance and distribution of *Chrysichthys nigrodigitatus* in relation to other fish species in Jebba Lake

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Physico-chemical Characteristics of Water Bodies

Water is essential for the survival of life on earth. The availability of water plays a significant role in the location, and activities of human beings, because growth explosion is placing great demands on natural fresh water resources (Waziri and Ogugbuaja, 2010). Fresh water bodies are important source of water for human consumption and activities, such as drinking, agriculture, domestic use (including cooking, washing), transportation, recreation and electricity generation (Andem *et al*., 2012).

Fresh water bodies, supports diverse plants and animals community that is affected due to changes in the physico-chemical parameters, as a result of untreated discharge of pollutants from domestic sewers, industrial waste and agricultural runoff (Singh, 2007). Changes in physico-chemical parameters affect the survival and growth rate of organisms in water bodies, which cause their disappearance (Edward and Ugwumba, 2010). To protect fisheries, either in culture or capture, water quality requirements in terms of physico-chemical parameters are of paramount importance. Any chemical, physical and biological changes in water quality could have a harmful effect on organism and makes water unsuitable for the desired use (Araoye *et al*., 2007). Physical parameters include length, width, area, volume and depth of water, water temperature, total suspended and dissolved solids, turbidity, transparency and total surface area of the water body. Chemical parameters include conductivity, pH, dissolved oxygen, biochemical oxygen demand, total alkalinity, salinity, nitrate, phosphate, etc.

Knowledge of the physico-chemical parameters, fish and fishery of a body of water are invaluable in the determination of its productivity, stock assessment and management tools for sustainable fishing (Atobatele and Ugwumba, 2008). In addition, these parameters form the basis for enlightened fisheries and water resources management (Araoye *et al*., 2007). Natural waters, whether rivers, lakes, dams and estuaries, contains some level and types of impurities at various state and concentration, which are subjected to continuous change (Araoye *et al*., 2007). Direct interactions of many frequently measured water quality parameters with biotic components, which affect productive potentials of fish species, have been documented (Adakole, 2002).

2.1.1 Water Temperature

Temperature has a pronounced effect on chemical and biological processes being an important water quality parameter and relatively easy to measure. Many aquatic organisms are sensitive to changes in water temperature (Bellingham, 2012). It is known that temperature affects the feeding, growth and behaviour of fish. Water bodies will naturally show changes in temperature seasonally and daily; however, man made changes to water temperature will affect fish's ability to reproduce. The recommended value of temperature in natural water bodies is $25^{o}C$ (WHO, 2004) and $20^{o}C$-$30^{o}C$ for aquatic life in tropical region (Horsfall and Spiff, 2003). Many lakes and rivers exhibit vertical temperature gradients as the sun warm the upper water and the deeper water remains cooler. Fish has poor tolerance to sudden changes in temperature, but readily tolerate gradual changes in temperature (Schwarzenbach *et al*., 2003). Aremu *et al*. (2011) recorded temperature range of 22^{o}C-23^{o}C and 23^{o}C-24^{o}C, for wet and dry seasons respectively in Doma, Farin ruwa and Mada Rivers. Temperature ranges of 22^{o}C-26^{o}C and 26^{o}C-28^{o}C for wet and dry seasons were recorded by Mustapha and Omotosho (2005) in Moro Lake and concluded that there was variation in temperature, but fall within the optimal for normal fish growth and survival of aquatic organisms. In Ona River, temperature range of 26.17^{o}C- 27.50^{o}C was recorded, where the discharge of effluents had influence in the water quality (Andem *et al*., 2012). Idowu *et al*. (2004) recorded temperature range of 25.05 ^{o}C -27.24^{o}C and asserted higher altitudes as responsible for extreme temperature in Lake Alau. Temperature range of 22.50^{o}C-27.00^{o}C was recorded in Lake Kubanni (Adakole *et al*., 2003), Anago *et al*. (2013) reported 24.00^{o}C-26.5^{o}C in Awba Reservoir. Edward and Ugwumba (2010) in Egbe Reservoir recorded temperature of 31.8^{o}C-26.8^{o}C.

2.1.2 Dissolved Oxygen (DO)

Dissolved Oxygen (DO) is essential to all forms of aquatic life including the organisms that break down man-made pollutants. Oxygen tends to be less soluble as temperature increases (Rao, 2005). The DO concentration in unpolluted fresh water range between 8mg/l and 10mg/l, for drinking purpose is 6mg/l, while for sustaining fish and aquatic life is 4mg/l-5mg/l, respectively (Bellingham, 2012). Typically, dissolve oxygen (DO) levels of less than 2 mg/l kills fish. The DO concentrations in unpolluted freshwater will be close to 100% (Kannel *et al*., 2007). Low DO can be lethal to fish, resulting to anoxia, and reduce fecundity thereby, influence spawning and egg hatchability (Boyd, 1990). Different fish

species have different requirements for the concentration of oxygen dissolved in water (Boyd, 1990).

There are two main sources of oxygen in fresh water - diffusion from the atmosphere and photosynthetic activities (Boyd, 1990). The atmosphere is known to contain nearly 21% oxygen gas but solubility in water is relatively low. Oxygen derived from photosynthesis through the activities of aquatic plants, mostly phytoplankton. The greater amount of dissolved oxygen in water comes from this source, which is readily available for fish and other organisms. Three significant factors have effect on the level of dissolved oxygen in water bodies (Boyd, 1990). These are temperature, photosynthesis and respiration. The solubility of oxygen in water decreases with increase in temperature, but this will depends on other features of the water body, such as length, depth, width, water inflow and out flow. Plankton density, especially phytoplankton has great effect on daily changes of oxygen concentration in water body. Oxygen is lowest at sunrise before any active photosynthesis, increase during daylight hours to peak during late afternoon or early evening and decline at night. Respiration carried out by organisms in the water be it fish, zooplankton, benthic organisms and during decomposition of organic matter will also have effect on the level of dissolved oxygen in water (Rao, 2005).

DO concentrations vary from one natural water body to another, whether lake, stream, floodplain, reservoir, river or lagoon. DO value range of 3.8 mg/l - 6.8 mg/l and 3.2 mg/l - 4.4 mg/l for wet and dry seasons, respectively was recorded in Moro Lake (Mustapha and Omotosho, 2005). In Usuma Dam, DO of 79.0 mg/l -110.0 mg/l for wet season and 23.0 mg/l-131.0 mg/l for dry season was recorded and

assertion for good level of DO in the river was due to high aeration rate and rapid aerobic oxidation of biological substances with low level of anthropogenic activities (Ugwu and Wakawa, 2012). DO of 2.24 mg/l - 3.46 mg/l was recorded for Ona River, which is lower than the permissible range of 5.0mg/l, therefore harmful to aquatic life, due to high levels of total suspended solids content of effluents and organic loads that required high levels of oxygen for oxidation (Andem *et al*., 2012). DO of 5.15 mg/l-6.35 mg/l was recorded in Lake Alau (Idowu *et al*., 2004), which is high due to constant mixing of the water mass by strong northeastern winds that aerate the water to increase oxygen level in the lake. Adakole *et al*. (2003) recorded 2.70 mg/l-9.40 mg/l in Lake Kubanni, 15.5 mg/l-3.0 mg/l was recorded in Egbe Reservoir (Edward and Ugwumba, 2010), Mustapha (2008) and Anago *et al*. (2013) recorded 4.8 mg/l-8.2 mg/l in Oyun Reservoir and 0.7 mg/l-1.8 mg/l in Awba Reservoir, respectively.

2.1.3 Hydrogen Ion Concentration (pH)

Hydrogen ion concentration otherwise known as pH is an important factor that plays a vital role in freshwater. It is a measure of the acidity of water or in other words, the measure of hydrogen ion (H+) availability in water. It affects many biological and chemical processes in the water; known to influence the toxicity of certain chemicals such as ammonia, cyanides and sulphides (Rao, 2005). The lower the pH, the more acidic is the water. In natural waters, a pH of 7 is considered neutral, therefore a pH less than 7 is acidic and that higher is considered to be alkaline (Bellingham, 2012). Aquatic organisms are affected by change in pH, because most metabolic activities are dependent pH level (Murdock *et al*., 2002). Acid waters of pH below 6.5 will not allow good plankton growth and so will not be productive (Rao, 2005). In addition, large changes in pH tend to stress fish and

reduce growth. Fresh water fish generally cannot survive in waters below pH 4 and above pH 11 for long periods. The optimum pH for fish is between 6.5 and 9 (Boyd, 1990). Similarly, pH range of 6.5-8.2 is optimal and suitable for aquatic life (Murdock *et al*., 2002).

The individual and combined effects of dissolved oxygen and pH are of great importance in spatial and temporal distribution of aquatic organisms particularly fish fauna (Araoye, 2008). Change in pH levels is due to industrial pollution, photosynthesis or respiration of algae that feed on contaminants. Most of the ecosystems are sensitive to pH changes and has been incorporated into the environmental laws of most countries, especially the industrialized world (Bellingham, 2012). pH of natural water bodies have been documented. Olele and Obi (2004) recorded 6.1-7.9 as pH in Onah Lake, and suggested that the lake is almost neutral. Aremu *et al*. (2011) recorded pH of 7.36-7.77 and 6.40-6.68 for wet and dry season respectively in Rivers Doma, Farinruwa and Mada. pH values of 7.19-7.89 and 6.89-7.53 for wet and dry season in River Usuma was reported (Ugwu and Wakawa, 2012) and Andem *et al*. (2012) recorded pH of 7.27-7.47 in Oni River, which did not show any difference, and concluded that it is uniform throughout the river. pH range 6.59 - 7.29 in Lake Alau did not show any difference but falls between acidic and alkaline lake depending on the season (Idowu *et al*., 2004). Adakole *et al*. (2003) recorded pH values 6.16-7.50 in Lake Kubanni, 7.4 -8.9 were recorded in Egbe Reservoir (Edward and Ugwumba, 2010) and Anago *et al*. (2013) reported 7.3-8.4 in Awba Reservoir.

2.1.4 Transparency

This is a measure of water clarity. It is the most obvious measures because the colour of water can give an indication of its quality (WAV, 2006). Transparency decreases with the presence of molecules and particles that can absorb or scatter light. The transmission of light into a body of water is extremely important, since the sun is the primary source of energy for all biological processes, that is, necessary for photosynthesis, a process that produces oxygen and food for consumers (Bellingham, 2012). The clearer the water the deeper sunlight will penetrate. Transparency influences the assemblage of fish species in the water body. Fish species with sensory adaptation to low light are dominant in turbid lakes, whereas those that rely on vision predominates clear lakes (Rodriguez and Lewis, 1997). Two techniques can be used to measure transparency. If the water body is deep and still (not flowing as a stream) secchi disc can be used, and if it is shallow or flowing transparency tube can be used.

Transparency of different water bodies has been documented. Mustapha and Omotosho (2005) recorded transparency during wet and dry seasons as 17.0cm - 55.0cm and 24.2cm - 44.6cm, respectively in Moro Lake, and asserted that the high values during the rains, resulted from washing of suspended particles long with floodwater into the lake, because of high water velocity. Transparency of 0.26 m - 0.42 m was recorded in Lake Alau (Idowu *et al.*, 2004). Adakole *et al.* (2003) recorded 5.00 cm - 65.00 cm, Edward and Ugwumba (2010) recorded 2.14 m - 0.56 m, and 0.2 m-0.4 m in Awba Reservoir.

2.1.5 Total Alkalinity and Hardness

Total alkalinity refers to the total concentration of bases in water expressed as mg/l of equivalent calcium. It is primarily, carbonate and bicarbonate ion. Soils, rocks,

plant activities and man activities influence water alkalinity. Waters with high alkalinities have higher buffering capacity than the ones with low alkalinities (Bellingham, 2012). Hardness is the total concentration of primarily magnesium expressed in mg/l of equivalent calcium carbonate. It is desirable to have water with a total hardness greater than 20mg/l. High total hardness is caused by high concentration of calcium and magnesium ions in the water and utilizing these ions by organisms decrease hardness (Mustapha, 2008).

The values of total alkalinity and total hardness are similar in magnitude because calcium, magnesium, bicarbonates and carbon ions in water are derived in equivalent quantities from limestone solution. However, there is generally no practical way of decreasing total alkalinity and hardness when it is above the desirable level (Mustapha, 2008). Aremu *et al*. (2011) recorded Alkalinity for wet and dry season in River Doma as 2.21 mg/l and 0.29 mg/l, River Farinruwa 1.56 mg/l and 0.57 mg/l, 1.14 mg/l and 0.66 mg/l in River Mada. Total hardness of 26.3 mg/l-44.2 mg/l and 26.3 mg/l-40.2 mg/l was recorded in Moro Lake (Mustapha and Omotosho, 2005). Idowu *et al*. (2004) reported 30.3 mg/l-47.0 mg/l in Lake Alau. Adakole *et al*. (2003) recorded 72.00 mg/l-288 mg/l total hardness and 19.00 mg/l-179 mg/l total alkalinity in Lake Kubanni. Alkalinity of 215.0 mg/l-125.6 mg/l and 67.76 mg/l-82.64 mg/l was recorded for Egbe Reservoir (Edward and Ugwumba, 2010) and Ona River (Andem *et al*., 2012), respectively. Alkalinity reported in River Usuma was 1.56 mg/l-3.16 mg/l during dry season, and 2.15 mg/l-5.44 mg/l during wet season (Ugwu and Wakawa, 2012).

2.1.6 Electrical Conductivity (EC) and Total Dissolved Solid (TDS)

Electrical conductivity in natural waters is the normalized measure of the water's ability to conduct electric current (Bellingham, 2012). This is mostly influenced by dissolved salts such as sodium chloride and potassium chloride. The common unit for electrical conductivity is Siemens per meter (S/m). Most freshwater sources will range between 0.001S/m to 0.1 S/m (Boyd, 1990; Rao, 2005). Ugwu and Wakawa (2012) reported that EC of most freshwater range between 0.1µS/cm - 10µS/cm. The source of EC could be traced to abundant of dissolved salts, because of poor irrigation management and minerals from runoffs (Bellingham, 2012).

Electrical Conductivity is also the measure of the water quality parameter "Total Dissolved Solids" (TDS) or salinity. At about 0.3 S/m crops and freshwater aquatic organisms will be affected by salinity. Higher TDS in natural water systems such as lakes, rivers and floodplains increase the chemical and biological oxygen demand and ultimately depletes the DO level in water (Ugwu and Wakawa, 2012). Field measurements of EC reflect the amount of total dissolved solids (TDS) in natural waters. The relationship between TDS and EC can be described by the equation;

TDS (mg/L) = EC (mS/cm) x 640

Electrical Conductivity of 62.4 µS/cm - 88.5 µS/cm and 63 µS/cm - 80.4 µS/cm was recorded in Moro Lake (Mustapha and Omotosho, 2005) and Aremu *et al*. (2011) recorded 0.58 µS/cm, 0.78 µS/cm, and 0.64 µS/cm in Doma, Farinruwa and Mada Rivers, during dry season and 0.31 µS/cm, 0.33 µS/cm, 0.34 µS/cm during wet season. Andem *et al*. (2012) reported 270.35µS/cm - 297.56 µS/cm as EC and 484.76 mg/l-625.42 mg/l as TDS in Ona River, where the values fall within the medium level 50 µS/cm-600 µS/cm, because of increase in the amount of organic materials in the river. EC of 81.30 µS/cm-299.00 µS/cm and 233.10 µS/cm- 540.00

µS/cm was recorded in Usuma Dam (Ugwu and Wakawa, 2012), also recorded TDS of 48.80 mg/l - 179.50 mg/l and 168.90 mg/l - 465.20 mg/l during dry and wet seasons, respectively in the same river. The EC values observed was due to storm water runoff, which brings a lot of water from farms with dissolved minerals and TDS values, was due to mixing of pollutants because of human activities such as washing, garbage dumping and sewage disposal into the river. EC of 31.45µS/cm-128.80µS/cm was recorded in Lake Alau by Idowu *et al*. (2004). High conductivity in Alau Lake could be due to ions concentration, because of decrease in depth. Waziri and Ogugbuaja (2010) recorded TDS of 47.75 µS/cm -83.20 µS/cm in River Yobe.

Adakole *et al*. (2003) recorded 100 µS/cm-4520 µS/cm EC and 65.00 mg/l-293.80 mg/l TDS in Lake Kubanni. Edward and Ugwumba (2010) reported 62.5 µS/cm-120 µS/cm EC and 0.02 mg/l -2.28 mg/l TDS in Egbe Reservoir and Anago *et al*. (2013) reported 290.75 µS/cm - 391.5 µS/cm EC and 143.7 mg/l-159.5 mg/l TDS in Awba Reservoir.

2.1.7 Turbidity and Total Suspended Solids (TSS)

Turbidity is also an important water quality parameter. Turbidity or TotalSuspend Solids (TSS) is the material in water that affects the transparency or light scattering of the water (Schwarzenbach *et al*., 2003). The measurement unit used to describe turbidity is Nephelometric Turbidity Unit (NTU). The range for natural water is 1NTU to 2000 NTU. There are a number of manual field methods for measuring total suspended solids, such as Secchi disc, where a metal disc is lowered in the water with a calibration line. The depth at which the disc disappears is directly correlated to total suspended solids. In situ electronic turbidity sensors

measure the backscatter of infrared light to determine the nephelometric turbidity unit of the water (Bellingham, 2012).

The term turbid indicates water containing suspended material, which interferes with the passage of light. Turbid water has many particles suspended in it, which may be plankton or suspended solid (silt, clay/mud). It is a measure of water transparency, often times, they are result of runoffs, which carries heavy load of silt and clay that hampers light penetration and retard planktonic growth (Rao, 2005, Ugwu and Wakawa, 2012).

Total suspended solids are typically composed of fine clay or silt particles, plankton, organic compounds, inorganic compounds or other micro-organisms. These suspended particles range in size from 10 nm to 0.1 mm although in standardized laboratory tests, total suspended solids is defined as the material that cannot pass through a 45 μm diameter filter (Rao, 2005). Man-made TSS includes erosion, storm water runoff, and industrial discharges (Bellingham, 2012). Total suspended solids as well as total dissolved solids can be influenced by changes in pH. Changes in the pH will cause some of the solutes to precipitate or will affect the solubility of the suspended matter (Bellingham, 2012).

A persistent clay turbidity, which restricts visibility into the water to 30 cm or less may prevent development of plankton bloom. Turbidity caused by plankton is not harmful to fish as it is a source of food and so beneficial, but in the case of turbidity caused by suspended solids also do not have direct effect on fish but it restricts the amount of light that will penetrate the water and limit photosynthesis and dissolved oxygen production (WAV, 2006). Clay turbidity that exceeded 20,000 mg/l, according to Pillay (1992) cause behavioral reactions in many species of fish, and

soil particles sedimentation destroyed benthic macro-invertebrates and smoothen fish eggs. The longer the water remains at unusually high values, the greater its effect on fish and other aquatic organisms, are, where the fish becomes stressed, leads to increased respiration rate, reduced growth and feeding rates, delayed hatching of eggs and even death (WAV, 2006).

Turbidity and total suspended solids documented included that of authors, such as, Ugwu and Wakawa (2012) that recorded 3.24 mg/l-246.00 mg/l during dry, 5.64 mg/l-290.00 mg/l during wet seasons in Usuma Dam, Idowu *et al*. (2004) recorded 59.17 mg/l-67.88 mg/l, and that naturally, the concentration and relative abundance of ions in lakes is highly variable. TSS of 0.01 mg/l-2.00 mg/l was recorded in Egbe Reservoir (Edward and Ugwumba, 2010). Aremu *et al*. (2011) recorded 9.77 mg/l, 7.06 mg/l and 207 mg/l as turbidity in Doma, Farinruwa and Mada Rivers during wet season, 0.7 mg/l, 0.5 mg/l and 0.40 mg/l during dry season in the same rivers.

2.1.8 Phosphate

Phosphorus is an essential nutrient for all life forms, being one of the key elements necessary for plants and animals growth. Lakes and reservoir sediments, serve as phosphorus sinks, where they settle on the substrate and continuous accumulation will increase its concentration in the water (Bellingham, 2012). There are two sources of phosphorus. Non-point source, which is natural from phosphate - rich rocks, seasonal overturns of lakes and reservoirs, and point source from sewage treatment plants, industrial products such as toothpaste, detergent, food - treating compounds and pharmaceuticals. Rao (2005) reported that the most common source of phosphate pollution is poor management of agricultural effluents and runoffs.

Phosphates occur in water as particulate or in dissolved form. Particulate form include living and dead plankton, precipitate and amorphous phosphorus, while the dissolved form include organic and inorganic phosphorus excreted by organisms. Rainfall can cause variation in amounts of phosphates by washing from farm soils into nearby water ways. It stimulates the growth of phytoplankton and aquatic plants that provide food for fish, which may increase fish population and improve the overall water quality. However, excess, often cause eutrophication or algal bloom, with resultant death of organic life, because of low dissolved oxygen level.

The natural total levels of phosphorus are generally less than 0.03mg/l, while that of phosphates range from 0.005 mg/l to 0.05 mg/l; it should not exceed 0.05 mg/L in a stream at a point where it enters a lake or reservoir and should not exceed 0.1 mg/l in streams that do not discharge directly into lake or reservoirs (Rao, 2005). Idowu *et al*. (2004) recorded 0.28 mg/l - 0.37 mg/l phosphorus in Lake Alau, and 0.3 mg/l-0.10 mg/l was recorded in Onah Lake and asserted the lake as oligotrophic (Olele and Obi, 2004). Edward and Ugwumba (2010) recorded 11.80 mg/l - 91.5 mg/l in Egbe Reservoir, and, Idowu and Ayoola (2008) recorded 1.56 mg/l - 5.56 mg/l phosphate at Lagoon systems in Ogun waterside. Phosphate values of 0.33 mg/l-1.66 mg/l and 2.76 mg/l-10.56 mg/l were recorded during dry and wet seasons, respectively in Usuma Dam (Ugwu and Wakawa, 2012).

2.1.9 Nitrate

Nitrogen is a very common gas, making up about 79% of the earth's atmosphere, which cannot be used by organisms unless fixed through nitrogen fixation, industrial methods, or certain bacteria transform it into useful nitrogen

compounds (Rao, 2005). Nitrates occur in small amounts in all aquatic environments, and are required to maintain the growth and metabolism of both plants and animals. However, excess amounts have proved harmful especially through the process of eutrophication, dissolved minerals and nutrients flow into streams, lakes, rivers (Bellingham, 2012). Natural sources of nitrate include igneous rock, plant decay, animal debris, and man-made sources, such as, fertilizers, livestock, runoff, septic tanks and waste water discharges (Rao, 2005). One of the wide spread types of pollution is the addition of large quantities of inorganic nutrients, particularly nitrogen and phosphorus to freshwater lakes and ponds. Nitrate levels of over 5mg/l indicate man-made pollution and become extreme at 200mg/l (Bellingham, 2012).

Levels of nitrates that are intolerable to organisms have been known to deplete dissolved oxygen levels by causing algae blooms. Ansar and Khad (2005) reported that eutrophication brings with it high amounts of phosphates and nitrates, which is a main cause in the destruction of lake ecosystems around the world. Similarly, Yanamadala (2005) reported that increased levels of nitrates often indirectly harm the environment by causing bacterial growth and huge algae blooms. Idowu *et al*. (2004) recorded 4.27 mg/l-6.30 mg/l of nitrates in Lake Alau, 0.02 mg/l-0.14 mg/l was recorded in Onah Lake (Olele and Obi, 2004) and 6.82 mg/l-128.0 mg/l was reported in Egbe Reservoir (Edward and Ugwumba, 2010). Idowu and Ayoola (2008) recorded 0.14 mg/l - 0.20 mg/l at Lagoon systems in Ogun waterside. Nitrate values of 0.01 mg/l-0.25 mg/l and 0.15 mg/l-2.54 mg/l were recorded during dry and wet seasons, respectively in Usuma Dam (Ugwu and Wakawa, 2012).

2.2 Growth and Age Parameters of *Chrysichthysnigrodigitatus*

2.2.1 Length-weight relationship and other morphometrics parameters of *Chrysichthys nigrodigitatus*

Length and weight are two basic components in the biology of fish species at individual and population levels. Ekanem (2000) reported *C. nigrodigitatus* total lengths range of 34.00cm- 64.00cm and weights range of 217.00g-2200.00g in Cross River. Dada and Araoye (2008) reported 240 specimens of *C. nigrodigitatus* in Asa Lake with standard length, total length and weight range as 10.50cm-16.50cm, 12.20cm-19.80cm and 9.76g-58.03g, respectively. The male and female had length range of 12.20cm-19.80cm and 13.40-19.50cm, and weight range of 9.76g-58.03g and 10.01g-56.61g, respectively.

Length-weight relationships of fish play a significant role in fishery management (Haimovici and Velasco, 2000), which gives an estimate of average fish weight at a given body length, assess the well-being of fish population (Bolger and Connolly, 1989) and in assessing their maturity, growth and production. Growth model in fish generally follows the cube law hence the use of Fulton's Condition Factor or the Isometric Factor. Attributing to the length - weight exponent, according to Gulland (1987), a value equal to 3 is isometric growth pattern. The growth exponent $b = 3$ indicate that the body form maintains a constant proportion to length (Weatherly and Gill, 1987) while when $b >< 3$ shows allometric growth pattern, which could be positive when b is greater than 3 or negative when b is less than 3. Pauly (1984) reported that a slope value greater than 3 denotes allometric growth while Pauly and Gayanilo (1997) reported that b values may range from 2.5-3.4 for fish species.

Yem *et al*. (2007) reported values of $b = 3.29$ and 2.49 for males and females respectively of *C. nigrodigitatus* in Lake Kainji and concluded that males showed positive allometric growth while females showed negative allometric growth. Ofori-

Danson *et al*. (2002) reported b value of 3.010 for females from in Lake Volta. Francis and Elewuo (2012) reported b-values of 1.93-2.09 in New Calabar River that showed negative allometry. Inyang and Ezenwaji (2004) reported isometric growth (3.109 ± 0.281) in the population of *Chrysichthys* species found in Agulu Lake. Similarly, Ecoutin *et al*. (2005) recorded b - value of 3.127 in Gambia and concluded that the fish exhibited isometric growth. Konan *et al*. (2007) reported a, b and r as 0.011, 2.899 and 0.938, respectively, that showed isometric growth and positive correlation between the length and weight of *C.nigrodigitatus*.The exponent (b) values of 2.951, and 2.82 for the pooled species reported by Etim (2000) and Yem *et al*. (2007) respectively showed allometric growth, while Fafioye and Oluajo (2005) obtained b value of 3.042, which showed isometric growth. Offem *et al*. (2008) recorded mean b values of 2.206, 2.995 and 3.040 in Cross River, which depicted negative and positive allometry growths. Abowei and Ezekiel (2013) obtained b value of 3.21 in Amassoma river flood plains, and asserted that the fish showed isometric growth, where the length and weight of the fish grows at the same proportion.

Lawal *et al*. (2010) did report b value of 2.8168 and that the length-weight relationship of *Chrysichthys nigrodigitatus* reflected an increase in weight with a corresponding increase in length. In other words, the regression coefficient (b) is approximately 3, which showed that the species exhibited isometric growth in Epe Lagoon. Correlation coefficient (r) of 0.8683 showed positive correlation between length and weight of the fish in the Lagoon.

Condition factors of different populations of the same species give some information about food supply, timing and duration of breeding (Thomas *et al*., 2003). Condition factors have been used as an indicator of fish growth, food supply and feeding intensity

(Abowei, 2009). It can also be used in assessing the well - being of fish (Oni *et al*., 1983). When condition factor (K) is equal to1 (unity) and above it indicate that the fish is doing well in the water body and is heavy. Estimation of well-being of standing stock biomass and densities of various species of fish in a locality could also be established through condition factor (Thomas *et al*., 2003).

Bagenal and Tesch (1978) documented condition factor (K) for mature freshwater fish to range from 2.9 to 4.8. Taiwo and Aransiola (2001) reported K value of 2.13 for males *C. nigrodigitatus* in Asejire Lake, which was better than 0.842 earlier reported for males in the same lake and concluded that the condition of the fish had improved over time. Ekanem (2000) reported a range of 0.77 - 1.80 of K-value from Cross River. K values obtained from Kainji Lake for males and females as reported by Yem *et al*. (2007) ranged from 0.44 - 1.74 with mean of 1.90 and 0.27 - 1.26 with mean of 0.765 respectively, Fafioye and Oluajo (2005) reported 0.79 ± 0.15, which is less than 1 for samples from Epe Lagoon. A mean condition factor (K) of 0.977 obtained for female *Chrysichthys nigrodigitatus* in Epe Lagoon is higher than 0.9673, 0.9159, and 0.7859 reported for females in Badagry Lagoon, Warri River and Imo River, respectively (Ezenwa *et al*., 1986). The fact that 58.2% of the samples examined in Cross River had K above unity indicated that majority of the fish in the population of the river were in excellent condition. Offem *et al*. (2008) on the other hand reported condition factor of 0.533 - 1.261 with annual mean of 0.718 ± 0.117 and 0.996 ± 0.062 for males in Cross River, where the highest condition factor was recorded between June and August. Dada and Araoye (2008) recorded condition factor of 1.67 for male and 0.53 for female with mean values of 1.12 and 0.98, respectively, while a mean value of 0.95 was reported for both sexes. Lawal *et al*. (2010) reported condition factors for males, females and combined as 1.25 - 1.92, 1.72 - 2.25 and 1.25 - 2.09, respectively. Mean condition factor values were 1.68, 1.96 and 1.76. There was a general decrease in condition factor with increased length of specimen. Atobatele and Ugwumba (2011) reported lowest K-value for male and female *Chrysichthys nigrodigitatus* as 3.03 and 2.76, respectively, while highest were 4.00 and 3.50 respectively. A mean K-value of 1.31 that ranged from 0.40 - 1.93 for samples from New Calabar River (Francis and Elewuo, 2012). Abowei and Ezekiel (2013) obtained K value of 0.99 in Amassoma river flood plains.

Taxonomy is basically the science of correctly naming species of both plants and animals. Fish taxonomy has often been confused with fish identification, which basically refers to the use of the latest taxonomic information to identify fishes. It is very significant and of paramount importance in any biological studies because it gives a clear picture of the species of fish being considered. Morphometric and meristic or counts are important characteristics on which fish identification is based. The clarification of the taxonomic status is vital for comparisons with natural conspecific population in other lakes. Closely related species have been reported to have similarities in their protein make up, whereas those taxonomically apart showed striking differences (Adepo-Gourene *et al*., 1997). Although, the use of microsatellite has been used in the taxonomic clarification of the status of some fish species, the use of serum and eye lens proteins has been proven to be more useful in fish taxonomy (Adepo-Gourene *et al*., 1997).

Chrysichthys nigrodigitatus is a common and commercial value fish in African and Asian fresh waters. It consists of many species out of which only two (2) species have been reported in Jebba Lake. These are *Chrysichthys auratus longifilis* synonym to *Chrysichthys auratus* and *Chrysichthys nigrodigitatus* synonym to *Chrysichthys furcatus*.

Chrysichthys nigrodigitatus, otherwise known as the silver catfish, has Dorsal II, 6; Anal V - VI, 9 - 10. Adipose fin is round and is not rayed. The head viewed from above is oval and the eye is very large and easily visible from above. It has a small mouth; the width of pre-maxillary tooth plate is 20% - 30% of the head's length. The dorsal fin is large and its upper edge round, where the second or third ray is longer than the rest in adult. The caudal fin is deeply forked and upper lobe also prolonged into filament. Fapohunda and Godstates (2007) reported that the species dorsal fin I, 9; anal I, 14; caudal fin 19; pectoral I, 7; and ventral fin I, 4 as meristics, while head length, body depth and body girth was 70mm, 60mm and 135mm respectively.The colour is grayish - blue, except for the ventral surface, which is white. The fins are grayish - pink, the adipose fin black, the lips and the barbels are pink. Immature or non-breeding ones could be identified by their pointed snout, which is slightly longer than or equal to the width of the mouth. Paugy *et al*. (2003) did report live specimens as grayish - silvery, but may become black under stress. Preserved specimens are dark brown on head and back, and white on belly. Adipose fin is often blackish; black spot behind gill cover very distinct; fins black - edged.

The square or rectangular teeth developed when the fish is 60 mm-70 mm in standard length, first as isolated teeth. The second or third ray is longer than the rest in adult dorsal fin. Spines are acute and not covered by epidermal tissue. The superior lobe of the caudal fin is much longer than the inferior. These morphological features differ with matured or breeding male and female. The species matures late at 200mm standard length. At maturity, the head and mouth gets swollen, as well as the premaxillary tooth plate, which becomes enlarged. The fins are round and the lobes of the caudal fin can be unequal if the fish attains a maximum total length of 650mm.

Catfishes are generally primary freshwater fishes with a wide geographical distribution. They are generally called catfishes because of the presence of ‘barbels’ or ‘whiskers’at the mouth region. There are 33 families of catfishes with 416 genera and 2,584 species (Paugy *et al*., 2003). *Chrysichthys nigrodigitatus*, (Plate 1) commonly known as ″Silver catfish″ belongs to the family Claroteidae (Pisces: Siluroidae), which are ray-finned fish. Members of the family Claroteidae, which are catfishes, are characterized by thr presence of four pairs of barbels with the exception of *Auchenoglanis* that has three pairs of barbels, well developed pectoral-fin spines, strong dorsal spine, a moderately or strongly developed pectoral-fins spines, strong strong dorsal spine, a moderately or strongly developed adipose fin, and a medium- sized anal fin (Paugy *et al*., 2003). Mouth supported dorsally by the premaxilla and part of the maxilla. They are all endemic to Africa and classified into 2 sub-families: Claroteinae and Auchenoglanidinae (Nelson, 2006).

The family comprised of five genera - *Auchenoglanis*, *Clarotes*, *Parauchenoglanis*, *Chrysichthys*, and *Notoglanidium*. The genus *Chrysichthys* was split off from Bagridae by Mo (1991) along with other African Bagrids as a monophyletic assemblage based on several anatomical structures. Claroteid catfishes are confined to freshwater but some of the species are also found in estuaries (brackish water).Below is the general classification of the silver catfish *Chrysichthys nigrodigitatus* (Nelson, 2006).

Kingdom:	Animalia
Subkingdom:	Bilateria
Infrakingdom:	Chordonia
Phylum:	Chordata
Subphylum:	Vertebrata

Infraphylum:	Gnathostomata
Super class:	Osteichthyes
Infraclass:	Actinopteri
Class:	Actinopterygii
Order:	Siluriformes
Family:	Claroteidae
Genus:	*Chrysichthys*
Species:	*nigrodigitatus*
Scientific name:	*Chrysichthys nigrodigitatus*
Common name:	Silver catfish

Plate I: The silver catfish,*Chrysichthys nigrodigitatus* (Lacepede, 1803)

2.2.2 Age composition and structure of *Chrysichthys nigrodigitatus*

The exact age determination of fish is one of the most important elements in the study of their population dynamics. It forms the basis for calculations leading to the knowledge of growth, mortality, recruitment and other fundamental parameters of their populations. Age and growth determination of fish species is an essential component in understanding the changes in fishery of any water body (Ogueri *et al*., 2009). Selection of appropriate method for age and growth determination in fishes often requires balancing precision and accuracy of the method with the limitation in sample size (Zymonas and McMahon, 2009).

There are basically three methods used to determine the age of fishes. The first is recovering the marked fish of a known age that requires the capture, release, and recapture of fish. This is otherwise known as mark-release-capture method, which is the most accurate method under natural conditions. It is expensive and time consuming, thereby limiting its application in fisheries. (Zymonas and McMahon, 2009). The second, referred to as Peterson method, involves comparisons of length-frequency distributions of fish population samples. It requires measuring the length of a large number of fish in a population. This method is most reliable in younger year classes of fish, older fish grow more slowly in length and variation among individuals tends to obscure variation between year classes (Cailliet *et al*., 1986). Peterson method can best be used in temperate species with seasonal spawning activities that can be adequately sampled. Tropical water fishes spawn throughout the year, therefore distinct year classes are difficult to be recognized in such setting. These methods are based on the assumption that each modal class in a frequency distribution will correspond to a cohort and represent different age classes determined at regular intervals (Cailliet *et al*., 1986). The presence of modes in the length distribution depends on the distance between the medians, the extent of the variance, the proportion of each age class in the population and the size of the sample studied (Zymonas and McMahon, 2009).

The third method is anatomical approach, which is commonly used, involve counting marks that develop periodically on some hard parts of fishes. Several kinds of parts in fishes that are calcified can be used to determine age, which are as follows; otoliths, scales, cross sections of ray fins, operculum and vertebrae. Ages of fish are estimated by comparison of the readings from various bony structures by different readers. Metin and Ilkyaz (2008) reported that age determination in fish can be carried out by counting seasonal growth annuli appearing on hard structures such as otolith, scale, fin ray and spine. According to Gomez-Marquez *et al*. (2008), annual growth rings may not be formed in most tropical fishes as in temperate fishes, which make fish ageing difficult. Attempt had been made to correlate spawning with annual growth rings on scales amongst others (Adeyemi *et al*., 2009).

2.2.2.1 Operculum

The operculum of a bony fish is the hard bony flap that covers and protects the gills. In most fish, the rear edge of the operculum marks the division between the head and the body. It is composed of four fused bones-opercle, and sub-opercle. The morphology of operculum varies greatly between species and in some species is vital in obtaining oxygen. Both the left and right operculum should be collected, cleaned and observed under the microscope with a dark background (Winter *et al*., 2002). Jimenez-Badillo (2006) reported complete growth rings on the opercular bones of *Oreochromis aureus*. Similarly, Gomez-Marquez *et al*. (2008) derived age data from opercular bone readings of *Oreochromis niloticus*.

2.2.2.2 Otoliths

Otolith has been used to determine the age of both tropical and temperate fishes in recent times. It is also known as ‘ear bone’- hard structure located in the cranial bones near the brain, which composed of calcium carbonate crystal embedded in an organic matrix. Fresh or frozen otolith are best used for age determination, which must be removed as soon as the fish dies and fixed immediately to avoid the loss of the growth structures. Both left and right otoliths should be collected and kept separate until their morphology can be differentiated and also used if either is damaged during handling, or is crystalline. The growth rings in both otoliths are usually identical. The way in which otoliths are removed depends on the type of fish and is usually examined on black background with reflected light in an aqueous medium (Jones, 1992). Similarly, Jones (1992) reported that otolith had been the most reliable indicator of age for most fish because it shows annual rings, and for younger fish, daily pattern of rings.

Many studies have documented the use of otoliths for age determination, which provides the most precise and accurate estimates. However, its removal can be difficult, preparation quite time consuming and fish sacrifice may not be visible in some situation. Fagade (1980) examined the gross morphology of otoliths of *Chrysichthys nigrodigitatus* from Asejire Lake and used it to determine its age. Brown *et al*. (2007) validated the use of otolith as a structure for age determination. Phelps *et al*. (2007) reported that otoliths have gained favour over other body structures because of their lack of absorption and its growth is acellular rather than by calcification.

2.2.2.3 Scale

Scales of fishes are remarkable bony structures because much information can be obtained about the growth history and longevity of individual fish by close examination of their scales or other bony structures. Scales are covered with a very thin, outer layer of skin called the epidermis. There are two principal types of scales, which can be distinguished on the basis of their structure. The first group is represented by the ganoid scales - thick, rhombic and covered by a shiny outer layer of ganoine. The second group comprises two different kinds: the cycloid scales, which are thin and smooth and ctenoid scales, which bear small spines on their posterior margin. It starts to form when a fish is about an inch long and the number remains constant throughout life (Schneider *et al*., 2000). It has been widely used because it is easy to collect and prepare or process, and their removal is non-lethal.

Age is determined by counting completed annuli (year marks) on the scale and recorded in Arabic numerals. At times, annuli could be difficult to discern on scales of older fish. Annuli are recognized by crowded ridges and also a consistent cutting across at both sides of the scale (Cailliet *et al*., 1986).

2.2.2.4 Others Parts

Other hard parts used for age determination includes the vertebrae, dorsal spine and fin rays. Cross sections of dorsal and pectoral fin rays also show growth rings/marks which can be used to age the fish. Ezenwa and Ikusemiju (1981) used dorsal spine to determine the age of *C. nigrodigitatus* in Lagos Lagoon and reported that the fastest growth in length was achieved during the first year of life, and that increase in length gradually decreased with age. Back calculations showed that mean total length of the fish with the first, second, third and fourth annuli were 18.5cm, 32.6cm, 43.5cm and 53.9cm, respectively. In addition, the relationship between body length and dorsal spine radius was linear and highly correlated. Zymonas and McMahon (2006) reported that fin rays are considered a non-lethal alternative to internal bones and reported that

Braaten *et al*. (1999) reported that age was more precise with fin rays than with scales in several studies to compare various structures. Other investigators rejected fin rays as a result of difficulties with sample preparation, identification of first annulus and distinction between true and false annuli (Zymonas and McMahon, 2006). Cross-section of annuli on fin rays varies markedly in appearance depending on the longitudinal position within the ray. Pelvic fin rays potentially provide advantages over other structures for age and growth analysis, but usefulness of fin rays depends on proper collection and preparation (Zymonas and McMahon, 2009).

The potential for high variability in age and growth estimation using soft rays emphasis the need for more detailed assessments of accuracy and precision. Ezenwa and Ikusemiju (1981) reported that annual rings on the first dorsal spine of *Chrysichthys nigrodigitatus* provided accurate method of determining age and growth of this species and found out that the first annulus was formed at the time the fish was 18.5cm total length, 32.6cm for the second annulus, 43.5cm for the third annulus and 53.9cm for the fourth annulus. The greatest growth of this species took place during first year of life and, thereafter, growth decreased with age.

Growth parameters, such as, growth performance index (GPI), maximum assumed length to which fish tends to grow ($L\infty$), growth coefficient (K), theoretical time when fish length is zero (T_o) are essentials for the estimation of production, stock size, recruitment and mortality of fish (Ogueri *et al*., 2009). Values for $L_{\infty,}$ K and ø using total length as 1.09cm, $0.17yr^{-1}$ and 3.29 respectively was reported. du Feu and Abiodun (1998) reported values for $L_{\infty,}$ K and ø using total length as 49.0cm, $0.53yr^{-1}$ respectively in Kainji Lake, Nigeria; Ofori - Danson*et al*. (2002) reported values for $L_{\infty,}$ K and ø using standard length as 44.5cm, $0.65yr^{-1}$ and 3.11 respectively in Lake Volta, Ghana. *C.*

nigrodigitatus examined in River Katsina-Ala, Nigeria with 10cm-25.50cm body lengths range had four distinct modes, which showed four-year classes with, K = $0.51yr^{-1}$, L_{∞} = 28.8cm and t_0 =0.12, and (ø) = 2.63 (Ogueri *et al*., 2009).

2.3 Food and Feeding habit of *Chrysichthys nigrodigitatus*

2.3.1 Seasonal changes of the food of *Chrysichthys nigrodigitatus*

Study of dietary habits of fish based on stomach contents analysis is widely used in fish ecology as an important means of investigating tropic relationship in the aquatic communities (Fagbenro *et al*., 2000). Numerous studies have been conducted on the food and feeding habits of different fishes in many water bodies. Food studies reveal the status of foraging, rate of growth and seasonal changes in life history of fish species, which are useful for their rational exploitation (Ugwumba and Ugwumba, 2007). The diversity and plasticity in feeding habits of most fishes have been reported and it is known that fishes have preferences to particular food organism in their diets.

Asuquo (2000) reported that wild *C. nigrodigitatus* is largely a benthic feeder but not completely so because of the presence of phytoplankton and zooplanktons in the stomach. The major food items for this species in order of importance consisted of fish, crustaceans, bivalves and gastropods, which gave it the status of a top predator, while the minor food items were diatoms, mysids, euphausids, amphipods, polychaete worms, insects, palm fruits, plant materials and detritus. The species, according to Inyang and Ezenwaji (2004), fed on both plant and animal materials with the animal component been dominant. *C. nigrodigitatus* fed on seeds, insects, bivalves and detritus (Akinsanya *et al*., 2007) Dada and Araoye (2008) reported plant materials as a major food, followed by molluscs, worms, insects, ova, protozoans, and fries while the least was sand grains.

Detritus was not in discrete unit. Detritus, filamentous algae, plant tissues/remains, chironomid larvae and pupae were most preferred by the species (Yem *et al*., 2009). Atobatele and Ugwumba (2011) reported insect, crustacea, arachnida, rotifera and mollusca, fish scale, unidentified green eggs, detritus, seed, macrophyte parts and sand as food composition of *C. nigrodigitatus*.

Chrysichthys nigrodigitatus favoured bivalves followed by detritus, caddisfly, chironomids, chaoborids and mayflies. Also included are crustaceans and vegetable matter. The ubiquity of chironomids and mayflies in the diet of this species in Kainji Lake is suggestive of their predominance, as well as the case in Lake Volta, where chironomid larvae and *Povilla adusta* nymphs dominated with 89.13% of the total fauna at the bottom of these important lakes. *C. nigrodigitatus* relied on detritus and insects supplemented with crustaceans, molluscs and fish remains. *C. nigrodigitatus* remained below the thermocline (as low as 1ppm in dissolved oxygen ingesting chaoborid and other benthic insect larvae. The fish fed on sand, green algae, crustacean, insects, molluscs, fish scales and remains, detritus and vegetable matter in Kainji Lake. Offem *et al*. (2008) reported fish and fish parts, insects, crustaceans and seeds as dominant food in Cross River. Other items included mollusc, worms, algae, plant parts, detritus and rotifers. Yem *et al.* (2009) reported fish fry, scales, chironomid, choaborus, insects, crustacea, algae, plant matter, mollusca, sand/mud, detritus and nematode as food of the species. Lawal *et al*. (2010) found that the fish fed on variety of food items of which phytoplankton (mainly algae and diatom), crustaceans and molluscs were of primary importance. Other food items that probably served as supplements were plant materials and fish parts. Atobatele and Ugwumba (2011) did report insect as the dominant prey item (56.67%) followed by crustacean (41.92%). The fish consumed more of insects and less of crustacean as it increased in size (Atobatele and Ugwumba, 2011). Feeding becomes specialized with age and size; larger fish may feed on decapods and fish (Akinsanya *et al*., 2007).

Fish species have specific time for feeding in the aquatic environment. It could be in the morning, afternoon, evening or night because fish species are visual feeders. *Chrysichthys* species have been reported to mass fed at night when food items were readily available. Also, Taiwo and Aransiola (2001) reported that large number of *Chrysichthys* species spawned in the rainy season when there was plenty of food to feed the offspring. The availability of food items in any water body influences the diet of fish, which could result to shift in diet of fish species. Ekanem (2003) reported that there was shift in diet composition of *C. nigrodigitatus* with increase in size. Larger species prefer fishes and shrimps in their diets where such are available, while smaller fish has a broader spectrum of diet. Temporal changes in diet composition reflect the changes in abundance of food organisms in the water environment. In Lekki Lagoon where shrimps are scarce or absent, *C. nigrodigitatus* depends more on molluscs, insects, cladocera, ostracods and mysids for food (Oluwarotimi *et al*., 2006).

Seasonal variation plays a major role in the influence of food items in the diet of the fish. Although, Victor and Brown (1990) reported that there was diversity and plasticity in feeding habits of most fishes, preference for a particular food organism in fish diet have been reported (Ofojekwu and Ejike, 1992). Dada and Araoye (2008) reported seasonal variations in the food of *C. nigrodigitatus* in Asa Lake, with plant materials and plankton consumed more during the rainy and dry season respectively. Yem *et al*. (2009) reported that *C. nigrodigitatus* ingested more of human food remains during the rainy season than any other food item. Filamentous algae then chironomid larvae and pupae followed it, while during the

dry season plant tissues/remains was predominantly ingested followed by detritus, *Limnaea* spp and filamentous algae (Yem *et al*., 2009). Atobatele and Ugwumba (2011) reported that insects, especially chaoborus and chironomid, dominated the stomach contents of *C. nigrodigitatus* during dry season compared with wet season. Other items included sand, mollusca and detritus.

2.3.2 Feeding intensity of *Chrysichthys nigrodigitatus*

The rate at which fish feed can be determined by comparing the frequency of stomachs fullness to that of empty stomachs. These stomachs can be categorized as almost empty, half full, almost full and full for those with food as the case may be, and empty for those without food. If the number or frequency of individuals with half (1/2) full stomach is higher than containing food, then the rate of feeding or feeding intensity is also higher. Individuals are said to have fed poorly when the frequency of less than half (1/2) full stomach is higher than or equal to half (1/2) full stomach (Ogbeibu and Ezeunara, 2005).

Feeding intensity is influenced by a number of factors such as season and food availability. Ogbeibu and Ezeunara (2005) found that feeding intensity and diet of *C. nigrodigitatus* varied among sampling sites because of unequal feeding rate. Ogbeibu and Ezeunara (2005) reported high feeding intensity in both rainy and dry seasons because of high percentage of full stomachs. Similarly, Dada and Araoye (2008) and Yem *et al*. (2009) recorded high feeding intensity in both seasons. Spatial feeding intensity and diets showed that *C. nigrodigitatus* had high feeding intensity with chironomid and plant parts as its diet. However, Offem *et al*. (2008) reported spatial heterogeneity, with fish and fish remains been dominant, followed by insects, crustaceans, worms, rotifers and plant materials.

2.3.3 Classification of *Chrysichthys nigrodigitatus* based on feeding habits

Fish species can be classify into broad categories according to their predominant feeding habits. However, the validity of any classification can be of doubt because each species feeds on a variety of food items. Several workers have made attempt to classify fish based on feeding habits. The morphology of the species is adopted for bottom feeding although the contents of the stomach may prove otherwise as the different kind of food found in fish stomach often reflect their ability to obtained food from different locations.

Ajani (2001) reported the species as a carnivore; *Chrysichthys* species were omnivorous (Dada and Araoye, 2008), while Ogbeibu and Ezeunara (2005) reported these species as bottom- feeding meso-predators. The ability to feed at the shoreline, open water surface and the bottom is contributory to this non-specialization. In Ikpoba River, *C. nigrodigitatus* were detritivores (Oboh *et al*., 2003; Ogbeibu and Ezeunara, 2005). Similarly, in Ethiope, a tropical river, *C. nigrodigitatus* was an omnivorous detritivore (Oronsaye and Nakpodia, 2005). The species was considered detritivores because it fed on vegetable debris and associated animal communities. This was observed by Oboh *et al*. (2003) for Jamieson River, Ogbeibu and Ezeunara (2005) for Ikpoba River and Yem *et al*. (2009) for Lake Kainji. Lawal *et al*. (2010) reported *Chrysichthys nigrodigitatus* as omnivore feeder and that its flexibility in trophic level gave the fish ecological advantage to feed effectively on different categories of diet based on the availability of the food items. Atobatele and Ugwumba (2011) reported the species as general mesopredators. *Chrysichthys nigrodigitatus* has also been reported as an omnivore in Nun River (Akinsanya *et al*., 2007).

2.3.4 Classification of *Chrysichthys nigrodigitatus* based on gut length

The structure and length of the intestine are closely related to the diet of fish (Hickman *et al*., 2001). In fishes, just like in many other vertebrates, the intestine length is an indicator of diet (Akombo *et al*., 2010). Miller and Harley (2002) reported that the structure, length and conformation of the intestine length are closely related to fish diet. Apart from being an indicator of fish diet, it can be used for interspecific dietary comparisons (Karachle and Stergiou, 2010). For a given body length, intestine in herbivorous species is longer than in omnivorous, and that of omnivorous species is longer than in carnivorous ones (Karachle and Stergiou 2010). Edema and Aiguobasinmwin (2007) reported that morphometric classification measurements such as intestine length to body length ratio in addition to gut contents analysis gives a better understanding in determining the feeding manner of fishes. Similarly, Malami *et al*. (2007) noted that body structures and fish diet could be important for predicting fish diet, how fishes feed and the mechanics of feeding. This could also help to ascertain the adaptive food of the fish species and to select the right ingredients to formulate balanced feed.

Any fish species with high ratio of gut length to body length will require more proportion of plant items to animal items in its diet, while those with low ratio needs more proportion of animal to plant materials. German and Horn (2006) reported that in all vertebrates, herbivores exhibit longer digestive tracts than carnivores and the pattern is consistent among mammals. Omnivores, which eat both plants and animal materials, have longer intestines than species that eat only other animals. Carnivores have low ratio compared to herbivores and omnivores. Bundit (2000) reported fish species with intermediate ratios as omnivores that tend towards animal diet and those with large ratio are also omnivores that tend to plant diet. Edema and Ojeh (2006) identified herbivores, carnivores and omnivores, and Edema and Aiguobasinmwin (2007) reported carnivores, herbivores and omnivores. *C. furcatus* (synonyms - *Chrysichthys nigrodigitatus*) was reported to have gut length to body length ratio of 1.6, and classified as omnivore (Edema and Aiguobasinmwin, 2007).

Bond (1979) reported gut length to body length ratios range as 0.7-1.5 for carnivores, 2.5-10.0 for herbivores, 1.5-21.0 for detrivores and 1.0-1.3 for omnivores. Smith (1989) reported that any fish with ratio less than 1 was classified as carnivores, those with 2 or 3 as omnivores while 4-6 or more as herbivores. Edema and Ojeh (2006) reported a ratio range of 0.22-1.00 as carnivores, 2.18-9.27 as herbivores, while 1.41-1.62 fitted between the two but noted that there was no rigid demarcation ratio for carnivores, herbivores and omnivores, where the carnivores could extend to 2; ratio range for *Chrysichthys nigrodigitatus* from Kainji Lake as 1.21 - 2.13 with mean ratios of 1.65:1 was reported. This correlated with the feeding habit and was therefore classified as omnivore.

2.4 Reproductive Indices of *Chrysichthys nigrodigitatus*

Studies on the reproductive biology of fish species is an essential component in understanding the ecology, life history and population dynamics. Such studies provide an understanding of the extent to which the species' reproductive strategies are controlled by abiotic factors, food availability, presence of predators and the habitat of the parental fish (Agarwal, 2004). Welcomme (2001) reported that reproductive strategies such as age-at-maturity or size and spawning seasonality are of particular interest to fisheries managers because some of the information required for developing fisheries management regulations are been provided. Knowledge of a species' reproductive biology also provides input parameters for the application of stock assessment methods such as spawner biomass-per-recruit analyses (Agarwal, 2004).

2.4.1 Sex ratio of *Chrysichthysnigrodigitatus*

Sex ratio can be defined as the number of male to the number of female present in a population. It has been reported in some water bodies that male species are dominant over the female in terms of number and size especially in catfishes, which is attributed to differential survival and tolerance over certain environmental conditions. Sex ratio provides information on the proportion of male to female in a given fish population, necessary for fish reproduction, stock size assessment, and the dominance of sex (Vicentini and Araujo, 2003).

Male dominance of *Chrysichthys nigrodigitatus* had been reported by Taiwo and Aransiola (2001) and Offem *et al*. (2008) in the ratios 1:0.15 in Asejire Lake and 1:0.5 in Cross River. However, Yem *et al*. (2007) recorded lower male: female as 1:4 and 1:1.14, respectively in Kainji Lake. Similarly, Fapohunda and Godstates (2007) reported more females than males at 91% to 9% in Owena Reservoir. Dada and Araoye (2008) reported 240 *Chrysichthys nigrodigitatu*s, of which 155 were male and 85 female with ratio of 1.8:1. Lawal *et al*. (2010) reported that of the 600 specimen examined, 393 were males while 207 were females, which showed males to be significantly higher than females in Epe Lagoon.

2.4.2 Maturity stages and Gonadosomatic Index (GSI) of *Chrysichthys nigrodigitatus*

Knowledge of the phases of gonadal development is important for understanding the dynamics of the gonads and to assess reproductive mechanism of a species. The gonads can be found in the ventral part of the fish body cavity where they can fill the available area in sexually mature male and female. Ovaries are usually tubular, pink/red and granular while testes are flat, white/grey with central edges frequently wave-like outline (Cailliet *et al*., 1986).

Gonad maturity can be classified into stages based on the level of development. To estimate proportions of sexually matured individual fish, precise criteria for the classification of maturity should be defined which could be six or seven stages (Cailliet *et al*., 1986).

(i) Stage I (immature virgin)

Gonads are thin, thread-like, translucent and colourless; sexes usually cannot be distinguished at this stage.

(ii) Stage II (developing virgin/recovering spent)

Testes: thin and strap-like, translucent and grayish in colour.

Ovaries: more rounded, usually translucent and colourless; eggs not visible to the naked eyes.

(iii) Stage III (developing)

Testes: thickening opaque and grayish white in colour.

Ovaries: thickening, opaque; small, pale yellowish eggs may be visible to the naked eyes.

(iv) Stage IV (maturing)

Testes: swollen, elongated, often extend ¾ of the way along length of body cavity of the fish.

Ovaries: swollen, rounded, extend ¾ way along length of body cavity; larger opaque, yellow eggs clearly visible.

(v)Stage V (mature/ripe)

Testes: may extend length of body cavity; opaque white, generally with a smooth creamy texture, milt may be extruded from fresh specimens by pressure on abdominal wall.

Ovaries: may fill body cavity and distend abdominal wall; large yellow eggs often translucent, free from ovarian connective tissues; may be extended by pressure on the abdominal wall of fresh fish.

(vi) Stage VI (spent)

Testes: thin, flaccid, strap-like; blood vessels and ‘bruising’ evident; may contain white areas of residual sperm.

Ovaries: Hollow, thin and flaccid; sac-like; may contain both residual and undeveloped eggs; blood vessels and ‘bruising’ evident.

Offem *et al*. (2008) reported that males *Chrysichthys nigrodigitatus* of total length (11.5cm) reached sexual maturity before females (16.7cm - size at first maturity). It was observed that ovaries and testes changes with increase in fish length. Dada and Araoye (2008) reported *C. nigrodigitatus* with low level of abundance from stages VI - VIII and high levels of abundance with stages I - III, although there was also high abundance level between stages IV - V.

Gonado somatic index (GSI) is an indicator of the state of gonadal development and maturity. It is the ratio of fish gonad weight to body weight. It is also the measure of relative weight of gonad with respect to weight. (Abraham and Akpan, 2012). The percentage of fish body weight that is used for the production of eggs is determined by the gonadosomatic index. GSI is particularly helpful in identifying days and seasons of spawning, as the ovaries of gravid females swiftly increase in size just prior to spawning. If it is possible to collect reasonable numbers of gonads each month from adults (e.g., 30 - 50 individuals) over a year, one can usually determine the spawning season for any fish species. Offem *et al*. (2008) reported that GSI of *C. nigrodigitatus* varied from 1.25 to 7.91 with a mean index of 4.78 ± 3.21 in females, and from 0.57 to 3.17 with a mean index of 2.89 ± 1.41 in males, with higher values during the rainy season. Dada and Araoye (2008) reported GSI for both male and female from 0.12 - 8.16% with a mean of 1.69%. Male and female GSI ranged from 0.12 - 0.87% and 0.53 - 8.16, respectively, with a mean of 3.27% for female. This indicated that least GSI was recorded in male and the highest was found in female.

2.4.3 Fecundity and lengths/eggs size/weight of *Chrysichthys nigrodigitatus*

Fecundity is defined as the number of eggs contained in the ovary of a fish (Ezenwaji and Offiah, 2003). This varies from one species of fish to another, depending on the environmental conditions, length and age. Fecundity is an index, which measures the number of eggs found in a gravid female fish (Victor *et al*., 2013). Knowledge of fecundity is important, in stock size estimation, stock discrimination, eggs and larval survival and fish recruitment (Shalloof and Salama, 2008). It can be used to calculate the reproductive potential of a population and to estimate stock size (Agarwal, 2004). Fecundity of fish increases with body size. Abraham and Akpan (2012) reported environmental factors, such as, water quality, temperature and location within the water body, can influence fecundity. Similarly, the volume of eggs a fish can produce depends on space available in the body cavity to accommodate the eggs before spawning, and larger eggs enhance fry and larval viability. Absolute fecundity is the total number of ripe eggs in the ovaries prior to spawning of an individual female fish, and it is a function of its body size (Agarwal, 2004). Fecundity and spawning habits are among the important aspects of the biology of fishes, which must be understood to explain the variation of the level of fish harvest. Khan *et al*. (2002) reported that information on fecundity is important to evaluate the commercial potentials of fish stock, and to assess abundance and reproduction potentials of fishes. Information on egg size is also important because it helps to determine the spawning and period of breeding of fish.

The methods used in egg estimation depends on the species of fish under investigation and available laboratory facilities. There are basically three well-known methods in use to determine the fecundity of freshwater fish, these are gravimetric, volumetric and numerical/total counts.

2.4.3.1 Gravimetric Method

This is currently the most common method used to estimate fecundity of fish. This is based on the relation between ovary weight and the oocyte density in the ovary. Fecundity is determined as a product of gonad weight and oocytes density. The number of oocytes per gram of oocytes tissue is determined by counting the number of oocytes in a known weight sample of ovarian tissue (Cailliet *et al*., 1986). Gravimetric method can be used to estimate total, batch or potential annual fecundity. The advantages of using this method is that it is accurate, less expensive and easy to conduct; provide information on oocytes diameter and frequency and very useful for batch fecundity estimations. The disadvantages are lack of information on atresia, time consuming, and the whole ovaries have to be returned to the laboratory (Hunter *et al*., 1989).

2.4.3.2 Volumetric

This is also based on the same principles as gravimetric method, but uses ovarian volume and the sub-sample volume instead of the weight of ovary and the weight of sub-sample eggs (Cailliet *et al*., 1986). Advantages of this method includes less expensive; easy to be done; provide information on oocytes diameter and frequency. Disadvantages are no information on atresia; time consuming; the whole ovaries have to be return to the laboratory; requires histological analysis (Murua *et al*., 2003).

2.4.3.3 Numerical/total counts

This is the most accurate method of fecundity estimation. It involves the total count of eggs in a fish, though it can be tedious and time consuming. It is not based on sub-sampling like in the case of volumetric and gravimetric methods. Advantages include it's accurate, and less cost. Disadvantages include no information on atresia; time consuming; required the whole ovaries to be return to the laboratory (Cailliet *et al*., 1986). Other methods have been reported though for marine fish (Murua *et al*., 2003) but could be applicable to freshwater fish. This include automated particle counting method where an automated particle counter is used to count the number of oocytes in a sub-sample (Kraus *et al*., 2000); stereometric method, which is based on the histological sections to determine the number of cells in the oocytes (Emerson *et al*., 1991) and auto - diametric fecundity method, which estimate the potential fecundity from the mean oocytes and the total ovary weight using calibration curve that relates mean diameter to oocyte density (Thorsen and Kjesbu, 2001).

Ekanem (2000) found that fecundity and egg size of population of *C. nigrodigitatus* in

Cross River Estuary varied from 3,046 eggs for a fish of total length 28.5cm to 28,086 eggs for 64cm fish. A mean fecundity of 23 eggs/cm and 13eggs/g of fish were obtained from this population while the mean egg diameter of the population varied from 0.65mm to 3.54mm depending on the state of development. Fagade and Adebisi (1979) reported 2,884 as maximum number of eggs for samples of *Chrysichthys nigrodigitatus* from Asejire Lake,which indicated that the lake's population had a lower fecundity; Minimum and maximum fecundity of the species with length range of 13.0 - 25.2mm TL as 189 and 2,884 eggs, respectively, with a mean of 1,442 eggs was also reported. Taiwo and Aransiola (2001) reported fecundity of *Chrysichthys nigrodigitatus* of weight 45.0g and standard length of 14.0cm as 466 eggs, and weight of 525.0g with standard length of 31.0cm as 16,490 eggs and concluded that length and body weight had effect on fecundity of the fish. In a fecundity study, Inyang and Ezenwaji (2004) reported fecundity range of between 733 and 1,988 oocytes (mean 1261 ± 384 oocytes) in *Chrysichthys nigrodigitatus*.

Offem *et al*. (2008) found that absolute (individual) fecundity of *C. nigrodigitatus* ranged from 6,844 eggs (16.7cm TL; 87.8g W) to 25,905 eggs (42.4cm TL; 2354.8g W) with relative fecundity range from 342 - 432 eggs cm^{-1} to 67 - 82 eggs cm^{-1}. *Chrysichthys nigrodigitatus* of size 22.3cm produced 3,072 eggs. The diameter of oocytes ranged from 0.2mm - 0.8mm and 0.30 - 0.60 mg in weight for immature eggs; 0.81-1.6 mm and 0.70 - 0.78mg weights for maturing eggs, and 1.7 - 4.7mm with weight of 0.082 - 1.88mg as matured samples. Abraham and Akpan (2012) reported the highest estimated fecundity of *C. nigrodigitatus* to be 28,676eggs with absolute fecundity of 3,865 (35.0cmTL, 685.2g) to 28,675eggs (76.0cm TL, 2,483.39g), and Victor *et al*. (2013) recorded fecundity of 975 eggs (23.2cmTL; 99.0g) to 11,280eggs (50.0cm TL; 1,420g), bigger fish had more eggs than smaller fish. Oocytes diameter recorded varied between 1.0mm-3.6mm and observed that egg size did not depend on fish length; some smaller fish had higher eggs diameter than some bigger ones (Abraham and Akpan, 2012).

Ezenwa *et al*. (1986) reported variations in egg size, fecundity and condition factor of *C. nigrodigitatus* at various locations and established that the population in Warri River produced larger eggs and had higher fecundity than those from other locations, and recommended that population was the best brood stock. Ekanem (2000) reported that absolute fecundity varies with individual fish from 3,046 eggs (for a fish with standard length of 28.5cm and weight of 214.7g) to 28,086 eggs (for a fish with length of 64cm and weight of 2.2kg). Mean relative fecundity and the standard deviation were obtained as 13±6eggs/g or 231±87eggs/cm of female fish. Egg diameter was found to vary from 0.65mm to 3.45mm. Increase in egg number is directly related to fish egg weight and total length.

Fecundity of *C. nigrodigitatus* seems to decrease with stage of maturity and there was no relationship between body weight and gonad weight. Neither did the largest egg belong to the biggest fish nor was the smallest egg found in the smallest fish. The smallest gravid fish with length 28.5cm had eggs with a mean diameter of 1.02mm, while the biggest fish with length of 64cm had a mean egg diameter of 2.30mm. Eggs with the greatest mean diameter of 3.54mm were found in fish of intermediate size i.e. length of 39.0cm and weight of 486.5g. However, Offem *et al*. (2008) reported direct proportional relationship between fecundity to length and weight of the fish. Inyang and Ezenwaji (2004) reported the diameter of ripe oocytes as 2.1 ± 0.36 mm in *Chrysichthys nigrodigitatus*. Khan *et al*. (2002) reported increased fecundity with increase in size of the fish but the relationship with fecundity was stronger in terms of body weight than total length to fecundity.

2.5 Abundance and Distribution of *Chrysichthys nigrodigitatus*

Fish distribution and abundance is reported to be influenced by factors, such as, conductivity or habitat availability (Melo, 2000), flow velocity and heterogeneity(Willis *et al*., 2005), water temperature (Cetra and Petrere, 2006), altitude (Suárez and Petrere Jr, 2007) and other physico-chemical parameters such as dissolved oxygen and pH (Araújo *et al*., 2009). Riparian vegetation provides food and also increases availability of aquatic refuges for small fish species through the falling of tree trunks and branches into the water course (Casatti *et al*., 2003). Plant leaves incorporated into water channels also favour the establishment of a diverse fauna that can be used as food by fish (Uieda and Uieda, 2001) as well as influence fish abundance and distribution.

Several catfish genera are widespread and common in Afro-tropical waters. The genus *Chrysichthys* with approximately thirty species is the largest of the family Claroteidae and is distributed from the Senegal River in the West, across the Sahelo-sudanian region to the Nile, south to the Zaire Basin and occurs in most major rivers of Africa (Paugy *et al*., 2003). They are more prominent in low brackish water areas and major rivers of Nigeria, particularly the lagoon, where it is more commonly captured. It is widely distributed in fresh and brackish waters in West Africa. In Jebba Lake, *C. nigrodigitatus* is also among the fishes in commercial catches (Abiodun and Odunze, 2011).

The fish, commonly known as silver catfish, and inhabits both freshwater and brackish water of West Africa from Senegal to Angola and fills a different ecological niche, being most common in off shore part of lakes. It has been reported as a euryhaline species, inhabiting waters in the salinity range of 1-12 percent and its abundance in the brackish zones of coastal rivers, creeks and estuaries (Odum, 1995). Ekanem (2003) reported that as salinity increases, the fish migrate towards freshwater or low salinity area. Mature adults with ripe gonads are abundant in the headwaters especially during the first half of the rainy season. Therefore, salinity also plays a major role in their distribution.

The abundance and distribution of *C. nigrodigitatus* has been documented. Allison and Okadi (2009) reported the species as being highest by number at the bottom of Lower River Nun, with 33 (0.99%), followed by 30 (0.84%) in mid water and 29 (0.70%) at the surface. Ufodike and Zakari (1992) reported 13 fish families with 28 species in Dadin Kowa Reservoir, where *C. nigrodigitatus* had 0.02% abundance in the total catch and the least within the family with 0.2% abundance. Ogbeibu and Ezeunara (2005) reported 14 families with 28 species in Ikpoba River, where the family Bagridae (*C. nigrodigitatus* formerly belong) dominated (26%) followed by Malapteruridae (16%), Mochokidae (14%), Cichlidae (13%) and Clariidae (10%). Yem *et al*. (2005) reported the species in a sampling site on Kainji Lake to make up 0.24% and 0.05% in terms of number and weight, respectively. Idowu and Iyoola (2008) reported that the Lagoon systems of Ogun waterside had 70.20% and 52.50% of the total catch in dry and wet season, respectively, with 55.70% of the overall catch to be *C. nigrodigitatus* and concluded that the species contributed the highest number of fish in the two seasons. Agboola *et al*. (2008) reported in **Badagry Creek (Nigeria) that** *C. nigrodigitatus* had the highest relative abundance with 15.7% followed by *Ethmalosa fimbriata* 15.5% and *Tilapia zillii* 8.5% while *Caranx hippos* with 0.9% was least. Offem *et al*. (2009) found that *C. nigrodigitatus* was the most abundant fish species in Cross River wetlands and asserted for 12.8% and 4.3% of the overall catch in the wet and dry seasons, respectively. Allison and Okadi (2009) reported relative abundance of 0.82% of *C. nigrodigitatus*, which ranked 4th in abundance and scored as common in the lower Nun River in Niger Delta. Odo *et al*. (2009) reported that out of 576 fish caught in Anambra River Basin, 13 in number were *C. nigrodigitatus*, which contributed only 2.3% to the overall catch from three sampling sites. Adeosun *et al*. (2011) reported that the species in Ikere Gorge contributed 96.7% and 34.51% in number and weight, respectively, and were more abundant at the peak of the wet season in four sampling stations. *Chrysichthysnigrodigitatus* is known to be the most dominant fish, accounted for considerable number in both artisanal and trawl fishery of Cross River estuary (Victor *et al*., 2013).

2.6 Plant and Animal Communities of Jebba Lake

Jebba Lake is blessed with a lot of both plants and fish species, which also reflects the composition of the Niger River being the major source of the lake. There are many aquatic plants in the lake. Among those identified are *Pistia* sp. and *Salvinia* sp. These are obligate or free floating water plants that require all vegetative parts to be submerged or supported by water in order to complete their generative cycle. Others include *Echinochloa crassipes*, *Vossia cuspidate*, *Lemna* sp., *Ipomoea aqautica*, *Vetivera nigritana*, *Polygonum* sp., *Typha australis, Sesbania dalzel*, *Nymphea lotus, Minosa pigra*, *Ludwigia decurrens* and *Eichhornis crassipes* etc. Adesina *et al*. (2011) reported 46 plant species in Jebba Lake that belongs to 22 families, which included *Vossia cuspidate*, *Sesbania dalzielii*, *Eichhornia crassipens*, *Mimosa pigra*, *Marisans longbracteatus*, *Ipomoeo aquatica*, *Vetiveria nigritana* and *Polygonum lanigerium*. Aquatic macrophytes found in in any water body play a significant role in nutrient cycle because they accumulate and release nutrients slowly, which are the major causes of eutrophication of flood plains, associated lakes, swamps and ponds. Their stands can also serve as suitable spawning sites and feeding grounds for fish in the lake. Similarly, these plants also provide breeding substrate for a large number of insects and other invertebrates, which serve as food for fish.

Some of the fish species commonly found in the lake include *Synodontis membranaceus*, *Mormyrops deliciosus*, *Malapterurus electricus*, *Schilbe intermedius*, *Mormyrus rume*, *Hydrocynus* spp., *Hyperopisus bebe*, *Citharinus citharus*,Al*estes dentex*,*Bagrus bayad*, *Oreochromis niloticus*, *Clarotes laticeps*, *Labeo senegalensis*, *Auchenoglanis occidentalis*, *Brycinus nurse*, *Lates niloticus*, *Bagrus docmac*, *Mormyrops deliciosus*, *Clarias gariepinus*, *Alestes baremose*, *Tilapia zillii*, *Chrysichthys nigrodigitatus* (Abiodun and Odunze, 2011).

Plankton algae recorded on the lake include green (*Chlorophyceae*), blue green (*Myxophyceae*) and diatoms (*Bacillariophyceae*), while Cladocera, copepods and rotifer are the zooplankton. Others include fish larvae, ostracods, chironomid larvae and pupae, chaoborid larvae and pupae. Blue greens algae increased in number and produced a layer of bloom on the lake surface (Adesina *et al*., 2011).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Jebba Lake is a man-made lake that was created in July 1983 by damming the Niger River about 100km below Kainji Lake at Jebba for the generation of electricity. It is located in the north - western part of Nigeria, situated between Latitudes 9° 35′ N and 9° 50′ N and Longitudes 4°30′ E and 5°00′ E.

The lake has an estimated surface area of 303km^2, which is about 35000ha and a volume of 3.31x109m^3. The lake is about 100km long and about 12km at its widest point. The maximum depth is 105m while the mean depth is about 11m. The lake gets the major bulk of its water supply from the discharge of Lake Kainji, while tributaries like Rivers Eku, Awun and others also discharges their water into the lake (Ita *et al*., 1983).

3.1.1 Sampling Zones

The Lake was divided into three sampling zones with two stationseach (Figure1). These stations were sampled for *Chrysichthys nigrodigitatus* and other fish species. These zones were chosen because of accessibility, high fishing activities around the areas and low water current. The first zone, designated as Zone I – Kpatachi; secondly, Zone II – New Awuru and finally, Zone III – Old Awuru (Figure 1).

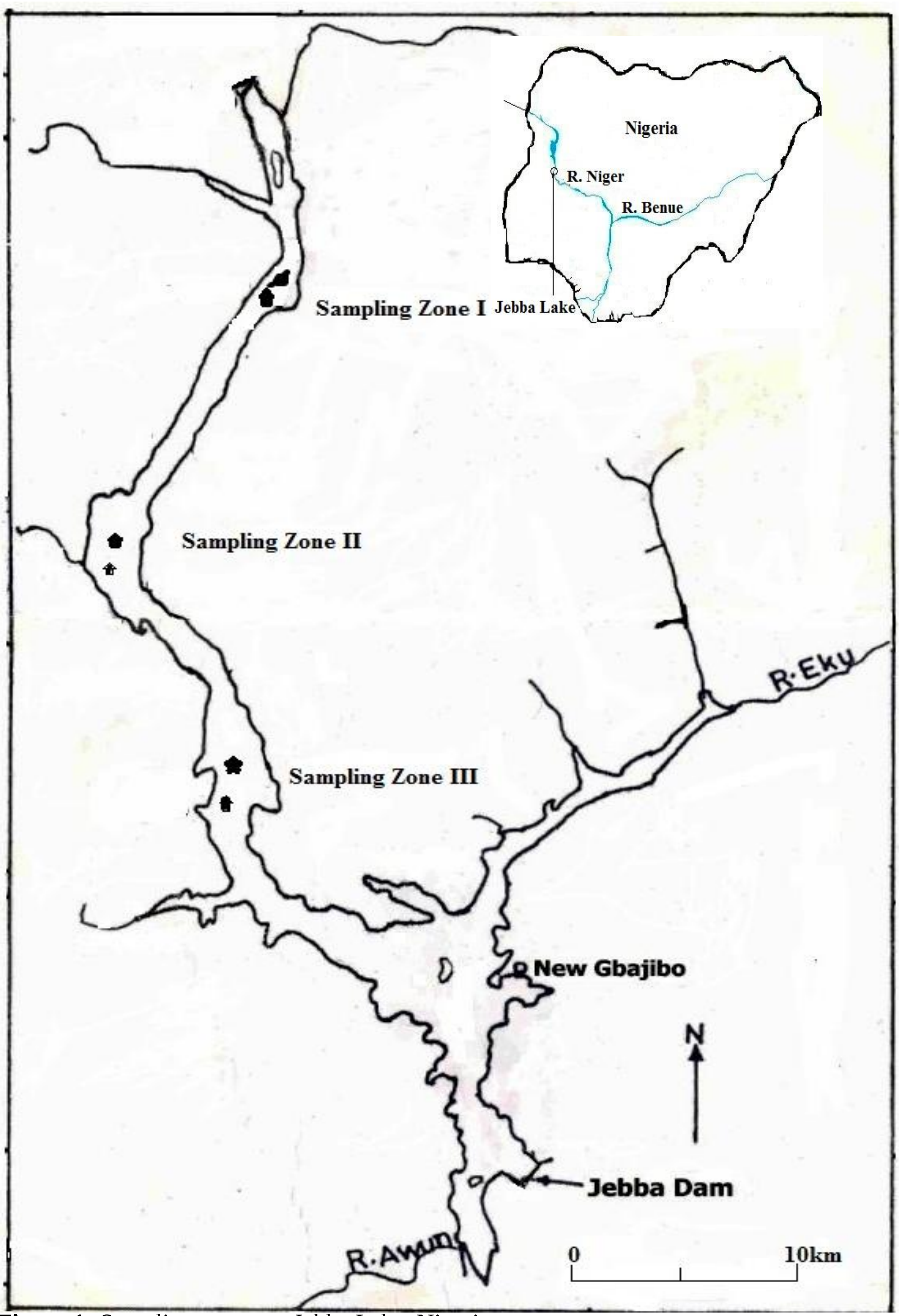

Figure 1: Sampling zones on Jebba Lake, Nigeria

3.1.2 Description of Sampling Zones

3.1.2.1 Zone I (*Kpatachi*)

The zone is the uppermost part of the lake. This comprises of open water and the shoreline is comprised of bush and farmlands. At about 2km below the dam, Kpatachi Islands extend for about 5.5km, though the two parts of the island are separated by the River Niger just before River Oli estuary. It is supported by guinea savanna vegetation with some scattered palm trees.

There are fishing activities at and around the zone and locals of the communities used the water from the lake for domestic activities such as washing, drinking and bathing, and irrigation activities especially during low water level.

3.1.2.2 Zone II (New Awuru)

The shoreline of this zone is made up of flooded bush and farmlands. Seasonal River that enters the lake through this area has their water channel filled up, giving rise to indentations. Trees along the western side are not cleared and as a result most of them are already submerged; there is also a part of the area that is a bit rocky. There is a fairly well - developed shore with moderate littoral areas.

There is a fishing community close to the bank of the lake. The locals used the water for domestic activities such as washing, drinking and bathing.

3.1.2.3 Zone III (Old Awuru)

The western shore here has just been cleared. A prominent feature was the algal bloom, which was about 3.5mm thick. The shores are cleared as a result of the rising water, most of the cleared trees formally on land are now floating all over the area. As the water receded, aquatic plants (weeds and grasses) and tree stumps covered the shores; small to medium islands are also formed within the area.

The fishing communities close to the bank of the lake engaged in irrigation activities during period of low water level. They also use the water for domestic activities such as washing, drinking and bathing.

3.2 Physico-chemical Parameters

Water sample was collected at the various zones early in the morning between 6:00am and 8:00am from 10cm depth into 1liter plastic water bottles rinsed with distilled water. This was done twice in a month at the zones. The electrode of the meters used was inserted in a beaker containing the water sample and values taken. The following physico-chemical parameters were determined during the period of study:

(i) Water Depth

The depth of each sampling station at the various zones was measured in meters using calibrated marine rope tied on a heavy metal. The rope was lowered from the boat into the water until it reached the floor of the lake at that spot. The depth for each station was then read.

(ii) Temperature

Mercury-in-glass thermometer having accuracy of $0.1^{o}C$ and range $0^{o}C$ to $50^{o}C$ was used to measure temperature at the various sampling stations in each zone.

(iii) Dissolved Oxygen

Well-knit oxygen meter(Model - DO 510) was used to determine the dissolved oxygen at the various sampling stations.

(iv) pH (Hydrogen ion concentration)

The pH of the water was determined using a pH meter (Model - 0009 (III) Pentype - automatic temperature compensation (0^{o} C - 50^{o} C)at the various sampling stations.

(v) Transparency

Transparency was determined by extinction method using the Secchi disc by measuring the mean depths at which the Secchi disc disappears at the various sampling stations.

(vi) Electrical Conductivity

Electrical conductivity was determined at the various sampling stations using Pye Unicam (Model 292) conductivity meter (standardized with buffer solution at pH 4.0, 7.0 and 9.0).

(vii) Phosphates

Phosphate-phosphorus for the various sampling stations on the lake was determined using the Deniger's method. The regents used were prepared as follows:Deniger's solution was prepared by mixing 10% solution of ammonium molybidate with 300ml of 50% sulphuric acid. 4.0g of $SnCl_2$ was dissolved in 100ml glycerine to prepare stannous chloride ($SnCl_2$) solution. The stock solution was prepared by dissolving 4.39g solid KH_2PO_4 in 1litre of distilled water. This gave 10µg/l of phosphorus, which was used to obtain the following concentrations:0.1ml in 100ml H_2O= 1µg/l, 0.2 in 100ml H_2O= 2µg/l, 0.3ml in 100ml H_2O= 3µg/l and 0.5ml in 100ml H_2O=5µgl. To these concentrations, 1ml of Deniger's reagent was added and mixed. 5-6 drops of $SnCl_2$ was also added and allowed to stand for about 10 minutes. The absorbance of the solution was measured at 882nm in a spectrophotometer.

(viii) Nitrates

Nitrate-nitrogen for the various sampling stations in each zone on the lake was determined by phenoldisulphonic acid method. 100ml of water sample was evaporated to dryness, after which 2ml phenol disulphonic acid was added, shaken and allowed to remain for 10 minutes. 15ml of water was added and stirred slowly to cool. 10ml of NH_3 solution was also added. A yellow colour developed;the intensity of the colour depended on the amount of NO_3 in the water. The absorbance was measured using spectrophotometer set at 410nm.

3.3 Sampling of Fish

Fish were caught at the various stations using a fleet of experimental gill nets with mesh sizes 50.8mm, 63.5mm, 76.2mm, 88.9mm, 101.6mm, 127.0mm, 152.4mm, 177.8mm and 190.5mm. Each net was 30m in length and 3m in depth.

The nets were set in the evening between the hours of 4pm-6pm and checked in the morning between the hours of 6.00am - 9.00am and also in the evening between the hours of 4.00pm - 6.00pm after which they are being reset. The nets covered the shore, surface and bottom of the lake at the stations in the various zones. This was done for a period of 24 months from January, 2009 to December, 2010. Fish samples caught during the period were used for the study.

3.4 Collection and Identification of Fish Samples

Collection of samples was done immediately after capture. Samples were removed from the nets, collected in ice-chest box to maintain freshness at each station. Various sizes of *Chrysichthys nigrodigitatus* ranging from small, medium to large were sorted out and used for the study.

Samples were identified tentatively and then taken to the laboratory for further identification with the aid of texts by Holden and Reed (1991), (Paugy *et al*., 2003) and Olaobesikan and Raji(2004).

3.5 Fish Measurement

Morphometric and meristic parameters were measured on each sample with the aid of measuring board, measuring rule, weighing balance (top-loaded, Mettler balance model 2000 and Model HR 2385/A for small fish), dial calipers (Mitutoyo Corporation), pair of divider and thread of various length. These parameters were measured in centimeters (cm) and grams (g), recorded on data collection sheets for each sample separately and according to sampling zones.

Validation of *C. nigrodigitatus* was done by comparing the values of the body proportions and meristic counts obtained with standard keys by De Vos (1995) and Paugy *et al*. (2003).

3.5.1 Morphometric Parameters

Morphometric parameters measured (Figure 2) were standard length (SL), total length (TL), weight (Wt), snout length, body depth; caudal peduncle depth, head length, pre-dorsal length, pelvic length, anal base length, eye diameter, suborbital width, caudal peduncle length, dorsal length base, dorsal fin height, anal fin height, pectoral fin height, longest dorsal spine length, head width, upper jaw length, gape width, pelvic-anal fin distance, pectoral-anal fin distance, nostril distance, nostril-eye distance, body colour, shape of the fish, the presence or absence of scales, shape of the head, shape of the snout and its projection.

3.5.2 Meristic Parameters

Meristic parameters counted were number of dorsal fin and soft rays, number of spines, number of barbels, anal soft rays, total pectoral rays and total gill rakers on the first arch. Fins and spines were represented with digits and roman numerals, respectively. These parameters were compared with the findings of Holden and Reed (1991) and Paugy *et al*. (2003).

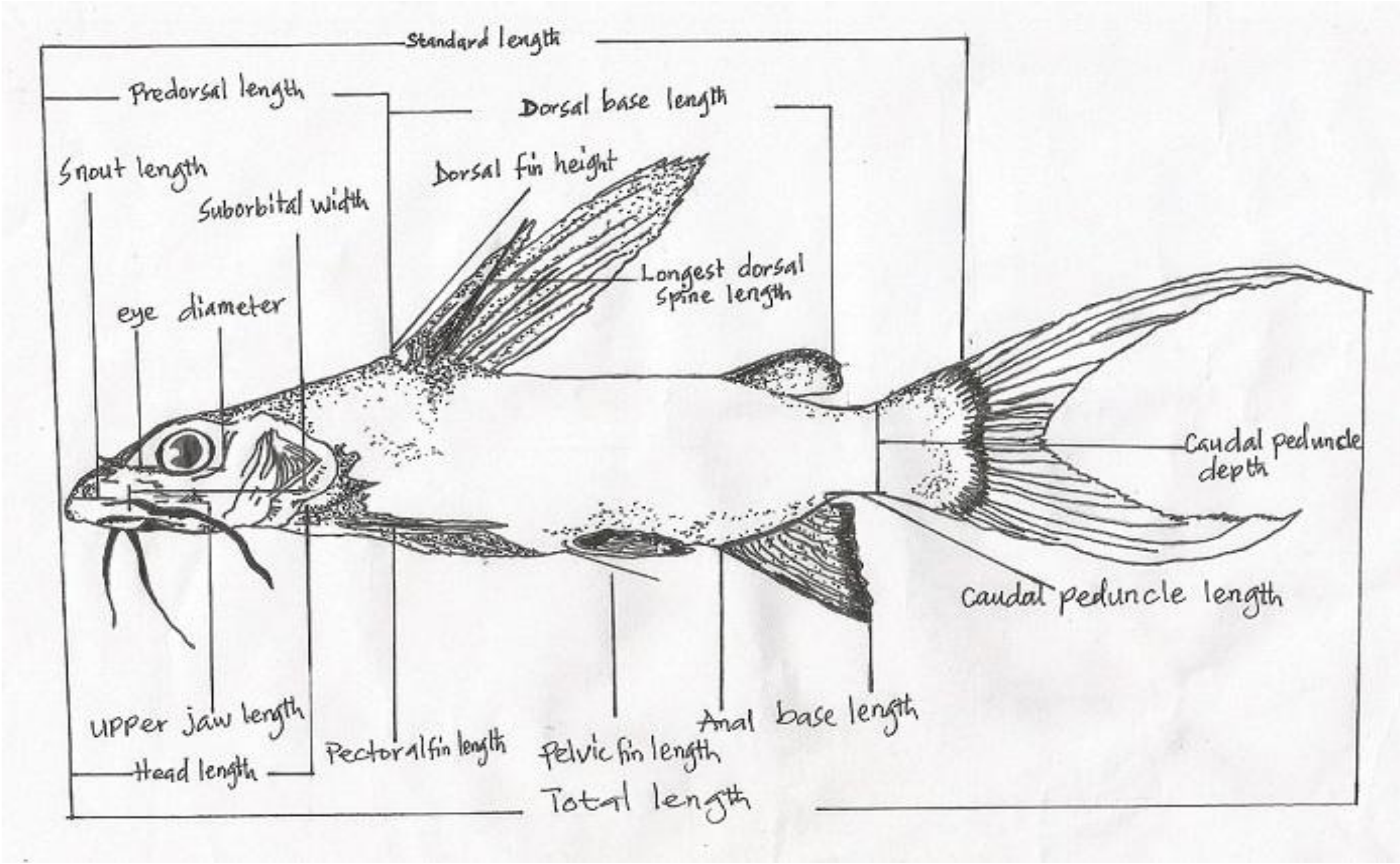

Figure 2: Morphomeristic characteristics (measurements and counts) of *Chrysichthys nigrodigitatus*

3.5.3 Definition of Terminologies(Paugy *et al*., 2003)

i. **Standard Length** (SL): The distance from the tip of the snout to the caudal peduncle.

ii. **Total length** (TL): Distance from the tip of the snout to the tip end of the caudal fin.

iii. **Body Depth**: The maximum vertical depth, excluding fins.

iv. **Head Length**: The horizontal distance from front tip of snout to hind margin of gill cover or the horizontal distance from front tip of snout to hind of

occiput v. **Snout length**: This is taken from the most anterior point on the snout

or upper lip to the front margin of the orbit.

vi. **Eye Diameter**: Horizontal diameter of eye.

vii. **Pre-dorsal Length**: Horizontal distance from tip of snout to the articulation of first dorsal - fin ray.

viii. **Pre-anal Length**: Horizontal distance from the tip of snout to the

articulation of first anal-fin ray.

ix. **Pre-pectoral Length**: Horizontal distance from the tip of the snout to the articulation of first pectoral-fin ray.

x. **Pre-pelvic Length**: Horizontal distance from the tip of snout to the articulation of first pelvic (ventral) - fin ray.

xi. **Length of Dorsal-fin Base**: The maximal horizontal distance measured between both ends.

xii. **Length of Anal-fin Base**: The maximal horizontal distance measured

between both ends.

xiii. **Pectoral-fin Length**: The length from articulation of first ray to tip of

longest ray.

xiv. **Pelvic (ventral)-fin Length**: The length from articulation of first ray to tip of

longest ray.

xv. **Caudal-peduncle Length**: Horizontal distance from hind margin of anal fin (or from that of dorsal fin if this extends further backwards than anal) to baseof caudal fin.

xvi. **Depth of caudal peduncle**: This is the minimum vertical depth of caudal peduncle.

3.6 Length-Weight Relationship (LWR)

The length-weight relationship of male, female and combined sexes was determined from the formula:

$W = aL^b$ ……………………………………………(Pauly, 1984)

Which, was transformed to Log 10 as Log W = Log a + b Log L, where, log length was plotted against log weight to obtain a, b and r values.

Where:

W = body weight of fish (g)

L = standard or total body length of fish (cm)

a = intercept

b = growth exponent or regression coefficient

3.7 Length-Length Relationship (LLR)

The relationship that described standard and total lengths of males, females and combined sex of *Chrysichthys nigrodigitatus* was determined. Standard length values were plotted against the respective total length as a scatter diagram. This is to establish the relationship between these parameters.

The formula; $L = a X^{b}$ ……………………………………… (Pauly, 1984)

Where:

L = Length of fish (cm)

a = intercept and b = slope

This was transformed to give a straight line regression

Log SL = Log a + b Log TL

3.8 Condition Factor (K)

The condition factor (K) of male, female and combined sex was calculated using the formula:

$$K = \frac{100 \times W}{L^{b}}$$ ………………………………………… (Pauly, 1984)

Where:

K = Condition factor

L = Total fish length (cm)

W = Weight of fish (g)

b = growth exponent

3.9 Age Composition/Structure Determination

Operculum (Sutherland, 2008) was used to determine the age of *C. nigrodigitatus*. Opercula bones were removed with the aid of scalpel and dipped in boiling water for about a minute or two before cleaning manually. They were dried at room temperature and preserved in clean labeled envelops for growth marks examination. It was viewed under the microscope at X4magnification using reflected light. The most prominent lines represented the yearly annuli (growth marks) formed while the non - prominent and regular circuli were the seasonal ones (Plate 2).

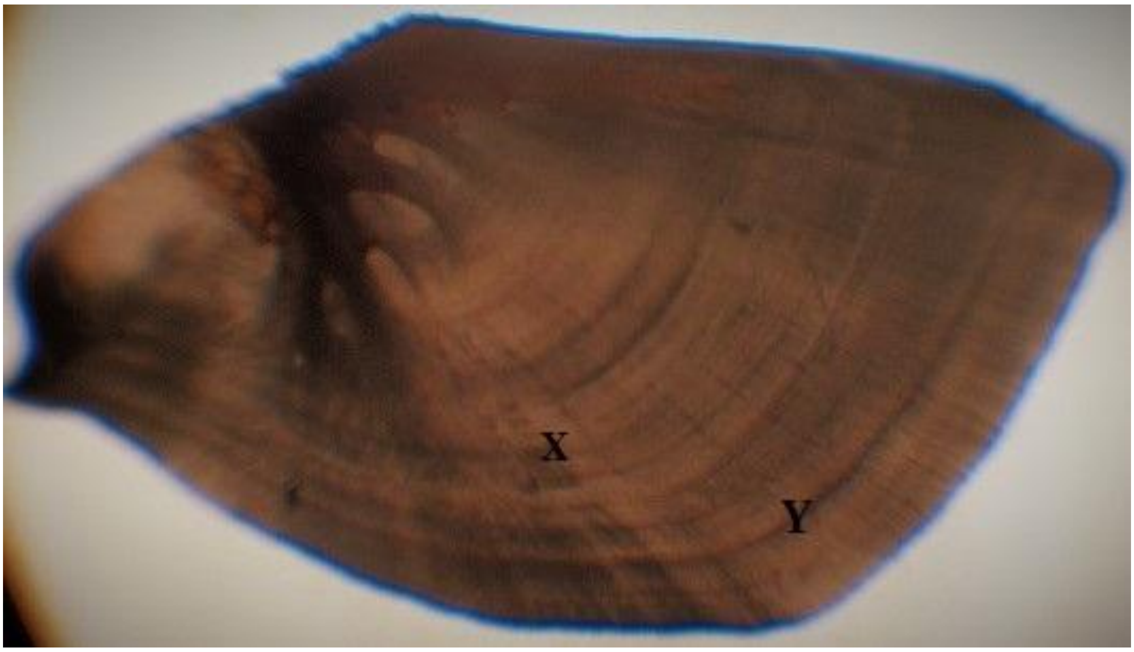

Plate II: Operculum of *Chrysichthys nigrodigitatus*showing growth marks (X and Y)

Growth was estimated by back calculation as

$l_n = S_n/S \times l$ ………………………………..……………. (Ricker, 1978)

Where:

l_n= fish length when annulus 'n' was formed

l = fish length when operculum was obtained

S_n = radius of annulus 'n' (at fish length ln)

S = total operculum radius

Growth parameters - L∞ (cm), K (yr^{-1}), and (t_0) were calculated using Fish Key facts (4) (Froese and Binohlan, 2000). These parameters were fitted into the von Bertalanffy's model (Gulland, 1983) below:

$$L_t = L_\infty (1- e^{- k (t - to)})$$

Where:

L_t = predicted length at time t

$L\infty$ = maximum length predicted by equation

e = base of the natural logarithm

t = time

t_o= size at which the organism would theoretically have been age 0

K = the growth coefficient (instantaneous rate)

Growth Performance Index (GPI) was obtained from the formula:

GPI = Log_{10} K+2Log_{10} $L\infty$ ……………………… Getabu (1992)

Where;

K = Growth coefficient

$L\infty$ = Predicted maximum length

3.10 Stomach Fullness Classification

Stomach contents classification of *Chrysichthys nigrodigitatus* based on degree of fullness was determined (Ugwumba *et al*., 1990) as shown in Table 3.1.

Table 3.1: Classification of Stomach Fullness

Stomach fullness	Score/Point
Empty	0
Almost empty	¼
Half full	½
Almost full	¾
Full	1

The score or point is between the scale of range 0 and 1

3.11 Stomach Contents Analysis

The stomach contents were emptied into petri-dish to which 10% saline was added to disperse the contents. The food items were sorted into categories and identified to species level where possible using manual by Pennak (1953). Stomach contents were analyzed using two (2) methods, frequency of occurrence and numerical methods. To avoid post mortem digestion, the stomach contents were kept in the refrigerator for further analysis.

3.11.1 Frequency of Occurrence

The number of stomachs in which each food item occurred was sorted out and expressed as percentage of the total number of fish stomachs examined.

$$F_1 = 100\, n_i / n \quad \text{……………………………………… (Bowen, 1983)}$$

Where

F_1: frequency of occurrence of the i food item in the sample

n_i: number of stomachs in which the i item is found

n: number of stomachs with food in the sample

3.11.2 Numerical Method

The number of individual of each food item was counted in each stomach, sum up to give the total of each kind, then grand total of items was calculated and expressedas percentage of the overall items found in each stomach (Crisp *et al*., 1978).

3.12 Index of Relative Importance (IRI)

Index of relative importance shows how important, each food item plays in the diet of fish. This was obtained separately for each food item found in the stomachs of using the formula below:

IRI = % F x [% N + % G] ………………… (Simenstad *et al*., 1991)

Where:

IRI: Index of Relative Importance of food item in the sample

% F: Frequency of occurrence of each food item

% N: Numerical composition of food item

% G: Gravimetric composition of each food item

3.13 Sex Ratio Determination

The sex of the samples captured over each sampling period was determined. This was done by visual observation of the external features and binocular dissecting microscopic examination of the various gonads. Females were recognized by reddish round inflammation around the genital aperture and the distended aperture, slightly sticky skin, and, by the presence of testes in the case of males. Also, the mouth of the male is broader and with larger heads than that of the female (Paugy *et al*., 2003).

The number of identifiable males and females of *Chrysichthys nigrodigitatus* for each sampling period were recorded and used to determine the sex ratio. This was done using the formula:

Sex ratio = $\frac{\text{number of males}}{\text{number of females}}$ .... (Akombo *et al*., 2013)

3.14 Maturity Stages

The visual approach was used to determine the maturity stages of *Chrysichthys nigrodigitatus*. The abdominal area of samples were gently pressed to see if milt or eggs were extruded and afterwards dissected by cutting away the abdominal wall to expose the gonads, which were removed, weighed and stored in Gilson's fluid for preservation. Stages of gonads were classified as represented in Table 3.2. Ovaries in females are tubular and granular, while testes in males are flat and their ventral edges frequently had a wave - like outline.

Table 3.2: Stages of gonad maturity

Gonad stage	Characteristic
I (immature virgin)	Gonads are small, thin, colourless, and thread-like
II(developing virgin / recovering spent)	Testes are thin, transparent and grayish in colour; ovaries colourless and more rounded in shape
III (developing)	Testes changes from transparent to grayish-white; ovariespale yellow and distinguishable to the eyes
IV (maturing)	Gonads reached maximum weight; testes elongated, ovaries rounded and yellow eggs clearly visible.
V (mature/ripe)	Testes white with smooth creamy texture, ovaries with large yellow eggs. Sexual products easily released with light pressure on the belly
VI (spent)	Sexual product already discharged; Testes thin and strap-like and fewer eggs contained in the ovaries

3.15 Length at First Maturity

The length at first maturity (LFM) was considered to be the length at which 50% of the fish examined had a gonadal maturity stage later than III. This was calculated for male and female using Fish Key Facts (4) (Froese and Binohlan, 2000).

3.16 Gonadosomatic Index (GSI)

The body weights of *Chrysichthys nigrodigitatus* with their corresponding gonad weights were both taken and used to calculate the gonadosomatic index (GSI). This was determined as:

GSI = W/B x 100 ……………………………….……………… (Allison *et al*., 2008)

Where;

W = weight of both gonads (g)

B = weight of the fish (g)

3.17 Fecundity Estimation and Oocyte/Egg Diameter

This is the number of eggs in the ovaries that will mature during a particular spawning season. Ripe eggs were removed from gravid fish, weighed and preserved in Gilson's fluid. The preserved ovaries were washed several times in distilled water to get rid of the preservative, then eggs were separated from the ovaries, placed on filter paper to remove excess water. Clumped eggs were carefully separated and air dried at room temperature. The diameters of ten oocytes from each ovary were measured, and the mean oocytes diameter determined.Volumetric and gravimetric methods were employed to estimate the number of eggs in each of the gravid fish.

3.17.1 Volumetric Method

One hundred eggs were counted and volume of displaced water measured. The total displacement of the entire eggs including the sample were measured and calculated using the formula below:

$X/n = V/v$ ………………………………. (Cailliet *et al*., 1986)

Where;

X = unknown number of eggs in the total sample collected

n = number counted in sample

V = total displaced volume

v = volume of the sample

3.17.2 Gravimetric Method

Sub-sampling dry gravemtric method: All the eggs in each fish were weighed.Three sub- samples of 200 eggs from each fish were then selected randomly and weighed. The total weight of eggs was divided by the mean weight of the sub-samples and multiplied by 200 to give estimated fecundity of the fish.

3.18 Fish Abundance and Distribution

Sampling of fish was done at the various station in the sampling zones to determine fish distribution and abundance in the study area. All the samples at each station from each sampling zone were collected, sorted according to species, counted, recorded, and used to determine the relative abundance and distribution (%) of individual species in the lake was calculated using the following formula according to Negi and Mamgain (2013).

$$\text{Relative abundance} = \frac{\text{number of samples of a particular species}}{\text{Total number of samples of all species}} \text{X } 100$$

3.19 Statistical Analyses

Means, Standard Error (SE) and Standard Deviation (SD) were computed using Microsoft Excel (2013). Morphomeristic data were analysed in order to validate the species using Fisheries Stock Assessment Tools (FiSAT) Programme.Analysis of variance (ANOVA) was used to test for significant differences at 5% from data of stomach contents, standard and total lengths, weights and condition factors, morphometric parameters, fish abundance and distribution at the sampling stations, and length-class interval of the species measured. Length-weight, length-length, and morphometric data were subjected to least square regression and correlation analysis. Student t-test was used to test forsignificant difference in the physico-chemical parameters, fullness index, sex ratio and stomach contents between seasons. Least Significant difference (LSD) and new Duncan Multiple Range Test (NDMRT) was carried out to rank means where necessary.

CHAPTER FOUR

4.0 RESULTS

4.1 Mean physico-chemical parameters of Jebba Lake, Nigeria

Table 4.1 shows the mean measurements of each of the physico-chemical parameters in Jebba Lake.

The various parameters measured fluctuated (that is, decrease and increase) during the period of study. While electrical conductivity (6.30-75.90µs/cm,$\bar{X}$ = 66.41±13.80), depth (3.00-18.50m, $\bar{X}$ = 10.00±4.75), and phosphate (0.006-0.511mg/l, $\bar{X}$ =0.20±0.15) showed high variation, nitrate (0.001-0.006, $\bar{X}$ = 0.003±0.0001) showed low variation.

Monthly physico-chemical parameters showed fluctuations (Table 4.2).Temperature was highest in Mayand lowest in January; dissolved oxygen in Julyand lowest in June; transparency highest in October and lowest in May. Electrical conductivity was highest in January and lowest in August with less fluctuations; pH in March and lowest in June; phosphate in September and lowest in January, and nitrate was highest in November.

There was significant difference ($p<0.05$) in the temperature, Dissolved oxygen, phosphate and nitrate during the period of study.

Table 4.1: Mean physico-chemical parameters of Jebba Lake, Nigeria

Parameter	Range	Mean±SD
Depth (m)	3.00 - 18.50	10.00±4.75
Temperature (^oC)	20.60 - 32.50	25.80±3.18
Dissolved Oxygen (mg/l)	6.10 - 10.20	7.71±1.03
pH	6.40 - 7.50	6.98±0.35
Transparency (m)	0.33 - 1.02	0.63±0.21
Electrical Conductivity (µs/cm)	6.30 - 75.90	66.41±13.80
Phosphate (mg/l)	0.006 - 0.511	0.20±0.15
Nitrate (mg/l)	0.001 - 0.006	0.003±0.001

Table 4.2:Monthly mean physico-chemical parameters of Jebba Lake, Nigeria (2009-2010)

Parameter	Temperature	Dissolved Oxygen (mg/l)	pH	Transparency (cm)	Electrical Conductivity (µs/cm)	Phosphate (mg/l)	Nitrate (mg/l)
January	21.7±0.30[a]	7.3±0.31[a]	7.2±0.15	0.54±0.07	68.7±1.77	0.006±0.002[a]	0.003±0.0007[a]
February	24.6±0.46[a]	7.9±0.20[c]	7.4±0.21	0.52±0.11	68.4±1.55	0.015±0.003[a]	0.002±0.0006[a]
March	27.9±1.47[a]	7.4±0.10[a]	7.7±0.23	0.49±0.04	67.5±1.99	0.114±0.068[a]	0.003±0.0006[a]
April	30.0±1.59[b]	7.5±0.40[b]	7.3±0.20	0.44±0.21	67.6±10.84	0.136±0.21[a]	0.003±0.0005[a]
May	31.8±0.44[a]	7.1±0.56[a]	7.2±0.21	0.43±0.16	66.6±6.57	0.170±0.13[a]	0.005±0.001[a]
June	31.4±0.64[c]	6.9±0.78[a]	7.0±0.21	0.49±0.12	65.9±2.35	0.176±0.05[a]	0.004±0.002[a]
July	27.4±0.53[a]	8.8±0.10[a]	7.1±0.06	0.53±0.12	64.5±4.09	0.177±0.17[c]	0.003±0.001[a]
August	27.8±2.23[a]	7.9±0.17[a]	7.3±0.25	0.59±0.15	64.2±4.78	0.250±0.19[d]	0.004±0.002[a]
September	27.6±1.20[a]	8.4±0.64[a]	7.3±0.10	0.55±0.19	65.4±7.24	0.291±0.22[a]	0.007±0.001[b]
October	27.1±0.42[d]	8.3±0.90[a]	7.3±0.38	0.62±0.18	64.9±7.73	0.241±0.19[a]	0.002±0.0006 [a]
November	25.8±1.00[e]	8.5±0.10[a]	7.2±0.10	0.59±0.20	65.9±6.94	0.127±0.23[a]	0.072±0.002[c]
December	24.3±0.75[f]	8.5±0.26[a]	7.5±0.15	0.58±0.23	66.7±11.73	0.072±0.27[c]	0.005±0.001[a]

Means with the same superscript within the rows are not significantly different ($p>0.05$)

4.2 Correlation and physico-chemical parameters at various zones of Jebba Lake, Nigeria

Table 4.3 presents the correlation of physico-chemical parameters of Jebba Lake, Nigeria during the period of study. The pH had a high correlation with DO (r=0.50). Others include EC and DO (r=0.50), pH and Phosphates (r=0.58).Low correlation values were recorded between EC and Nitrates (r=0.002), Temperature and Phosphate (r = 0.003). Transparency showed negative correlation with EC (r = -0.55), Phosphates with EC (r= -0.16) and Nitrates with phosphates (r= -0.06).

Physico-chemical parameters of the various sampling zones recorded water depth (m) as highest in zone I, and lowest in zone III, while temperature and transparency were highest in zone III and lowest in zone I. Electrical conductivity (µs/cm) was highest in zone II than other zones, phosphate and nitrate was highest in zone II and lowest in zone I (Table 4.4). There was no significant difference (p>0.05) in temperature, dissolved oxygen, pH, transparency and nitrate but significant difference (p<0.05) in electrical conductivity and phosphate between sampling zones on the lake.

Seasonal physico-chemical parameters of the various sampling zones on the lake recorded depth (m) and temperature (^{o}C) as highest in zones I in both wet and dry seasons; electrical conductivity was highest in zone II in both wet and dry seasons(Table 4.5). Overall, phosphate was highest in zone III during dry season, transparency was highest during dry season in zone II. While depth, temperature, dissolved oxygen and pH were lowest in zone III during dry season, phosphate was lowest in both wet and dry season in zone I. There was no significant difference (p>0.05) in dissolved oxygen, temperature, pH and nitrates but significant difference

($p<0.05$) in transparency, electrical conductivity, and phosphate at the various zones during the period of study.

Table 4.3: Correlation of physico-chemical parameters of water in Jebba Lake, Nigeria (January 2009-December 2010)

Parameter	**Depth (m)**	**Temperature (^{o}C)**	**Dissolved Oxygen (mg/l)**	**pH**	**Transparency (m)**	**Electrical Conductivity (µS/cm)**	**Phosphates(mg/l)**	**Nitrates(mg/l)**
Depth (m)	1							
Temperature (oC)	0.19	1						
DO (mg/l)	0.12	0.13	1					
pH	0.16	0.19	0.50	1				
Transparency	-0.31	-0.42	-0.46	-0.55	1			
EC (µS/cm)	0.26	0.28	0.50	0.58	-0.75	1		
Phosphates (mg/l)	0.05	0.003	0.11	0.26	0.33	-0.16	1	
Nitrates (mg/l)	-0.46	-0.08	-0.003	0.10	0.11	0.002	-0.06	1

Table 4.4: Mean physico-chemical parameters of the various sampling zonesin Jebba Lake, Nigeria

Parameter	Zone I	Zone II	Zone III
Water depth (m)	15.40±2.53	11.75±1.56	4.40±0.94
Temperature (^oC)	26.12±2.76	26.53±3.04	27.47±3.73
Dissolved Oxygen (mg/l)	8.18±1.05	8.26±0.95	8.51±1.21
pH	7.34±0.22	7.48±0.29	7.54±0.27
Transparency (m)	0.43±0.16	0.60±0.09	3.38±10.27
Electrical Conductivity (µs/cm)	70.4^a±5.43	79.0^b±4.33	69.9^a±2.11
Phosphates (mg/l)	0.05^b±0.03	0.29^a±0.20	0.26^a±0.17
Nitrates (mg/l)	0.0026±0.001	0.0031±0.002	0.0027±0.001

Means with the same superscript within the rows are not significantly different ($p>0.05$)

Table 4.5: Mean seasonal physico-chemical parameters of the various sampling zones in Jebba Lake, Nigeria

Parameter	Zone I		Zone II		Zone III	
	Wet	Dry	Wet	Dry	Wet	Dry
Depth (m)	18.5±2.08	10.3±1.24	13.5±1.65	7.0±1.06	5.3±0.32	3.0±0.18
Temperature (^{o}C)	29.7±3.60	25.2±2.36	28.6±2.80	24.5±1.55	28.0±2.2	24.2±1.81
Dissolved Oxygen (mg/l)	8.83±1.50	8.2±0.85	8.51±1.18	8.0±0.65	8.58±1.32	7.8±0.52
pH	7.63±0.34	7.45±0.15	7.5±0.29	7.45±0.31	7.43±0.23	7.25±0.19
Transparency	0.63±0.06^{a}	0.57±0.10^{a}	0.43±0.08^{a}	6.33±14.53^{b}	0.29±0.03^{b}	0.57±0.10^{a}
Electrical Conductivity (μs/cm)	72.22±5.32^{a}	68.58±5.36^{a}	82.12±2.24^{b}	75.85±3.56^{b}	69.78±2.00^{a}	70.0±2.42^{a}
Phosphates (mg/l)	0.06±0.02^{b}	0.03±0.04^{b}	0.46±0.10^{a}	0.13±0.14^{a}	0.34±0.12^{a}	0.17±0.19^{a}
Nitrates (mg/l)	0.002±0.001	0.003±0.001	0.003±0.002	0.003±0.002	0.002±0.001	0.003±0.001

Wet season: Means with the same superscript within rows are not significantly different (p>0.05)

Dry season: Means with the same superscript within rows are not significantly different (p>0.05)

4.3 Length-weight Relationship (LWR) and Length-length Relationship (LLR) of *Chrysichthys nigrodigitatus* in JebbaLake

The length-weight relationship of *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria during the period of study are presented in figures 4.1, 4.2 and 4.3. The b-values of males (2.49), and combined sexes (2.66) reveal negative allomerism that of females (3.18) reveal isomerism. Both sexes had positive correlation (r= 0.7841 males, r= 0.7848 female).

The log standard length-log total length relationship of *Chrysichthys nigrodigitatus* during the period of study is presented in figures 4.4, 4.5, and 4.6. There is a positive correlation (r) in males (0.93), females (0.83), and combined sexes (0.90).

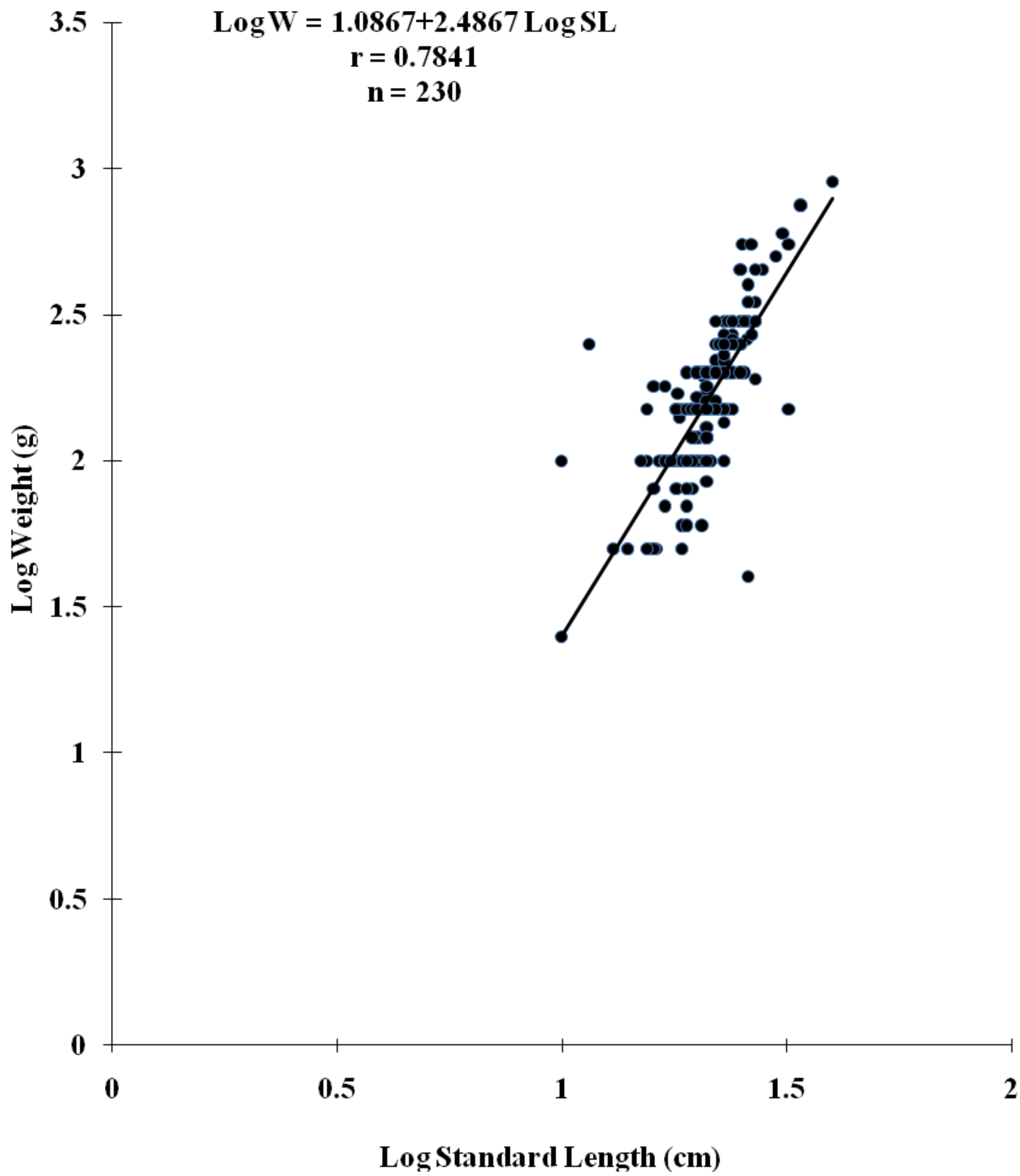

Figure 4.1: Log length-log weight of male *Chrysichthys nigrodigitatus* in Jebba Lake,Nigeria

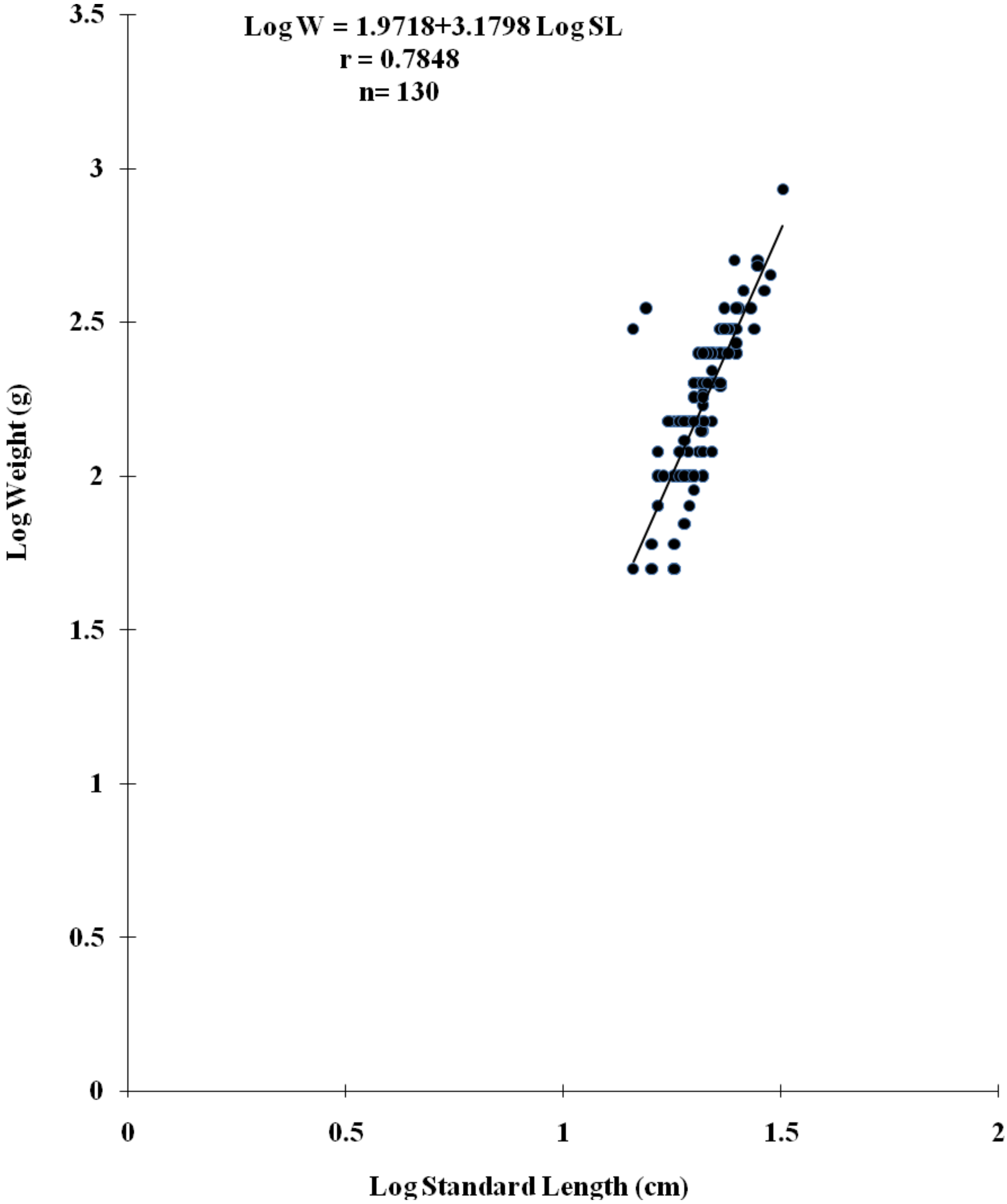

Figure 4.2: Log length-log weight of female *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria

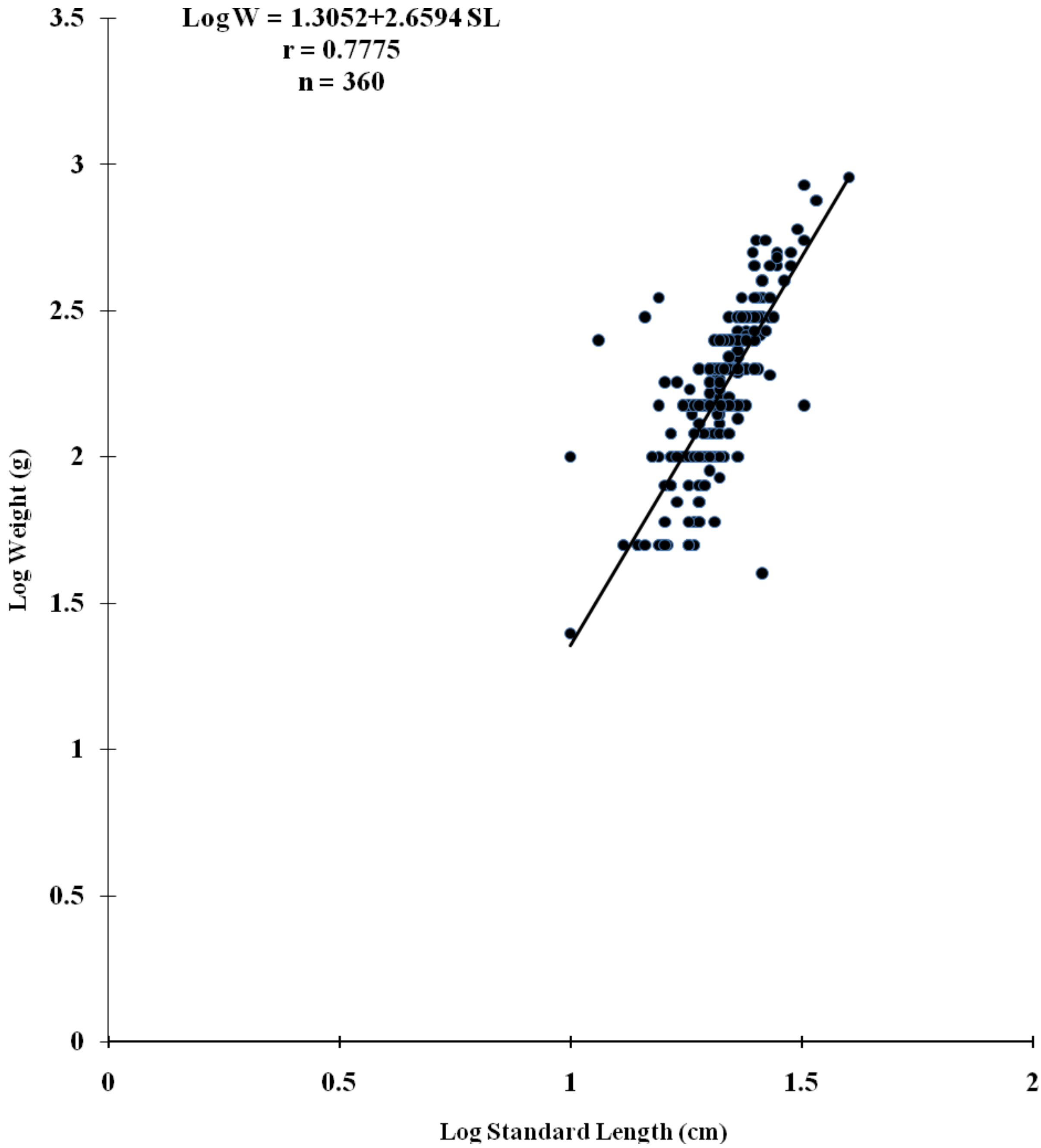

Figure 4.3: Log length-log weight of combined sexes of *Chrysichthys nigrodigitatus*in Jebba Lake, Nigeria

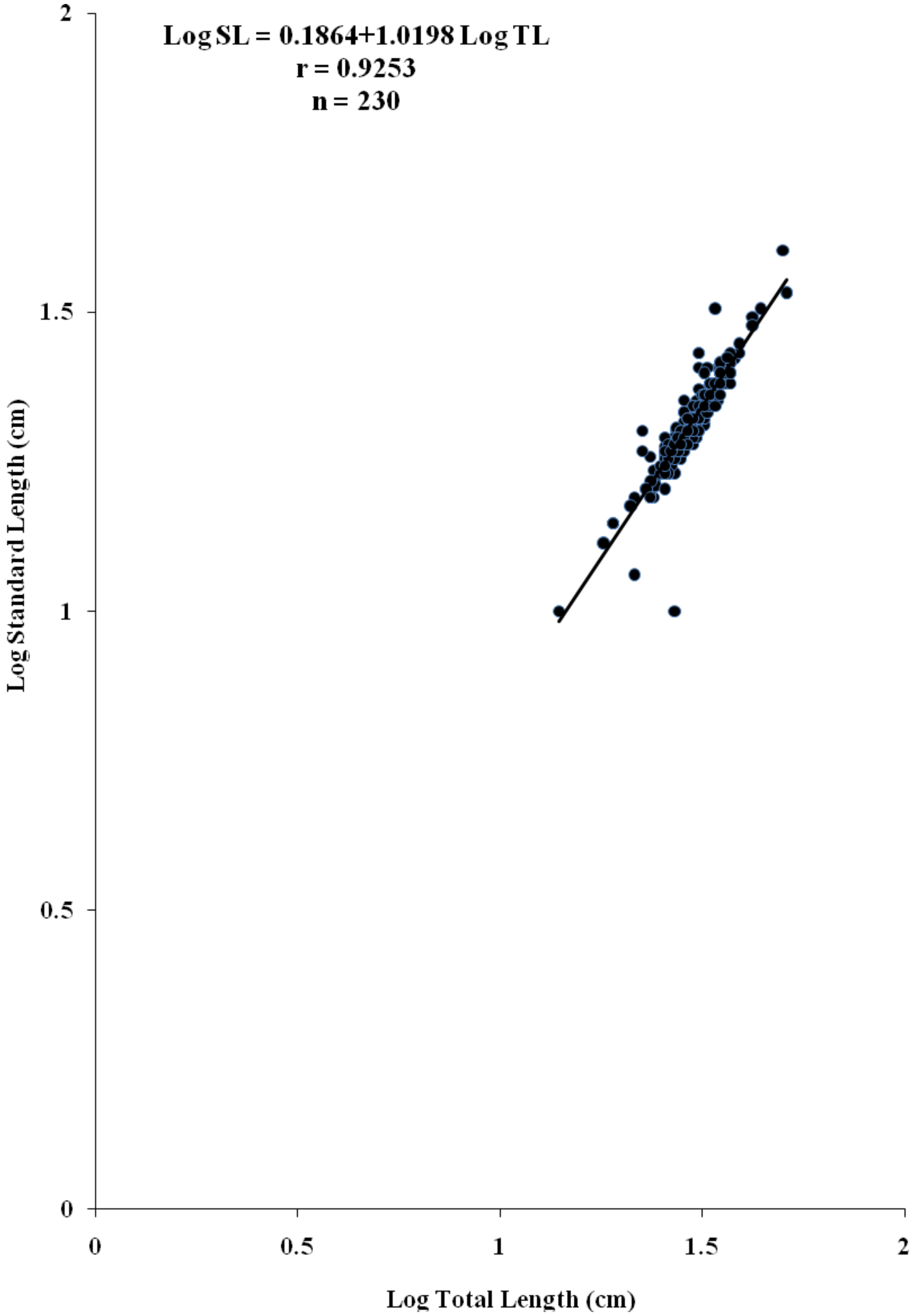

Figure 4.4: Log standard-log total length relationship of male *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria

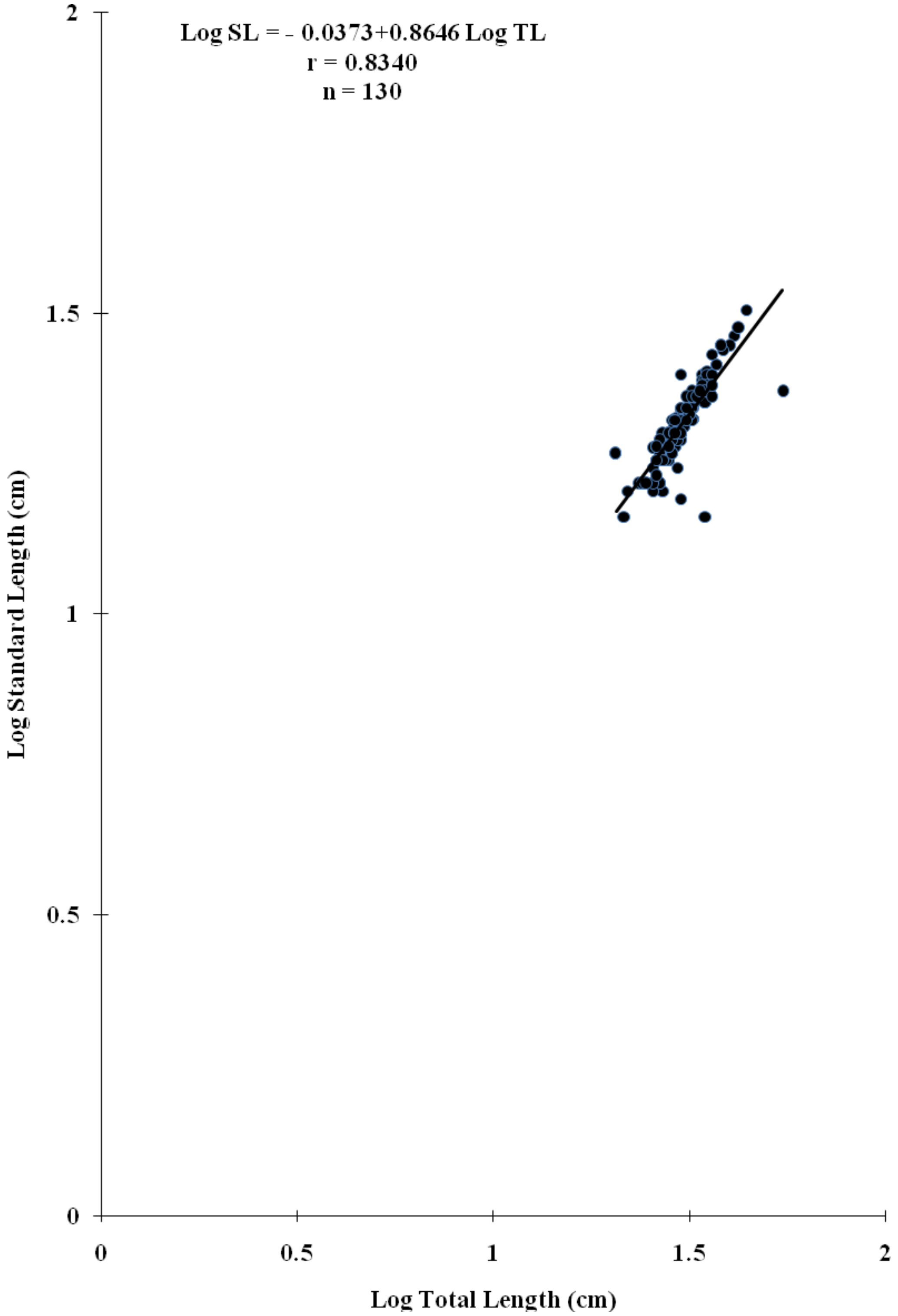

Figure 4.5: Log standard-log total length relationship of female *Chrysichthys nigrodigitatus*in Jebba Lake, Nigeria

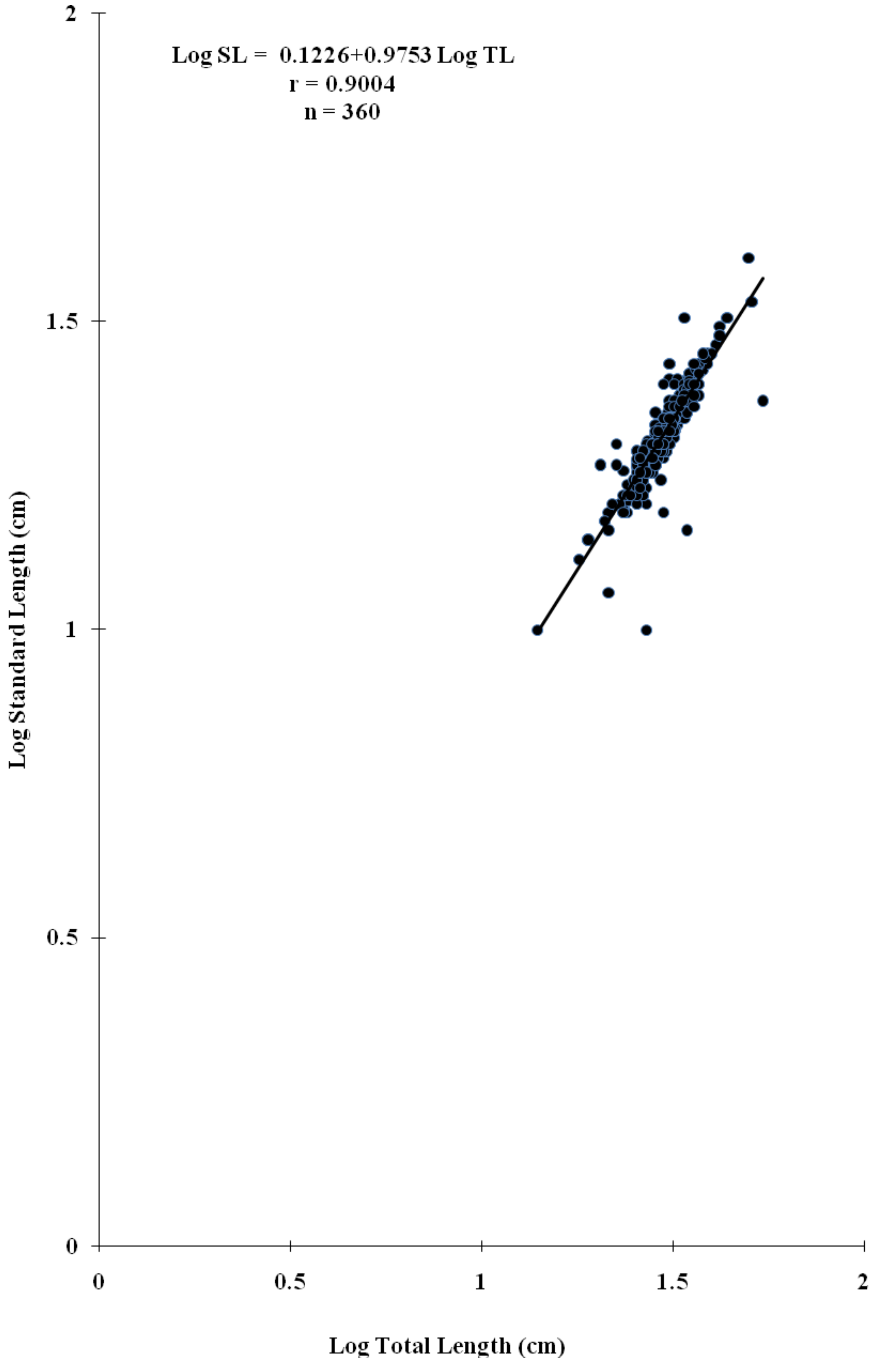

Figure 4.6: Log standard-log total length relationship of combined sexes *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria

4.4Mean condition factor (K) and morphometric measurements of *C. nigrodigitatus* in Jebba Lake, Nigeria

The mean monthly condition factor (K) ranged from 0.47 – 1.83. The highest values were recorded in September (1.74), June (0.83) and April (0.80) in the male population (Figure 4.7). June (1.83), September (0.88), and October (0.81) in the female population. Condition factor increased during wet season in male population (April, June and September) than in dry season.

A total of 250 samples were measured for morphometric parameters. The ranges showed variations of these parameters. The standard and total lengths ranged from 10.00cm-40.00 cm ($\bar{X}$ = 21.28±3.47) and 14.00cm-54.50cm ($\bar{X}$ =30.50±4.58), respectively (Table 4.6). The weights of samples ranged from 25.00g-900.00g with ($\bar{X}$ = 188.36±116.75).Other parameters measured included pectoral-anal fin (3.08cm-11.42cm, $\bar{X}$ = 12.67±10.86) and gape width (0.39cm-0.65 cm, $\bar{X}$ = 0.34±0.82).

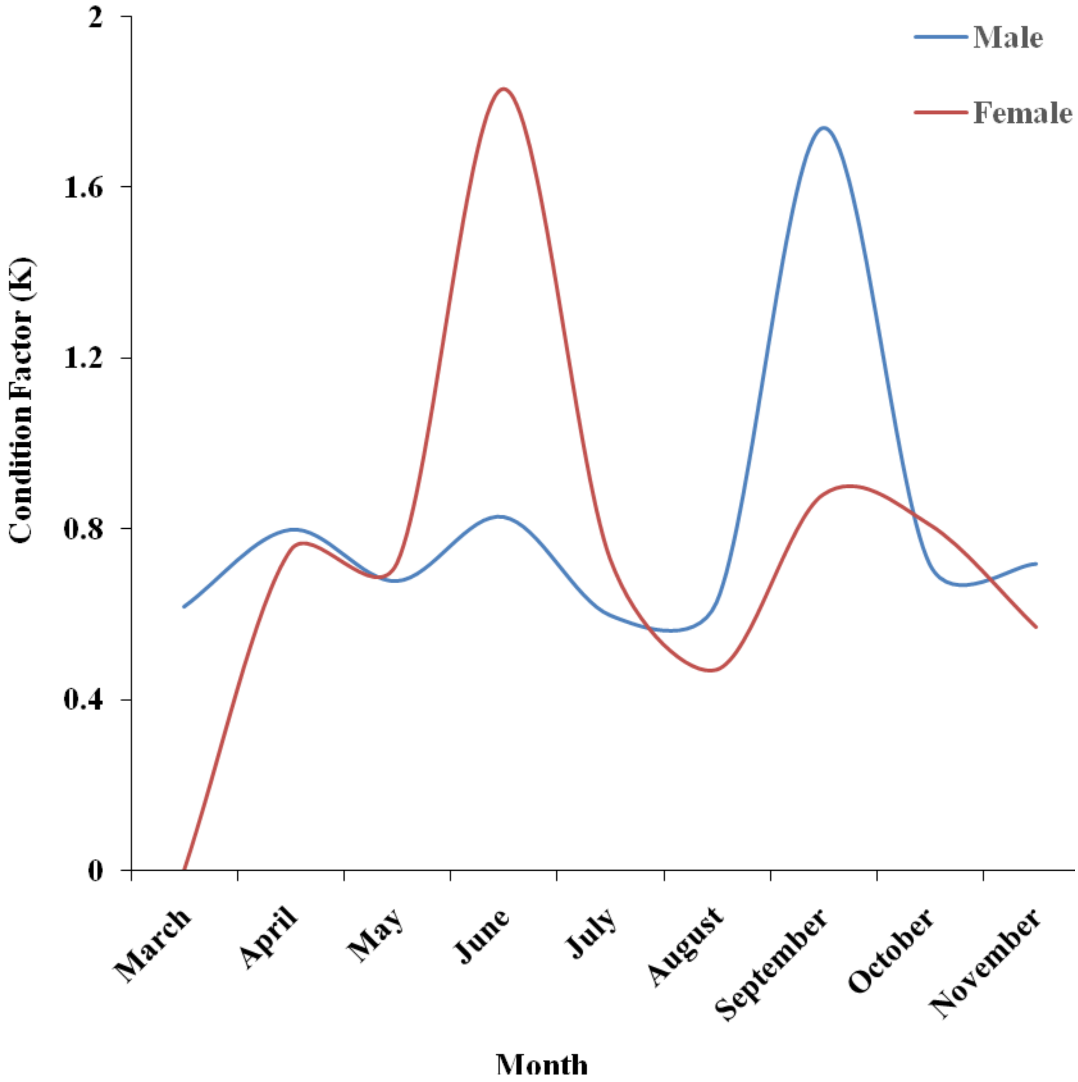

Figure 4.7: Condition factor of *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria

Table 4.6: Morphometric measurements (cm) of *Chrysichthys nigrodigitatus* in Jebba Lake

Parameter	**Range**	**Mean ± SD**
Standard length	10.00-40.00	21.28±3.47
Total length	14.00-54.50	30.50±4.58
Weight	25.00-900.00	188.36±116.75
Body depth	2.43-25.00	9.81±4.33
Caudal peduncle depth	0.65-32.00	1.79±2.65
Caudal peduncle length	0.82-11.50	1.53±0.94
Pre-dorsal length	2.32-63.00	8.24±4.86
Length of dorsal base	1.22-93.00	12.67±1.00
Length of anal base	1.41-20.50	2.71±1.59
Height of dorsal fin	2.62-72.00	7.98±5.64
Height of anal fin	2.04-37.90	4.60±2.94
Length of pectoral fin	1.68-36.60	4.46±2.85
Length of pelvic fin	1.71-30.60	3.98±2.35
Length of longest dorsal spine	2.22-40.12	4.78±3.09
Head length	3.07-47.50	6.53±3.66
Head width	2.00-23.80	3.48±1.94
Distance pelvic-anal fin	2.90-11.42	5.09±1.42
Distance pectoral-anal fin	3.08-111.50	12.67±10.86
Snout length	0.41-17.08	2.55±1.35
Suborbital width	0.47-8.33	1.09±0.85
Eye diameter	0.49-1.96	1.42±0.18
Upper-jaw length	1.56-5.33	2.93±0.66
Gape width	0.39-0.65	0.34±0.82
Nostril distance	0.53-6.71	0.98±0.64
Nostril-eye distance	0.69-3.60	1.84±0.64

4.5Measurements (%) and correlation of Morphometric parameters of *C. nigrodigitatus*

The ranges of morphometric measurements showed different percentages these parameters occupy on the body of the fish (Table 4.7). Length of dorsal fin had the highest percentage with mean 35.60±5.26, while the lowest was caudal peduncle length had a mean of 6.85±1.19. The length of dorsal base had the highest percentage of mean 183.49±10.90 with the lowest being eye diameter of mean 23.20±3.82.Caudal peduncle length had the highest percentage (20.07±7.62) as it relates to body depth. Head length and caudal peduncle depth also had high percentage as it relates to length of dorsal fin and caudal peduncle length, respectively.

Table 4.8 presents the correlation of morphometric parameters of *Chrysichthys nigrodigitatus* measured during the period of study. The pectoral-anal fin and pelvic-anal fin exhibited positive correlation (r = 0.87). Others include nostril-eye and snout length (r=0.86), head width and head length (r = 0.86), snout length and pre-dorsal (r = 0.85), standard and total length (r = 0.84). Standard length showed high positive correlation with other parameters, with the exception of caudal peduncle depth (r = 0.14) and eye diameter r = 0.35), which showed low correlation. Correlation between dorsal fin height and body depth (r = -0.1), eye diameter and caudal peduncle depth (r = -0.07).

Table 4.7: Percentage morphometric measurements of *Chrysichthys nigrodigitatus* from Jebba Lake

Parameters		Mean ± SD
As percentage of standard length		
Body depth	15.13 - 88.67	7.35±19.77
Caudal peduncle length	4.01 - 11.50	
Length of dorsal fin	16.95 - 45.42	6.85±1.19
Length of anal fin	11.48 - 31.57	35.60±5.26
Length of pectoral fin	10.98 - 45.20	21.00±3.29
Length of pelvic fin	13.63 - 24.43	20.29±3.29
Length of longest dorsal spine	14.57- 45.40	18.24±1.71
Head length	14.39 - 67.26	21.95±3.64
		30.38±5.98
As percentage of head length		
Head width	36.63 - 67.64	
Snout length	29.09 - 69.32	52.39±6.71
Eye diameter	9.07 - 36.12	
Length of dorsal base	160.35-218.82	39.29±4.20
Length of pectoral fin	44.16 - 89.61	23.20±3.82
Length of pelvic fin	43.56 - 72.63	183.49±10.90
Length of anal fin	56.73 - 85.08	67.81±7.37
		60.86±4.78
As percentage of body depth		69.06±5.99
Caudal peduncle length	7.14 - 40.06	
Caudal peduncle depth	7.02- 41.93	
		6.18±9.30
As percentage length of dorsal fin		20.07±7.62
Head length	61.90 - 99.21	
As percentage caudal peduncle length		84.53±9.37
	35.93-99.05	

Caudal peduncle depth	70.82±14.15

Table 4.8: Correlationof morphometric parameters of *C. nigrodigitatus* in Jebba Lake

Parameter	SL	TL	Wt	BD	CPD	CPL	PDL	DBL	ABL	DFH	AFL	PcFL	PlFL	lDSL	HL	HW	SnL	SoW	ED	GW	UjL	dPlAF	dPcAF	dNE
SL	1																							
TL	0.84	1																						
Wt	0.70	0.70	1																					
BD	0.61	0.38	0.44	1																				
CPD	0.14	0.07	0.15	0.11	1																			
CPL	0.47	0.46	0.49	0.23	0.17	1																		
PDL	0.79	0.73	0.73	0.56	0.12	0.51	1																	
DBL	0.76	0.70	0.79	0.56	0.16	0.47	0.77	1																
ABL	0.69	0.67	0.76	0.51	0.18	0.45	0.72	0.75	1															
DFH	0.40	0.48	0.50	-0.1	0.04	0.30	0.39	0.38	0.40	1														
AFL	0.74	0.70	0.68	0.53	0.08	0.42	0.78	0.69	0.73	0.42	1													
PcFL	0.76	0.70	0.71	0.55	0.15	0.43	0.79	0.71	0.65	0.44	0.79	1												
PlFL	0.78	0.75	0.73	0.51	0.10	0.48	0.82	0.74	0.67	0.52	0.76	0.85	1											
lDSL	0.61	0.59	0.50	0.55	0.11	0.26	0.63	0.57	0.50	0.28	0.63	0.66	0.66	1										
HL	0.78	0.73	0.73	0.49	0.10	0.49	0.83	0.74	0.71	0.44	0.76	0.78	0.80	0.59	1									
HW	0.68	0.69	0.76	0.52	0.13	0.48	0.73	0.71	0.70	0.35	0.69	0.66	0.71	0.57	0.73	1								
SnL	0.79	0.74	0.73	0.51	0.11	0.56	0.85	0.74	0.69	0.43	0.76	0.74	0.79	0.56	0.86	0.74	1							
SoW	0.44	0.43	0.47	0.43	0.08	0.28	0.52	0.46	0.39	0.07	0.45	0.51	0.53	0.45	0.49	0.47	0.50	1						
ED	0.35	0.38	0.43	0.20	-0.07	0.27	0.39	0.35	0.28	0.27	0.42	0.39	0.41	0.35	0.36	0.41	0.34	0.37	1					
GW	0.70	0.66	0.75	0.59	0.12	0.46	0.76	0.71	0.68	0.34	0.66	0.67	0.74	0.58	0.73	0.80	0.75	0.48	0.35	1				
UjL	0.70	0.66	0.64	0.46	0.09	0.46	0.77	0.67	0.57	0.38	0.69	0.72	0.77	0.56	0.81	0.68	0.79	0.48	0.33	0.70	1			
dPlAF	0.72	0.68	0.73	0.51	0.14	0.49	0.74	0.72	0.57	0.38	0.64	0.67	0.75	0.51	0.68	0.74	0.75	0.44	0.33	0.71	0.69	1		
dPcAF	0.77	0.77	0.84	0.51	0.17	0.54	0.80	0.80	0.74	0.46	0.74	0.76	0.80	0.61	0.80	0.79	0.78	0.47	0.37	0.75	0.73	0.87	1	
dNE	0.75	0.71	0.77	0.58	0.12	0.48	0.81	0.72	0.68	0.37	0.75	0.76	0.79	0.59	0.83	0.75	0.86	0.64	0.37	0.77	0.78	0.75	0.79	1

Key:

TL (cm)-total length; **SL** (cm)-standard length; **BD**-body depth; **Wt** (g)-weight; **CPD**-caudal peduncle depth; **CPL**-caudal peduncle length; **PDL**-pre dorsal length; **DBL**-dorsal base length; **ABL**-anal base length; **DFH**-dorsal fin height; **AFH**-anal fin height; **PcFL**-pectoral fin length, **PlFL**-pelvic fin length; **lDSL**-longest dorsal spine length; **HL**-head length; **HW**-head width; **SnL**-snout length; **SoW**-sub orbital width; **ED**-eye diameter; **GW**-gape width; **UjL**-upper jaw length; **dPlAF**-distance pelvic-anal fin; **dPcAF**-distance pectoral-anal fin; **dNE**-distance nostril-eye

4.6 Meristic parameters and size distribution and class of *C. nigrodigitatus* in Jebba Lake,Nigeria

Meristic parameters of the species counted during the study were dorsal rays, anal rays, total pectoral rays, pelvic rays and dorsal spine (Table 4.9). Dorsal fin rays was between 5-6; anal fin rays was between 12-15; anal fin spine was between III-V; total pectoral fin rays was between 7-10; pelvic fin ray was between 5-9; dorsal spine was between 1-2.*Chrysichthysnigrodigitatus* has 2 pairs of nostrils (four in number) between the eyes and mouth.

Table 4.10 shows the various body measurements of *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria. A total of 360 samples were analyzed, 230 were males and 130 were females. The total length of males ranged between 10.00 cm and 40.00 cm ($\bar{X}$=21.20±3.52cm), while it ranged between 14.50cm and 32.00cm ($\bar{X}$=20.78±2.78cm) in females and there is no significant difference ($p>0.05$)between the male and female fish.Weights of males ranged between 25.00g and 900.00g ($\bar{X}$=181.46±108.68g) and females ranged between 50.00g and 850.00g ($\bar{X}$=185.71±107.24g). Females are heavier than males, which did not differ significantly ($p>0.05$).

The class size of 230 males and 130 females of *Chrysichthys nigrodigitatus* during the period study in Jebba Lake is presented in Table 4.11. Majority of males (61.30%) and females (53.85%) were within the class intervals of 30.00 cm and 39.00 cm. None was recorded for class 10.00cm and 19.00 cm in females.

Table 4.9: Meristic/counts parameters of *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria

Parameter	**Author**		
	Holden and Reed (1991)	**Paugy *et al*. (2003)**	**This study**
Dorsal fin rays	6	6	6
Dorsal spine	II	II	I-II
Anal fin rays	9-10	8-12	8-11
Anal spine	V-VI	III-VII	III-V
Pectoral fin rays	-	8-10	7-9
Pectoral spine	-	I	I
Pelvic fin rays	-	5	5-7
No of gill rakers on lower part of 1st gill arch	-	14-21	14-21
Head is oval and eyes very large when viewed from			
above			2
Number of nostrils (pair)			
Presence of nasal barbels			

Table 4.10: Size distribution of *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria

Sex	**No**	**Standard length (cm)**	**Mean±SD**	**Total length (cm)**	**Mean±SD**	**Weight (g)**	**Mean±SD**
Male	230	10.00-40.00	21.20±3.52	14.00-51.00	30.37±4.53	25.00-900.00	181.46±108.68
Female	130	14.50-32.00	20.78±2.78	20.50-54.50	30.22±4.15	50.00-850.00	185.71±107.24
Combined	360	10.00-40.00	21.05±3.31	14.00-54.50	30.31±4.40	25.00-900.00	182.98±108.08

Table 4.11: Size class (cm) of *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria

Class interval	Male	Female	Total
10.00 - 19.00	7	-	7
20.00 - 29.00	76	55	131
30.00 - 39.00	141	70	211
40.00 - 49.00	3	4	7
50.00 - 59.00	3	1	4
Total	**230**	**130**	**360**

4.7 Age composition and Growth parameters of *Chrysichthys nigrodigitatus* in Jebba Lake

Table 4.12 reveals the ages and modal length (cm) composition of *C. nigrodigitatus* in Jebba Lake, Nigeria. The males attained age range of 0+ and 3+, where age 2 had the highest number (29.09%) in the population. The female age ranged between 0+ and 3, with age 2+ being highest (41.82%) of the population. No female at age 3+ was recorded during the period of study.The modal length (cm) of *C. nigrodigitatus* at the various age group showed increase in length with increased age.

The growth parameters of males and females of *C. nigrodigitatus* in Jebba Lake, Nigeria during the period of study is presented in Table 4.13. The growth performance index (GPI) was higher in males (3.43) than females (3.09). The assumed maximum length fish can grow ($L\infty$) was also higher in males (53.00cm) than females (36.60cm).

Table 4.12: Age composition (mean) of *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria

Age (years)	Modal length (cm)	No of fish	Composition (%)
Male			
0+	19.00	6	5.45
1+	26.50	18	16.36
2	32.00	38	34.55
2+	35.00	32	29.09
3	36.00	15	13.64
3+	51.00	1	0.91
Female			
0+	21.50	2	3.64
1+	24.00	6	10.91
2	30.00	15	27.27
2+	33.00	23	41.82
3	35.00	9	16.36
3+	0.00	0	0.00

Table 4.13: Growth parameters of *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria

Sex	GPI	L∞ (cm)	K (yr-^{1})	T_o (years)
Male	**3.43**	**53.00**	**0.96**	**0.06**
Female	**3.09**	**36.60**	**0.96**	**0.09**

GPI = Growth performance index

L∞ (cm) = Maximum assumed length to which fish tends to grow

K (yr-^{1}) = Growth coefficient

T_o (years) = Theoretical time when fish length is zero

4.8Food composition of *Chrysichthys nigrodigitatus*using frequency of occurrence and numerical methods

The stomach contents of *C. nigrodigitatus* analyzed by frequency of occurrence and numerical methods are presented in Table 4.14.

Chrysichthys nigrodigitatus fed on food items that are of plant and animal sources. These are broadly grouped into insects, detritus, vegetable matter, crustacean, sand/mud, fish, algae, nematode and unidentified materials for both frequency of occurrence and numerical methods.

Detritus was determined as the highest item ingested by the fish in frequency of occurrence and numerical methods, *Bosmonia* and scales were the items lowest. Overall, insects was the most abundant for both frequency of occurrence (28.97%) and numerical (36.84%) methods in the food composition.

Table 4.14: Food composition of *Chrysichthys nigrodigitatus* usingfrequency of occurrence and numerical methods

Items	Items category	No	% Occurrence	No	% Numerical
INSECTA					
Diptera					
	***Chaoborus* larvae**	**152**	**6.12**	**487**	**8.82**
	***Chironomid* larvae**	**283**	**11.40**	**916**	**16.6**
	***Chironomid* pupae**	**110**	**4.43**	**179**	**3.42**
Insect fragments (wings, limbs, head)		**174**	**7.02**	**438**	**7.93**
DETRITUS		**402**	**16.20**	**1068**	**19.34**
VEGETABLE MATTER	**Plant materials**	**250**	**10.07**	**500**	**9.06**
	Seeds	**45**	**1.81**	**102**	**1.86**
CRUSTACEAN					
Copepoda					
	***Diaptomus*62**		**2.50**	**130**	**2.35**
	***Cyclops*116**		**4.67**	**179**	**3.42**
Cladocera					
	***Daphnia* 66**		**2.66**	**160**	**2.90**
	***Bosmonia* 11**		**0.45**	**22**	**0.40**
SAND/MUD		**118**	**4.75**	**275**	**4.98**
FISH					
	Fry/remains	**318**	**12.81**	**723**	**13.10**
	Scale	**25**	**1.01**	**9**	**0.16**
ALGAE					
	Filamentous	**211**	**8.50**	**110**	**1.99**
	Blue-green	**34**	**1.37**	**167**	**3.20**
Nematode		**64**	**2.58**	**36**	**0.65**
Unidentified materials		**41**	**1.65**	**20**	**0.36**
Total		**2482**	**100**	**5521**	**100**

4.9Frequency of occurrence of items ingested by *Chrysichthys nigrodigitatus*

The monthly frequency of occurrence (%) of items ingested by *Chrysichthys nigrodigitatus* during the period of study are presented in Table 4.15.Nine (9) different items ranging from plants to animal materials were ingested by *Chrysichthys nigrodigitatus*. This included insect, detritus, vegetable matter, crustacean, sand/mud, fish, algae, nematode, and unidentified materials.

There was variations in the items ingested. Detritus had highest occurrence in March, June, July, September and November; insect fragments in April and May; fish fry/remains in August and *chironomid* larvae in October. While *Bosmonia* occurred only in March, plant materials was absent in April. November and April had the highest and lowest range of different items ingested. *Chrysichthys nigrodigitatus* was not recorded between December and February.

Percentage seasonal variation of items ingested by *Chrysichthys nigrodigitatus*(Table 4.16)recorded detritus as the highest (17.64%) item ingestedduring the wet season, followed by fry/remains (16.93%), while during dry season *chironomid* larvae was highest (15.32%) and followed by detritus (13.83%).*Diaptomus*, *Daphnia* and *Bosmonia* were not ingested during the wet season, while scale and blue-green algae were also not ingested during the dry season.

There was no significant difference ($p<0.05$) in the variation of items ingested by *Chrysichthys nigrodigitatus* between the seasons.

Table 4.15:Monthly frequency of occurrence (%) of items ingested by *Chrysichthys nigrodigitatus*in Jebba Lake, Nigeria

Items		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
INSECTA										
Diptera										
	***Chaoborus* larvae**	-	-	-	-	-	-	13.25	14.49	6.15
	***Chironomid* larvae**	1.82	-	-	10.87	12.98	9.89	8.66	17.68	14.58
	***Chironomid* pupae**	5.46	-	-	-	-	16.35	2.83	6.38	3.87
Insect fragments		4.55	37.74	37.95	-	10.32	11.03	-	2.32	4.56
Detritus		35.45	-	-	39.67	20.06	-	23.14	17.39	16.17
VEGETABLE MATTER	**Plant materials**	8.19	-	25.55	9.78	5.61	19.01	9.72	7.24	6.83
	Seeds	1.82	33.96	-	-	2.65	-	-	2.32	1.38
CRUSTACEAN										
Copepoda										
	Diaptomus	5.44	-	-	-	-	-	-	-	11.39
	Cyclops	-	-	-	10.87	4.72	1.52	-	11.01	8.66
Cladocera										
	Daphnia	11.36	-	-	-	-	-	-	7.25	3.64
	Bosmonia	5.00	-	-	-	-	-	-	-	-
Sand/Mud		-	-	-	-	16.52	14.45	-	4.64	1.82

FISH										
	Fry/remains	**-**	**-**	**22.63**	**13.05**	**15.34**	**22.43**	**16.78**	**9.28**	**5.69**
	Scale	**-**	**-**	**-**	**-**	**2.95**	**-**	**2.65**	**-**	**-**
ALGAE	**Filamentous**	**14.55**	**-**	**-**	**-**	**5.61**	**-**	**17.67**	**-**	**13.67**
	Blue-green	**-**	**28.30**	**13.87**	**-**	**-**	**-**	**-**	**-**	**-**
Nematode		**6.36**	**-**	**-**	**15.76**	**3.24**	**2.28**	**-**	**-**	**0.91**
Unidentified materials		**-**	**-**	**-**	**-**	**-**	**3.04**	**5.33**	**-**	**0.68**

Table 4.16: Seasonal variation (%) of items ingested by *Chrysichthysnigrodigitatus* inJebba Lake, Nigeria

Items		No.	Wet	No.	Dry
INSECTA					
Diptera					
	***Chaoborus* larvae**		**4.86**	**77**	**8.19**
	75		**9.01**	**144**	**15.32**
	***Chironomid* larvae**		**3.83**	**51**	**5.43**
	139				
	***Chironomid* pupae**				
	59				
Insect fragments (wings, limbs, and head)	**136**		**8.82**	**38**	**4.04**
Detritus			**17.64**	**130**	**13.83**
	272				
VEGETABLE MATTER	**Plant materials**	**177**	**11.48**	**73**	**7.77**
	Seeds		**1.75**	**18**	**1.91**
	27				
CRUSTACEAN					
Copepoda	***Diaptomus***		**-**	**62**	**6.60**
	-		**2.59**	**76**	**8.09**
	***Cyclops* 40**				
Cladocera	***Daphnia* -**		**-**	**66**	**7.02**
	Bosmonia		**-**	**11**	
	-			**1.17**	
Sand/Mud		**94**	**6.10**	**24**	**2.55**
FISH					
	Fry/remains		**16.93**	**57**	**6.06**
	261				
	Scale		**1.62**	**-**	**-**
	25				
ALGAE					
	Filamentous		**7.72**	**92**	**9.79**
	119		**2.20**	**-**	**-**
	Blue-green				
	34				
Nematode			**2.98**	**18**	**1.91**
	46				

Unidentified materials	**38**	**2.47**	**3**	**0.32**
Total	**1542**	**100**	**940**	**100**

4.10 Food composition of *Chrysichthys nigrodigitatus* at stages of life in Jebba Lake,Nigeria

Percentage food composition of *Chrysichthys nigrodigitatus* at the different stages in the lake are presented on Table 4.17.Juvenile ingested insects with *chironomid* larvae (20.58%) as highest; sub-adult on detritus (16.40%) and *Bosmonia* as lowest (0.29%); adult with fry/remains (27.86%) as the highest. Scale was absent in juveniles, while in adult *chironomid* larvae, *Diaptomus*, *Bosmonia*, seed, and blue-green were absent.

Percentage seasonal food composition of *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria at various stages of life are presented on Table 4.18.During the dry season, juveniles of *Chrysichthys nigrodigitatus* fed predominantly on insects, especially chironomid larvae (20.36%); sub-adult on detritus (18.01%), and the adult on fry/remains (19.65%). While scale and blue-green algae were not ingested by all the stages, juvenile in addition did not ingest nematode; adult-chironomid larvae, seed, *Diaptomus*, *Bosmonia*, and blue-green algae.

During the wet season, juveniles of *C. nigrodigitatus* fed predominantly on *chironomid* larvae (20.75%); sub-adult and adult on detritus, and fry/remains, respectively. All the stages did not ingest *Diaptomus*, *Daphnia*, and *Bosmonia*. Juvenile in addition did not ingest scale and nematode, adult - chironomid larvae, seed and blue-green algae.

Table 4.17: Food composition (%) of *Chrysichthys nigrodigitatus* at different stages of life in Jebba Lake, Nigeria

Item		Juvenile	Sub-adult	Adult
INSECTA				
Diptera				
	***Chaoborus* larvae**	**6.10**	**6.96**	**4.80**
	***Chironomid* larvae**	**20.58**	**11.53**	**-**
	***Chironomid* pupae**	**3.94**	**4.48**	**4.95**
Insect fragments		**6.10**	**5.72**	**10.22**
Detritus		**14.36**	**17.45**	**16.40**
VEGETABLE MATTER				
	Plant materials	**8.89**	**8.77**	**13.62**
	Seeds	**2.16**	**2.68**	**-**
CRUSTACEAN				
Copepoda	***Diaptomus***	**5.97**	**1.43**	**-**
	Cyclops	**6.61**	**3.81**	**3.72**
Cladocera				
	Daphnia	**4.57**	**2.38**	**0.77**
	Bosmonia	**1.03**	**0.29**	**-**
Sand/Mud		**2.67**	**5.53**	**6.04**
FISH				
	Fry/remains	**3.18**	**10.77**	**27.86**
	Scale	**-**	**0.76**	**2.63**
ALGAE				
	Filamentous	**9.78**	**10.87**	**3.10**
	Blue-green	**3.30**	**0.76**	**-**
Nematode		**-**	**3.81**	**3.72**
Unidentified materials		**0.76**	**2.00**	**2.17**

Table 4.18: Seasonal food composition (%) of *Chrysichthys nigrodigitatus* at various stages of life in Jebba Lake, Nigeria

Items		Dry Season			Wet Season		
		Juvenile	Sub-adult	Adult	Juvenile	Sub-adult	Adult
INSECTA							
Diptera							
	***Chaoborus* larvae**	4.19	10.16	10.98	7.51	4.71	2.54
	***Chironomid* larvae**	20.36	17.55	-	20.75	7.30	-
	***Chironomid* pupae**	3.59	5.31	9.26	4.19	3.90	3.38
Insect fragments		2.69	2.31	10.98	8.61	8.12	9.94
Detritus		6.59	18.01	17.34	20.1	17.06	16.07
VEGETABLE MATTER							
	Plant materials	7.48	6.93	10.40	9.93	10.06	14.80
	Seeds	3.29	1.63	-	1.32	3.40	-
CRUSTACEAN							
Copepoda							
	Diaptomus	14.07	3.64	-	-	-	-
	Cyclops	9.28	6.24	10.40	4.64	2.11	1.27
Cladocera							
	Daphnia	10.78	5.77	2.89	-	-	-
	Bosmonia	2.40	0.69	-	-	-	-
Sand/Mud		1.50	3.70	1.73	3.53	6.82	7.61
FISH							
	Fry/remains	1.80	3.93	19.65	4.19	15.58	30.87
	Scale	-	-	-	-	1.30	3.59
ALGAE							
	Filamentous	11.98	10.62	3.48	8.17	11.04	2.96
	Blue - green	-	-	-	5.74	1.30	-
Nematode		-	3.00	2.89	-	4.38	4.01
Unidentified materials		-	0.69	-	1.32	2.92	2.96

4.11Index of relative importance and stomach fullness of *Chrysichthys nigrodigitatus*in JebbaLake, Nigeria

The percentage of relative importance index of food items ingested by *Chrysichthys nigrodigitatus* at various stages of life in Jebba Lake, Nigeria are presented onTable 4.19. In both juveniles and sub-adult, *chironomid* larvae was highest, followed by detritus; unidentified materials and *Bosmonia* as lowest for juveniles and sub-adult, respectively; in adult fish fry/remains was highest followed by detritus, while unidentified materials and scale was lowest.

Table 4.20 depicts the stomach fullness of *C. nigrodigitatus* throughout the period of study.More of the stomachs examined had food (71.11%) while the remaining (28.89%) were without food or empty. The stomachs of *Chrysichthys nigrodigitatus*recorded different degree of fullness, from full stomach to empty stomach. Full stomach was highest 85 (23.61%) while the lowest was almost full stomach 47 (13.05%).

Table 4.21 reveal stomach fullness of *C. nigrodigitatus*for the various seasons in Jebba Lake, Nigeria. There was variation in the stomach fullness between the seasons. More stomach contained food during the wet season than dry season. Similarly, stomachs without food (28.89%) were more in wet than dry seasons during the period of study.

Table 4.19: Index of relative importance (%) of *Chrysichthysnigrodigitatus* at various stages of life in Jebba Lake, Nigeria

Item		Juvenile	Sub-adult	Adult
INSECTA				
Diptera				
	***Chaoborus* larvae**	8.67	**10.25**	**6.89**
	***Chironomid* larvae**	40.03	**23.24**	**-**
	***Chironomid* pupae**	2.51	**2.96**	**3.19**
Insect fragments		6.40	6.22	10.84
Detritus		13.70	17.25	15.80
VEGETABLE MATTER				
	Plant materials	9.78	**10.00**	**15.14**
	Seeds	1.46	**1.88**	**-**
CRUSTACEAN				
Copepoda	***Diaptomus***	1.96	**0.49**	**-**
	Cyclops	1.41	**0.84**	**0.80**
Cladocera				
	Daphnia	**2.94**	**1.58**	**0.50**
	Bosmonia	**0.21**	**0.07**	**-**
Sand/Mud		1.99	4.27	4.54
FISH				
	Fry/remains	**4.48**	**15.73**	**39.65**
	Scale	**-**	**0.14**	**0.43**
ALGAE				
	Filamentous	**3.07**	**3.53**	**0.98**
	Blue-green	**1.24**	**0.29**	**-**
Nematode		-	0.85	0.81
Unidentified materials		0.15	0.41	0.43

Table 4.20: Stomach fullness of *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria

Parameter	**Number**	**%**
Stomach with food	256	71.11
Stomach without food	104	28.89
Degree of Fullness		
Full (4/4)	85	23.61
Almost full (3/4)	47	13.05
Half full (2/4)	56	15.56
Almost empty (1/4)	73	20.28
Empty (0/4)	99	27.50

Table 4.21: Seasonal stomach fullness of *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria

Season	**Wet**	**Dry**
No. of stomach examined	256 (71.11%)	104 (28.89%)
Degree of Fullness		
Full (4/4)	56 (21.88%)	29 (27.88%)
Almost full (3/4)	29 (11.32%)	18 (17.32%)
Half full (2/4)	40 (15.63%)	16 (15.38%)
Almost empty (1/4)	48 (18.75%)	25 (24.04%)
Empty (0/4)	83 (32.42%)	16 (15.38%)

4.12Gut length to total length and Sex ratio of *Chrysichthys nigrodigitatus* in Jebba Lake

Table 4.22 shows the gut length (cm) to total length (cm) ratio of males and females *C. nigrodigitatus* in Jebba Lake during the period of study.Out of the 360 samples examined, 230 males had gut length range between 21.50cm - 87.00cm and 130 females had gut length range between 30.00cm - 78.00cm.

The gut length to total length of males (0.73-2.71) is less than that of females (0.86-2.88). Overall, it is greater in males ($\bar{X}$ =1.80±0.51) than females ($\bar{X}$ =1.70±0.48).

Table 4.23 reveals the sex ratio of *C. nigrodigitatus* from Jebba Lake, Nigeria during the period of study.Out of thesamples of *C. nigrodigitatus* recorded, 63.74% were males, while 36.26% were females. Both sexes were more abundant in September, while no female was recorded in March, but the lowest number of males was in March. Sex ratio showed that there are more males than females (1.77:1) in the population.

Table 4.22:Gut length to total length of *Chrysichthys nigrodigitatus*in JebbaLake, Nigeria

Sex	Male	Female	Combined Sexes
No	230	130	360
Gut Length (cm)	21.50 - 87.00	30.00 - 78.00	21.50 - 87.00
Total Length (cm)	14.00 - 51.00	20.50 - 54.50	14.00 - 54.50
Range of Gut Length/Total length	0.73 - 2.71	0.86 - 2.88	0.73 - 2.88
Mean	**1.80±0.51**	**1.70±0.48**	**1.76±0.50**

Table 4.23: Sex ratio of *Chrysichthys nigrodigitatus* from Jebba Lake, Nigeria

Month	No. of Male	No. of Female	Sex ratio
March	5	-	-
April	28	10	2.8:1
May	16	7	2.3:1
June	27	16	1.7:1
July	14	12	1.2:1
August	20	17	1.2:1
September	73	48	1.5:1
October	13	7	1.9:1
November	29	11	2.6:1
Total/ratio	230	130	1.77:1

4.13Stages of gonad maturity,mean gonado-somatic index (GSI), Fecundity and diameter of eggsof *Chrysichthys nigrodigitatus* in Jebba Lake,Nigeria

Table 4.24 reveals the stages of gonad maturity of *C. nigrodigitatus* in Jebba Lake, Nigeria during the period of study.Males and females fish specimen were in stages II (56.96%) and IV (41.54%) gonadal development stages respectively, while the lowest in

both sexes was stage VI.

Mean gonado-somatic index (GSI) of males and females of *C. nigrodigitatus* in Jebba Lake, Nigeria during the period of study is presented in Figure 4.8.Mean gonadosomatic index (GSI) was highest in September (17.53), June (10.68), May (7.35) and July (6.61) forfemales, September (3.6) and May (2.17) for males. Lowest GSI was recorded in April for both males (0.09) and females (0.28). Gonado-somatic index increased during the wet seasonin both populations but decreased in male population during dry season.

Table 4.25 shows fecundity and diameter of eggs of *Chrysichthys nigrodigitatus* observed during the period of study. Out of the samples of gravid *C. nigrodigitatus* observed, total lengths of 30.60cm and 39.00 cm had the highest number (121,500) and lowest (8,400) of eggs, respectively. While highest fecundity was recorded in September, May had the lowest.

Mean egg diameter of *C. nigrodigitatus* ranged between 0.23 mm to 3.80 mm in fish, with mean total length of 32.60 mm and 31.24 mm respectively.

Table 4.24:Stages of gonad maturity of *Chrysichthys nigrodigitatus*in Jebba Lake, Nigeria

Stages	Male	Female
I	15	6
II	131	28
III	47	20
IV	17	54
V	11	18
VI	9	4
Total	230	130

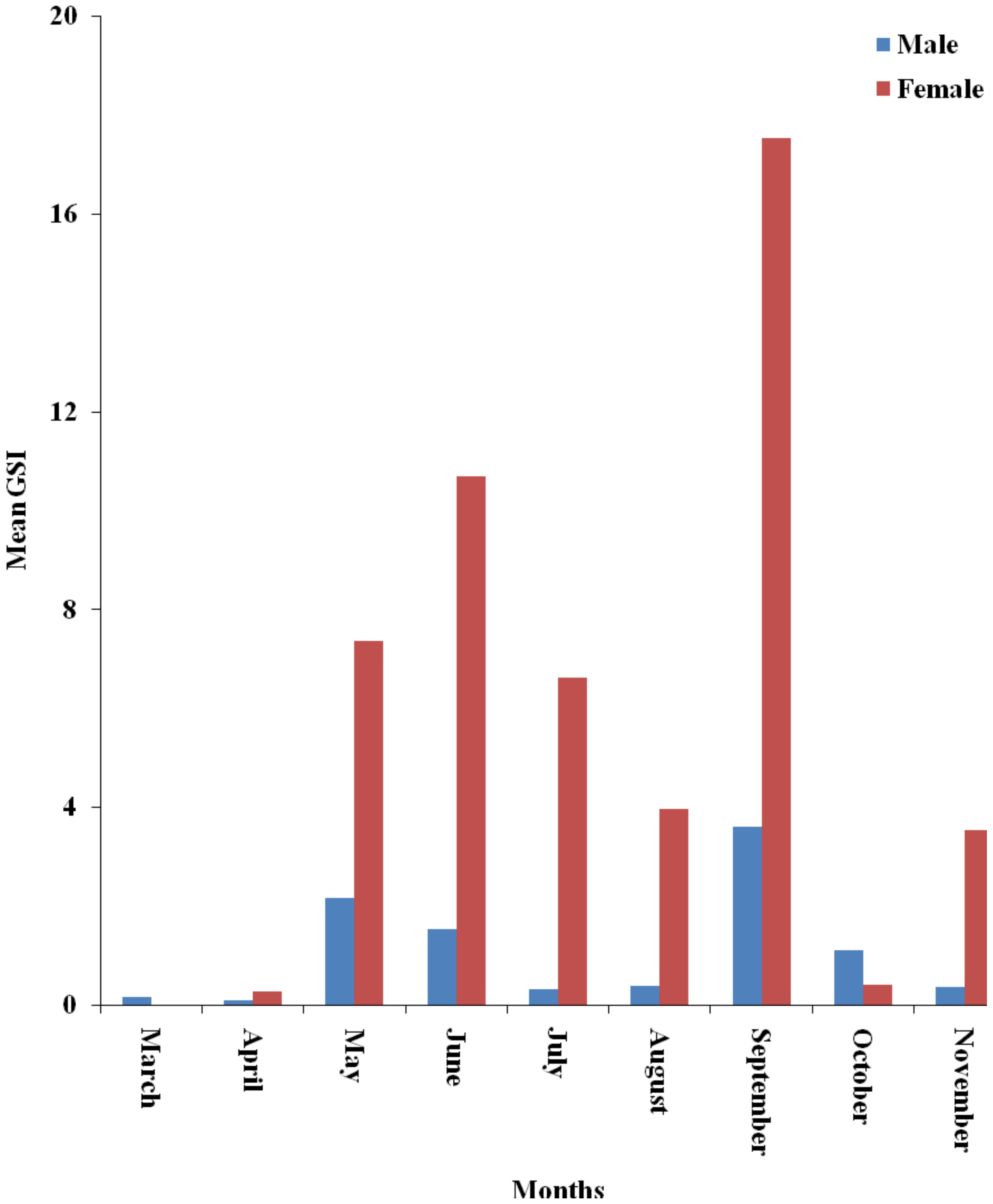

Figure 4.8: Mean gonado-somatic index (GSI) of *Chrysichthys nigrodigitatus* in Jebba Lake

Table 4.25:Fecundity and egg diameter (mm) of *Chrysichthys nigrodigitatus* in Jebba Lake, Nigeria

Total length (cm)	No.	Weight (g)	Mean	Month	No. of eggs	Mean	Mean egg diameter
39.00	**3**	**200.00-470.00**	**323.3**	**May**	**8,400**	**2,800**	**0.26**
28.00	**10**	**50.00-250.00**	**148.5**	**June**	**16,700**	**1,670**	**0.33**
31.24	**9**	**50.00-350.00**	**187.2**	**July**	**28,493**	**3,166**	**0.23**
32.60	**14**	**100.00-500.00**	**224.3**	**August**	**46,325**	**3,308**	**0.38**
30.60	**36**	**50.00-850.00**	**210.56**	**Septembe r**	**121,500**	**3,375**	**0.25**

4.14Fish species abundance (%) in gillnets in Jebba Lake, Nigeria

Twenty-nine (29) different species belonging to thirteen fish families were recorded in Jebba Lake during the period of study. These were Cichlidae, Alestidae, Mochokidae, Schilbeidae, Citharinidae, Distichodontidae, Mormyridae, Bagridae, Claroteidae, Clariidae, Cyprinidae, Centropomidae and Malapteruridae (Table 4.26).

A total of 3,074 fish samples were caught and *C. nigrodigitatus* accounted for 11.71% of the total catch, followed by *Synodontis membranaceus* (6.63%), and then *Labeo senegalensis* (5.44%), while the lowest were *Tilapia zillii* and *Synodontis filamentosus* (0.91%) each. *Chrysichthys nigrodigitatus* had the highest catch (57.70%) within the family Claroteidae followed by *Clarotes laticeps* (16.67%) while the least was *Auchenoglanis occidentalis* (11.22%).

The overall weight of the fish samples was 260,270kg, where *C. nigrodigitatus* ranked third(7.97%). Within the family Claroteidae, the species recorded the highest weight (54.39%) of catch followed by *Clarotes laticeps* (2.84%), while the least was *Auchenoglanis occidentalis* (1.40%).

Table 4.26: Fish species abundance (%) in gillnets on Jebba Lake, Nigeria

Family/Species	No	%	Wt (kg)	%
Cichlidae				
Oreochromis niloticus	90	2.93	2250	0.86
Tilapia zillii	28	0.91	1190	0.47
Sarotherodon galilaeus	110	3.58	4860	1.87
Alestidae				
Brycinus macrolepidotus	115	3.74	8100	3.11
Alestes baremose	165	5.37	4090	1.57
Alestes dentex	85	2.77	5600	2.15
Hydrocynus forskalii	145	4.72	15600	5.99
Mochokidae				
Synodontis membranaceus	204	6.63	20700	7.95
Synodontis nigrita	66	2.14	3650	1.41
Synodontis filamentosus	28	0.91	1540	0.59
Synodontis schall	62	2.02	6750	2.59
Schilbeidae				
Schilbe intermedius	140	4.55	3350	1.29
Parailia pellucida	69	2.24	500	0.19
Citharinidae				
Citharinus citharus	50	1.63	9900	3.80
Distichodontidae				
Distichodus rostratus	105	3.42	18820	7.23
Mormyridae				
Mormyrus rume	122	3.97	9350	3.59
Hyperopisus bebe	54	1.75	4100	1.58
Mormyrops deliciosus	63	2.05	6100	2.34
Bagridae				
Bagrus bayad	159	5.17	29530	11.35
Bagrus docmac	89	2.89	9100	3.50
Claroteidae				
Auchenoglanis occidentalis	70	2.28	4300	1.65
Clarotes laticeps	104	3.38	8750	3.36
Chrysichthys nigrodigitatus	360	11.71	20750	7.97
Chrysichthys auratus	90	2.94	4350	1.67
Clariidae				
Clarias gariepinus	56	1.82	4940	1.90
Cyprinidae				
Labeo senegalensis	167	5.44	5470	2.10
Labeo coubie	53	1.72	4050	1.56
Centropomidae				
Lates niloticus	147	4.78	34200	13.14
Malapteruridae				
Malapterurus electricus	78	2.54	8380	3.22
Total	**3074**	**100**	**260,270**	**100**

4.15 Monthly and Seasonal fish abundance (%) in Jebba Lake, Nigeria

*Chrysichthys nigrodigitatus*was caught between March - November. The highest and lowest catch was in September (18.90%) and August (0.27%), respectively (Table 4.27). *Chrysichthys nigrodigitatus*was less in number than *Lates niloticus* (20.80%) in April, *Bagrus bayad* (12.90%) in June, *Synodontis membranaceus* (14.20%) in July and August (18.5%), and *Hydrocynus forskalii* (12.0%) in October. Generally, fish abundance was highest in September, and lowest in January. There was significant difference ($p<0.05$) in fish species abundance between the months during the period of study.

A total of 3074 fish species were recorded, with 67.27% and 32.73% recorded in the wet season and dry seasons, respectively. Out of this, *C. nigrodigitatus* was highest in number during wet and dry seasons with 13.06% and 8.95%, respectively (Table 4.28). *Chrysichthys nigrodigitatus* was also highest in terms of number within the family Claroteidae in wet and dry seasons. The weight of *C. nigrodigitatus* was less than that of *Synodontis membranaceus*, *Bagrus bayad*, and *Lates niloticus* in wet season, but higer than that of *Synodontis membranaceus* in dry season.

There was significant difference ($p<0.05$) in fish abundance between wet and dry seasons.

Table 4.27: Monthly fish abundance (%) in Jebba Lake, Nigeria

Family/Species	January % No	February % No	March % No	April % No	May % No	June % No	July % No	August % No	September % No	October % No	November % No	December % No
Cichlidae												
Oreochromis niloticus	-	-	2.46	-	2.09	-	6.38	8.72	-	4.09	4.12	-
Tilapia zillii	-	-	-	1.19	-	-	-	2.72	1.77	2.30	-	-
Sarotherodon galilaeus	-	-	8.86	3.57	-	3.44	5.22	3.54	2.78	2.05	5.76	7.04
Alestidae												
Brycinus macrolepidotus	-	7.52	7.39	-	-	9.20	4.93	3.82	-	3.58	5.35	-
Alestes baremose	17.35	9.02	-	4.76	12.9	11.5	-	6.81	3.00	1.28	6.17	-
Alestes dentex	10.20	11.28	1.48	8.34	4.60	-	2.32	0.27	-	4.35	-	4.23
Hydrocynus forskalii	-	-	7.88	-	6.28	-	5.79	-	3.78	12.0	8.23	8.45
Mochokidae												
Synodontis membranaceus	-	-	-	-	-	7.74	14.2	18.5	9.00	2.56	5.76	-
Synodontis nigrita	-	3.02	2.96	5.95	-	3.81	4.93	-	2.26	0.77	-	2.11
Synodontis filamentosus	-	-	2.96	-	-	-	2.03	0.82	-	1.53	2.47	-
Synodontis schall	-	-	3.45	-	1.67	1.15	0.58	-	2.53	4.35	3.29	7.04
Schilbeidae												
Schilbe intermedius	-	9.77	3.45	-	-	-	10.1	4.63	8.00	5.12	-	11.3
Parailia pellucida	8.16	1.50	-	4.76	6.28	2.58	-	1.36	2.00	1.53	3.29	-
Citharinidae												
Citharinus citharus	-	-	-	-	-	-	1.45	-	-	6.65	5.35	4.23
Distichodontidae												
Distichodus rostratus	-	3.76	-	4.17	-	5.16	1.74	3.82	2.00	4.86	2.88	14.8
Mormyridae												
Mormyrus rume	-	12.78	4.93	-	-	8.02	-	-	8.59	2.05	-	17.6
Hyperopisus bebe	1.02	-	1.97	4.17	5.02	3.72	0.87	-	0.76	1.53	-	3.52
Mormyrops deliciosus	4.08	-	4.93	-	5.44	-	5.79	1.63	-	0.77	2.88	-

Bagridae												
Bagrus bayad	-	12.78	5.91	-8.93	-		4.35	6.27	4.28	-	6.17	-
Bagrus docmac	11.22	-	8.37		5.44	12.90 3.15	-	4.09	3.28	1.53	-	2.11
Claroteidae												
Auchenoglanis occidentalis	11.22	4.51	-	-	-	4.58	-	1.91	1.01	3.32	5.35	-
Clarotes laticeps	-	-	4.43	-	4.18	3.81	3.19	3.00	4.55	3.84	3.29	5.63
Chrysichthys nigrodigitatus	-	-	10.34	17.6	17.6	11.5	11.0	15.5	18.90	9.46	12.40	-
Chrysichthys auratus	5.10	-	4.43	-	9.62	3.81	-	2.18	4.55	2.56	1.24	-
Clariidae												
Clarias gariepinus	4.08	6.02	-	5.95	6.69	-	-	1.09	-	2.05	2.47	-
Cyprinidae												
Labeo senegalensis	14.29	8.27	-	9.52	5.02	-	4.64	3.82	10.9	6.14	-	11.9
Labeo coubie	13.28	-	2.96	-	2.94	-	3.48	2.72	-	1.28	-	-
Centropomidae												
Lates niloticus	-	5.26	5.91	20.8	-	3.44	4.64	2.72	6.82	4.86	3.70	-
Malapteruridae												
Malapterurus electricus	-	4.51	4.93	-	4.18	-	2.32	-	5.56	3.58	3.29	-
Total	**97**	**135**	**203**	**168**	**235**	**349**	**343**	**367**	**402**	**391**	**238**	**142**

Table 4.28: Seasonal fish abundance (%) in gillnets in Jebba Lake, Nigeria

Family / Species	Wet Season				Dry Season			
	No.	%	Wt	%	No.	%	Wt	%
Cichlidae								
Oreochromis niloticus	81	3.92	1000	0.60	9	0.89	1250	1.48
Tilapia zillii	22	1.06	800	1.46	6	0.60	390	0.46
Sarotherodon galilaeus	96	4.65	3120	1.78	14	1.39	1740	2.06
Alestidae								
Brycinus macrolepidotus	81	3.92	5700	3.24	36	3.58	2250	2.84
Alestes baremose	92	4.45	2863	1.63	71	7.06	1227	1.45
Alestes dentex	46	2.22	2408	1.37	39	3.88	3192	3.76
Hydrocynus forskalii	47	2.27	4992	2.84	98	9.74	10608	12.54
Mochokidae								
Synodontis membranaceus	196	9.48	18930	10.76	8	0.80	1770	2.09
Synodontis nigrita	49	2.37	2920	1.66	17	1.69	730	0.86
Synodontis filamentosus	17	0.82	1000	0.60	11	1.09	540	0.64
Synodontis schall	24	1.16	2025	1.15	38	3.78	4725	5.59
Schilbeidae								
Schilbe intermedius	95	4.59	2178	1.24	45	4.47	1172	1.39
Parailia pellucida	38	1.85	360	0.20	31	3.08	140	0.17
Citharinidae								
Citharinus citharus	6	0.29	1200	0.68	44	4.37	8700	10.28
Distichodontidae								
Distichodus rostratus	59	2.85	8420	4.79	46	4.57	10400	12.30
Mormyridae								
Mormyrus rume	86	4.16	7210	4.10	36	3.58	2140	2.53
Hyperopisus bebe	42	2.03	3000	1.71	10	0.99	1100	1.30
Mormyrops deliciosus	51	2.47	4580	2.61	14	1.39	1520	1.80
Bagridae								
Bagrus bayad	127	6.14	24130	13.73	32	3.18	5400	6.39
Bagrus docmac	54	2.61	6150	3.50	35	3.48	2950	3.26
Claroteidae								
Auchenoglanis occidentalis	29	1.40	700	0.40	41	4.08	3600	4.26
Clarotes laticeps	66	3.19	7850	4.45	38	3.78	900	1.06
Chrysichthys nigrodigitatus	270	13.06	18520	10.54	90	8.95	2230	2.64
Chrysichthys auratus	71	3.43	3550	2.02	19	1.89	800	0.95
Clariidae								
Clarias gariepinus	28	1.35	3275	1.86	28	2.78	1665	1.97
Cyprinidae								
Labeo senegalensis	113	5.46	3710	2.11	54	5.37	1760	2.08
Labeo coubie	29	1.40	2655	1.51	24	2.38	1395	1.65
Centropomidae								
Lates niloticus	98	4.74	28400	16.15	49	4.87	5800	6.86
Malapteruridae								
Malapterurus electricus	55	2.66	4060	2.31	23	2.29	4320	5.11

Total	**2068**	**100**	**175706**	**100**	**1006**	**100**	**84564**	**100**

4.16 Fish abundance (%) in gillnet at sampling zones in Jebba Lake, Nigeria

Zones I had the highest species of fish caught (38.45%), and zone III lowest (28.14%) during the period of study (Table 4.29). *Chrysichthys nigrodigitatus*was highest in the three zones;but zone I had the lowest (10.15%).*Chrysichthys nigrodigitatus*also had the highest number within the family Claroteidae in the three zones.

There was no significant difference (p>0.05) in the number of fish species abundance between the zones.

Fish abundance (%) at various sampling zones showed fluctuations in the seasons. *Chrysichthys nigrodigitatus* had the highest number in zones I (14.05%) and II (13.97%). *Synodontismembranaceus* (12.21%) was most abundant in zone III during the wet season (Table 4.30). *Chrysichthys nigrodigitatus* was the highest in zone II, while *Hyperopisus bebe* was least (0.29%) in zone II during the dry season. In zone III, *Hydrocynus forskalii* was highest; *C. nigrodigitatus* was not recorded in zone I during the dry season.

Tilapia zillii was not recorded in zones I and III; *Oreochromis niloticus, Synodontis filamentosus*, *Parailia pellucida* was not recorded inzone II, likewise *Bagrus docmac* and *Lates niloticus* in zone III.There was no significant difference (p>0.05) in fish abundance between zones during the period of study.

Table 4.29: Fish abundance (%) in gillnets at sampling zones in Jebba Lake,Nigeria

Family/Species	Zone I		Zone II		Zone III	
	No.	%	No.	%	No.	%
Cichlidae						
Oreochromis niloticus	62	5.25	-	-	28	3.24
Tilapia zillii	-	-	28	2.73	-	-
Sarotherodon galilaeus	40	3.38	54	5.26	16	1.85
Alestidae						
Brycinus macrolepidotus	15	1.27	60	5.84	42	4.86
Alestes baremose	48	4.06	79	7.69	36	4.16
Alestes dentex	32	2.70	13	1.27	40	4.62
Hydrocynus forskalii	66	5.59	34	3.31	45	5.20
Mochokidae						
Synodontis membranaceus	92	7.78	47	4.58	65	7.51
Synodontis nigrita	30	2.54	13	1.27	23	2.66
Synodontis filamentosus	18	1.52	-	-	10	1.16
Synodontis schall	25	2.12	16	1.56	21	2.43
Schilbeidae						
Schilbe intermedius	35	2.96	45	4.38	60	6.94
Parailia pallucida	36	3.05	-	-	33	3.82
Citharinidae						
Citharinus citharus	7	0.59	23	2.24	20	2.31
Distichodontidae						
Distichodus rostratus	24	2.03	18	1.75	63	7.28
Mormyridae						
Mormyrus rume	56	4.74	29	2.82	37	4.28
Hyperopisus bebe	28	2.37	11	1.07	13	1.50
Mormyrops deliciosus	25	2.12	31	3.02	9	1.04
Bagridae						
Bagrus bayad	52	4.40	74	7.21	33	3.82
Bagrus docmac	35	2.96	54	5.26	-	-
Claroteidae						
Auchenoglanis occidentalis	18	1.52	36	3.51	16	1.85
Clarotes laticeps	36	3.05	26	2.53	42	4.86
Chrysichthys nigrodigitatus	120	10.15	145	14.11	95	10.98
Chrysichthys auratus	35	2.96	17	1.65	38	4.39
Clariidae						
Clarias gariepinus	22	1.86	22	2.14	12	1.38
Cyprinidae						
Labeo senegalensis	77	6.51	58	5.64	32	3.70
Labeo coubie	22	1.86	13	1.27	18	2.08
Centropomidae						
Lates niloticus	98	8.29	49	4.77	-	-
Malapteruridae						
Malapterurus electricus	28	2.37	32	3.12	18	2.08
Total	**1182**	**100**	**1027**	**100**	**865**	**100**

Table 4.30: Seasonal fish abundance (%) in gillnets at various sampling zones in Jebba Lake, Nigeria

Family/Species	Zone I				Zone II				Zone III			
	Wet		Dry		Wet		Dry		Wet		Dry	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Cichlidae												
Oreochromis niloticus	58	6.79	4	1.23	-	-	-	-	23	4.32	5	1.50
Tilapia zillii	-	-	-	-	22	3.24	6	1.73	-	-	-	-
Sarotherodon galilaeus	32	3.63	8	2.46	48	7.06	6	1.73	16	3.01	-	-
Alestidae												
Brycinus macrolepidotus	11	1.29	4	1.23	38	5.59	22	6.34	32	6.02	10	3.00
Alestes baremose	25	3.16	23	7.10	48	7.06	31	8.93	19	3.57	17	5.11
Alestes dentex	22	2.58	10	3.09	9	1.32	4	1.15	15	2.82	25	7.51
Hydrocynus forskalii	39	4.57	27	8.33	6	0.88	28	8.07	2	0.38	43	12.91
Mochokidae												
Synodontis membranaceus	84	9.84	8	2.47	47	6.91	-	-	65	12.21	-	-
Synodontis nigrita	27	3.16	3	0.96	5	0.74	8	2.31	17	3.20	6	1.80
Synodontis filamentosus	11	1.29	7	2.16	-	-	-	-	6	1.13	4	1.20
Synodontis schall	10	1.17	15	4.63	14	2.06	2	0.58	-	-	21	6.31
Schilbeidae												
Schilbe intermedius	21	2.46	14	4.32	34	5.00	11	3.17	40	7.51	20	6.01
Parailia pallucida	25	2.93	11	3.40	-	-	-	-	13	2.44	20	6.01
Citharinidae												
Citharinus citharus	2	0.23	5	1.54	4	0.59	19	5.48	-	-	20	6.01
Distichodontidae												
Distichodus rostratus	10	1.17	14	4.32	11	1.62	7	2.02	38	7.14	25	7.51
Mormyridae												
Mormyrus rume	42	4.92	14	4.32	25	3.68	4	1.15	19	3.57	18	5.41
Hyperopisus bebe	19	2.22	9	2.78	10	1.47	1	0.29	13	2.44	-	-
Mormyrops deliciosus	25	2.69	-	-	19	2.79	12	3.46	7	1.32	2	0.60

Bagridae												
Bagrus bayad	37	4.33	15	4.63	66	9.70	8	2.31	24	4.51	9	2.70
Bagrus docmac	24	2.81	11	3.40	30	4.40	24	6.92	-	-	-	-
Claroteidae												
Auchenoglanis occidentalis	5	0.59	13	4.01	14	2.06	22	6.34	10	1.88	6	1.80
Clarotes laticeps	20	2.34	16	4.93	10	1.47	16	4.60	36	6.77	6	1.80
Chrysichthys nigrodigitatus	120	14.05	-	-	95	13.97	50	14.4	55	10.34	40	12.01
Chrysichthys auratus	19	2.22	16	4.93	17	2.50	-	-	35	6.58	3	0.90
Clariidae												
Clarias gariepinus	13	1.41	9	2.78	7	1.03	15	4.32	8	1.50	4	1.20
Cyprinidae												
Labeo senegalensis	52	6.09	25	7.72	39	5.74	19	5.48	22	4.14	10	3.00
Labeo coubie	16	1.87	6	1.85	3	0.44	10	2.88	10	1.88	8	2.40
Centropomidae												
Lates niloticus	67	7.85	31	8.95	31	4.56	18	5.19	-	-	-	-
Malapteruridae												
Malapterurus electricus	20	2.34	8	2.46	28	4.12	4	1.15	7	1.32	11	3.30
Total	**856**	**100**	**326**	**100**	**680**	**100**	**347**	**100**	**532**	**100**	**333**	**100**

4.17 Fish distribution (%) at various water columns in Jebba Lake, Nigeria

Fish distribution (%) at thewater columns in Jebba Lake is presented in Table 4.31. *Labeo senegalensis* was highest (8.46%), *Malapteruruselectricus* and *Synodontis membranaceus*werelowest (0.37%) at the shore; the surfacehad *Lates niloticus* (13.88%) as the highest species while *Chrysichthys auratus* (0.32%) as lowest; at the lake bottom,*C. nigrodigitatus* (39.45%) and *Labeo coubie* (0.39%) were the highest and lowest respectively.

*Chrysichthys nigrodigitatus*wasalso the most abundant species at the bottom of the lake in the family Claroteidae;*Clarotes laticeps* and *Auchenoglanis occidentalis*were highest at the shore and surface respectively. *Hydrocynus forskalii* was not recorded at the surface of the lake.The gillnet catch at the bottom of the lake had highest number of fish species not recorded during the period of study.

There was no significant difference (p>0.05) in the fish distribution in water columns during the period of study.

Table 4.31: Fish distribution (%) in gillnets at various water columns in Jebba Lake, Nigeria

Family/Species	Shore	Surface	Bottom
Cichlidae			
Oreochromis niloticus	5.66	1.37	-
Tilapia zillii	1.69	0.53	-
Sarotherodon galilaeus	4.55	5.04	-
Alestidae			
Brycinus macrolepidotus	3.46	4.42	3.41
Alestes baremose	6.47	5.15	3.67
Alestes dentex	3.68	-	4.59
Hydrocynus forskalii	8.30	1.68	2.10
Mochokidae			
Synodontis membranaceus	0.37	4.63	20.31
Synodontis nigrita	2.50	0.63	3.41
Synodontis filamentosus	0.74	1.05	1.05
Synodontis schall	1.84	1.26	3.28
Schilbeidae			
Schilbe intermedius	4.85	5.05	3.40
Parailia pellucida	2.94	1.37	2.10
Citharinidae			
Citharinus citharus	3.09	0.84	-
Distichodontidae			
Distichodus rostratus	1.99	8.20	-
Mormyridae			
Mormyrus rume	3.46	4.84	3.80
Hyperopisus bebe	2.43	2.21	-
Mormyrops deliciosus	2.57	2.94	-
Bagridae			
Bagrus bayad	5.07	8.93	0.66
Bagrus docmac	4.48	2.94	-
Claroteidae			
Auchenoglanis occidentalis	2.50	3.79	-
Clarotes laticeps	6.40	1.79	-
Chrysichthys nigrodigitatus	3.16	1.68	39.45
Chrysichthys auratus	3.31	0.32	5.50
Clariidae			
Clarias gariepinus	2.21	0.42	2.88
Cyprinidae			
Labeo senegalensis	8.46	5.47	-
Labeo coubie	2.35	1.89	0.39
Centropomidae			
Lates niloticus	1.10	13.88	-
Malapteruridae			
Malapterurus electricus	0.37	7.68	-
Total	**1360**	**951**	**763**

4.18 Seasonal fish distribution (%) at the water columns in Jebba Lake, Nigeria

Table 4.32show variations in seasonal fish distribution at the various water columns in Jebba Lake, Nigeria.At the shore *Hydrocynus forskalii* (9.27%) and *Brycinus macrolepidotus*(8.23%) were highest in wet and dry seasons respectively; *Lates niloticus*in wet season, *Distichodus rostratus* and *Mormyrus rume*each with8.71% at the surface, and *Chrysichthys nigrodigitatus* in both seasons at the bottom of the lake.

Overall, *C. nigrodigitatus* was the highest in both wet and dry season during the period of study. Most of the fish species were not recorded at the bottom of the lake.

There was no significant difference ($p>0.05$) at the surface and bottom,but significant difference ($p<0.05$) at the shore in fish distribution between seasons in water columns.

Table 4.32: Seasonal fish distribution at the various water columns in Jebba Lake, Nigeria

Family/Species	Shore		Surface		Bottom	
	Wet	Dry	Wet	Dry	Wet	Dry
Cichlidae						
Oreochromis niloticus	5.49	5.97	1.34	1.40	-	-
Tilapia zillii	1.14	2.67	0.84	-	-	-
Sarotherodon galilaeus	5.26	3.29	6.39	2.81	-	-
Alestidae						
Brycinus macrolepidotus	0.80	8.23	5.21	3.08	3.85	2.59
Alestes baremose	6.52	6.38	5.38	4.78	1.42	7.78
Alestes dentex	2.75	5.35	-	-	4.06	3.56
Hydrocynus forskalii	9.27	6.58	1.01	2.81	1.22	3.70
Mochokidae						
Synodontis membranaceus	0.57	-	4.37	5.06	18.60	21.20
Synodontis nigrita	3.43	0.82	0.67	0.56	3.25	3.70
Synodontis filamentosus	0.69	0.82	-	2.81	0.81	1.48
Synodontis schall	1.83	1.85	1.34	1.12	2.23	5.19
Schilbeidae						
Schilbe intermedius	4.58	5.35	3.36	7.87	2.43	5.19
Parailia pellucida	2.97	2.88	1.51	1.12	2.43	1.48
Citharinidae						
Citharinus citharus	4.35	0.82	1.34	-	-	-
Distichodontidae						
Distichodus rostratus	2.29	1.44	7.90	8.71	-	-
Mormyridae						
Mormyrus rume	2.86	4.53	2.52	8.71	-	10.74
Hyperopisus bebe	3.32	0.82	2.18	2.25	-	-
Mormyrops deliciosus	2.17	3.29	1.01	6.18	-	-

Bagridae						
Bagrus bayad	5.15	4.95	11.09	5.34	0.41	1.12
Bagrus docmac	4.81	3.91	3.03	2.81	-	-
Claroteidae						
Auchenoglanis occidentalis	1.49	4.32	2.35	6.18	-	-
Clarotes laticeps	6.86	5.56	1.18	2.81	-	-
Chrysichthys nigrodigitatus	3.55	2.47	2.35	0.56	48.68	22.59
Chrysichthys auratus	3.55	2.88	0.17	0.56	8.31	0.37
Clariidae						
Clarias gariepinus	1.83	2.88	0.35	0.56	1.83	4.81
Cyprinidae						
Labeo senegalensis	8.92	7.61	4.03	7.87	-	-
Labeo coubie	2.52	2.06	0.67	3.92	0.40	0.37
Centropomidae						
Lates niloticus	1.03	1.24	19.33	4.78	-	-
Malapteruridae						
Malapterurus electricus	-	1.03	9.08	5.34	-	-
Total	**874**	**486**	**595**	**356**	**497**	**266**

4.19 Fish distribution (%) in water columns at the sampling zones in Jebba Lake, Nigeria

Table 4.33 depicts seasonal fish distribution at the zones in the water columnsin Jebba Lake, Nigeria.*C. nigrodigitatus* was highest at the shore (17.38%) and bottom (12.77%) in zone I and bottom in zone III (16.67%), but was not recorded at the surface of the water column in the three zones.

At the surface in zone I,*Lates niloticus* was the highest followed by *Bagrus bayad* (15.16%), while at the bottom in zone II had *Alestes dentex*as the highest (20.48%) during the period of study.

There was no significant difference (p>0.05) in fish distribution in water columns at the zones during the period of study.

Table 4.33: Fish distribution in gillnets at sampling zones in water columns in Jebba Lake, Nigeria

	Zone I			Zone II			Zone III		
Family/Species	**Shore**	**Surface**	**Bottom**	**Shore**	**Surface**	**Bottom**	**Shore**	**Surface**	**Bottom**
Cichlidae									
Oreochromis niloticus	5.73	4.37	-	4.69	-	-	7.00	-	-
Tilapia zillii	-	-	-	6.91	-	-	-	-	-
Sarotherodon galilaeus	5.11	2.62	-	9.88	7.14	-	0.50	-	-
Alestidae									
Brycinus macrolepidotus	1.84	-	2.19	3.46	2.55	16.47	6.00	8.07	-
Alestes baremose	7.78	-	3.65	2.72	8.66	20.48	5.00	7.18	-
Alestes dentex	-	-	11.68	3.21	-	-	5.00	-	15.27
Hydrocynus forskalii	6.13	4.66	7.30	8.40	-	-	11.25	-	-
Mochokidae									
Synodontis membranaceus	-	-	33.58	0.49	-	18.07	0.75	22.42	9.16
Synodontis nigrita	2.86	1.75	-	0.74	0.51	4.02	5.75	-	-
Synodontis filamentosus	-	-	4.38	-	-	-	-	-	-
Synodontis schall	1.84	1.17	1.46	3.21	2.55	-	4.00	-	3.82
Schilbeidae									
Schilbe intermedius	1.23	7.29	4.38	3.46	1.02	11.65	3.75	20.18	-
Parailia pellucida	3.48	2.33	1.46	-	-	-	8.25	-	-
Citharinidae									
Citharinus citharus	0.41	1.47	4.38	5.68	-	-	2.50	4.48	-
Distichodontidae									
Distichodus rostratus	2.04	4.08	-	-	9.18	-	13.25	4.48	-
Mormyridae									
Mormyrus rume	3.27	9.04	-	0.74	1.53	9.24	8.25	-	3.05
Hyperopisus bebe	4.09	2.93	3.29	2.72	-	-	3.25	-	-
Mormyrops deliciosus	2.25	-	-	7.16	1.02	-	2.25	-	-

Bagridae									
Bagrus bayad	-	15.16	5.10	13.58	8.16	1.20	-	-	-
Bagrus docmac	7.16	-	-	-	-	-	-	-	-
Claroteidae									
Auchenoglanis occidentalis	2.04	2.33	-	-	18.40	-	-	7.17	-
Clarotes laticeps	-	-	-	0.49	12.24	-	-	-	-
Chrysichthys nigrodigitatus	17.38	-	12.77	-	-	-	1.25	-	68.70
Chrysichthys auratus	3.68	2.04	3.65	0.74	2.04	4.02	6.50	8.07	-
Clariidae									
Clarias gariepinus	2.86	-	2.92	5.44	-	-	3.00	-	-
Cyprinidae									
Labeo senegalensis	9.82	8.45	-	14.32	-	-	2.50	9.88	-
Labeo coubie	1.22	4.66	-	1.96	-	2.00	-	-	-
Centropomidae									
Lates niloticus	7.78	17.49	-	-	25.00	-	-	-	-
Malapteruridae									
Malapterurus electricus	-	8.16	-	-	-	12.85	-	8.07	-
Total	**404**	**353**	**425**	**435**	**168**	**424**	**445**	**216**	**204**

CHAPTER FIVE

5.0 DISCUSSION

5.1 Physico-chemical Parameters of Jebba Lake

Physico-chemical parameters, which include pH, temperature, dissolved oxygen, electrical conductivity, transparency, phosphate and nitrate, plays an important role because it determines the survival and existence of living organisms found in the aquatic environment. These parameters are known to operate in the lake ecosystem, amongst others. Mustapha and Omotosho (2005) reported that interaction of both physical and chemical properties of water play a significant role in the composition, distribution and abundance of aquatic organisms. In addition it gives understanding of the relationship between the organism and their environment; determine the quality of water and its productivity. Temperature, pH and depth showed marked variation during the period of study. Temperature ranged from 20.60^{o}C - 32.50^{o}C with mean 25.80±3.18; pH ranged from 6.4 - 7.5 with mean 6.98±0.35 and depth ranged from 3.00m - 18.50m with mean 10.00±4.75. pH is a crucial factor in the aquatic environment because most metabolic activities depend on that (Wang *et al.*, 2002). The values recorded during the study, though showed show some level of fluctuation falls between 6.0 - 7.5 and 6.5 - 8.2 as reported by Boyd (1978) and Murdock *et al.* (2001) as tolerable level by fish and for sustainable aquatic life in freshwater environment. Similarly, the temperature values recorded during the period of study falls within the ranges for tropical lakes as reported by Ovie and Adeniji (1993), Mustapha and Omotosho *et al.* (2005) and optimal temperature range of 25^{o}C - 32^{o}C for warm water fish and a range of 13^{o}C - 22^{o}C for cold water fish. The normal range of temperature to which fish

is adapted according to Alabaster and Lloyd (1980) is between 8^{o}C - 30^{o}C. Dissolved oxygen, transparency, electrical conductivity, phosphate and nitrate also falls within the tolerable limit for fish and other aquatic organisms.

Monthly variation in physico-chemical parameters is a well-known phenomenon in the aquatic ecosystem. These parameters in a lake can be altered significantly as a result of factors such as human activities - agricultural activities and then natural dynamics, which in turn affect the quality and quantity of water, fish species distribution and diversity, production capacity. Highest temperature (31.8^{o}C) was recorded in May. This was followed by April (30.0^{o}C) and the lowest was in January (21.7^{o}C), which differ significantly ($p<0.05$). The lowest temperature recorded coincides with the period of harmattan when temperatures usually drop. This is in line with the works of Kolo and Oladimeji (2004) in Shiroro Lake, Mustapha and Omotosho (2005) in Moro Lake, Kwara State, and Ibrahim *et al.* (2008) in Kontagora Dam. The amount of dissolved oxygen in water has been found to fluctuate as a result of factors such as action of wind and amount of biological activities, which include degradation. Dissolved oxygen also varies during the period of study with highest in July (8.8mg/l), November and December (8.5mg/l) each, then September (8.4mg/l) and the lowest was in May (7.1mg/l). The drop in dissolved oxygen could be due to vertical mixing and low water level. High organic enrichment of lakes according to Grossman and Freeman (1987) had been reported as a possible reason responsible for low oxygen values. Araoye (2008) reported that vertical mixing of the water could result in the depletion of oxygen and decomposition reduces the amount of oxygen with increase in the amount of carbon (IV) oxide in the affected environment. Odinetz (1989) and

Boyd (1990) reported that dissolved oxygen values range between 5.0-9.0mg/l for good water quality suitable for aquatic organism. The values reported during this study falls within the range. The transparency increases from October through February and decreases from April through July. Whereas the highest (0.62m) was in October, the lowest was in May (0.43m). This could be due to absence of flood water, surface run-off and settling effect of suspended materials that accompanied rainfall cessation (Ibrahim *et al*., 2008). The electrical conductivity increases from October to January then decrease from February to August, which had the lowest (64.2µs/cm). Asuquo (2000) did report that the conductivity of freshwater ranged from 10µs/cm-1000µs/cm but may exceed 1000µs/cm. This is within the range recorded during the study. The gradual reduction in conductivity with time could be due to the uptake of ions by organisms for their metabolism (Mustapha and Omotosho, 2005) and concentration effect due to reduced water volume from main tributary channels (Ovie and Adeniji, 1993; Kolo and Oladimeji, 2004).Phosphate increase from March through September and decrease from October through February while the lowest was January (0.006mg/l), which differ significantly ($p<0.05$). Offem *et al*. (2011) reported high values of phosphate ion concentration in the lake could be attributed to effluents from agricultural lands with high content of phosphate fertilizers. Nitrate increases from March to September and then decreases in October with the lowest in February and October (0.002mg/l), which also differ significantly ($p<0.05$). The increase could be due to the effect of concentration as a result of reduced water volume or due to lower water hardness - less precipitation of phosphate with calcium carbonate, which is a common phenomenon often observed in many freshwater

lakes. Ovie and Adeniji (1993) reported high nitrate and phosphate during low water level, which could be attributed to calm water and low water level that favors settling of suspended materials and dissolved salt concentration.

Mean physico-chemical parameters of the sampling zones showed that zone I had the lowest dissolved oxygen, pH, temperature and transparency, while zone II had the highest electrical conductivity and phosphate. There was significant difference ($p<0.05$) in electrical conductivity and phosphate, but no significant difference ($p>0.05$) in pH, temperature, DO, and nitrate at the zones. This could be due to decrease in water level, high activities of organisms found in such location and farming activities at the bank of the lake. Ovie and Adeniji (1993) attributed high nitrates to be due to low water level and eutrophication according to Ansar and Khad (2005) and algal bloom (Yanamadala, 2005).

Seasonal physico-chemical parameters variation has been reported by several authors. Offem *et al*. (2008) reported the influence of seasons on water quality in relation to fish and plankton abundance. Zone I had highest depth, temperature and dissolved oxygenin both wet and dry seasons; zone II had highest in electrical conductivity. While phosphate was highest during wet season at zone II, it was highest at zone III during dry season. Electrical conductivity, transparency and phosphate, showed significant difference ($p<0.05$), Offem *et al*. (2008) did report lower nitrate concentration in dry season than wet season in some Eastern Nigeria Rivers and lower values of phosphate was observed in wet season and attributed it to effects of rains and flood waters. The higher dry season mean electrical conductivity, nitrate and transparency at zone III could be due to low volume, which brought about concentration effect. Ovie and Adeniji (1993) also made similar observation in Shiroro Lake. The higher wet season mean phosphate at zones II and III could be due to the farming activities around the areas because phosphate fertilizer application is commonly used on most farms.

5.2 Length-weight Relationship and Morphometric Parameters

Age and growth determinations are essential for estimates of production, stock size and recruitment. Length and weight are two fundamental components that can be used to know the growth, estimate average weight of fish at a given body length, assess the well-being, maturity and production of fish in the aquatic environment. Length-weight relationship predicts the growth pattern of fish. If the value is equal to 3 it is known as isometric growth and less than or greater than 3 are known as allometric growths. Male, female and combined sexes had b-values of 2.49, 3.18 and 2.66, respectively. This shows that while males exhibited negative allometric growth, female exhibited isometric growth pattern. Growth model in fish according to Gulland (1987) generally follows the cube law, hence the use of Fulton's condition factor or the isometric factor. This is in line with the findings of Entsua-Mensah *et al*. (1995), Inyang and Ezenwaji (2004), Fafioye and Oluajo (2005), Offem *et al*. (2008) and Lawal *et al*. (2010) but contrary to the findings of Yem *et al*. (2009). This could be due to location difference, period of sampling, sizes caught and number of samples used amongst other factors. Pauly and Gayannilo (1997) reported b - values range from 2.5-3.4 for fish species. The values of this study fall within that range. Correlation coefficient value (r) of male, female and combined sexes showed positive correlation between the length and weight of *C. nigrodigitatus*, which indicated a homogenous population. This is in line with the findings of Konan *et al*. (2007).

Length-length relationship is also a vital component of fish because it also shows the growth of fish. The linear relationship from plots between standard length and total length can be predicted based on r-value. The correlation coefficient (r-values) for males, females and combined sex were 0.93, 0.83 and 0.90, respectively. This shows that there was strong association between the standard length and total length of *C.nigrodigitatus* during the period of study. This could be due to the conducive nature of the lake in terms of adequate physico-chemical parameters, availability of food, shelter amongst others for the survival of the species.

Condition factor (K) is very important because it shows the well-being of an organism in its immediate environment; whether it is conducive for survival or not. Oni *et al*. (1983) reported that condition factor can be used to assess the well-being of fish. The mean condition factor (K) varied during the different months, and was higher during wet season, which coinceded with high water level. Ekanem (2000); Yem *et al*. (2009) and Lawal *et al*. (2010) reported K-value of 1 and above for both sexes of *C. nigrodigitatus*. When K-value is equal to 1 and above it indicated that the fish is doing well in the water body as reported by Thomas *et al*. (2003). This shows that the environment is good for the survival of the species in the lake. This is in line with the findings of this study but contrary to the works of Ezenwa *et al*. (1986), Ekanem (2003), Fafioye and Oluajo (2005), Dada and Araoye (2008) reported K - value of less than 1. This could be due to predation, breeding season, competition for food, pollution and size of fish amongst other factors. Haruna and Bichi (2005) reported that low condition factor was recorded when environment condition was poor, there was spawning pressure on females. Atobatele and Ugwumba (2011) did report that low condition factor could be due to reduced availability of food and prey items. Jebba Lake is a favorable environment for the survival of *C. nigrodigitatus*.In addition, the high number medium sizes of *C. nigrodigitatus* observed show that the fishery is still developing.

Morphometric and meristic measurements, whether in the raw form, ratio and residual values are key parameters used to establish the identity of fish, evaluate racial relationship between them, and also used to segregate species of fish. According to Carpenter *et al*. (1996), morphometric analysis helps to understand the relationship between body parts of an animal. Eyo (2003) used 54 morphometric characteristics to discriminate among four fish species using raw, ratio and residual values. Twenty-five of such characteristics were used to validate the presence of *C. nigrodigitatus*in the lake. Ajado *et al*. (2005) reported significant differences only between the head length of the species in different water bodies. Fapohunda and Godstates (2007) did report mean head length and body depth of 7.0cm and 6.0cm, respectively, for *C. nigrodigitatus*. Mean head length for this study is 6.53cm and 9.81cm. This could be due to location difference because the species is found in both fresh and brackish water systems, and also the sizes collected. Adepo-Gourene *et al*. (1997) reported morphological variations in *C. nigrodigitatus*in different water bodies with the exception of those from Cote d'Ivoire and Congo and concluded that the variations was due to geographical location; those that are farthest apart are the most differentiated populations.

Comparison of morphological parameters showed that length of dorsal fin occupied highest percentage of the fish standard length, which was followed by head length, and length dorsal base to have occupied that of fish head length.

Likewise the caudal peduncle depth with body depth. Adedeji and Araoye (2006) did report head length and body depth of *C. nigrodigitatus*to have occupied a high percentage of the standard length. The low percentage of body depth recorded in this study could be due to the size caught. The body of *C. nigrodigitatus*is long and the dorsal spine, which is long and well-developed, could be used as a defensive mechanism. There was an increase in body weights with lengths. There wasa strong relationship between the standard length and total length, and also with other parameters with the exception of caudal peduncle length, dorsal fin height, sub-orbital width and eye diameter. Ajado *et al*. (2005) reported a positive relationship between head length and standard length for *C. nigrodigitatus* from Lagos and Badagry Lagoons. This is in line with the findings of this study. Similarly, Ndimele and Kumolu-Johnson (2011) reported that body depth, head length and head depth examined showed consistently high correlations with standard length and total length of the fish. Correlation between dorsal fin height and body depth, eye diameter and caudal peduncle depth was negative in this study. Morphological characters according to Austin (1999) are phenotypically plastic and influenced by physical environment during the period of spawning and early juvenile stages each year. This could be a reason for the difference observed during the period of the study.

Eight (8) important meristic/counts were recorded for *C. nigrodigitatus* in Jebba Lake, Nigeria. Roman numerals and number represents spines and fin rays in the dorsal, pelvic and anal region of a fish. Six (6) fin rays and I-II spines were observed on the dorsal region, though the first spine is tiny and can be noticed only on the bigger species. Holden and Reed (1991), Paugy *et al*.

(2003) and Ajado *et al*. (2005) reported six fin rays and I spine on the dorsal region of *C. nigrodigitatus*, which is in line with the findings of the study, but contrary to the findings of Fapohunda and Godstates (2007) that reported nine rays and I spine on the dorsal region, fourteen rays and I spine on the anal region. The anal region has between 8-11 and II -V fin rays and spines. Though, Ajado *et al*. (2005) reported 10-12 anal fin rays, it also falls within the range 8-12 and III-VII as reported by Paugy *et al*. (2003). This could be due to geographical location and environmental differences. Kapuscinki and Miller (2007) reported that plasticity has effect on the phenotype such that differences in the counts of individuals within the same genotype could result in different phenotype. This study, like that of Paugy *et al*. (2003) reported 8-10 and I fin rays and spine on the pectoral region, Ajado *et al*. (2005) reported constant value of 9 for fin rays. Similarly, 5-6 pelvic fin rays were earlier reported, 5-7 pelvic fin rays was reported during this study. The number of gill rakers (14-21) falls within the range reported by Paugy *et al*. (2003) but not in line with that of Ajado *et al*. (2005) that reported 25-28. Njoku and Keke (2002) reported that keys for identification are mere guides to identify fish species that may not fit the existing key, but not necessarily new species. Similarly, Adepo-Gourene *et al*. (1997) reported small differences in meristic characters (number of gill rakers and branched anal fin rays) from populations of *C. nigrodigitatus*in Congo, Senegal, Mali and Coted'Ivoire water systems. In addition, Anyanwu and Ugwumba (2003) reported overlaps in some meristic counts in fish, which was also reported in this study.

Size distributions of *C. nigrodigitatus*in Jebba Lake during the period of study showed different sizes with females beingbigger than males on the overall. The

meanweight of females were higher than that of males, which did not differ significantly (p>0.05). Dada and Araoye (2008) reported females being bigger than males. On the contrary, Atobatele and Ugwumba (2011) did report males' *C. nigrodigitatus* to be bigger than the females, which contradicts this study. The disparity in length and weight could be due to ecological differences, seasonality, size caught and the time of sampling, effect of physico-chemical parameters amongst other factors. The study has also shown that most of the samples collected fall within the range of small to average sizes.

Size class or length-frequency distribution of *C. nigrodigitatus* showed fluctuation during the period of study. For both sexes, sizesbetween 30cm and 39.00cm dominated the catch, 10.00cm -19.00cm size was not recorded in females. This shows that more of the young population was caught than the older ones. Ekanem (2000) reported 34.00cm-64.00cm total length of *Chrysichthys nigrodigitatus* in Cross River, while Dada and Araoye (2008) did report 12.20cm-19.80cm and 13.40cm-19.50 for male and female, respectively in Asa Lake. This could be due to their adaptive behavior, tolerance to environmental changes and recruitment. The abundance of the class sizes during the period of study could be due to the selective nature of gear used,the available sizes in the lake, abundance and availability of food. As the class size increased there was a decline in the number of fish caught. This could also be due to recruitment into the cohort.

5.3 Age Composition/Strucutre of *Chrysichthys nigrodigitatus*

A six age - group or cohort of *C. nigrodigitatus* was recorded during the period of study. This range from 0+ to 3+, with 3+ not recorded in females. The growth at 1-year was reported was less than that of Ezenwa and Ikusemiju (1981) that reported mean total lengths of 18.50 cm, 32.60 cm, 43.5cm and 53.9cm for 1, 2, 3 and 4 years, respectively, which did not differ much with the findings of this study. The age population that dominated the catch for males was age 2 of modal length 32.00cm, while that of female was age 2+ of modal length 33.00cm. This could be due to the hard parts used for such determination or as a result of differences in environment that allows for fast growth. Though it is difficult to age tropical fish since they do not experience sharp seasonal fluctuations, annual rings are still valid in age determination. Adeyemi *et al*. (2009) did report that though it could be difficult to determine age of fish using scale and length-frequency, it is possible to deduce reasonable conclusions with hard parts such as opercula bones and scales.

Growth parameters shows the values for $L\infty$, $t_{o,}$ K and growth performance index (GPI) for males as 53.00 cm, 0.06, 0.96, and 3.43, that of females as 36.00 cm, 0.09, 0.96, and 3.09. Ogueri *et al*. (2009) reported *C. nigrodigitatus* sample size ranged of 10.00cm - 25.50cm, with $L\infty$, t_o and GPI values of 28.80cm, 0.12 and 2.63 respectively. De graaf and Ofori-Danson (1997) also reported values of $L\infty$, $t_{o,}$ K and GPI as 45.50cm, 0.65, 0.22 and 3.129 for *C. nigrodigitatus*. Disparities in these values could be due to differences in location, food availability, predation, fishing pressure and physico-chemical parameters more to every water body is unique in its characteristics. Getabu (1992) reported that besides the genetic make - up that determine the growth potential of fish species, overfishing, diet type and its utilization could affect the GPI of a particular species. The value shows that the species has the tendency to grow to larger sizes and appear to be good for aquaculture.

5.4 Food and Feeding Habit of *Chrysichthys nigrodigitatus*

Food is a very vital in the life living organisms because all life processes depend on it. Food and feeding habit of fish, apart from its relevance in aquaculture and optimization of fish yield, also helps to describe habitat types, ecological productivity and environmental heterogeneity. Nine (9) major items were eaten as food by *C. nigrodigitatus*. Theseranged from plant to animal materials. *C. nigrodigitatus* fed on insects - dipterans that include chaoborus, chironomid larvae and pupae; detritus, vegetable matter - plant remains and seeds, crustaceans - copepods and cladocera, sand/mud, fish - fry and scales, algae- filamentous and blue-green, nematode and unidentified materials.This is in line with the findings of Asuquo (2000) and Yem *et al*. (2009) where they examined the stomach contents of *C. nigrodigitatus*in Cross River Estuary and Kainji Lake respectively. They reported that the fish fed on animal and plant materials that range from fish, crustaceans, gastropod, bivalves, and worms to plant materials and detritus. Similarly, Lawal *et al*. (2010) reported food organisms for the species to consist of phytoplankton, crustaceans, mollusks, plant materials and fish parts. Offem *et al*. (2008) also reported 8 major groups of food item - fish, insects, crustaceans, mollusc, worms, rotifers, plant materials, and detritus as food of *C. nigrodigitatus*. Also, Inyang and Ezenwaji (2004) similarly reported the species to have fed on both plant and animal materials with the animal materials component being dominant. This was not in agreement with Dada and Araoye (2008), who reported plant materials as a major food for the species in Asa Dam. This could be as a result of unspecialized mode of feeding by the fish. Welcomme (2001) did report that unspecialized feeders eat insects, zooplankton, detritus and plant matter according to their abundance. Overall, insect was most preferred, followed by detritus, then fry/remains by *C. nigrodigitatus*. Nematode and sand/mud were minor items. Lawal *et al*. (2010)

reported variety of food items eaten by the species of which phytoplankton (mainly algae and diatom), crustaceans and mollusc were of primary importance. Atobatele and Ugwumba (2011) did report insect as the dominant prey item followed by crustacean. This observation could be due to difference in plant and animal communities found in the water bodies and available food item found at that particular time. The occurrence of sand/mud, worms, detritus and insect larvae in the food of *C. nigrodigitatus* could be interpreted as bottom feeding. Similar observation was reported by Idodo-Umeh (2003), where the items are abundant in the benthos region of the water body. Ekanem (2003) did report that temporal change in diet composition reflected changes in abundance or number of food organism in the water environment. Physical and chemical composition of the aquatic environment if significantly altered according to Ogbeibu and Ezeunara (2005) which would in turn affect the food and feeding habit of fish species. *C. nigrodigitatus* was also observed to feed on a broad spectrum of food items, ranging from plants to animals materials. Similarly, Offem *et al*. (2009) reported the species to have wider food spectrum, which showed trophic flexibility. This enables the fish to switch from one food to another if there is any change in their abundance.

The monthly variations or trend of percentage composition of items ingested by *C. nigrodigitatus* showed that changes could have taken place in the aquatic environment, which influenced the items that constituted food composition and resulted in their absence in some months. Similarly, presence or absence of any item in the diet of the fish at a particular month could be due to its feeding dynamics or unavailability during the period. The presence of fish fry/remains in the diet of the species in the months of May -October, through with November coincided with the period when most fish species are in their state of breeding. Similarly, plant materials were common from May through November, which is the period of increased water level, when the lake water is becoming brownish and quite dirty. Dada and Araoye (2008) reported that plant materials were high in the months that coincides with rainy season. Insects - Choaborusand chironomid commonly found in the stomachs of the species also coincide with the period of insect reproduction, especially dipterans. Atobatele and Ugwumba (2011) reported chaoborus, mollusca, detritus and sand with higher percentage in the stomach of *C. nigrodigitatus* during the months that falls within dry season, which is in line with the findings of this study.

Seasonal variation influences abundance and diversity in the diet of most fish species because in most tropical waters feeding by fish is highly seasonal. In other words, feeding by fish especially in tropical waters is highly seasonal as a result of fluctuation in temperature and other factors such as availability of food. Fishes also appear to be highly facultative in their feeding in tropical waters, an indication that the same food resource could be shared by numerous species and that each species may successfully exploit several different resources during the year. *Chrysichthys nigrodigitatus*consumed more of detritus than any food item in wet season, though on the overall insect is most preferred; *Diaptomus*, *Daphnia* and *Bosmonia* were absent in wet season. Insects, vegetable matter, seed, and filamentous algae showed less variation in both seasons.Dada and Araoye (2008) reported seasonal variations in food items of *C. nigrodigitatus*, with plant materials being high during wet season; insects, nematode, worms and detritus showed less variation seasonally. Scale and blue-green algae, which also constitute part of the items consumed, were not eaten during dry season.This could be as a result of their unavailability or non-preference of the food items during a particular season. Ogbeibu and Ezeunara

(2005) reported that ecological conditions governed by seasonal diversity of food items could influence the feeding habits, diets and feeding intensity of fish species. It is also an indication that there could be seasonal dearth of preferred food items. In dry season detritus dominate, while scale and blue-green algae being absent. The absence of scale and blue-green algae in the diet of *C. nigrodigitatus* could be due to non-preference or inaccessibility of this food items. Atobatele and Ugwumba (2011) reported insects especially *Chaoborus* and chironomid as dominant stomach contents of the species during the dry season, which supports the findings of this study.

Food composition of *C. nigrodigitatus*showed a wide spectrumof items ingested at the various stages of life.Broad classification showed that Juveniles fed on insects as dominant item (36.72%), followed by detritus (14.36%); sub-adult fed on insect on the overall, followed by detritus (17.45%), while adult fed on fish (27.86%) followed by insect overall, then detritus (16.40%). This shows that as the fish species increases in size food item ingested also increase. Atobatele and Ugwumba (2011) reported that *C. nigrodigitatus* consumed more insects as it increased in size with decrease in crustacean. Ekanem (2003) did report that larger sizes of the species preferred fishes and shrimps, while smaller sizes had a wide range of items in the diet. This is agrees with the findings of this study. Nematode and scale was absent in juvenile; chironomid larvae, seed, *Diaptomus*, *Bosmonia*, and blue-green in adult. This contrast the findings of Ajah *et al*. (2006) that adults of *C. nigrodigitatus* consumed more of diatoms (23%), Chlorophyceae and crustaceans (22%). The presence of detritus in the items ingested by the species in all the sized groups corroborates the findings of Idodo-Umeh (2002), which showed that feeding was mainly done at the bottom of the lake.

Seasonal food composition of *C. nigrodigitatus* at various stages of life showed variations in the items consumed during wet and dry season. Juvenile of *C. nigrodigitatus* fed on insects as dominant food item in both seasons,followed by *Diaptomus*, and detritus during dry and wet season, respectively. Sub-adult fed on insects and detritus as dominant food items during dry and wet season, respectively. While adult fed on detritus as dominant food item in dry season, fish was ingested in wet season. This shows that there is seasonal variation in the food of the species in the lake. Similarly, Dada and Araoye (2008), Yem *et al*. (2009) and Atobatele and Ugwumba (20011) reported seasonal variations in the food of *C. nigrodigitatus*. This is in line with the findings of this study. Temporal changes in diet composition of fish reflect changes in abundance of food organisms found in the water body.

Index of relative importance indicates the importance of an item in the diet of fish. Dipteran - chironomid larvae had the highest index for juvenile and sub-adult with fish (fry/remains) for adult of *C. nigrodigitatus*, which indicates that they are the most relevant items in the diet of the fish at the different stages in life. Ekanem (2003) did report shift in diet of the species with increase in size, where larger ones prefer fishes and shrimps, smaller ones has a broad spectrum of diet. This agrees with the findings of this study. The reliance of *C. nigrodigitatus* on chironomid, detritus and fish could be due to their abundance, preference or because the fish is a bottom dweller as reported by Ogbeibu and Ezeunara (2005). Other items of preference include detritus, plant materials, and insect fragments for juvenile; detritus, fry/remains, and chaoborus larvae for sub-adult; detritus, plant materials, and insect fragments for adult, which are also important. Food item absent in juveniles was scale and nematodes; in adult chironomid larvae, seed, *Diaptomus*, *Bosmonia* and blue-green algae. Atobatele and Ugwumba (2011) reported that insects increased numerically with increase in size and crustaceans decreased with fish size. This is in agreement with the findings of this study.

Fish to some extent can be classified into broad category based on the dominant food item or items in its diet. From this study items ingested by *C. nigrodigitatus* varied from plant to animal materials; insects, detritus, vegetable matter, crustacean, fish, algae, and nematode as important constituents. This result indicates that *C. nigrodigitatus* is an omnivore. This is in agreement with the findings of Dada and Araoye (2008) and Lawal *et al*. (2010) but contrary to Idodo-Umeh (2003), Oronsaye and Nakpodia (2005) and Yem *et al*. (2009) that reported the species as omnivorous detrivores. Though the species was considered detritivore because it fed on vegetable debris and associated animal communities, it is worthwhile to say that the species can also be classified as an omnivorous detrivore. Similarly, Ajah (2006) did report juveniles of the species as omnivorous. Ajani (2001), Ogbeibu and Ezeunara (2005), Atobatele and Ugwumba (2011) in contrast reported the species as carnivore, bottom meso-predator and general meso-predator respectively. This could be due to the trophic flexibility or opportunistic feeding behavior and the ability to switch from one diet to another depending on availability. The morphology of *C. nigrodigitatus* is adapted for bottom feeding, though stomach contents may prove otherwise because food items found in the stomach of fish often reflects its ability to obtain food from different locations within the aquatic environment. Idodo-Umeh (2003) reported that morphological features cannot limit *Chrysichthys* species as exclusively bottom feeders.

Frequency of stomach fullness is a key that can be used to determine the feeding intensity of fish in the aquatic environment. The low percentage of empty stomach and high percentage of stomach with food of *C. nigrodigitatus* suggests that there was abundance of food throughout the period of study. This could be due to the availability of the diverse or wide variety of food items the lake. This agrees with the findings of Yem *et al*. (2009). The degree of stomach fullness determines the feeding category as well as feeding intensity of fish. Ogbeibu and Ezeunara (2005) did report that ecological conditions governed by seasonal diversity of food could affect the feeding habits, feeding intensity and diets of fish. On a general note, the results of the fullness method of stomach contents analysis revealed that there was high degree of feeding intensity due to the fact that percentage of full stomach was more than that of empty stomach. Ogbeibu and Ezeunara (2005) reported that even at species level, fish in the same genus sometimes has different feeding intensity or category. Feeding by fish in tropical waters is highly seasonal as a result of fluctuations in factors such as temperature, and availability of food. Idodo-Umeh (1987) did report that feeding intensity is influenced by season and food availability. The feeding intensity was higher in wet than dry season, because of higher stomachs with food items, which is in agreement with the findings of Idodo-Umeh (2003), Ogbeibu and Ezeunara (2005), Dada and Araoye (2008) and Yem *et al*. (2009). Each category of stomach fullness showed higher percentage in wet than in dry season. It is imperative to note that food availability and season did not have much effect on the feeding intensity of *C. nigrodigitatus* in this study. Peak feeding took place at different times in different species. While some fish carried out intensive feeding during periods of food abundance, others ceased to feed at low water despite the adequate supply of food, which enable continued feeding throughout the year. This could be the reason why *C. nigrodigitatus* recorded high number of empty stomach in dry season.

Fish species differ in the length of the gut and as such feed on different kinds of items as food. The ratio of gut length to body length could be used to predict the feeding habit of fish. Hickman *et al*. (2001) did report that structure and length of the intestine are closely related to the food consumed by the fish. It also gives better understanding in determining the feeding manner of fish (Edema and Aiguobasinmwin, 2007). These values for male, female clearly shows that the species is an omnivore. Edema and Aiguobasinmwin (2007) did report the species to have a ratio of 1.6 and classified it as an omnivore. Similarly, Ajayi (1987) reported ratio of 1.65, which correlated with the feeding habit and termed *C. nigrodigitatus* asan omnivore which is in line with the findings of this study. Ratio of 1.5-21.0 for detrivores and 1.0-1.3 for omnivores was reported by Bond (1979). A detrivore could also be said to be an omnivore because both plant and animal materials are consumed. This study also reveals that *C. nigrodigitatus* has moderate gut length and as such consumes both plant and animal materials.

5.5 Sex Ratio and Fecundity of *Chrysichthys nigrodigitatus*

It is a common phenomenon in animals like fish that males are more in abundance than female. The sex ratio of *C. nigrodigitatus* varied for the various months with the highest male to female ratio of 2.8:1 in April, more males than females were also reported generally, which was significantly different ($p<0.05$) between the months. Similarly, Abayomi and Arawomo (1996), Taiwo and Aransiola (2001), Offem *et al*. (2008) did report dominance of males over females, which is similar to the findings of this study. Fagade and Adebisi (1979) also reported that in African water bodies it is common that in fish populations males dominate because they generally present more growth than females. Similarly, Fapohunda and Godstates (2007) reported more females than males in Owena Reservoir. Dada and Araoye (2008) reported 155 males and 85 females with ratio of 1.8:1. Lawal *et al*. (2010) reported 393 males and 207 females, which showed males to be significantly higher than females in the water body. This could be due to spawning and environmental conditions such as feeding activities amongst others. Offem *et al*. (2008) reported that females could go towards submerged vegetation and rocky areas to avoid fishermen to spawn and protect their offspring, while the males' possibly migrate from spawning areas to feeding grounds where they are captured. On the average the ratio of male to female during the period of study was 1.8:1. This could be due to more population of males than females, feeding behavior, migration, more tolerance to physico-chemical parameters and breeding.Although, more males were recorded than females in dry season, it did not differ significantly ($p>0.05$), unlike in the case of wet season, which showed significant difference ($p<0.05$). This may not be unconnected with the period of spawning.

Stage of gonad maturity or development is a key factor to the understanding of the dynamics of gonads as they develop in order to assess the reproductive mechanism of any fish species. Stages I-VI was recorded during the period of study, and as the ovaries develop there is increase in volume and also differences in size and form. The distribution shows that there were more males at the developing (II) and maturing (III) stages, more females at the matured stages (IV), and maturing stage (III). This showed that females were more matured than males during the period of study. This is unlikely connected with the period of breeding or spawning activities and food availability. Dada and Araoye (2008) reported high abundance of stages I-III, VI-VIII though IV-V was the highest. In this study males and females of total lengths 21.50cm and 25.55cm respectively reached first maturity. Offem *et al*. (2008) reported males and females of total lengths (11.50cm) and (16.70cm) to have reached first maturity and concluded that males attained maturity earlier that females, which is in line with the findings of this study.

Gonado-somatic index is helpful in identifying days and seasons of spawning, as the ovaries of gravid female fish increase in size just prior to spawning. It varied between males and females, where the females had higher values than males during the period of study. Offem *et al*. (2008) reported that gonado somatic index (GSI) of *C. nigrodigitatus* varied with mean index of 4.78 ± 3.21 for females and mean index of 2.89 ± 1.41 for males. Dada and Araoye (2008) reported that GSI for both males and females ranged from 0.12 - 0.87 and 0.53 - 8.16, which indicated that lower gonado somatic index (GSI) was recorded in males and higher in females, which corroborates the findings of this study. Gonado-somatic index showed that of females to be higher in September, June and May, which coincided with the wet season than dry season.Similar tremd was also observed in males. This could be related to the breeding or spawning activities and abundant of food. Offem *et al*. (2008) reported gonado-somatic index in females to be higher during the wet season, which is also supported by the findings of the study.

Fecundity is important in the estimation of stock size and stock discrimination of fish. It reveals useful information about the reproductive potential of fish. On the overall, fecundity range from 8,400-121,500 eggs, mean fecundity of 1,670-3,375 eggs, during the period of study.*C. nigrodigitatus*with absolute fecundity of 8,400 had total length of 53.00 cm and weigh of 850g. Ekamem (2000) reported 28,086 eggs as absolute fecundity for the species, while Offem *et al*. (2008) did report 10,816 eggs; absolute and mean fecundity of 6,844-25,905 eggs and 4,522-20,321 eggs, respectively; which was high during April-June and fall sharply during August - September, which is contrary to the findings of this study. These disparities could be due to the sizes and number of gravid fish caught, location, abundance of food, and physico-chemical parameters. This shows a high fecundity during the period of study compared with that of Fagade and Adebisi (1979) and Ekamen (2003). Low fecundity according to Ekanem (2000) could be affected by greater abundance of food or due to free movement in search of food as the supply in the lake is limited compared with river. Similarly, Offem *et al*. (2008) reported factors such as fish size, type of species, season and reproductive behavior to have affected fecundity. Adeyemi and Akombo (2010) reported that low fecundity could be due to fishing intensity and possibly strong intra and inter specific food competition. Adeyemi (2011) did report food and environmental factors apart from genetic factor to influence fecundity of fish. There was also increase in the number of eggs as the fish increase in size. The disparities in the absolute fecundity observed could be due to the number of samples examined. Wooton (1998) and Offem *et al*. (2008) did report that the volume of eggs a fish can produce depended on space available in the body cavity that accommodate the eggs before spawning, which is in line with the findings of the study. 1,000 eggs were found in *Chrysichthys nigrodigitatus* of weight and total length of 50g and 25.50 cm,and 850g of total length 44.00cm had 8,400 eggs. This indicates that as body size increased, fecundity also increase, though little variations between fish size and number of eggs was observed.

Similarly, Offem *et al*. (2008) reported fecundity to be directly proportional to length and weight of the fish. Ekanem (2000) reported that though fecundity is proportional to fish size when length is considered but not quite when weight is considered. The size of fish egg plays an important role in the quality of the resulting offspring. The highest mean eggs diameter of 0.38 mm in August, and lowest in July could be due to the stages of maturity of samples caught. This shows the presence of mature female ovaries during the rainy season. Ekanem (2000) reported mean egg diameter of 0.65 mm-3.54 mm in varied populations depending on the state of development while Offem *et al*. (2008) did report diameter of 0.2mm-0.8mm for immature eggs, 0.8-1.6mm for maturing and 1.7mm-7mm for mature eggs and concluded that mature eggs were present in fish ovaries during April -June with peak in May. This did not agree with the findings of this study. Based on this classification majority of ovaries reported during the period of study were at maturing and mature stages. Ezenwa *et al*. (1986) reported variations in egg size of *C. nigrodigitatus* at various locations and established that the population in Warri River produced larger eggs and had higher fecundity than those from other locations and recommended that population was the best brood stock.

5.6 Abundnace and Distribution of *C. nigrodigitatus* in relation to other fish species

Thirteen (13) fish families with twenty-nine (29) species were recorded during the period of study. Claroteidae, Mochokidae and Alestidae had the highest diversity of 4 species. This could be due to their wide spread, adaptation to tropical water environment, feeding strategies and tolerance to changes in the

aquatic environment. Welcomme (2001) reported that several catfishes are wide spread and common in Afro-tropical waters. This is inline with the findings of this study because all members of the families Claroteidae and Mochokidae are belong to this group. *C. nigrodigitatus*was the highest in abundance with 11.71% of the total catch with 57.70% abundance within the family Claroteidae. Similar findings were reported by Ogbeibu and Ezeunara (2005) in Ikpoba River, Idowu and Iyoola (2008) in Ogun water side, Agboola *et al*. (2008) in Badagry Creeks and Offem *et al*. (2009) in Cross River that *C. nigrodigitatus*was the most abundant fish species. Ikenweiwe *et al*. (2007) reported the species as the highest within the family Claroteidae with 63.82% and the overall catch in Oyan Lake, Ogun State. Similarly, Araoye (2008) categorized the species as been abundant in Asa Lake, Ilorin. Ufodike and Zakari (1992), Yem *et al*. (2005), Allison and Okadi (2009) and Odo *et al*. (2009) reported *C. nigrodigitatus*as least within the family Claroteidae with 0.2%, 0.24%, 0.82% and 2.3% of the overall catch, which is contrary to the findings of this study. This could be due to the sampling size, period of sampling, geographical location, availability of food, and population variation.

In water bodies, especially those in the tropics, fish abundance differs in months. The highest catch recorded in September was *C. nigrodigitatus*(18.90%), but absent in January, February and December, which differ significantly ($p<0.05$) compared with other species. Similarly, in the family Claroteidae the species was most abundant in March-November. This is inline with the findings of Ogbeibu and Ezeunara (2005), Agboola *et al*. (2008) and Allison and Okadi (2009) but contrary to that of Offem *et al*. (2011). This could be due to high water level at that period, spawning, migration,

abundance of food and favourable physico-chemical parameters. Sanni (2005) reported that factors such as competition, predation, survival rate, high level of fishing activities amongst others caused changes in fish abundance and distribution. *C. nigrodigitatus*has been reported to inhabit both fresh and brackish water and fills a different ecological niche, and the most common species in off shore part of most lakes.

Seasonal differentiation in fish abundance is a common phenomenon in tropical water bodies. The highest catch which accounted for 67.27% of total catch was during wet season with the family Claroteidae being the highest, *C.* n*igrodigitatus* with 13.06% in abundance, and *Citharinus citharus* as lowest (0.29%). Dry season accounted for 32.73% of the catch with Alestidae being highest followed by Claroteidae. Ufodike and Zakari (1992), and Offem *et al*. (2009) reported higher number of fish caught during wet season. This is in line with the findings of this study but contrary to that of Offem *et al*. (2011) that reported higher number of fish species caught during dry season. This could be due to foraging for food, favourable physico-chemical parameters and spawning activities, which make fish more vulnerable to catch. *C. nigrodigitatus*was highest during wet season within the family Claroteidae and in overall season. Adeosun *et al*. (2011) reported *C. nigrodigitatus, Sarotherodon galilaeus, Tilapia melanopleura* and *Lates niloticus* as the most abundant fish species at the peak of wet season. Similarly, Idowu and Ayoola (2008) reported *C. nigrodigitatus*as the dominant fish species in both wet and dry season which was correlated to high water level. Lae *et al*. (2003) distributed fishes into ecological classes where*C. nigrodigitatus*occurred in the water system in both seasonsbecause of tolerance to changes in the aquatic environment. This is in

line with the findings of this study because the species was reported in both season.

Fish abundance at the various zones shows that zone I had the highest (38.45%) of the overall catch, and zone III (28.14%) lowest, whichdiffer significantly ($p<0.05$). This could be due to difference in water depth, fishing activities in the area, availability of food, physico-chemical parameters and water current. Zone I is at the upper course of the lake, where the bulk of water from Kainji Dam is first received before flowing down stream to Jebba Dam. This could also contribute to the high fish abundance during the period of study. *C. nigrodigitatus*was highest in abundance in the zones,compared to other fish species. This observation may not be unconnected with the above factors in addition to its adaptive strategies. However, Idowu and Ayoola (2008) reported water depth to influenced fish species abundance, Offem *et al*. (2009) attributed vegetation cover, flow velocity and water level to cause changes in fish abundance in water bodies.

Seasonal fish abundance at the sampling zones showed that more fish species were recorded during wet season than dry season, though did not show significant difference ($p<0.05$). *C. nigrodigitatus*accounted for 14.05% of the total catch in wet season, but absent during dry season in zone I. Idowu and Ayoola (2008) reported *C. nigrodigitatus*as the most abundant fish species in both wet and dry seasons. The abundance of the species in zones I, II, and IIIcould be due to favourable water depths, abundance of food and adaptive measures or reproductive strategies. Also within the family Claroteidae the species was highest both in wet and dry season. This could be attributed to its

flexibility in feeding and the variety of items eaten as food. There is an indication that the species occur throughout the year, though not the dominant fish species in zone III, which supported Lae *et al*. (2003) who reported that *C. nigrodigitatus*occur in water systems throughout the year because of the ability to tolerate changes in the aquatic environment.

Fishes are known to live or occupy different water columns known as habitat. These water columns are divided into shore, surface and bottom. The dominance of *C. nigrodigitatus*recorded at the bottom of the lake (39.45%), followed by *Synodontis membranaceus*(20.31%). While *Labeo senegalensis* dominated the shore, *Lates niloticus* dominated the surface (12.21%), which was not significantly different ($p>0.05$). This could be due to availability of food, preference for deep waters, feeding habit amongst other factors. It has also been reported that most catfishes are bottom dwellers. Balogun (2005) reported the dominance of catfish in the bottom and shore habitats of water bodies. The inability of *C. nigrodigitatus*to frequent edge of the water could account for lower catches from the surface and shore. In addition, the abundance of other fish species over *C. nigrodigitatus* could be due to better environmental factors such as physico-chemical parameters, feeding strategies, low level of predation amongst other factors.

Seasonal variations in fish distribution based on water columns have been reported for several water bodies. Fish distribution at the various water columns showed that the shore had the highest during wet and dry seasons, which show significant difference ($p<0.05$) at the shore. This could be due to favorable conditions, which include availability of food, physico-chemical

parameters, open nature of the water column and low fishing activities among other factors.The dominance of *C.nigrodigitatus*at the bottom of the lake during in both seasonscould be due to availability of preferred food, feeding behavior and the ability to thrive at the water column. *C. nigrodigitatus*was recorded more at the bottom of zone III in the overall catch and the family Claroteidae during the period of study. Generally, the species was more represented at the bottom than any other water column though, without any significant difference (p>0.05). This could be due to its feeding habit, reproductive behavior amongst other factors.

CHAPTER SIX

6.0 SUMMARY AND CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The physico-chemical parameters of Jebba Lake varied throughout the study period but where within the accepatable range for fish survival.

Length-weight relationship showed allometric and isometric growth for males and females. Condition factor (K) of *C. nigrodigitatus*waswithin the favourable range. Length-length relationship showed strong relationship between theseparameters.

Morphometric parameters and meristic counts were used to validate the identity of *C. nigrodigitatus* in the lake. Correlation coefficient showed positive relationship among these parameters.

Size or body measurements showed various range of sizes of *C. nigrodigitatus*; females were heavier than males.

Age composition of *C. nigrodigitatus*ranged from 0+ and 3+ with the bulk of the samples falling within ages 2 and 2+. Growth performance index showed that the species can grow bigger and better if properly managed.

Nine major items were eaten by *C. nigrodigitatus*, whichincludedplant and animal materials. Insects, fry/remains, vegetable matter, detritus, algae and crustaceans were major food items, nematodes, sand/mud and unidentified materials were minor items.These items fluctuated in months and seasons at various stages of life.

Prey importance index of *C. nigrodigitatus*showed that *chironomid* larvae, detritus and fish were the most important food items of *C. nigrodigitatus*.

Stomach fullness index of*C. nigrodigitatus* showed high feeding intensity. *C. nigrodigitatus*is an omnivore.This is also supported by gut length to body length ratios.

Sex ratio of *C. nigrodigitatus*showed more males in the population than females both in months and seasons. Stages of gonad maturity showed females mature earlier than the males. Female *C. nigrodigitatus*showed higher gonado-somatic index than males. *Chrysichthysnigrodigitatus*produces minimum eggs compared to the clariids cichlids. Fecundity increased as the fish also increased in size.

Thirteen (13) fish families with twenty-nine specieswere recorded with *C. nigrodigitatus*being the most abundant overall and in the family Claroteidae, with similar trend in both wet and dry seasons.

*Chrysichthysnigrodigitatus*was the most abundant in overall catch and in the family Claroteidae at zone II and lowest in zone III.*Chrysichthys nigrodigitatus*population was higher in wet than dry season. Fish distribution at the different columns in the lake, on the overall showed that *C. nigrodigitatus*dominated the bottom of the lake,*Labeo senegalensis* the shore,and *Bagrus bayad* at the surface.

6.2 Conclusions

Physico-chemical parameters measured, which include temperature, phosphate, pH, electrical conductivity, dissolved oxygen showed significant difference ($p<0.05$) in seasons and months, but did not differ significantly ($p>0.05$) in zones.

Males exhibits allometric growth (increase in weight and length are not proportional), females exhibits isometric growth (increase in weight and length are proportion).Morphometric and meristic parameters is reliable, and can be use to confirm the presence of *C. nigrodigitatus* in the lake.

The age of males and females differs, and fall within the range 0+ and 3+ with males bigger than females. *C. nigrodigitatus* can be a good candidate for culture based on growth performance index.

*Chrysichthysnigrodigitatus*is an omnivore with changes in items ingested from insects at juvenile and sub-adult to fish at adult stage.

There are more males that females in the population; female attained maturity than the male.

Chrysichthysnigrodigitatus is among the abundant fish found in the lake, common especially during the wet season, and mostly distributed at the bottom of the lake.

6.3 Recommendations

- Morphometric parameters, especially those with strong correlations and meristic parameters should be used to identify*C. nigrodigitatus*.
- More study should be done on the population structure to ascertain if there are sizes bigger than the onesreported in this study.
- Plant and animal components should constitute the diet of *C.nigrodigitatus*.
- *C. nigrodigitatus* from the lake has aquaculture potential, therefore culture trials should be carried out.
- Nets should be set to cover the bottom of water body in order to catch *C. nigrodigitatus*.

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APPENDIX I

Analysis of physico-chemical parameters of Jebba Lake, Nigeria
Analysis of variance of Temperature

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Months	325.5097	11	29.59179	44.79663	1.8E-12	2.258518
Zones	0.427222	2	0.213611	0.323369	0.727089	3.443357
Error	14.53278	22	0.660581			

Total	340.4697	35

F-value is greater than F-crit ($p<0.05$), Ho is rejected, there was significant difference in temperature in months
F-value is less than F-crit, there was no significant difference ($p>0.05$) in temperature among the sampling zones, Ho is accepted

APPENDIX II

Analysis of variance of Dissolved Oxygen (DO)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Months	33.65667	11	3.059697	15.23501	7.7E-08	2.258518
Zones	0.695	2	0.3475	1.73029	0.200492	3.443357
Error	4.418333	22	0.200833			
Total	38.77	35				

F-value is greater than F-crit ($p<0.05$), Ho is rejected, there was significant difference in DO in the months
F-value is less than F-crit, there was no significant difference ($p>0.05$) in DO among the zones, Ho is accepted

APPENDIX III

Analysis of variance of Dissolved Oxygen pH

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Months	2.923056	11	0.265732	5.743996	0.000253	2.258518
Zones	0.108889	2	0.054444	1.176856	0.326913	3.443357
Error	1.017778	22	0.046263			
Total	4.049722	35				

F-value is greater than F-crit ($p<0.05$), Ho is rejected, there was significant difference in pH in months
F-value is less than F-crit, there was no significant difference ($p>0.05$) in pHin zones, Ho is accepted

APPENDIX IV

Analysis of variance of Electrical Conductivity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Months	471.8889	11	42.89899	2.453849	0.035181	2.258518

Zones	494.0556	2	247.0278	14.13015	0.000113	3.443357
Error	384.6111	22	17.48232			
Total	1350.556	35				

F-value is greater than F-crit ($p<0.05$), Ho is rejected, there was significant difference in EC in the months
F-value is greater than F-crit, there was significant difference ($p<0.05$) in EC in zones, Ho is rejected

APPENDIX V

Analysis of variance of Phosphate

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Months	0.09383	11	0.00853	2.838316	0.017924	2.258518
Zones	0.048371	2	0.024186	8.047609	0.002383	3.443357
Error	0.066117	22	0.003005			
Total	0.208318	35				

F-value is greater than F-crit ($p<0.05$), Ho is rejected, there was significant difference in phosphate in months

F-value is greater than F-crit, there was significant difference ($p<0.05$) in phosphatein the zones, Ho is rejected

APPENDIX VI

Analysis of variance of Nitrate

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Months	0.000178	11	1.62E-05	3.694864	0.004391	2.258518
Zones	1.43E-05	2	7.15E-06	1.628399	0.219022	3.443357
Error	9.65E-05	22	4.39E-06			
Total	0.000289	35				

F-value is greater than F-crit ($p<0.05$), Ho is rejected, there was significant difference in nitrate in the months

F-value is less than F-crit, there was no significant difference ($p>0.05$) in nitrate among the sampling zones, Ho is accepted

APPENDIX VII

Paired t-Test ofTemperaturebetween season

	Wet	*Dry*
Mean	29.40277778	25.21388889
Variance	5.363134921	6.016087302
Observations	36	36
Pearson Correlation	-0.005590255	
Hypothesized Mean Difference	0	
Df	35	
t Stat	7.429939251	
P(T<=t) one-tail	5.37005E-09	
t Critical one-tail	1.689572458	
P(T<=t) two-tail	1.07401E-08	
t Critical two-tail	2.030107928	

Since t-stat is greater than t-crit, there was significant difference ($p<0.05$) in temperature between the seasons; Ho is rejected

APPENDIX VIII

Paired t-Test for DObetween season

	Wet	*Dry*
Mean	7.777777778	8.063888889
Variance	1.881777778	0.34465873
Observations	36	36
Pearson Correlation	0.360490933	
Hypothesized Mean Difference	0	
Df	35	
t Stat	-1.338126699	
P(T<=t) one-tail	0.094742171	
t Critical one-tail	1.689572458	
P(T<=t) two-tail	0.189484341	
t Critical two-tail	2.030107928	

Since t-stat is less than t-crit, there was no significant difference ($p>0.05$) in dissolved oxygen between the seasons; Ho is accepted

APPENDIX IX

Paired t-Test for pH between season

	Wet	*Dry*
Mean	7.205555556	7.344444444
Variance	0.179968254	0.061968254
Observations	36	36
Pearson Correlation	-0.024048991	
Hypothesized Mean Difference	0	
Df	35	
t Stat	-1.676703702	
P(T<=t) one-tail	0.051255771	
t Critical one-tail	1.689572458	
P(T<=t) two-tail	0.102511542	
t Critical two-tail	2.030107928	

Since t-stat is less than t-crit, there was no significant difference (p>0.05) in pH between the seasons; Ho is accepted

APPENDIX X

Paired t-Test for EC between season

	Wet	*Dry*
Mean	65.68611111	67.01666667
Variance	123.6960873	41.91285714
Observations	36	36
Pearson Correlation	0.827276412	
Hypothesized Mean Difference	0	
Df	35	
t Stat	-1.171036343	
P(T<=t) one-tail	0.124747662	
t Critical one-tail	1.689572458	
P(T<=t) two-tail	0.249495323	
t Critical two-tail	2.030107928	

Since t-stat is less than t-crit, there was no significant difference (p>0.05) in EC between seasons; Ho is accepted

APPENDIX XI

Paired t-Test for Phosphate

	Wet	*Dry*
Mean	0.200152778	0.095758333
Variance	0.028586526	0.012979829
Observations	36	36
Pearson Correlation	0.367649787	
Hypothesized Mean Difference	0	
df	35	

t Stat	3.783842346
P(T<=t) one-tail	0.000290292
t Critical one-tail	1.689572458
P(T<=t) two-tail	0.000580583
t Critical two-tail	2.030107928

Since t-stat is greater than t-crit, there was significant difference ($p<0.05$) in phosphate between seasons; Ho is rejected

APPENDIX XII
Paired t-Test for Nitrate

	Wet	*Dry*
Mean	0.003641667	0.002797222
Variance	8.39279E-06	2.47685E-06
Observations	36	36
Pearson Correlation	-0.256276136	
Hypothesized Mean Difference	0	
Df	35	
t Stat	1.394208778	
P(T<=t) one-tail	0.086021449	
t Critical one-tail	1.689572458	
P(T<=t) two-tail	0.172042897	
t Critical two-tail	2.030107928	

Since t-stat is less than t-crit, there was no significant difference ($p>0.05$) in nitrate between seasons; Ho is rejected

APPENDIX XIII

Paired t-Test of condition factor (K)

	Male	*Female*
Mean	1.844310345	1.952758621
Variance	0.239734303	0.159237541
Observations	116	116
Pearson Correlation	0.070671311	
Hypothesized Mean Difference	0	
Df	115	
t Stat	-1.9167105	
P(T<=t) one-tail	0.028878128	
t Critical one-tail	1.65821183	
P(T<=t) two-tail	0.057756255	
t Critical two-tail	1.980807541	

t-stat is less than t-critical, hence Ho is accepted; there was no significant difference ($p>0.05$) in the condition factor between the males and females of *C. nigrodigitatus*

APPENDIX XIV

t-Test of sex ratio according to month of *C. nigrodigitatus*

	Male	*Female*
Mean	18	9.083333
Variance	350.9091	139.1742
Observations	24	24
Pearson Correlation	0.849886	
Hypothesized Mean Difference	0	
Df	23	
t Stat	2.887294	
P(T<=t) one-tail	0.007389	
t Critical one-tail	1.795885	
P(T<=t) two-tail	0.014777	
t Critical two-tail	2.200985	

t-statistic is greater than t-critical, Ho is rejected; there is significant difference (p<0.05) in sex ratio between months.

APPENDIX XV

t-Test of sex ratio of *C. nigrodigitatus*inwet season

	Males	*Female*
Mean	29.66666667	18.33333
Variance	482.6666667	225.0667
Observations	6	6
Pearson Correlation	0.954305517	
Hypothesized Mean Difference	0	
Df	5	
t Stat	3.129953701	
P(T<=t) one-tail	0.012979396	
t Critical one-tail	2.015048373	
P(T<=t) two-tail	0.025958793	
t Critical two-tail	2.570581836	

t-statistic is greater than t-critical, Ho is rejected; there is significant difference (p<0.05) in sex ratio in wet season.

APPENDIX XVI

t-Test of sex ratio of *C. nigrodigitatus*indry season

	Males	*Female*
Mean	7.833333333	3

Variance	133.3666667	23.2
Observations	6	6
Pearson Correlation	0.967196319	
Hypothesized Mean Difference	0	
Df	5	
t Stat	1.691889917	
P(T<=t) one-tail	0.075726012	
t Critical one-tail	2.015048373	
P(T<=t) two-tail	0.151452024	
t Critical two-tail	2.570581836	

t-statistc is less than t-critical, Ho is accepted; there is no significant difference (p>0.05) in sex ratio in dry season.

APPENDIXXVII

Analysis of variance of fish abundance according to zones in Jebba Lake

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Species	39562.67	57	694.0819	4.450350169	6.31E-12	1.441995818
Zones	866.4253	2	433.2126	2.777695315	0.066395	3.075852636
Error	17779.57	114	155.9612			
Total	58208.67	173				

F-stat is greater than F-crit, hence Ho is rejected; there is significant difference (p<0.05) in fish species abundance
F-stat is less than F-crit, hence Ho is accepted; there is no significant difference (p>0.05) in fish abundance between zones

APPENDIXXVIII

Paired t-Test of fishabundance between seasons in Jebba Lake

	Wet	*Dry*
Mean	23.77011494	11.56321839
Variance	492.6674686	108.8070035
Observations	87	87
Pearson Correlation	0.25077298	
Hypothesized Mean Difference	0	
Df	86	
t Stat	5.168166047	
P(T<=t) one-tail	7.5758E-07	
t Critical one-tail	1.662765449	
P(T<=t) two-tail	1.51516E-06	
t Critical two-tail	1.987934206	

Since t-stat is greater than t-crit, there is significant difference ($p<0.05$) in fish abundance between the seasons; Ho is rejected

APPENDIXXIX

Analysis of variance of fish distribution at the zones during wet season in Jebba Lake

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Species	28258.74	28	1009.241	4.596325	6.12E-07	1.677507
Zones	1814.437	2	907.2184	4.131692	0.021197	3.161861
Error	12296.23	56	219.5755			
Total	42369.4	86				

F-value is greater than F-crit ($p<0.05$), Ho is rejected, there is significant difference in fish distribution between species

F-value is greater than F-crit, there is significant difference ($p<0.05$) in fish distribution between zones, Ho is rejected

APPENDIXXX

Analysis of variance of fish distribution at the zones during dry season in Jebba Lake

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Species	4822.07	28	172.217	2.13015	0.00808	1.67751
Zones	7.88506	2	3.94253	0.04877	0.95245	3.16186
Error	4527.45	56	80.8473			
Total	9357.4	86				

F-value is greater than F-crit ($p<0.05$), Ho is rejected, there is significant difference in fish distribution between species during dry season

F-value is less than F-crit ($p>0.05$), Ho is accepted, there is no significant difference in fish distribution between zones during dry season

APPENDIX XXI

Analysis of variance of fish distribution at water columns in Jebba Lake

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*

Rows	40746.7	28	1455.238095	0.735267215	0.81056	1.67751
Columns	6425.68	2	3212.83908	1.623304977	0.20639	3.16186
Error	110835	56	1979.196223			
Total	158007	86				

F-stat is less than F-crit, hence Ho is accepted; there is no significant difference (p>0.05) in fish distribution in the water columns

APPENDIXXXII

Analysis of variance of fish distribution at water columns in wet season inJebba Lake

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	25339.52	28	904.9828	0.78028761	0.759802578	1.677506545
Columns	2682.828	2	1341.414	1.156583981	0.321957801	3.161861165
Error	64949.17	56	1159.807			
Total	92971.52	86				

F-value is less than F-crit (p>0.05), Ho is accepted, there is no significant difference in wet season

APPENDIX XXIII

Analysis of variance of fish distribution at the shore in the zones

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Row	9122.598	28	325.8071	1.29988	0.199493	1.67751
Zone	25.31034	2	12.65517	0.05049	0.950806	3.16186
Error	14036.02	56	250.6433			
Total	23183.93	86				

F-value is less than F-crit (p>0.05), Ho is accepted, there is no significant difference inspecies at the shore

F-value is less than F-crit (p>0.05), Ho is accepted, there is no significant difference in fish distribution between zones

APPENDIX XXIV

Analysis of variance of fish distribution at the surface in the zones

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
row	6391.333	28	228.2619	1.5909	0.06981	1.67751
Zone	441.1264	2	220.5632	1.53724	0.223907	3.16186
Error	8034.874	56	143.4799			
Total	14867.33	86				

F-value is less than F-crit (p>0.05), Ho is accepted, there is no significant difference in species at the surface

F-value is less than F-crit (p>0.05), Ho is accepted, there is no significant difference in fish distribution between zones

APPENDIX XXV

Shore

t-Test: Paired Two Sample for Means

	Wet	*Dry*
Mean	30.13793103	16.75862069
Variance	434.408867	120.046798
Observations	29	29
Pearson Correlation	0.592567721	
Hypothesized Mean Difference	0	
df	28	
t Stat	4.276759679	
P(T<=t) one-tail	9.96318E-05	
t Critical one-tail	1.701130934	
P(T<=t) two-tail	0.000199264	

t Critical two-tail	2.048407142

t-stat is greater than t-critical, there is significant difference ($p<0.05$) in fish distribution

APPENDIX XXVI

t-Test: Paired Two Sample for Means

	Wet	*Dry*
Mean	20.51724138	12.27586207
Variance	612.3300493	95.20689655
Observations	29	29
Pearson Correlation	0.425681673	
Hypothesized Mean Difference	0	
Df	28	
t Stat	1.98087786	
P(T<=t) one-tail	0.028752346	
t Critical one-tail	1.701130934	
P(T<=t) two-tail	0.057504692	
t Critical two-tail	2.048407142	

Since t-stat is less than t-crit, there was no significant difference ($p>0.05$) in the bottom between seasons; Ho is accepted.

APPENDIX XXVII

Bottom
t-Test: Paired Two Sample for Means

	Wet	*Dry*
Mean	17	9.310344828
Variance	2177.857143	269.1502463
Observations	29	29
Pearson Correlation	0.802246495	
Hypothesized Mean Difference	0	
Df	28	
t Stat	1.18625772	
P(T<=t) one-tail	0.122744608	
t Critical one-tail	1.701130934	

P(T<=t) two-tail	0.245489216
t Critical two-tail	2.048407142

Since t-stat is less than t-crit, there was no significant difference ($p>0.05$) in the bottom between seasons; Ho is accepted.