A SURVEY OF FISH SPECIES DIVERSITY AND ABUNDANCE IN DOGON RUWA WATER BODY OF KAMUKU NATIONAL PARK, BIRNIN GWARI, KADUNA STATE, NIGERIA

BY

STEPHEN DADA OYEWO

DEPARTMENT OF BIOLOGICAL SCIENCES,

FACULTY OF SCIENCE,

AHMADU BELLO UNIVERSITY, ZARIA

NIGERIA

DECEMBER, 2015

A SURVEY OF FISH SPECIES DIVERSITY AND ABUNDANCE IN DOGON RUWA WATER BODY OF KAMUKU NATIONAL PARK, BIRNIN GWARI, KADUNA STATE, NIGERIA

BY

Stephen Dada OYEWO B. AQUACULTURE AND FISHERIES MANAGEMENT, UNAAB 2000
(MSC/SCIE/1439/2011-2012)

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (M.SC.) DEGREE IN FISHERIES

DEPARTMENT OF BIOLOGICAL SCIENCES,

FACULTY OF SCIENCE,

AHMADU BELLO UNIVERSITY, ZARIA

NIGERIA

DECEMBER, 2015

DEDICATION

This work is dedicated to my God-sent helper- Alhaji Lamidi Monshur "Baba-awon-baba" for his immeasurable contributions to the success of this work.

DECLARATION

I declare that the work in this dissertation entitled **"A Survey of Fish Species Diversity and Abundance in Dogon Ruwa Water Body of Kamuku National Park, Birnin Gwari, Kaduna state, Nigeria"** has been performed by me in the Department of Biological Sciences, Faculty of Science, Ahmadu Bello University, Zaria. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this project thesis was previously presented for another degree at this or any other institution.

Stephen Dada OYEWO …… ……...

Signature Date

CERTIFICATION

This dissertation entitled **"A Survey of fish species Diversity and Abundance in Dogon ruwa water body of Kamuku National Park, Birnin Gwari, Kaduna State, Nigeria"** by Stephen Dada OYEWO, meets the regulations governing the award of the Degree of Master of Sciences of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Prof. T. O. L. Aken'Ova ……. …. Date ……..
Chairman, Supervisory Committee, Signature
Department of Biological Science,
Ahmadu Bello University.
Zaria, Kaduna State.

Prof. J. K. Balogun ……... Date …….
Member, Supervisory Committee, Signature
Department of Biological Science,
Ahmadu Bello University.
Zaria, Kaduna State

Prof. A. K. Adamu …… Date ……
Head of Department, Signature
Department of Biological Science,
Ahmadu Bello University.
Zaria, Kaduna State

Prof. K. Bala …… Date ……
Dean, School of Postgraduate Studies, Signature
Ahmadu Bello University.
Zaria, Kaduna State

ACKNOWLEDGEMENTS

I am deeply indebted to Professors: T. O. L. Aken'Ova and J. K. Balogun, the supervisors of this work, for their many valuable suggestions and constructive criticism.

I will forever be grateful to my mentor and God-sent helper, Alhaji Lamidi Monshur "Baba-awon-baba" for his immeasurable contributions to the success of this work and to my success in life generally.

I am also grateful to the staff and management of Kamuku National Park, most especially the following people: Mamman Maria, Jauro Fxentirimam, Abdulahi Shehu, Gunu Mora, and Amidu Alhassan for their technical advice and support; Yakubu Emmanuel Adegbe, Ibrahim Akilu, Mathiaias Adie for their contribution in typesetting of this thesis, John Inaku, Ajagun Morris Ebinbin and Aminu Jakarda for their moral support throughout the period of the study.

I wish to express my profound gratitude to my wife (Mrs. Oyewo-Stephen Munah) and my children (Mary, Testimony and Precious) for their patience and love.

I thank my friends- Micah David, Samuel Adoun, Areo Oluwagbemiga, Alex Jatau Kamba Bayo and Mr and Mrs Adebisi Adekunle for their love and understanding towards the success of this work.

All honour and adoration back to God Almighty. I remain thankful to him for guiding me through to the end of this study and to my family for their understanding and prayers.

ABSTRACT

A survey of fish species diversity in Dogon ruwa water body of Kamuku National Park, Birnin Gwari, Nigeria was carried out between April 2013 and March 2014. 2,161 fish, comprising 11 genera and 12 species, belonging to six families were caught using a fleet of nine multifilament gill nets of 2.5, 3.75, 5.0, 7.5, 8.75, 10.0, 12.5, 15.0 and 17.5 cm stretched meshes. The family Cichlidae dominated the catches by number and abundance (631 fish, 29.20%); *Tilapia zillii* was the numerically dominant species (321 fish, 14.8%). Monthly and seasonal abundance of all the fish species was highest in November (early dry season) (534 fish, 24.71%); the dominant fish family in November was the Cichlidae (155 fish, 29.03%), whereas, the fewest were members of the family Mochokidae (41 fish, 7.68%). The fewest fish (33 fish, 1.53%) were caught in April (the driest month), with the dominant family being the Cichlidae (9 fish, 27.27%) and the least prevalent, the family Mochokidae (2 fish, 6.06%). The largest fish caught was *Clarias gariepinus* with a standard length of 23.82 cm, total length of 27.36 cm and a total weight of 266.91g; the smallest was *Mormyrus rume*, with standard and total lengths of 11.06 cm and 13.74 cm, respectively; *Mormyrops anguilloides* had the lowest weight. The mean condition factor 'K', by species was greater than 1 (one), indicating that all the fish species were in good condition. All the 12 fish species had a condition factor values range of 0.59-7.42. *Clarias gariepinus* had a range of 0.59-3.64; *Oreochromis niloticus* 2.56-6.12 and *Schilbe mystus* 0.94-3.56. The growth pattern of the fish species was negatively allometric with 'b' values of 1.44-2.75. *Clarias gariepinus, Oreochromis niloticus* and *Schilbe mystus* had mean values of 2.33, 1.44 and 1.57, respectively. There was a strong correlation between the length and weight of all the fish species except in *Oreochromis niloticus*, in which the correlation was weak. The mean ranges of

physico-chemical parameters of the water body were: temperature – 20.50-33.50°C; dissolved oxygen – 5.05-7.30 and total dissolved solids – 18.50-148.00; these values are within the limits for fish tolerance, survival and production.

TABLE OF CONTENTS

Content **Page**

Title Page……..... iii

Dedication…….. iv

Declaration…….. v

Certification …….. vi

Acknowledgements…… vii

Abstract……..... viii

Table of Contents……... x

List of Figures ……..……..... xv

List of Tables…….…… xvi

List of Plates ……. xvii

CHAPTER ONE

1.0 INTRODUCTION…….. 1

1.1 Background information……..……. 1

1.2 Statement of Research Problem……..…….…… 6

1.3 Justification……. 6

1.4 Aim of Study…… 7

1.5 Objectives of the Study……..… 7

1.6 Research Hypotheses…….....7

CHAPTER TWO

2.0 LITERATURE REVIEW……..8

2.1 Fish Species Diversity…….8

2.1.1 Inland freshwater fish species diversity……..... 9

2.1.2 Inland fishery resources of Nigeria…….. 9

2.1.3 List of endangered freshwater fishes in Nigeria…… 13

2.2 Problems of Aquatic Conservation…… 14

2.2.1 Sustainability of fishery resources……..…….. 14

2.3 Problem of Fish Resources…….. 15

2.4 Reproductive Biology of Fish…….. 17

2.5 Condition Factor ('K')……..……...19

2.6 Length-Weight Relationship…….. 20

2.7 Relative Fish Species Abundance……21

2.8 Water Quality Parameters……..22

2.8.1 Temperature……..22

2.8.2 Dissolved oxygen…….23

2.8.3 Hydrogen-ion concentration…… 24

2.8.4 Total dissolved solids……..…24

2.8.5 Electrical conductivity……..25

2.9 Fish Species Composition of Some West African Water Bodies..……..25

CHAPTER THREE

3.0 MATERIALS AND METHODS……29

3.1 Study Area……... 29

3.2 Experimental Gill Nets Sampling……..……31

3.3 Collection and Identification of Fish…….32

3.4 Length-weight Relationship…….……..32

3.5 Condition Factor ('K')…….…. 33

3.6 Physico-Chemical Parameters…….34

3.6.1 Temperature……34

3.6.2 Dissolved oxygen……34

3.6.3 Hydrogen-ion concentration……35

3.6.4 Electrical conductivity…….35

3.6.5 Total dissolved solids..……35

3.7 Relative Abundance of Fish…….……35

3.7 Data Analysis…….36

CHAPTER FOUR

4.0 RESULTS…….37

4.1 Fish Species Composition……37

4.2 Descriptions of Fish Species……37

4.2.1 *Clarias gariepinus*…….37

4.2.2 *Clarias anguillaris*……37

4.2.3 *Brycinus nurse*……...40

4.2.4 *Hydrocynus vittatus*…….. 40

4.2.5 *Marcusenius abadii*……...43

4.2.6 *Mormyrus rume*…… 43

4.2.7 *Hippopotamyrus psittacus*…… 43

4.2.8 *Mormyrops anguilloides*……....43

4.2.9 *Oreochromis niloticus* ……46

4.2.10 *Tilapia zillii* …….. 46

4.2.11 *Synodontis budgetti* …….. 46

4.2.12 *Schilbe mystus*……48

4.3 Total Fish Caught According to Family…….. 48

4.4 Distribution of Fish…… 50

4.5 Monthly Fish Catches Using Nets of Different Mesh Sizes……50

4.6 Number of Fish Species Caught Monthly ……...…….50

4.7 Fish Species Caught Based on Different Mesh Sizes……..55

4.8 Growth Pattern of the Fish Species and Their Condition Factors ('K').....55

4.9 Sex Ratio of Fish Species……. 64

4.10 Seasonal Weight of Fish Species in Dogon Ruwa……..… 64

4.11 Seasonal Abundance of Fish Species in Relation to Sex……68

4.12 Physico-Chemical Parameters of Dogon Ruwa Water Body……68

4.13 Correlation Matrix of the Physico-Chemical Parameters of the Water Body……68

CHAPTER FIVE

5.0 DISCUSSION ……72

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS ……..81

6.1 Conclusion……..… 81

6.2 Recommendations…….. 81

REFERENCES ……..……83

LIST OF FIGURES

FIGURE **PAGE**

Figure 3.1 Map of Kamuku National Park……...……..30

Figure 4.1 Fish catch per month according to mesh size of nets…….53

Figure 4.2 Scatter diagram of length-weight relationship of *Clarias gariepinus*…….....58

Figure 4.3 Scatter diagram of length-weight relationship of *Clarias anguillaris*……..58

Figure 4.4 Scatter diagram of length-weight relationship of *Brycinus nurse*…..59

Figure 4.5 Scatter diagram of length-weight relationship of *Hydrocynus vittatus*…….....59

Figure 4.6 Scatter diagram of length-weight relationship of *Marcusenius abadii*…… 60

Figure 4.7 Scatter diagram of length-weight relationship of *Mormyrus rume*…60

Figure 4.8 Scatter diagram of length-weight relationship of *Hippopotamyrus psittacus*……..61

Figure 4.9 Scatter diagram of length-weight relationship of *Mormyrops anguilloides*……61

Figure 4.10 Scatter diagram of length-weight relationship of *Oreochromis niloticus*……..62

Figure 4.11 Scatter diagram of length-weight relationship of *Tilapia zillii*……..62

Figure 4.12 Scatter diagram of length-weight relationship of *Synodontis budgetti*……...……....63

Figure 4.13 Scatter diagram of length-weight relationship of *Schilbe mystus*……63

LIST OF TABLES

TABLE **PAGE**

Table 1.1 Projected human population, fish demand and supply (2000 – 2015)..... 2

Table 2.1 some endangered freshwater fish in Nigerian water……13

Table 4.1 Fish species identified in Dogon Ruwa.……. 38

Table 4.2 Relative abundance and total weight of fish species in Dogon Ruwa water body……..... 51

Table 4.3 Distribution of fish species in Stations X and Y of Dogon Ruwa water body…… 52

Table 4.4 Number of fish species caught on monthly basis in Dogon Ruwa water body…. …… 54

Table 4.5 Fish species caught based on different mesh size in Dogon Ruwa water body ……..... 56

Table 4.6 Length-weight relationship and growth pattern of fish species in Dogon Ruwa water body of Kamuku National Park……..,…….57

Table 4.7 Condition factor of the fish species in Dogon Ruwa water body and their sizes…….……..... 65

Table 4.8 Fish species in Dogon Ruwa water body and their sex ratio…… .. 66

Table 4.9 Seasonal variation in the sizes of fish species in Dogon Ruwa and their size…… 67

Table 4.10 Seasonal abundance of different fish species in relation to sex……. 69

Table 4.11 Seasonal physico-chemical parameters of Dogon Ruwa water body of Kamuku National Park ……. 70

Table 4.12 Correlation matrix of the physico-chemical Parameters of Dogon Ruwa water body of Kamuku National Park ……. 71

LIST OF PLATES

PLATE		PAGE
Plate I	Dorso-lateral view of *Clarias gariepinus*…… …….	41
Plate II	Dorso-lateral view of *Clarias anguillaris*……..……..	41
Plate III	Lateral view of *Brycinus nurse*……	42
Plate IV	Lateral view of *Hydrocynus vittatus*……	42
Plate V	Lateral view of *Marcusenius abadii*……..	44
Plate VI	Lateral view of *Mormyrus rume*……...	44
Plate VII	Lateral view of *Hippopotamyrus psittacus*…..…….....	45
Plate VIII	Lateral view of *Mormrops anguilloides*……...	45
Plate IX	Lateral view of *Oreochromis niloticus*…….	47
Plate X	Lateral view of *Tilapia zillii*……	47
Plate XI	Dorso-lateral view of *Synodontis budgetti*……...	49
Plate XII	Lateral view of *Schilbe mystus*…….	49

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

Nigeria is blessed with over 14 million hectares of reservoirs, lake, ponds and major rivers capable of producing over 980,000 metric tonnes of fish annually (FDF, 2003). Statistical surveys have shown that the demand for fish in the country exceeds supply; also, domestic production is still very low, considering the increasing human population. Production from aquaculture is increasing compare to artisanal sources and supplied between 5–22% of total domestic fish production between 2000 and 2007 (FDF, 2007). This increasing production is not able to meet the increasing rate of consumption because of the wide gap between fish demand and supply (Table 1.1), which is on the rise as a result of population explosion in the country in the recent years (Falaye and Jenyo-Oni, 2009).

Fish are important in that they contribute as much as 17% of the world's animal protein (Olusola and Arawomo, 2008). Inland fisheries play an important role in the provision of protein to Nigerians with a high population of about 178.5 million people (FDF, 2008), especially when imported fish is becoming too expensive for low income earners as observed by Olusola and Arawomo (2008).

Balogun (2006) stated that in Nigeria, studies of fish biodiversity, distribution, abundance and yield of most of the inland lacustrine water bodies have been limited to large sized water bodies (>1,000 ha) which include mainly Kainji, Jebba, Shiroro, Tiga, Bakolori and Goronyo among others. Studies on small/medium sized reservoirs (less than 2–less than 1,000 ha) have been limited to a few examples that include International Institute for Tropical Agriculture (IITA) Reservoir, Oguta Lake.

Table 1.1: Projected human population, fish demand and supply (2000 – 2015)

Year	Projected population (millions)	Projected fish demand (tonnes)	Projected domestic fish supply (Tonnes)	Deficit (Tonnes)
2000	114.4	1,430,000.00	467,098.00	962,902.00
2001	117.6	1,470,000.00	480,163.60	984,836.40
2002	121.0	1,412,500.00	507,928.20	1,004,572.00
2003	124.4	1,555,000.00	522,627.10	1,063,082.60
2004	128.0	1,600,000.00	536,917.60	1.063,072.40
2005	131.5	1,643,750.00	552,433.10	1,091,317.00
2006	135.3	1,691,250.00	567,984.60	1,23,301.40
2007	139.1	1,732,750.00	583,872.40	1,154,873.00
2008	143.0	1,782,300.00	600,612.80	1,186,887.20
2009	147.1	1,838,750.00	617,353.20	1,221,397.00
2010	151.2	1,810,000.00	634,500.20	1,255,440.00
2011	155.5	1,943,750.00	652,606.60	1,291,143.00
2012	160.0	2,000,000.00	689,958.00	1,328,508.00
2013	164.0	2,113,750.00	709,683.10	1,365,042.00
2014	169.1	2,175,000.00	730,248.00	1,404,067.10
2015	174.0	2,055,000.00	671,492.30	1,444,752.10

Source: (FDF, 2008)

FDF (2008) estimated the fish production from small water bodies in Africa as two million tonnes annually and argued that it could be considerably more if production enhancement fishing systems were applied, an approach to which small water bodies are particularly well suited.

Fisheries resources are on the decline in Nigeria due to over exploitation and inadequate management of the coastal waters. For sustainability of these resources, an adequate knowledge of species composition, diversity and relative abundance of the water bodies must be understood and vigorously pursued (Lawson and Olusanya, 2010). Biodiversity is often ambiguously misused or overused to describe the population dynamics of a location or community, but in the real sense, it is a measure of the members of species that make up a biological community and is considered to be one of the most important aspects of community organization and structure. Species richness and relative abundance describe key elements of biodiversity. The former is the number of different species in a given area, which is the fundamental unit in which to assess the homogeneity of an environment, it is commonly used in conservation studies to determine the sensitivity of ecosystems and their resident species, while the latter describes how common or rare a species is, relative to other species in a given community (Lawson and Olusanya, 2010).

According to Ita (1993), environmental management of aquatic ecosystems, particularly the inland water bodies have been of great concern to many scientists, resource managers and environmentalists in recent times. These ecosystems, which are endowed with some unique natural resources, are being increasingly degraded, leading to ecological instability and disappearance of valuable resources, some of which are irreversible. Ita (1993) further stated that the decimation of inland water

bodies, especially in Africa, has been attributed to poor management arising from the lack of adequate regulations or their non-implementation where they exist.

The management of inland water bodies and conservation of fisheries resources in Nigeria has been principally in the traditional domain, where traditional strategies such as water tenure, taboos, ritual prohibitions, magic, closed seasons, gear restrictions and flood plain intensification are employed. Some of these traditional strategies are inadvertent or unintentional in that, they were initially put in place for reasons other than the management and conservation of the local fisheries, while others were termed intentional because they were designed to protect, conserve and increase some specific fisheries for particular events or reasons (Odusanya, 2008). However, Ita (1993) also observed some unintentional traditional strategies in Sokoto and Kano States in northern Nigeria, where seasonal rivers and flood ponds are closed for fishing in the rainy season principally to protect the interest of the full-time farmer, who returns to part-time fishing in the dry season, rather than the protection of the fisheries. Ita (1993) also noted intentional traditional strategies such as gear restrictions and closed seasons in the management of Sokoto-Rima river in the Argungu fishing festival. Though Indigenous and traditional method in fish resource sustainability are common practices in Nigeria, but these practices had no legal framework and so could not be effectively enforced (Obasohan and Oronsaye, 2006).

The modern concept of conservation is no more than the combination of two ancient principles: the need to plan resources management, and the need to take protective measures to ensure that resources do not become exhausted (Lawan, 2002). Conservation has often been thought of as a protective ‘locking away’ of resources by powerful elite who has the time to enjoy the beauty of nature, as essentially selfish

and anti-development. Protected areas are now recognized as offering major sustainable benefits to society. Lawan (2002) stated that protected areas like National Parks play a central role in the social and economic development of rural environments and contribute to the economic well being of urban centres and the quality of life of their inhabitants.

There are over 161,000 protected areas in the world (as of October 2010) (Soutullo, 2010) with more added daily, representing between 10 and 15 percent of the world's land surface area (Mora, 2011).

The International Union on Conservation of Nature (IUCN, 2004) defines National Parks as natural areas of land and or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generation (b) excluding occupation inimical to the purpose of designation of the area (c) provide a foundation for spiritual, scientific, educational, recreational, and visitor's opportunities, all which must be environmentally and cultural compatible and it is managed through legal means or other effective means.

In global terms, Nigeria's experience with the establishment of National Parks is a recent development. It began in 1979 when the first Obasanjo administration promulgated Decree 46 of 1979 (later act 46 of 1979) and declared the Kainji Lake Game Reserve, a National Park (Lawan, 2002).

Apart from acting as vehicle for development of ecotourism, National Parks enhance ecological processes and life support systems such as soil regeneration, protection of nutrient cycles, cleansing and purifying hydrological cycle (IUCN, 2004). They also protect the environment and the indigenous genetic resources, which are the basis of any meaningful improvement in agricultural development or production. National

Parks also play a significant role in science, research and educational development, agriculture, medicine, psychology and spiritualism (Lawan, 2002).

A comprehensive understanding of the dynamics of a fish population is an important management tool for the sustainable exploitation of any fisheries resource. Thus, biological surveys of fish species composition and abundance are regular features in the management of fisheries (Peter, 1969).

The fish fauna of Nigerian freshwater systems has been the focus of many studies, such as those of Banks *et al.* (1966), Reed *et al.* (1967), Awachie (1976), Ita *et al.* (1982), Welman (1984), Akinyemi *et al.* (1985), Ita and Pandogari (1987), Chidi (1993), Balogun (2005) and Ibrahim *et al.* (2009).

1.2 Statement of Research Problem

Before initiating any fisheries development and management programme, it is desirable to have an idea of what fishes are available; their names, habits and habitat, edibility, suitability for processing and preservation, as well as their abundance (Reed *et al.*, 1967).

Data of fish that occur in the different inland water bodies of Nigeria are fragmentary and limited; an inventory of fish species in the Dogon Ruwa water body of Kamuku National Park is desirable for effective management and development. Thus, the need to conduct ichthyofauna surveys of the small water bodies is essential in order to determine productivity potential and fish distribution for proper management.

1.3 Justification

Being a protected area since 1936 where fishing activities are not allowed, it is desirable to know the status of the fish population and the ecology of Dogon Ruwa water body.

Comprehensive survey to assess the stock and biodiversity of fish species in the water body is essential. The data to be generated from the surveys will be useful in formulating strategies for the conservation, management and sustainable exploitation of these aquatic resources.

No survey of fish in Dogon Ruwa water body of Kamuku National Park has been carried out. The information gathered in this survey will be useful in the development of management strategies for fish in the water body.

1.4 Aim of The Study

To document information on fish species diversity and abundance in Dogon Ruwa water body of Kamuku National Park.

1.5 Objectives of The Study

1. To determine the composition and the relative abundance of fish species in Dogon Ruwa water body of Kamuku National Park.
2. To determine the length-weight relationship and condition factor of the fish species in Dogon Ruwa water body.
3. To determine the water quality and relate it to the fish species abundance.

1.6 Research Hypotheses

1. Dogon Ruwa water body of Kamuku National Park is not rich in fish species and there are no significant differences in the numbers of each fish species.
2. There are no significant differences in length-weight of fish species in Dogon Ruwa water body of Kamuku National park.
3. The Water quality of Dogon Ruwa water body of Kamuku National Park has negative impact on the abundance fish species.
4.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Fish Species Diversity

A review of the Nigerian fish fauna reveals that there are about 511 fish families in Nigeria (Ita, 1993). About 34% of these species are restricted to exclusive economic zone (EEZ) while approximately 44% are freshwater fisheries inhabiting water of very low salinity (below 1 part per thousand or conductivity of 1000µs/cm). The occurrence of *Potamotrygeon garouensis* in the waters of Northern Nigeria (Reed *et al.*, 1967) and River Ase in Delta State of Nigeria (Idodo-Umeh, 2003) are of scientific interest because *P. garouensis* (Dasyatidae) occur in both brackish and fresh waters, this is unique and require protection.

The most important fishes in terms of species diversity are the teleosts (Young 1962; Parker and Haswell, 1964). Among the Carangidae, only *Trachinotus goreens* is a marine species that has been reported in southern freshwaters in Lekki lagoon (Nwadiaro, 1984; Ikusemiju and Olaniyan, 1997). This species appear to be restricted in distribution and need to be protected.

The Mudskipper, *Periopthalmus papillio* (Periopthalmidae) is a fish of great biological and evolutionary significance. The continued existence of this fish is seriously threatened by pollution from oil spills and land reclamation exercise especially in the mangrove and Lagos Lagoon beaches (Ikusemiju and Olaniyan, 1997).

2.1.1 Inland freshwater fish species diversity

Banks *et al.* (1967) identified and described about 139 species of fish in River Niger within the then proposed Kainji Reservoir Basin. Reed *et al*. (1967) reported about 160 species within the then Northern Region of Nigeria. Since then, numerous studies have been undertaken on Lake Kainji and other freshwater bodies leading to the description of many species (Chude, 1979; Ita, 1987). According to Obasohan and Oronsaye (2006), Welman (1984) identified 181 species of fish from the major river systems and Lakes of Nigeria, including some estuarine and marine fish species which are frequent in the rivers. There are at least eighteen species which are endangered. A drastic decline has been observed among the larger species such as *Gymnarchus niloticus, Lates niloticus, Heterobranchus bidorsalis* and *Protopterus annectens* (Ita, 1993).

2.1.2 Inland fishery resources of Nigeria

Some fish species diversity data have been recorded for Nigeria water bodies, these include:

Oguta Lake. This lake is in Imo State, it is supplied with water by the River Njoba. The lake flows into the River Orashi, a tributary of the lower Niger. A total of about 40 species has been recorded in the lake.

Lake Ndakolowo. Located downstream of Jebba Reservoir, this is a floodplain lake of the Niger River. The lake had a surface area of about 9 km^2 which was reduced to about 3 km^2 after the damming of the Niger at Kainji and Jebba. The surface area continued to shrink until the whole lake area was covered with marsh plants and with no visible open water. The National Institute for Freshwater Fisheries Research conducted a survey in 1978 to identify the inlet and outlet of the lake with a view to

recharging the lake by excavating a channel at its natural inlet. The recommendations of this survey (Ita and Mohammed, 1979) were implemented in 1988 by the Institute and the lake was refilled to give open water extending over 3 km^2. The species diversity recovered from about 9 to 25 species after refilling.

Lake Chad. This is one of the most intensively studied natural lakes in Nigeria. A total of about 80 species of fish were recorded in the lake and the inflowing rivers by Hopson (1967). Since then, the lake has been seriously affected by the Sahelian drought of the early seventies and eighties leading to a drastic decline in fish species diversity. The Yobe River, which used to be the main source of water for flooding the lake along the Nigerian sector, is now broken up into extensive wetland marshes.

A survey conducted in 1985 revealed a total of 19 species (Bukar and Gubio, 1985). This was regarded as an improvement over the previous years when the lake was virtually reduced to a mass of highly vegetated wetland swamps with the number of species recorded reduced to about ten.

Hadejia/Nguru Wetland. This is a most extensive wetland area in the northern part of the country and it recently gained International recognition on account of the regular presence of migrant birds. It is estimated to have once covered about 2,000 to 3,000 km^2, between 1964 and 1971 over 2,000 km^2 of flooding occurred. However, from 1983 less than 900 km^2 has been flooded and even less than 300 km^2 were flooded in the drought year of 1984 (Adams and Hollis, 1987). In addition to drought, it is estimated that the damming of the Kano River at Tiga has caused a reduction of about 350 km^2 in the surface area of the wetland. This decreased flooding has resulted in a consequent decrease in fish species diversity within the wetland. Although, no pre-drought investigations were carried out in Tiga, the fish diversity figure (46

species) supplied in Tobor (1973) for the lower Yobe River is regarded as the most likely situation prior to the drought and completion of the Tiga dam.

Matthes (1990) records over 40 species for these wetlands, excluding about 30 unidentified species. This shows that, in spite of the intensive exploitation of the wetland fisheries, a comparatively high diversity has been sustained. The majority of the species identified are of little or no economic importance on account of their small sizes, such as some small mormyrids and cyprinids which are not usually trapped by fishermen's gear.

A drastic decline has been observed among the larger species such as *Lates, Gymnarchus, Heterotis*, and *Heterobranchus,* although not to the point of extinction. The wetlands appear to be the last hope for the conservation of river fishes. The Hadejia Nguru wetland is unique in this regard and therefore requires special attention in view of the deplorable impact of drought on Lake Chad.

The checklist produced in White (1965) covers the upper Niger within the then proposed Kainji Lake Basin and lists about 145 species. Species in the Anambra, Kaduna and Sokoto/Rima, major tributaries of the Niger are low in diversity as would be expected to be more than the 23, 28 and 22 species respectively, compared with the major investigations of White (1965) and Reed *et al.* (1967) which were funded internationally, the duration and extent of investigations by National Institutions are usually limited by inadequate funding. The same constraints also limited the investigations into the Cross River, and rivers Ogun and Oshun with 39, 23 and 23 species, respectively. In most cases, the identification of species was limited to genus.

Kainji Lake. This Lake tops the list with a total of 101 species followed by Jebba with 52 species. The high diversity index recorded for Kainji Lake is not unconnected with the intensity of investigations conducted in the lake since 1969.

Jebba Lake. It extends from the outflow of Kainji Lake for about 100 km to the dam, it is expected to harbour as many species as Kainji Lake if not more. However, on account of the paucity of investigations conducted on this reservoir, only about half the numbers of species in Kainji Lake have been documented for Jebba Lake.

Although Kainji Lake still retains some riverine features along its northern arm, a reduction in species diversity was recorded after impoundment from over 120 species to about 97 species. This was to be expected in view of the reduction in the flow rate that favoured the behaviour of most cyprinids and cyprinodonts. Some mormyrids disappeared soon after impoundment, but were later identified along some of the inflowing rivers.

The low species diversity in the other smaller reservoirs can be attributed partly to the fact that the dams are located nearer to the tributary river sources than to the confluences of the main rivers. Such areas are characterized by the rapids and rocky terrain preferred by a limited number of freshwater species.

In all, a total of 108 fish species have so far been recorded within the Nigerian natural lakes and wetlands (Ita, 1993), check lists fishes of Nigerian reservoirs is scanty. The fish species in the few reservoirs that have been surveyed total about 104. Of these, 101 species were recorded in Kainji Lake, while 52 species were recorded in Jebba Lake (Ita, 1993). Other reservoirs with fish species diversity recorded include Ikpoba Reservoir with 27 species, Shiroro Lake with 27 species (Ita, 1993).

2.1.3 List of endangered freshwater fishes in Nigeria

Table 2.1: Some of the endangered freshwater fishes in Nigerian waters as compiled by Egborge (1992)

S/No	Family	Species	Water-body
1.	Albulidae	*Albula vulpes*	Warri River
2.	Amphillidae	*Phractura clauseni*	Ogun River
3.	Carangidae	*Trachinotus goreensis*	Niger/Benue
4.	Centropomidae	*Lates niloticus*	widespread
5.	Cromerridae	*Cromeria nilotica*	Niger/Benue
6.	Gymnaichidae	*Gymnarchus niloticus*	widespread
7.	Hepsetidae	*Hepsetus odoe*	Widespread
8.	Lepidosirenidae	*Protopterus annectens*	Fair distribution
9.	Lutjanidae	*Lutjanus* sp.	River Cross
10.	Mastacembelidae	M*astacembelus loennbergii*	Fair distribution
11.	Malapteruridae	*Malapterurus electricus*	Widespread
12.	Polycentridae	*Polycentropsis abbreviata*	Fair distribution
13.	Ophiocephalidae	*Paraophiocephalus africana*	Oguta Lake
14.	Osteoglossidae	*Heterotis niloticus*	Widespread
15.	Pantodoltidae	*Pabtodon butcholzi*	Fair distribution
16.	Phracholaemidae	*Phratoleamus ansorgei*	Fair Distribution
17.	Synbranchidae	*Synbranchus afer*	Ethiope River
18.	Trigonidae	*Trigon margrarita*	Epe (Lagos) Lagoon
19.	Pristidae	*Pristis perrottetis*	Niger/Benue
20.	Trigonidae	*Potamotrygon garouensis*	Niger/Benue
21.	Monodactylidae	M*onodactylus sebae*	Niger/Benue

Source: Egborge (1992)

2.2 Problems of Aquatic Conservation

2.2.1 Sustainability of fishery resources

Many species within the families Mochokidae and Cyprinidae have restricted distribution and need to be protected (Egborge, 1992). Mochokids that are restricted to water bodies in northern Nigeria are *Chiloglanis micropogon, C. niloticus, Mochocus niloticus,* and *Synodontis xiphias* (Gunther) (Reed *et al.,* 1967). These species are considered endangered and require protection. The polypteridae is represented by five species in Nigerian freshwaters. These fishes are of evolutionary importance as they represent the chondrostean fishes that are characterized by internal skeleton of cartilage-bone, a body cover with ganoid scales and a dorsal fin divided into 8-14 finlets. These ancient fishes are believed to be derived from the placoderms in the Devonian period, 400 million years ago. The five species prevalent in Nigerian freshwaters, which are considered endangered according to Egborge (1992) and need to be protected are: *Polypterus birchir*, *Polypterus lapradei*, *Polypterus ansorgii*, *Polypterus senegalus senegalus* and *Erpetoichthys calabaricus*.

The fish diversity of the major inland freshwater bodies has been identified with special emphasis on potentially endangered species. The issue pertaining to the rational management and conservation of this important fisheries subsector for sustainability has only recently been highlighted. Economic activities in the sector have been unregulated and therefore haphazard with adverse consequences on the ichthyofauna especially the biological important endemic species. Though most Nigerian states have fisheries decree, but, these laws and regulations are not effectively enforced (Obasohan and Oronsaye, 2006). To harmonize the initiatives of the states and allow for uniform control and protection of the Nigerian Inland Fisheries, the Federal Government promulgated the Inland Fisheries Decree (now

Act) of 1992. Despite these efforts, impact of management on inland fisheries for protection of endangered fish species and sustainable fisheries development has been negligible. A number of problems account for this.

2.3 Problems of Fishery Resources

The problems of sustaining inland fisheries resources in Nigeria can be categorized as both human and natural. The human problems of inland fisheries' sustainability can be viewed from the perspectives of policy implementation, auditing and sampling, analysis and taxonomy, management, pollution and land reclamations (Asiwaju, 2011), Policy: investigations of inland fisheries in Nigeria including those of wetlands come under the mandate of the Nigerian Institute for Freshwater Fisheries Research (NIFFR).

There are usually no laws and regulations controlling the exploitation of the fisheries of most African inland waters. Even where such laws and regulations (such as registration and licensing of fishermen, mesh size regulation, gear size regulation, prohibition of the use of poison and explosives, fishing with electricity as well as closed season and area) exist, they are not often enforced (Asiwaju, 2011).

In Nigeria, the management of inland waters is regarded as the exclusive responsibility of the States to which such water bodies belong. Whereas there is a Sea Fisheries Decrees Act of 1971, as well as the relevant Fishery Regulations and the Exclusive Economic Zone (EEZ) Decree of 1978, which enable the Federal Government to control, regulate and protect the sea fisheries resources.

Although it could be argued that these waters are within State boundaries and should therefore be subjected to State Legislation, the waters usually traverse more than one

State. Apart from the fact that fish do not respect State boundaries, migratory fish often enter channels which pass through more than one State. Consequently, action or lack of action by one State can have a profound effect on the fishery resources and fishing in another State. In addition, migrant fishermen often cross State boundaries using unlawful methods to capture fish, and the dumping of poisonous products or industrial wastes in one State, which does not give priority to fisheries, can lead to mass destruction of valuable fishery resources downstream in another State where fishing may be of high priority.

Drought and predation are two outstanding natural problems. Bukar and Gubio (1985) reported ichthyofauna biodiversity changes, resulting from drought in Lake Chad, Nigeria and noted that the reduction in Lake water level resulted in increased temperatures, nutrients, carbon dioxide, hydrogen sulphide, pH, dissolved oxygen, competition, death and decomposition. Some of the lake fish's species were succeeded by *Clarias gariepinus*.

Predation was a serious biodiversity problem as the food web involved various taxa. Olatunde (1977) reported that the populations of *Eutropius niloticus* and *Schilbe mystus*, two important fish species in Lake Kainji, were preyed upon by the Nile perch (*Lates nilotcus).*

Other problems of fish resources are:

- Competing/Conflicting Interests.
- Escape: Offshore aquaculture of finfish uses cages or pens.
- Growing Exotic/Mutated Species.
- Growing Genetically Modified/Transgenic Organisms (GMOs).

- Habitat Impacts.
- Human Health Concerns: Farm-raised fish contain higher levels of chemical pollutants than wild fish, including poly chlorinated biphenyls (PCBs).
- Water Pollution: Water flowing out of an aquaculture facility can carry excessive nutrients, particulates, bacteria, other diseased organisms and polluting chemicals.

2.4 Reproductive Biology of Fish

The perpetuation and evolution of species is dependent upon reproduction, the success of which depends on resource allocation and the location and the timing of reproduction defined by the reproductive strategy of the species (Lagler *et al*., 1977; Wootton, 1990). Reproductive strategies are shaped largely by the abiotic environment, food availability, presence of predators and the habitat of parental fish (Lowe-McConnell, 1987; Wootton, 1990). Fecundity is defined as the number of ripe eggs prior to spawning; it varies intra-specifically and inter-specifically, and it is a function of somatic weight or body length (Bagenal, 1978; Lowe-McConnell, 1987; Wootton, 1990).

Total or single spawners produce a large number of small eggs which are deposited over a short period, while batch or multiple spawners produce fewer and larger eggs and have a longer breeding period which may last throughout the year; only a proportion of the eggs ripe in the gonad at any one spawning (Ekanem, 2000). Ekanem (2000) had suggested that multiple spawning is an adaptive response to fluctuation in water level. Wootton (1990) noted that acidic water, abrupt change in water level and pollutants may reduce fecundity in both kinds of spawners.

King (1997) studied weight fecundity relationships of Clariidae, Cyprinidae, Mormyridae, Characidae, Schilbeidae and Mochokidae and found that as the maximum body weight of fish increased, the number of eggs produced per gram also increased. King remarked that this could be linked to the fact that fish continued to grow after fecundity had stabilized. Ekanem (2000) reported variation in egg size even among individuals of the same length and attributed differences to individual ovulation time and the stage of egg development.

The gonado-somatic index (GSI) is the measure of the relative weight of the gonad to total or somatic weight of fish (Welcome, 1985; Wootton, 1990; King, 1995). Total spawners- fish that releases one batch of eggs per breeding season e.g brown trout have higher GSI than batch spawners- fish that releases multiple batches of eggs per breeding season (Wootton, 1990). Ikomi (1996) reported that there were fluctuations in GSI value of the mormyrid *Brienimyrus longianalis*, as a result of the quality of gonad maturation. The GSI values Ikomi (1996) obtained were higher in fish with standard length range of 6.5cm – 8.8cm than these with standard length of 5.1cm - 8.8cm.

Ikomi and Odum (1998) reported some aspects of the ecology of the catfish (*Chrysichthys auratus*). They observed that male: female ratio of 1: 0.98 was not significantly different from the expected ratio of 1:1. The fecundity estimate varied with size of fish and the average number of eggs in ripe ovary ranged from 260 to 620 for fish with total length range of 10.2cm to 14.0cm. Oniye *et al*. (2006) recorded a male to female ratio of 1:1.09 in *Protopterus annectens* examined from Jachi reservoir in Katsina State.

2.5 Condition factor ('K')

The condition factor in fish serves as an indicator of physiological state of the fish in relation to its welfare (Le Cren, 1951) and also provides information when comparing two populations living in certain feeding density, climate and other conditions (Weatherly and Gills, 1987). Thus, condition factor is important in understanding the life cycle of fish species and it contributes to adequate management of these species, hence, maintaining the equilibrium in the ecosystem (Imam *et al*., 2010).

Condition factors of different populations of the same species give some information about food supply, timing and duration of breeding, and can also be used in assessing well-being of fish (Weatherly and Rogers, 1987). In a study of some reproductive aspects of *Chrysichthys nigrodigitatus* from Cross River, Nigeria, Ekanem (2000) found that the condition factor of population varied from 0.24 to 1.34, with 0.977 as the mean; 52.8% had values higher than the mean and 47% had condition factor above unity, and noted that the smaller fishes were more efficient in finding food than the bigger ones.

Ikomi and Odum (1998) observed a monthly variation in the condition factor (K) of *Chrysichthys auratus*, which was higher in the wet than in the dry season, and appeared to be influenced by the rainfall regime and effective utilization of the rich resources of the rainy season. Ikomi and Odun (1998) concluded that increase in the K-value of both male and female fish was attributable to conservation of stored energy and increasing weight of maturing gonads and also that the condition factor of 1.51 they obtained, showed that the fish was in good condition throughout the study period and attributed it to favourable environmental condition, especially availability of food.

The value of 'K' is influenced by age of fish, sex, season, stage of maturation, fullness of gut, type of food consumed, amount of fat reserve and degree of muscular development. In some fish species, the gonads may weigh up to 15% or more of total body weight. With females, the **K** value will decrease rapidly when the eggs are shed (Charles and Alan, 1998). They established condition factor (K) value for trout and salmon with their status as follows:

K value	Status
1.60	**Excellent** condition, trophy class fish.
1.40	A **good**, well proportioned fish.
1.20	A **fair** fish, acceptable to many anglers.
1.00	A **poor** fish, long and thin.
0.80	**Extremely poor** fish, resembling a barracouta with big head and narrow thin body.

2.6 Length-Weight Relationship

Knowledge of some quantitative aspects such as length-weight relationship is important in studying fish biology. Length-weight relationships can be used to predict weight from length measurements made in the yield assessment (Pauly, 1993). Fish can attain either isometric growth, negative allometric growth or positive allometric growth. Isometric growth is associated with no change of body shape as an organism grows. Negative allometric growth implies the fish becomes more slender as it increase in weight while positive allometric growth implies the fish comes relatively stouter or deeper-bodied as it increases in length (Riedel *et al*., 2007).

Oniye *et al.* (2006) reported that the length-weight relationship of *Protopterus annectens* in Jachi Dam, Katsina State, showed positive correlation (r=0.85) in both

sexes, indicating an increase in weight as length increased. The regression exponent (b□ 3) for both sexes showed allometric growth. Thomas *et al*. (2003) stated that the isometric value of b=3 was for an ideal fish that maintained a three dimensional equality. Fafioye and Oluajo (2005) reported a mean b value of 3.0072 for *Clarias gariepinus, Illisha Africana, Chrysichthys nigrodigitatus, Chrysichthys walkeri* and *Ethmalosa fimbriata* in Epe Lagoon, Lagos; this showed a nearly isometric relationship with 60% of the variation in body weight being accounted for by changes in length of the fish.

Ogbe *et al.* (2006) reported a b value of 3.92 for *Bagrus bayad* from the lower Benue River which showed that the fish weight increased allometrically. When the b-value is □ 3, a fish has negative allometric growth, and when it is □ 3 it has positive allometric growth (Khaironizam and Norma-Rashid, 2002).

2.7 Relative Species Abundance

Relative abundance refers to how common or rare a species is, relative to other species in a given location or community (Hubell, 2001; McGill *et al*., 2007). Relative species abundance and species richness describe key elements of biodiversity (Hubell, 2001).

The relative abundance is calculated as the number of organisms of a particular kind as a percentage of the total number of organisms of a given area or community; the number of fish of a particular species as a percentage of the total fish population of a given area (Krohne, 2001).

2.8 Water Quality Parameters

Fish and other aquatic organisms such as shrimps and crayfish are known to be very rich in protein and the need to cultivate them in clean water is desired. The complexity of aquaculture system requires that water quality parameters such as temperature, pH, ammonia and dissolved oxygen (DO) be monitored (Olurin and Aderibigbe, 2006). The productivity of a given body of water is determined by its physical, chemical and biological properties; therefore environmental properties of water need to be conducive for fish to survive and grow well.

2.8.1 Temperature

Water temperature is one of the major environmental factors that affect and control food utilization at all levels and stages of fish growth (Dupree and Hunner, 1993). Fish are poikilothermic and water plays an important role in their feeding as it affects their metabolic activities, feeding potential, growth, reproduction and efficiency of food conversion (Dupree and Hunner, 1993; Martinez-Placios *et al.*, 1993). Dupree and Hunner (1993); Martinez-Placious *et al.,* 1993 suggested temperature range of 20ºC to 30ºC for fish, while the lethal levels are from less than 2ºC and higher than 42ºC for tropical fishes but cold water fishes can survive a temperature range of 5ºC-15ºC.

Temperature has a pronounced effect on the rate of chemical and biological processes in water; for instance, fish require twice oxygen at 30ºC than at 20ºC (Adeniji and Ovie, 1990). It is recommended that fish in the tropics be kept in water whose temperature range is between 25ºC and 30ºC (Auta, 1993). Sudden increase in temperature will stress or kill fish (Adeniji and Ovie, 1990).

Temperature affects the dominance and distribution of phytoplankton in water as it influences the growth rate and mortality of zooplankton and other organisms (Orchutt

and Porter, 1983). Temperature influences other factors such as Dissolved Oxygen and may affect organisms to varying degrees, depending on their sensitivity (Countant, 1987). The physiology of aquatic organisms is such that they can tolerate only narrow ranges of temperatures, outside which they cannot function normally (Willoughby, 1976; Orchutt and Porter, 1983).

2.8.2 Dissolved oxygen (DO)

Dissolved oxygen is very essential to life in aquatic environment as it affects the physiology and distribution of the aquatic organisms. Nearly all aquatic organisms, with the exception of some bacteria, must have oxygen to survive and most of these organisms must extract their oxygen from water. The two main sources of oxygen into the aquatic environment are the atmosphere and photosynthetic activities of aquatic plants. The ideal range of dissolved oxygen in water which must be at least 5mg/l is required to sustain fish and other aquatic life (Kutty, 1968).

Insufficient dissolved oxygen (DO) in a water system causes/results in anaerobic decomposition of organic material thereby leading to the production of obnoxious gases such as carbon dioxide, hydrogen sulphide and methane which bubble to the surface.

Kutty (1968) reported that Atlantic salmon stopped swimming when dissolved oxygen concentration remained below 5ppm, but that goldfish, Tilapia and carp swim at oxygen levels of 1-2 ppm. Inadequate dissolved oxygen has many effects on fish such as reduced feeding leading to impaired growth, which results in fish becoming more susceptible to disease. Cold water fish require large amounts of dissolved oxygen, while warm water fish are able to survive with low oxygen content.

2.8.3 Hydrogen-ion concentration (pH)

The hydrogen-ion concentration (pH) of any water is the measurement of the acidity or alkalinity of that water body. It is usually measured on a scale of 0-14 with 7 being neutral (Branco and Senna, 1996). The effects of pH on the chemical, biological and physical properties of a water system makes its study very crucial to the lives of the organisms in the medium. Freshwater with a pH of 6.5-9.0 is known to be productive and recommended as suitable for fish culture (Adeniji, 1986; Auta, 1993).

Increase in acidity and alkalinity of any water body may increase or decrease the toxicity of that water. Solar radiation and temperature accelerates photosynthesis, which in turn increase carbon dioxide's absorption, altering the Bicarbonate equilibrium and producing hydroxide (OH^-) thus raising the pH (Branco and Senna, 1996).

Hynes (1974) observed that pH values of below 5 or above 9 were harmful to most aquatic animals. Chronic pH levels may reduce fish reproduction and are associated with fish die-offs (Stone and Thomforde, 2006). Adeniji and Ovie (1990) reported that acid and alkaline death points are approximately at pH 4 and 11 respectively.

2.8.4 Total dissolved solids (TDS)

Total Dissolved Solids (TDS) are the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water, expressed in units of mg per unit volume of water (mg/L), also referred to as parts per million (ppm). TDS is directly related to the purity of water and the quality of water purification systems and affects everything that consumes, lives in or uses water, whether organic or inorganic, either for better or for worse (Murphy, 2009). When some of these substances are in suspension, they cause turbidity in the water thus reducing

photosynthesis and the amount of dissolved oxygen, which in turn affect the feeding of aquatic organisms that depend on sight to catch prey.

A certain level of TDS in water is necessary for aquatic life (Stone and Thomforde, 2006). TDS is one of the parameters used in measuring the fitness factor of fish and as a general measure of edaphic relationship that contributes to productivity within a water body (Ryder, 1965).

2.8.5 Electrical conductivity (EC)

Electrical conductivity is the ability of a water body to receive and conduct electrical current correlating with its salt content. It is an indicator of the type and number of ions present or dissolved in water or in solution, which are almost proportional to the amount of dissolved matter.

Freshwater fish thrive over a wide range of electrical conductivity. The desirable range is 100-2,000µSi/cm and the acceptable range is 30-5,000µSi/cm (Stone and Thomforde, 2006). The estimation of total ion in matter in a solution or water bodies is related to its fertility, and the electrical conductivity and mean depth of a reservoir could be used to calculate the potential fish yield of a lake (Ryder *et al.,* 1974). High conductivity is an indication of the presence of large amount of dissolved salts, while at low level major ions may be determined by the nature of the fauna (Moss, 1993).

2.9 Fish Species Composition of Some Nigeria Water Bodies

In Nigeria, there is a total of 137,802 hectares of existing lakes and reservoirs (Ita *et al*., 1985). These were created mainly for the generation of hydro-electric power and supply of irrigational and potable waters. Unfortunately, little attention is paid to the fishery potential of these lakes, but some of these lakes are capable of supplying good

fish (Peter, 1994). Lowe-McConnell (1987) reported that construction of dams usually created ecological regimes which have an impact on the existing biota.

The work of Adeosun *et al*. (2011) on Ikere Gorge, which is a man-made lake constructed on the River Ogun, eight kilometers East of Ikere village and thirty kilometers North East of Iseyin in Oyo State, Nigeria (Adeosun *et al*., 2011). Adeosun *et al*. (2011) reported that the preponderance of cichlids in Ikere Gorge could be attributed to their ability to thrive on a wide variety of foods and provision of suitable breeding and shelter ground provided by colonization of the banks with green plants. With the impoundment of water in the reservoir in 1992, some villages, namely Alagbon, Olaibi and Alagbede with some 150-farm families upstream of the dam were reportedly displaced and resettled at the upstream of Ikere Gorge. Ikere River takes its source from Northeast of Iseyin to the East of Ikere, and joins Ogun River some 14km upstream of Ikere after impoundment.

As at 31 December 1997, the civil works on the dam were 99.5% completed while construction works and the Mechanical and Electrical (M & E) component stood at 90% completion stage (Ogun-Oshun River Basin Development Authority, 1997).

Lates niloticus commonly known as Niger/Nile Perch was endemic to Ikere River before its impoundment and it successfully established itself throughout Ikere Gorge after impoundment (Adeosun *et al*., 2011).

The first documented survey of the fish population of the stretch of the Niger was conducted during the low water period between July and September 1965 (Holden and McConnell, 1965; Banks *et al*., 1966). Banks *et al.* (1966) noted that the Mormyridae was the most abundant family followed by Mochokidae, Citharinidae and Schilbeidae before the Lake was formed (Otobo, 1995). The Mormyridae made

up 35% by number of the total gillnet catch for the year 1965. The next in abundance were Mochokidae (30%), Citharinidae (16%) and Schilbeidae (6.8%). No other family made up more than 5% by number of the total catch (Banks *et al*., 1966).

A survey of fish catches made from fishermen in the Bussa-Yelwa stretch of the Niger River one year later in August 1966 (Motwani and Kanwai, 1970) showed that the Mochokidae, instead of the Mormyridae as was the case in 1965, was most abundant family commercially, followed in order of importance by Mormyridae, Cichlidae, Citharinidae, Polypteridae and Characidae.

Early in 1966, part of the western channel of the Niger around the Kainji Island was dammed, resulting in the formation of a small Lake that measured approximately 1.7km in length with a maximum width of 170m, and a surface area of about 180,000m^2. Later in the same year, this Coffeor dammed Lake was drained, and existed fish population captured and examined (Motwani and Kanwai, 1970). The composition of the fish population of this small Lake was typical of most of the deep rocky reaches of the river in the vicinity and therefore gives an indication of the relative abundance of the different families and species in at least part of the stretch of the Niger now covered by the Lake Kainji (Lewis, 1974). Numerically, the fish population of the Coffeor dammed channel was dominated by the Characidae, which comprised 36.3% of the the total catch. However, numerous small species of *Alestes baremose* (Joannis), *Alestes dentex* (Cuvier and Valenciennes) and *Alestes leuciscus* (Gunther) contributed to this figure and in terms of weight, the Characidae accounted for only 12.2% of the catch (Banks *et al*., 1966).

Mormyridae made up the greatest part of the catch by weight (19.5%) (20.7% by number) followed by Citharinidae (18.9% by weight and 6.12% by number) and the

Bagridae (18.2% by weight and 7.2% by number). It therefore appears that the fish population of the part of the Niger which is now submerged by Lake Kainji was dominated by the families Mormyridae and Mochokidae in the lower parts of the river and in swamps, the Cichlidae and Citharinidae were also considered to be of importance (Banks *et al.*, 1966; Motwani and Kanwai, 1970).

After the commissioning of the dam, Lelek (1972) sampled the fish of the then newly formed Lake from June 1969 through 1970 to May, 1971. Fishes were captured in fleets of floating gill-nets with meshes ranging from 2 inches to 7 inches, from 18 stations distributed throughout the lake and covering the majority of the habitat type. The percentage composition by weight and number made up by the major families in 1969 and 1970 showed that in 1969, a profound change in the composition of fish stock took place as a result of the closure of the dam. For example, Mormyridae, which dominated the catches from the river, had fallen to a significant 0.5% by weight and 1.0% by number of the 1969 experimental gill-nets' catch, the dominant family became the Citharinidae, which during 1969 made up 23.1% by weight (Lelek, 1972).

Other notable changes were an increase in the relative abundance and percentage by weight of the Characidae and Centropomidae which included the important predators like *Hydrocynus* spp. and *Lates niloticus.* There was a decline in the relative abundance of the Mochokidae (Lelek, 1972). Lelek's figures for the composition of the 1970 gill-net catch were rather different from the 1969 figures, suggesting that changes in the relative abundance of the major families had continued through the second year of the Lake's formation. The most notable changes were the dramatic increase in the Citharinidae and a spectacular increase in abundance of the Characidae (Lelek, 1972).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Kamuku National Park lies between 10°40' and 11°50' north, 6°12′ and 6°36′East. It is situated 120km west of Kaduna and north-west of Birnin-Gwari and is contiguous with Kuyambana Game Reserve in Zamfara State in the North and Kogo Forest Reserve in Katsina State to the East. It also shares boundary with Kontagora Emirates of Niger State (Figure 3.1). It has an area of about 1121km^2 (Lawan, 2002).

The park has an average annual rainfall of 1,250mm with an average temperature of 30°C. It is influenced by the dry season (November to April) and rainy season (May to October). The hottest months are March and April, while the coldest months are December and January, during the harmattan period when the temperature drops to freezing point in the evening and morning. The vegetation is guinea savanna with some traditional Sudan savanna elements in places (Lawan, 2002).

Dogon Ruwa Waterfall is one of the major natural features of Kamuku National Park; it is located at the northern end of the Park, along the Birnin Gwari-Funtua Road. The fall takes its source from two water bodies, one from Birnin Gwari and the other from the old Gugama stream. The two sources join at Kurazo village and flow directly to the Park (the length of the water body is 90 meters, its width 40 meters, while is depth is 9 meters during the dry season, in rainy season, the water body runs through the park of 420m in length, 120m in width and the depth is 30m). The fall is scenic and usually very attractive during dry season; it serves as a camping site for tourists, and used for educational purposes (Lawan, 2002), Dogon Ruwa waterfall is a seasonal waterfall (July - October), spreading over many strata of polished rock before being

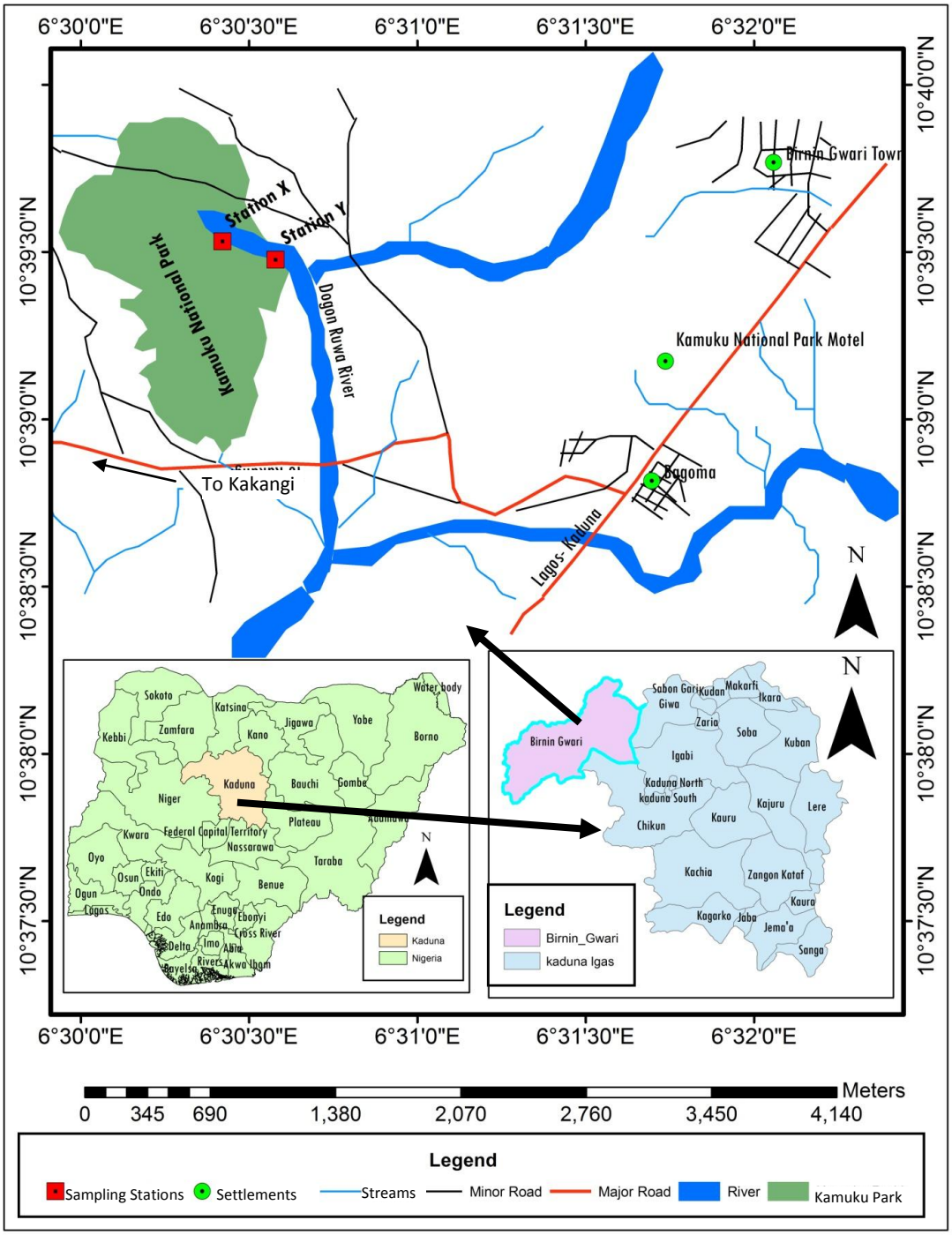


Figure 3.1: Map of Kamuku National Park

Source: Satellite Image (2015). From the Department of Geography, Ahmadu Bello University, Zaria

deposited into a gorge several metres down depicting a naturally occurring igneous rock formation that spans over four hectares.

3.2 Experimental Gill Net Sampling

Two sampling Stations (X and Y) were selected along the length of the river; these stations were chosen on the basis of accessibility, high presence of fish and low water current. Station X is closer to the fall, deeper and the water current is faster than in Station Y, the distance between the two stations was 40m. A fleet of experimental gill nets made up of nine multifilament nets of 210d/1" (2.5cm), 210d/1.5" (3.75cm), 210d/2" (5.0cm), 210d/3" (7.5cm), 210d/3.5" (8.75cm), 210d/4" (10.0cm), 210d/5" (12.5cm), 210d/6" (15.0cm), and 210d/7" (17.5cm) with 210/3 twine used for the first eight meshes and 210/6 for the 17.5cm stretched meshes were used across the length of the water body according to Mustapha (2003) and Komolafe and Arawomo (2008). Each net measured 30m long and 3m deep and formed a curtain of netting hanging vertically in the water, with floats attached to the top and sinkers fixed to the bottom to keep the net in its position. The fleet of nets was 810m^2 in total area.

The nets were set with the help of a staff of National Park (Amidu Alhassan- which was one time a fisherman) at Station X in the evening hours between 4p.m and 6p.m, checked in the morning between 6a.m and 9a.m. and fish caught removed and recorded. The nets were reset the same morning at Station X and checked in the evening between the hours of 4p.m and 6p.m. The fish caught were removed and recorded. The same nets were thereafter taken to Station Y the same evening and set, then checked the following morning between 6a.m and 9a.m. Any fish caught were removed and recorded. The same routine was followed as for Station X, following Mustapha (2003) and Komolafe and Arawomo (2008). The water body was sampled

twice monthly (every other week) in the same manner from April, 2013 to March, 2014 as follows: wet season (May to October) and dry season (November to April). Fishes caught at each time of sampling were separated by mesh size and later transported in plastic bowl with open tops, (the containers were filled with water to 50% of its volume, to keep the fish alive) to Kamuku National Park office (which was used as laboratory) for length and weight measurements as described by Turner (1970) and Lelek (1972).

3.3 Collection and Identification of Fish

The fish caught in each net were removed and transferred into large separate labelled plastic bowls, according to species and mesh size. The following morphometric characteristics of each fish were taken: total fish weight measured to nearest 0.1g using weighing balance (Hanna mechanical spring measuring scale- 20kg capacity), standard length (SL) from the snout to the point of attachment of the caudal rays and the hypural bones, and total length (TL) from the tip of the snout to the tip of the longest lobe of the caudal fin using a measuring board. Fish were collected bimonthly (every other week) from the months of April 2013 to March 2014. The total number of individual fish species caught from the water body was recorded; this enabled the determination of the relative abundance of the various fish species in the water body.

Fish were identified using guide/hand books by Reed *et al*. (1967); Idodo-Umeh (2003); Olaosebikan and Raji (1998) and Froese and Pauly (2015). Sex of fish was determined by visual observation according to Offem *et al.* (2008).

3.4 Length-Weight Relationship

The analysis of length-weight data is aimed at describing mathematically the relationship between length and weight to enable conversion of one to another. It also

measures the variation from the expected weight for length of individual fish. The L-W relationship was analyzed by using the equation $W= aL^b$ (Pauly, 1983).

Where:

L= Length of fish in cm

a = describe the rate of change of weight with length (intercept)

b = weight at unit length (slope)

The equation was log transformed to estimate the parameters 'a' and 'b'. When b is equal to three (3), isometric pattern of growth occurs but when b is not equal to 3, allometric pattern of growth occurs, which may be positive if >3 or negative if <3.

The L-W relationship was analyzed by using the equation $W= aL^b$ (Pauly, 1983).

3.5 CONDITION FACTOR ('K')

The condition factor ('K') which shows the degree of well-being of the fish in their habitat was determined by using the equation:

$$k = \frac{100w}{L^b}$$

Where:

K = condition factor

W = the weight of the fish in gram (g)

L = the total length of the fish in centimeters (cm)

b = the value obtained from the length-weight equation (Gomiero and Braga, 2005)

The exponent 'b' value, that is equal to 3, was not used to calculate the 'K' value. Bolger and Connolly (1989) claim that it is not a real representation of the length-weight relationship for greater majority of fish species, therefore the 'b value used

was obtained from the estimated length-weight relationship equation ($W = a L^b$) as suggested by Lima-Junior *et al*. (2002).

3.6 Physico-Chemical Parameters

3.6.1 Temperature

Temperature was measured both in the morning (between 7a.m and 9a.m) and evening (between 4p.m and 6p.m) during sampling at various sampling sites using Hanna measuring instrument (combo pH/EC/TDS/T°C model HI98129). The meter was standardized with buffer solution at pH 4.0, 7.0 and 9.0. The meter was lowered into the water body and readings were taken and recorded immediately the timer stabilized.

3.6.2 Dissolved oxygen (DO)

The DO was determined using the modified Winkler Test. Water samples were collected in 25ml stoppered bottle. 0.1ml of manganese (ii) sulphate solution was added, and mix carefully without letting in air. Then 0.2 ml of alkaline potassium iodide was also added, without letting in air. A pinky brown precipitate appeared. It was then stored for latter analysis in the laboratory. In the laboratory, 0.3ml sulphuric acid was addded to the sample and mixed and the sample was allowed stand for 2 mins. Atimes when the precipitate does not dissolve into the iodine solution, 0.1ml acid was further added. The burrette was filled with 0.0125N sodium thiosulphate solution and adjust to zero, 10ml of the sample was transferred to a conical flask, and a few drops of starch solution were added. The sub sample then turned blue. The sub sample aws titrated with thio sulphate until it turned clear. The end point is easier seen or easily seen if the conical flask is stood on a sheet of filter paper. The reading was then taken and recorded in Mg/L.

3.6.3 Hydrogen ion concentration (pH)

pH was measured both in the morning (between 7a.m and 9a.m), evening (between 4p.m and 6p.m) at sampling sites during sampling using Hanna measuring instrument (combo pH/EC/TDS/T°C model HI98129). The meter was standardized with buffer solution at pH 4.0, 7.0 and 9.0. The meter was lowered into the water body and reading taken immediately the timer stabilized.

3.6.4 Electrical conductivity

Electrical conductivity was measured using the same Hanna measuring instrument (combo pH/EC/TDS/T°C model HI98129) and the measurement was done at the same time as above.

3.6.5 Total dissolved solids (TDS)

Total dissolved solid was also measured at the same time as above and using the same Hanna measuring instrument.

3.7 Relative Abundance of Fish

All fish from the two sampling sites were pooled, sorted, counted and recorded. The species abundance was calculated as the percentage of each species represented in the total catch for each station. Catch data were averaged within monthly time intervals and expressed as average monthly catches for the water body as described by Alphonse and Rudi (1995).

The relative abundance was calculated as follows:

$$\text{Relative abundance} = \frac{\text{Frequency of species } \times 100}{\text{Frequency of all species}}$$

3.8 Data Analysis

Data on morphometric were analysed using descriptive statistics to determine (means and standard deviations). The data of fish abundance were subjected to one way analysis of variance (ANOVA) to determine differences between seasons, and where differences existed they were separated with Duncan multiple range test (DMRT) at 0.05% according to Steele and Torrie (1980).

CHAPTER FOUR

4.0 RESULTS

4.1 Fish Species Composition

A total of 12 fish species belonging to 6 families were recorded during the study period of April 2013 to March 2014 (Table 4.1). The family Clariidae was represented by 2 species: *Clarias gariepinus* (Burchell, 1822) and *Clarias anguillaris* (Linnaeus, 1758). Alestiidae was represented by 2 species: *Brycinus nurse* (Ruppell, 1832) and *Hydrocynus vittatus* Castelnau, 1861. Mormyridae was represented by 4 species: *Marcusenius abadii* (Boulenger, 1901), *Mormyrus rume* Valenciennes, 1847, *Hippopotamyrus psittacus* (Boulenger, 1897) and *Mormyrops anguilloides* (Linnaeus, 1758). The Cichlidae was represented by 2 species: *Oreochromis niloticus* (Linnaeus, 1758) and *Tilapia zillii* (Gervais, 1848) and the Mochokidae was represented by *Synodontis budgetti* Boulenger, 1911, while the Schilbeidae was represented by only *Schilbe mystus* (Linnaeus, 1758).

4.2 Descriptions of Fish Species Caught in Dogon Ruwa

4.2.1 *Clarias gariepinus* (Burchell, 1822)

Scaleless fish, body depth is 6-8 times in standard length, head 3.3-5 times body length. Barbels long, 1/2 times as head length. Dorsal fin almost reaches the caudal fin. Anal fin origin is closer to caudal fin base than to snout; it nearly reaches caudal fin. Pelvic fin is closer to snout than to caudal fin base. Two colour patterns can be discerned: uniform and marbled pattern (Plate I) (Froese and Pauly, 2015).

4.2.2 *Clarias anguillaris* (Linnaeus, 1758)

Head is oval-shaped to rectangular in dorsal outline; snout is broadly rounded. Dorsal fin base is situated close to occipital process; dorsal fin always terminates before

Table 4.1: Fish species identified in Dogon Ruwa Water Body of Kamuku National Park

Fish family	Species	Common Names	Local Names*
Clariidae	*Clarias gariepinus*	Catfish	Tarwada (Hausa), Imunu (Ijaw), Kemudu (Kanuri), Ejengi (Nupe), Arira (Igbo), Aro (Yoruba).
	Clarias anguillaris	Catfish	Hana noma, Kuluni, Tarwada (Hausa), Arira (Igbo), Imunu (Ijaw), Kemudu (Kanuri), Ejengi (Nupe), Aro (Yoruba).
Alestiidae	*Brycinus nurse*	Silverside	Jam, Kawara (Hausa), Benibu lou-ipo (Ijaw), Kaya (Kanuri), Egbagi (Nupe), Ajarapo (Yoruba).
	Hydrocynus vittatus	African tiger fish	Zawai (Hausa), Kabi (Ijaw), Kiri shelia (Kanuri), Owulueze (Igbo), Ijakere (Yoruba).
Mormyridae	*Marcusenius abadii*	Trunkfish	Afinfin (Yoruba).
	Mormyrus rume	Trunkfish	Milligi (Hausa), Ugbala (Ijaw), Bunyi karam (Kanuri), Dwanga (Nupe), Lele (Yoruba).
	Hippopotamyrus psittacus	Trunkfish	Bakin lali (Hausa), Ugbala (Ijaw), Gwopa zhiko (Nupe)
	Mormyrops anguilloides	Trunkfish	Milligi (Hausa), Ogboro (Ijaw), Bunyi karam (Kanuri), Dwangwa (Nupe), Lele, Ogodorobo (Yoruba).
Cichlidae	*Oreochromis niloticus*	Nile tilapia	Bugu, Falga, Garagaza, Gargaza, Karfasa (Hausa), Ifunu, Mpupa (Igbo), Tome, Ukuobu (Ijaw), Karwa (Kanuri), Tsokungi (Nupe), Epia (Yoruba).

Table 4.1 (contd): Fish species caught and identified in the Dogon Ruwa Water Body of Kamuku National Park

Fish family	Species	Common Names	Local Names
	Tilapia zillii	Red belly Tilapia	Karfasa, Bugu, Gargaza (Hausa), Ifunu, Mpupa (Igbo), Tome, Ukuobu (Ijaw), Karwa (Kanuri), Epia, Wesafun (Yoruba)
Mochokidae	*Synodontis budgetti*	Catfish	Mai Kayatala (Hausa), Okpo (Igbo), Mini-ikpoki (Ijaw), Fono (Kanuri), Egungigi (Nupe), Okokoniko (Yoruba).
Schilbeidae	*Schilbe mystus*	Butterfish	Balo, Harya, Nalanga (Hausa), Bou-anyi (Ijaw), Bambui (Kanuri), Elangi (Nupe), Asan (Yoruba).

Source(s) of Local names; Idodo-Umeh (2003); Olaosebikan and Raji (1998) and Pauly and Froese(2014)

caudal fin base and distance between both is small. Anal fin originates closer to caudal fin base than to tip of the snout; although nearly reaching caudal fin, it is never confluent with it. Pelvic fin base is slightly closer to tip of the snout than to caudal fin base; it reaches the base of the first anal fin rays. Pectoral fin extends from operculum to base of first dorsal fin rays. Two colour patterns can be discerned: uniform and marbled pattern. Irregular black spots occur toward the tail and on caudal fin (Plate II) (Froese and Pauly, 2014).

4.2.3 *Brycinus nurse* (Ruppell, 1832)

Anal spines: 0; anal soft rays: 13-18. Diagnosis: fronto-parietal fontanel absent in adults, sometimes pore-like in juveniles, disappearing with growth; dorsal fin origin at about same level as pelvic fin insertion; sexual dimorphism affecting anal fin shape; 24-34 lateral line scales; 5.5 scales between lateral line and dorsal fin; 10-15 anal fin branched rays; 14-20 gill rakers on lower limb of first gill arch; 8 teeth in outer premaxillary row. Snout short, more than 3 times head length; head length/snout length 3.6-4.3; 10-11.5 predorsal scales; flanks without lateral band; adults medium-sized (Plate III) (Froese and Pauly, 2014).

4.2.4 *Hydrocynus vittatus* Castelnau, 1861

Dorsal spines (total): 0; dorsal soft rays (total): 10; anal spines: 0; anal soft rays: 15. Diagnosis: 2 scale rows between lateral line and scaly process at pelvic-fin bases; eye < 70% of interorbital space. Dorsal-fin origin at about same level as pelvic-fin insertions; tips of adipose and dorsal fins black; forked edge of caudal fin black (Plate IV) (Froese and Pauly, 2014).



Plate I: Dorso-lateral view of *Clarias gariepinus*



Plate II: Dorso-lateral view of *Clarias anguillaris*
Note the irregular black spots (BS) in the tail region and body



Plate: III: Lateral view of *Brycinus nurse*

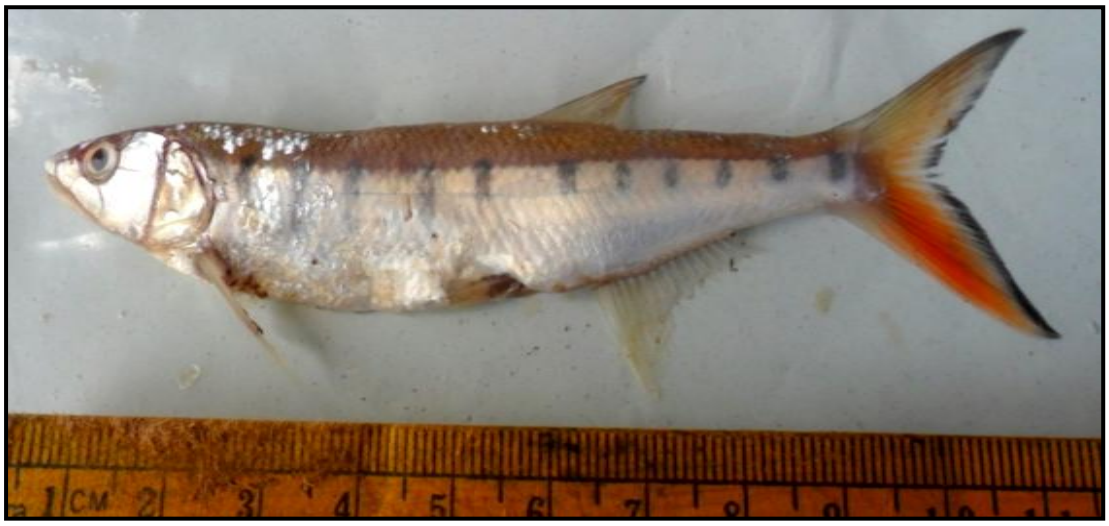


Plate IV: Lateral view of *Hydrocynus vittatus*

4.2.5 *Marcusenius abadii* (Boulenger, 1901)

Dorsal spines (total): 0; dorsal soft rays (total): 34-39; anal spines: 0; anal soft rays: 32-36. Dorsal fin origin at same level as anal fin origin; body depth 3.0-4.7 times of standard length; peduncle height 3.2-5.0 times of its length (Plate V) (Froese and Pauly, 2014).

4.2.6 *Mormyrus rume* Valenciennes, 1847

Dorsal spines (total): 0; dorsal soft rays (total): 72-95; anal spines: 0; anal soft rays: 16-21. Anal fin base 4.6-6.5 times that of dorsal fin; 20-26 scales on caudal peduncle; body height 3.5-6.1 times standard lenght; height of caudal peduncle 1.3-3.0 times of its length (Plate VI) (Froese and Pauly, 2014).

4.2.7 *Hippopotamyrus psittacus* (Boulenger, 1897)

Dorsal spines (total): 0; dorsal soft rays (total): 30-37; anal spines: 0; anal soft rays: 22-27. Dorsal fin origin before anal fin origin; length of dorsal base to anal base ratio 1.2-1.6. Back convex and hull shaped. Standard length/depth ratio 2.9-3.8. Height of caudal peduncle 2.9-4.4 times of its length (Plate VII) (Froese and Pauly, 2014).

4.2.8 *Mormyrops anguilloides* (Linnaeus, 1758)

Dorsal spines (total): 0; dorsal soft rays (total): 21-33; anal spines: 0; anal soft rays: 38-51. Diagnosis: head depressed mouth large and terminal; body elongated. Origin of dorsal fin behind origin of anal fin, nearer caudal fin base than tip of snout; dorsal fin shorter than anal fin; mouth width subequal to snout length: snout long. Standard length/body depth 4.9-7.5; head 3.4-5.1 times in standard length; snout almost as wide as head; interorbital space wide, head length/interorbital space 2.9-6.8 (Plate VIII) (Froese and Pauly, 2014).



Plate V: Lateral view of *Marcusenius abadii*



Plate VI: Lateral view of *Mormyrus rume*



Plate VII: Lateral view of *Hippopotamyrus psittacus*



Plate VIII: Lateral view of *Mormyrops anguilloides*

4.2.9 *Oreochromis niloticus* (Linnaeus, 1758)

Dorsal spines (total): 15-18; dorsal soft rays (total): 11-13; anal spines: 3; anal soft rays: 9-11; vertebrae: 30-32. Diagnosis: jaws of mature male not greatly enlarged (length of lower jaw 29-37 % of head length); genital papilla of breeding male not tassellated. Most distinguishing characteristic is the presence of regular vertical stripes throughout depth of caudal fin (Plate IX) (Froese and Pauly, 2014).

4.2.10 *Tilapia zillii* (Gervais, 1848)

Dorsal spines (total): 13-16; dorsal soft rays (total): 10-14; anal spines: 3; anal soft rays: 8-10. Diagnosis: upper profile of head not convex; lower pharyngeal bone about as long as broad, and with anterior lamella shorter than toothed area; median pharyngeal teeth not broadened; dorsal fin with 14-16 spines and 10-14 soft rays (mean 15, 12); 8-11 lower gillrakers; dark longitudinal band appears on flanks when agitated; no bifurcated dark vertical bars on flanks; dorsal and caudal fins not or feebly blotched. Body brownish-olivaceous with an iridescent blue sheen; lips bright green. Chest pinkish. Dorsal, caudal and anal fins brownish-olivaceous with yellow spots, dorsal and anal fins outlined by narrow orange band; "tilapian" spot large, extending from last spine to 4th soft ray and always bordered by yellow band. Completely yellowish or greyish caudal fin with dots (Plate X) (Froese and Pauly, 2014).

4.2.11 *Synodontis budgetti* Boulenger, 1911

Dorsal spines (total): 1; anal spines: 0. Diagnosis: gill slits not extending ventrally beyond pectoral-fin insertions; maxillary barbels distinctly fringed, longer than head, unbranched and lacking tubercles, but with a broad, long and dark basal membrane;



Plate IX: Lateral view of *Oreochromis niloticus*



Plate X: Lateral view of *Tilapia zilli*

outer mandibular barbels with few simple, short ramifications, inner mandibular barbels with tuberculate, subdivided branches; mandibular teeth moderately developed, numbering 45-64 (64 in the holotype); denticulations on pectoral-fin spines weaker on outer than on inner margin; dorsal-fin spine smooth anteriorly; first ray of dorsal and pectoral fins, as well as both caudal-fin lobes extended into filaments; humeral process pointed, granulose, its ventral margin keeled and bearing 3 backward-pointing spines (sometimes only 1 or 2 in young individuals); adipose fin normally developed and distinctly separated from rayed dorsal fin. Coloration: ground colour uniformly greenish-yellow; series of black spots sometimes present on fins in young individuals (Plate XI) (Froese and Pauly, 2014).

4.2.12 *Schilbe mystus* (Linnaeus, 1758)

Dorsal spines (total): 1; dorsal soft rays (total): 6; anal soft rays: 45-64. Diagnosis: adipose fin present; anterior nostrils more closer to each other than posterior ones; inner margin of pectoral-fin spine strongly denticulate posteriorly; nasal barbel reaching to anterior eye margin, but never extending beyond hind margin of eye; mouth subterminal; 45-64 branched anal-fin rays and 9-14 gill rakers on lower limb of first gill arch. Coloration: ground colour generally silvery-white; head and back brownish, fins usually colourless. Coloration: ground colour generally silvery-white; head and back brownish, fins usually colourless (Plate XII) (Froese and Pauly, 2014).

4.3 Total Number of Fish Caught According to Family

The relative abundance of fish species, based on family, revealed that the Cichlidae (2 species) (631 fish, 29.20%) had the highest fish composition in the catches in Dogon Ruwa Water Body of Kamuku National Park; next was the family Mormyridae (4 species) (546 fish, 25.27%). However, the family Mormyridae had the highest fish



Plate XI: Dorso-lateral view of *Synodontis budgetti*



Plate XII: Lateral view of *Schilbe mystus*

weight of 151.651kg (30.13%), while the family Mochokidae was lowest in both abundance and weight with a total of 168 fishes (7.77%) weighing 30.396kg (Table 4.2).

4.4 Distribution of Fish

There were no significant difference in the fish distribution in both Stations X and Y; the total number of fish caught in Station X (1054 fish, 48.77%) was not significantly different (P>0.05) with the total number of fish caught in station Y (1107 fish, 51.23%) (Table 4.3).

4.5 Monthly Fish-Catch Using Nets of Different Mesh Sizes

Figure 4.1 shows that there were higher catches from August to November in the mesh sizes of 1.5□ and 2□ nets, also more fish (1118 fish, 51.74%) were caught using the 2□ mesh size net than with the other mesh sizes; no fish were caught with the 3.5□–7□ mesh-size nets. Based on monthly catches, the majority of fish (24.71%) were caught in November, likely because of reduction in water current/flow due to the stoppage of the rain and the fewest in April (1.53%), probably being the driest month.

4.6 Number of Fish Species Caught Monthly

The monthly fish catches (Table 4.4) revealed that *Tilapia zillii* was highest in number (321, 14.85%) and *Mormyrus rume* (115, 5.32%) was lowest. Also the highest fish (79 fishes, 14.79%) was caught in November, while the least number of fish caught was in March. Generally, there were high catches of all the fish from August to November, also the cichlids was high from July to February while *Synodontis budgetti* and *Schilbe mystus* were high from August to January.

Table 4.2: Relative abundance and total weight of fish species in Dogon Ruwa water body of Kamuku National Park

Family	Fish Species	Total (%)	Weight (kg) (%)
Clariidae	*Clarias gariepinus*	164 (7.5)	63.595 (12.63)
	Clarias anguillaris	172 (8.0)	60.638 (12.05)
		336 (15.55)	**124.233 (24.68)**
Alestiidae	*Brycinus nurse*	134 (6.2)	21.647 (4.30)
	Hydrocynus vittatus	169 (7.8)	27.302 (5.42)
		303 (14.02)	**48.949 (9.72)**
Mormyridae	*Marcusenius abadii*	142 (6.6)	39.940 (7.83)
	Mormyrus rume	115 (5.3)	31.941 (6.35)
	Hippopotamyrus psittacus	135 (6.2)	37.496 (7.45)
	Mormyrops anguilloides	154 (7.1)	4.277 (8.50)
		546 (25.27)	**151.651 (30.13)**
Cichlidae	*Oreochromis niloticus*	310 (14.3)	55.855 (11.10)
	Tilapia zillii	321 (14.9)	57.836 (11.49)
		631 (29.20)	**113.691 (22.58)**
Mochokidae	*Synodontis budgetti*	**168 (7.77)**	**30.396 (6.04)**
Schilbeidae	*Shilbe mystus*	**177 (8.19)**	**34.480 (6.85)**
Total		**2,161 (100.00)**	**503.400 (100)**

Table 4.3: Distribution of Fish Species in Stations X and Y of Dogon Ruwa water body of Kamuku National Park

Family and Species	Station X No (%)	Station Y No (%)
CLARIIDAE		
Clarias gariepinus	80 (7.60)	84 (7.59)
Clarias anguillaris	82 (7.78)	90 (8.13)
	162 (15.38)	**174 (15.72)**
ALESTIIDAE		
Brycinus nurse	62 (5.88)	72 (6.50)
Hydrocynus vittatus	85 (8.06)	84 (7.59)
	147 (13.94)	**156 (14.09)**
MORMYRIDAE		
Marcusenius abadii	65 (6.17)	77 (6.96)
Mormyrus rume	65 (6.17)	50 (4.52)
Hippopotamyrus psittacus	70 (6.64)	65 (5.87)
Mormyrops anguilloides	70 (6.64)	84 (7.59)
	270 (25.62)	**276 (24.93)**
CICHLIDAE		
Oreochromis niloticus	150 (14.23)	160 (14.45)
Tilapia zillii	161 (15.28)	160 (14.45)
	311 (29.51)	**320 (28.91)**
MOCHOKIDAE		
Synodontis budgetti	**82 (7.78)**	**86 (7.77)**
SCHILBEIDAE		
Schilbe mystus	**82 (7.78)**	**95 (8.58)**
Total	**1,054 (48.77)**	**1,107 (51.23)**
P-value	**0.1046**	

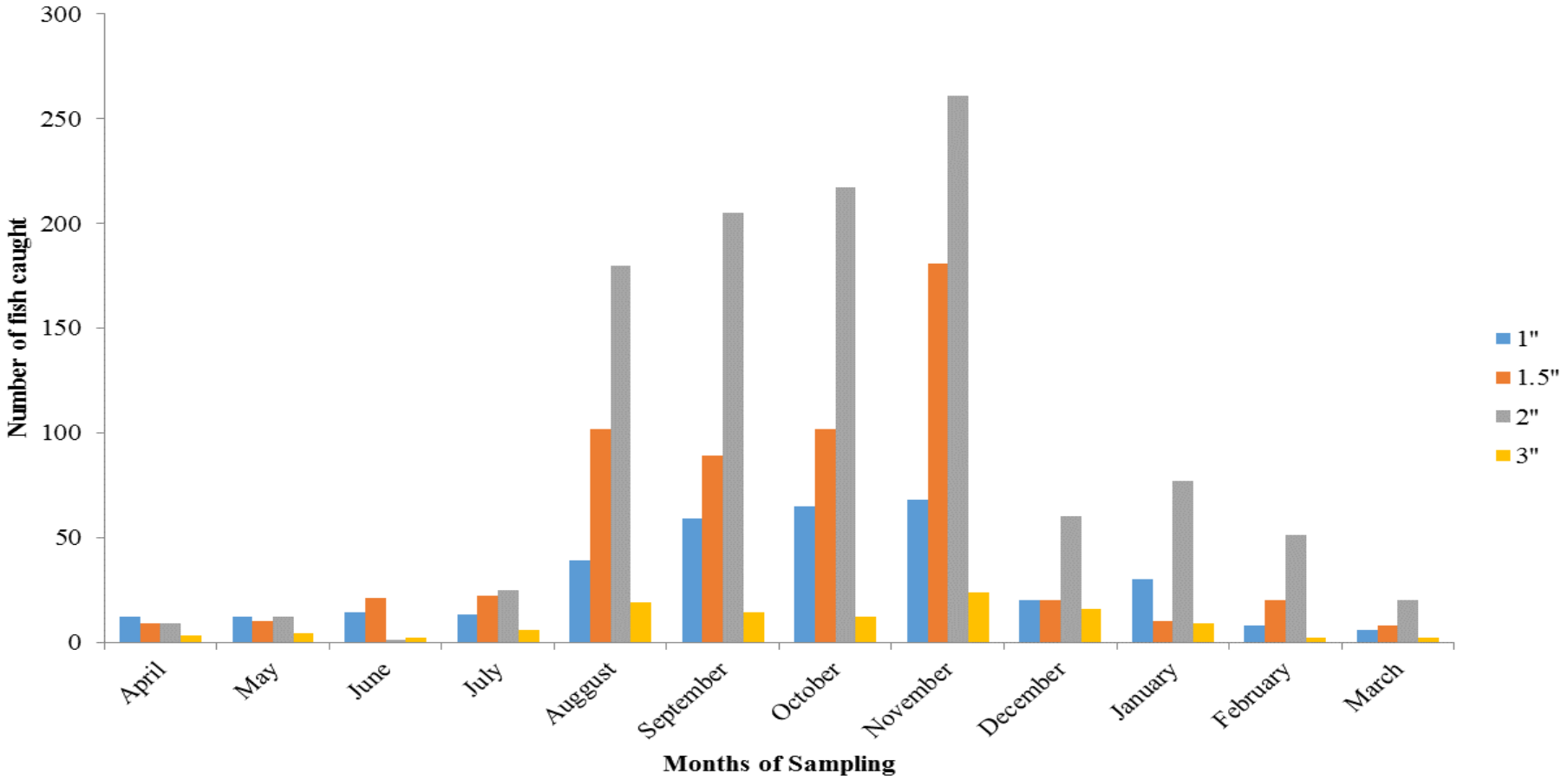


Fig 4.1: Fish-catch per month in Dogon Ruwa according to mesh-size of nets (April 2013 - March 2014)

Table 4.4: Number of Fish Species Caught on monthly basis in Dogon Ruwa (April 2013 - March 2014)

Fish species/ month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
Clarias gariepinus	3	2	4	5	25	27	30	41	9	9	7	2	164
Clarias anguillaris	2	3	2	5	27	29	31	42	12	10	1	8	172
Brycinus nurse	2	2	2	4	22	24	25	35	9	8	1	-	134
Hydrocynus vittatus	3	3	1	5	26	29	31	42	9	10	8	2	169
Marcusenius abadii	2	2	3	4	22	24	26	35	7	8	8	1	142
Mormyrus rume	2	2	1	3	18	19	21	28	6	7	5	3	115
Hippopotamyrus psittacus	2	2	2	4	21	23	25	33	7	8	6	2	135
Mormyrops anguilloides	2	2	3	4	24	26	28	38	8	9	6	4	154
Oreochromis niloticus	4	5	6	9	49	53	56	76	16	18	12	6	310
Tilapia zillii	5	6	7	10	53	54	59	79	17	19	8	4	321
Synodontis budgetti	2	3	2	5	26	28	31	41	9	10	7	4	168
Shilbe mystus	4	6	5	8	27	31	33	44	7	10	2	-	177
Total	**33**	**38**	**38**	**66**	**340**	**367**	**396**	**534**	**116**	**126**	**71**	**36**	**2,161**

4.7 Fish Species Caught Based on Different Mesh Sizes

Four mesh sizes were responsive; *Tilapia zillii* had the highest number of fish caught in the nets of 1□ ,1.5□ and 2□ mesh sizes (51 fish, 14.74%, 89 fish, 15.24% and 166 fish, 14.85%, respectively), while *Mormyrus rume* had the lowest (18 fish, 5.20%, 33 fish, 5.65%, and 59 fish, 5.28%). In the net of 3" mesh size, *Clarias anguillaris* and *Synodontis budgetti* had the highest number caught (17 fish, 15%) while the lowest was *Tilapia zillii* (2 fish, 1.77%) (Table 4.5); this is an indication that almost all the fish caught were of small size (juveniles and sub-adults).

4.8 Growth pattern of fish species and Their Condition Factor ('K')

The length-weight relationships of the fish species in Dogon Ruwa water body are presented in Table 4.6. *Clarias anguillaris* (2.75) had highest value of the exponent 'b' in the length-weight relationship, *Mormyrus rume* had 2.20 and the lowest was *Oreochromis niloticus* (1.44). The values for the other species are indicated in the table.

All the species exhibited negative allometric growth pattern. Their 'b' values were less than 3. There was a strong correlation between the length and the weight of all the species except *Oreochromis niloticus* in which these parameters were weakly correlated.

Figures 4.2 to 4.13 are the scatter diagrams of the length-weight relationship of the fish species caught between April 2013 and March 2014.

Table 4.5: Fish Species Caught Based On Different Mesh Sizes in Dogon Ruwa (April 2013 - March 2014)

Fish species/ mesh sizes	1□	1.5□	2□	3□	No	%
Clarias gariepinus	26	39	85	16	164	7.59
Clarias anguillaris	28	46	89	17	172	7.96
Brycinus nurse	22	36	69	7	134	6.20
Hydrocynus vittatus	27	46	88	9	169	7.82
Marcusenius abadii	23	38	73	10	142	6.57
Mormyrus rume	18	33	59	11	115	5.32
Hippopotamyrus psittacus	22	36	70	9	135	6.25
Mormyrops anguilloides	25	44	80	9	154	7.13
Oreochromis niloticus	49	84	160	3	310	14.35
Tilapia zillii	51	89	166	2	321	14.85
Synodontis budgetti	27	45	87	17	168	7.77
Shilbe mystus	28	48	92	3	177	8.19
Total	**346**	**584**	**1,118**	**113**	**2,161**	**100**

Table 4.6: Length-Weight Relationship and growth patterns of Fish Species in Dogon Ruwa water body of Kamuku National Park

Fish species	Length-weight relationship	Pattern of growth
Clarias gariepinus	y = 2.33x + 0.54	Negative allometric
Clarias anguillaris	y = 2.75x + 0.55	Negative allometric
Brycinus nurse	y = 2.30x + 0.54	Negative allometric
Hydrocynus vittatus	y = 2.29x + 0.55	Negative allometric
Marcusenius abadii	y = 2.26x + 0.56	Negative allometric
Mormyrus rume	y = 2.20x + 0.58	Negative allometric
Hippopotamyrus psittacus	y = 2.17x + 0.64	Negative allometric
Mormyrops anguilloides	y = 2.11x + 0.65	Negative allometric
Oreochromis niloticus	y = 1.44x + 0.73	Negative allometric
Tilapia zillii	y = 1.87x + 0.72	Negative allometric
Synodontis budgetti	y = 1.95x + 0.69	Negative allometric
Schilbe mystus	y = 1.57x + 0.70	Negative allometric

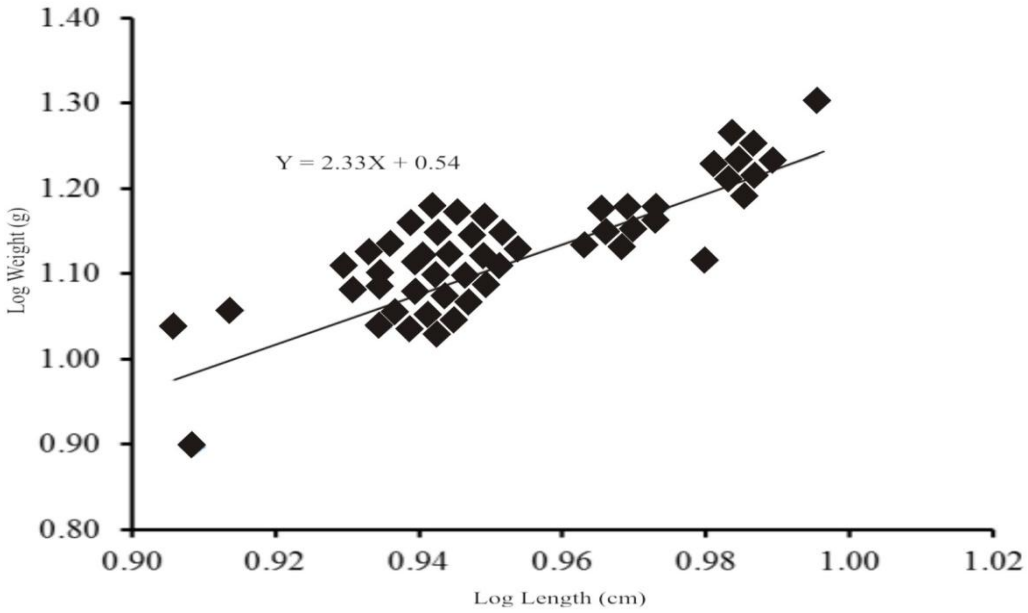


Fig. 4.2: Scatter Diagram of Length-Weight Relationship of *Clarias gariepinus*

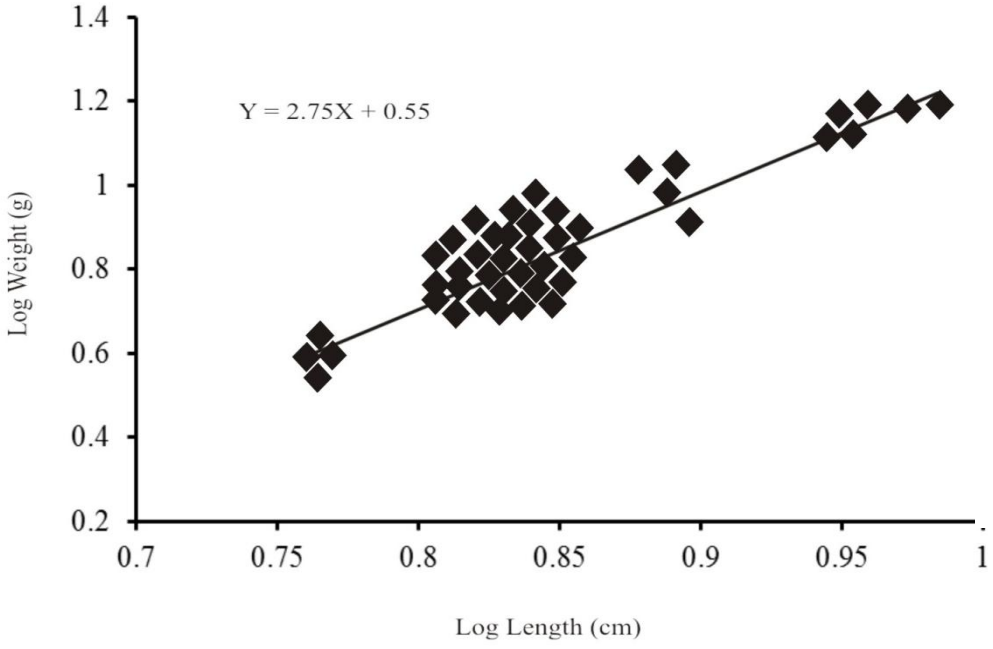


Fig. 4.3: Scatter Diagram of Length-Weight Relationship of *Clarias angullaris*

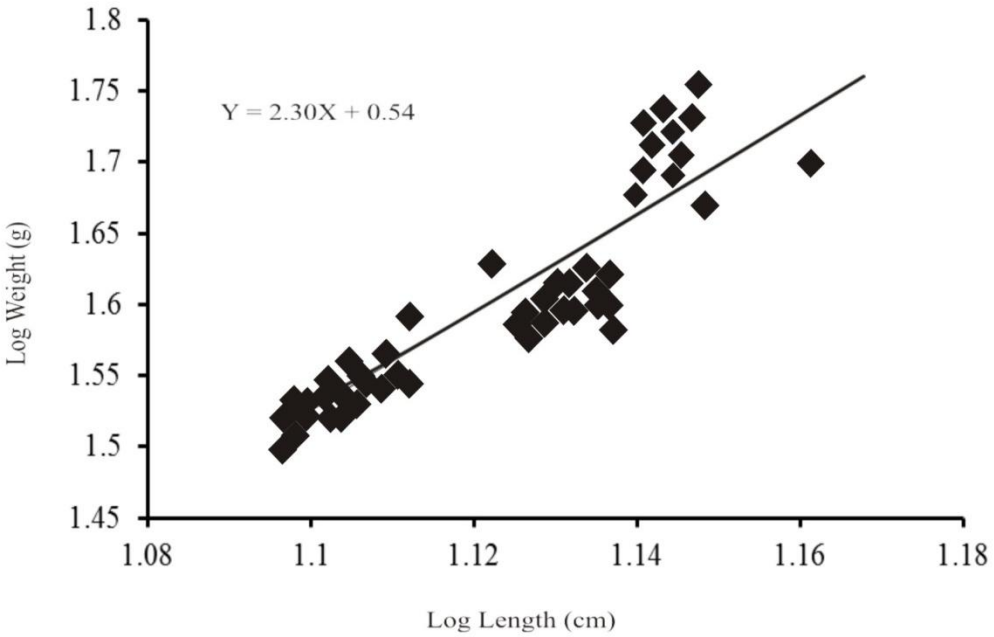


Fig. 4.4: Scatter Diagram of Length-Weight Relationship of *Brycinus nurse*

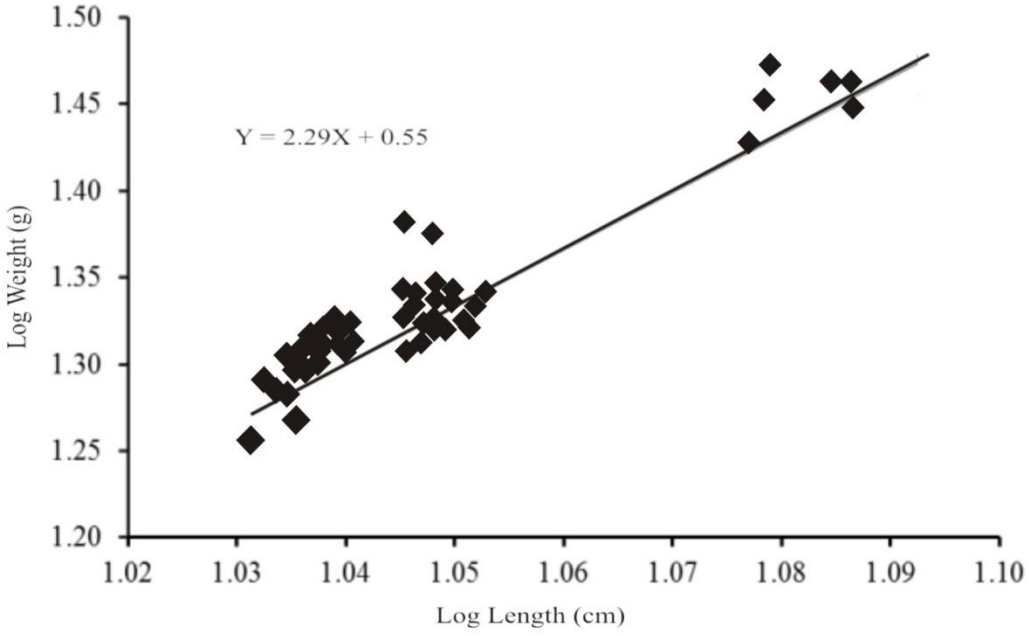


Fig. 4.5: Scatter Diagram of Length-Weight Relationship of *Hydrocynus vittatus*

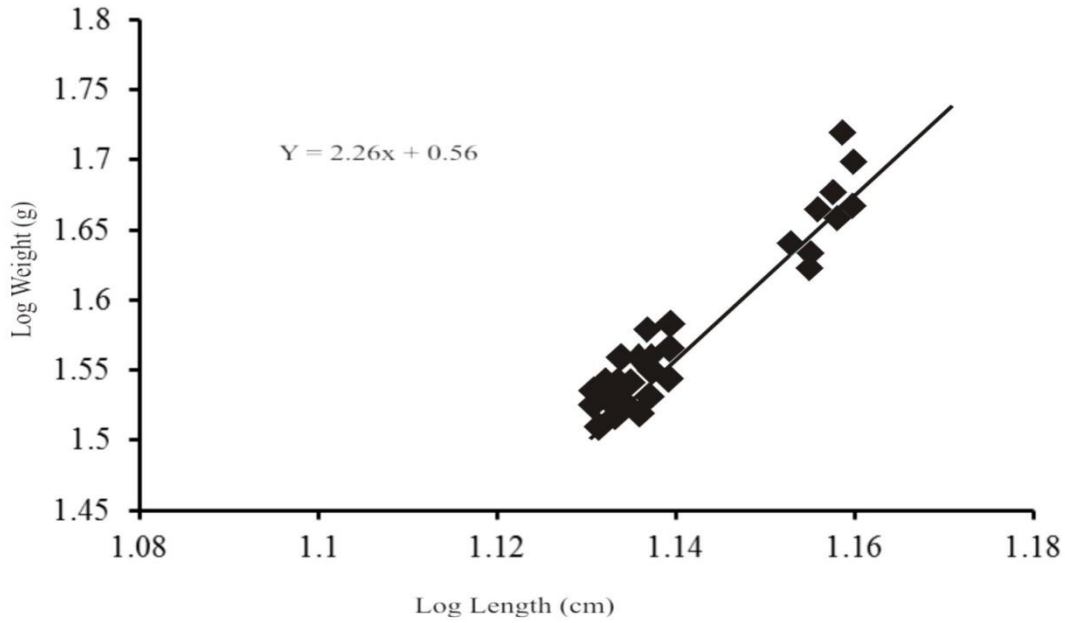


Fig. 4.6: Scatter Diagram of Length-Weight Relationship of *Marcusenius abadii*

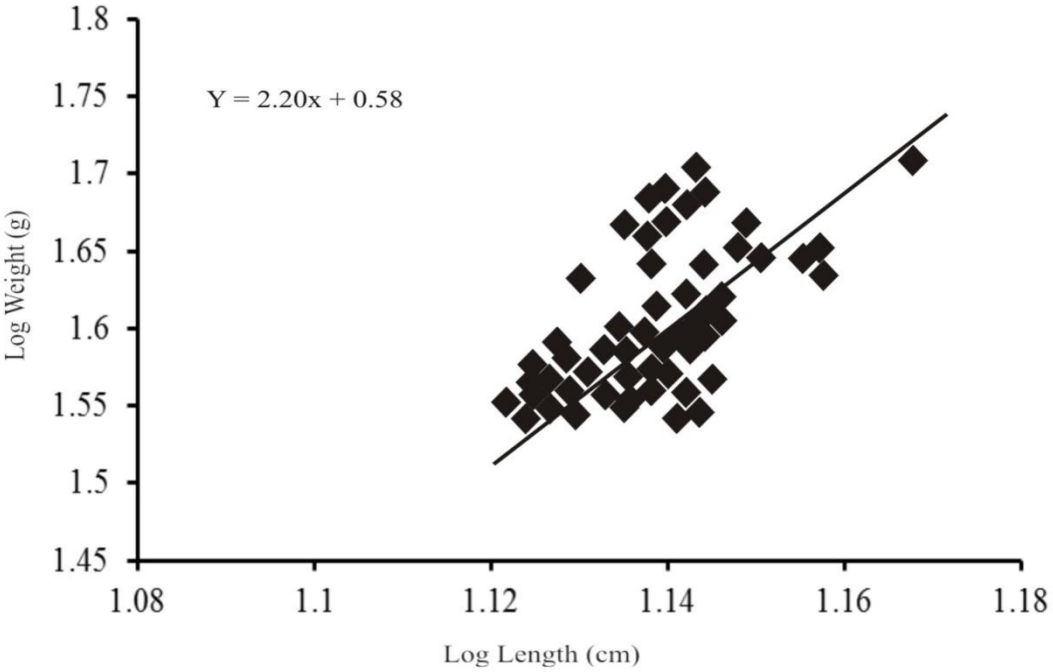


Fig. 4.7: Scatter Diagram of Length-Weight Relationship of *Mormyrus rume*

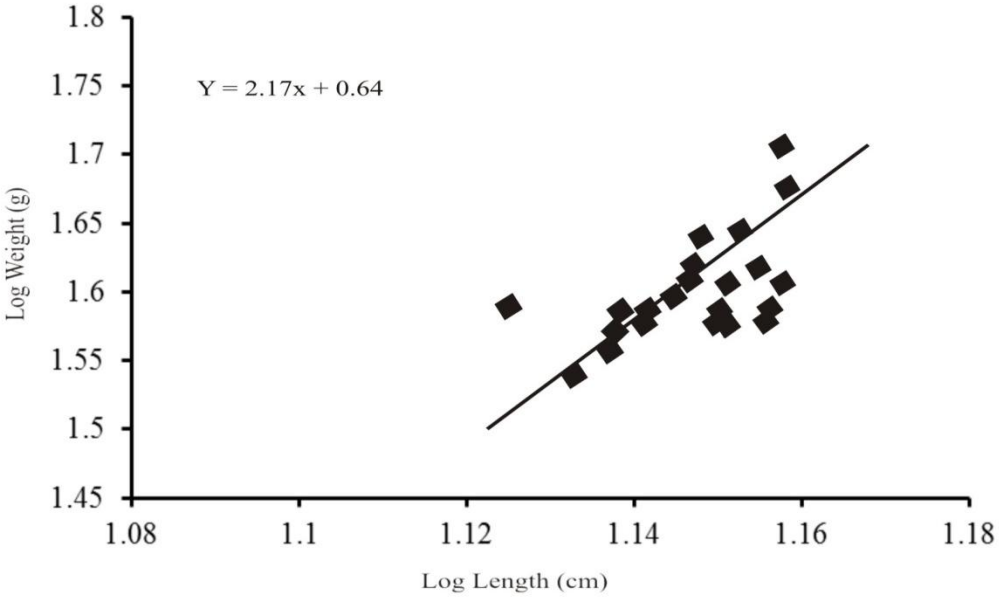


Fig. 4.8: Scatter Diagram of Length-Weight Relationship of *Hippopotamyrus*

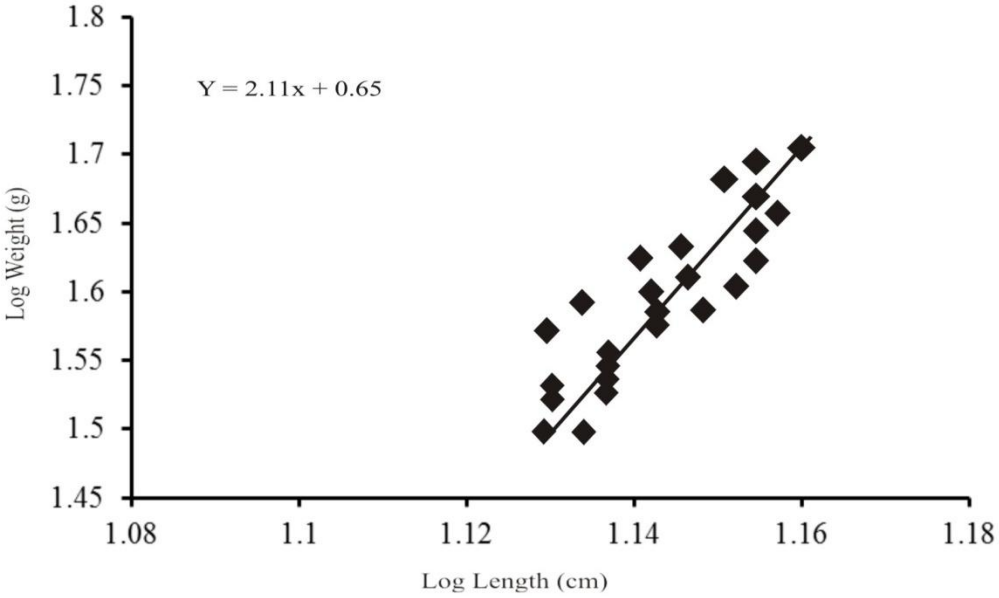


Fig. 4.9: Scatter Diagram of Length-Weight Relationship of *Mormyrops anguilloides*

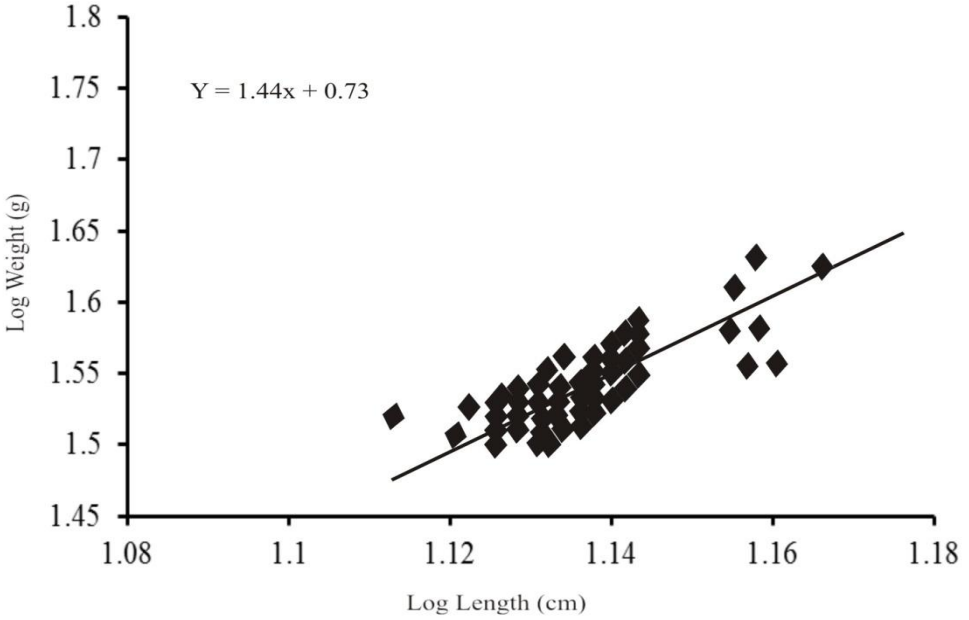


Fig. 4.10: Scatter Diagram of Length-Weight Relationship of *Oreochromis niloticus*

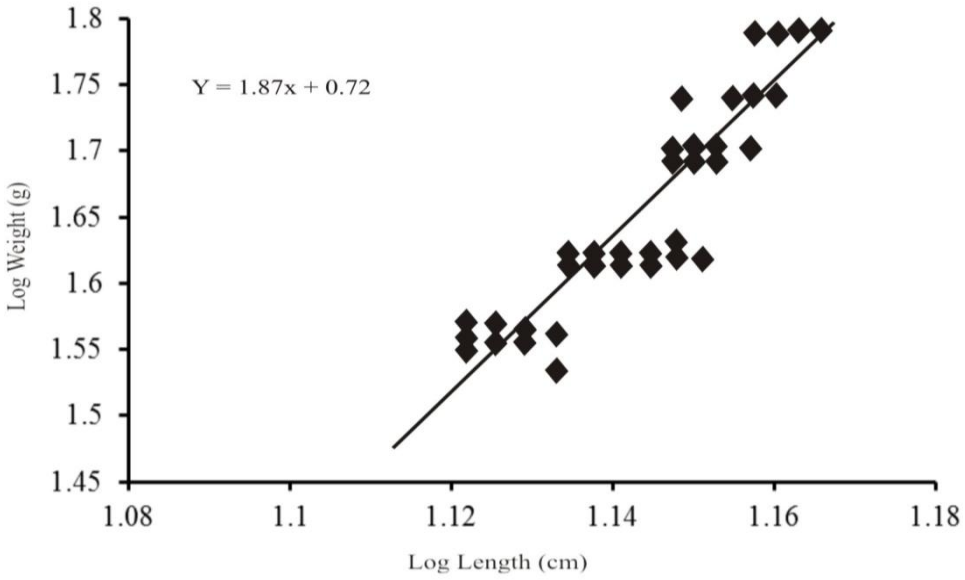


Fig. 4.11: Scatter Diagram of Length-Weight Relationship of *Tilapia zillii*

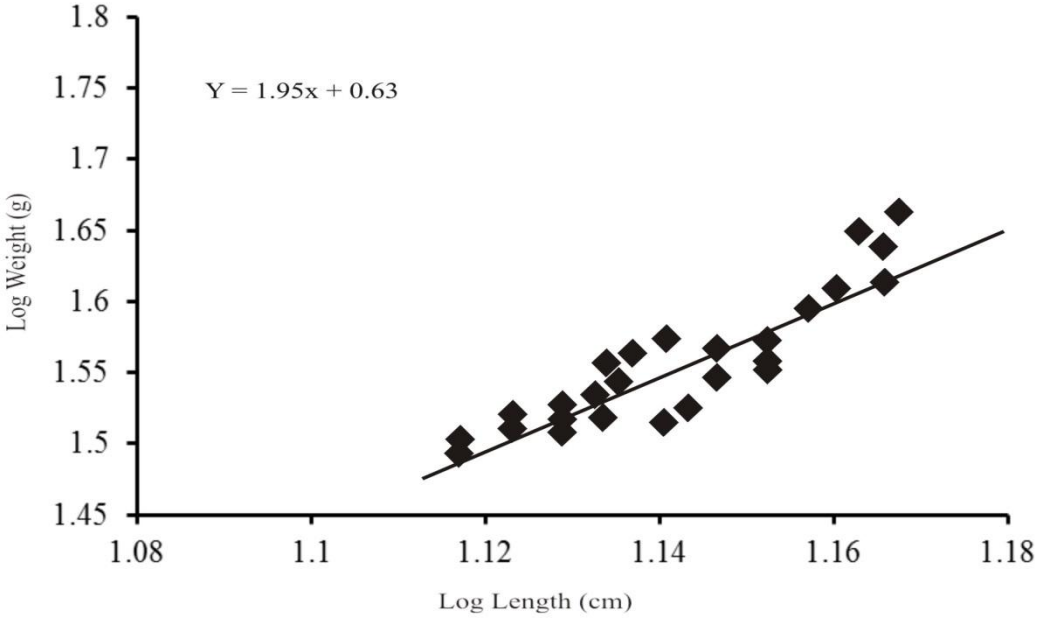


Fig. 4.12: Scatter Diagram of Length-Weight Relationship of *Synodontis budgetti*

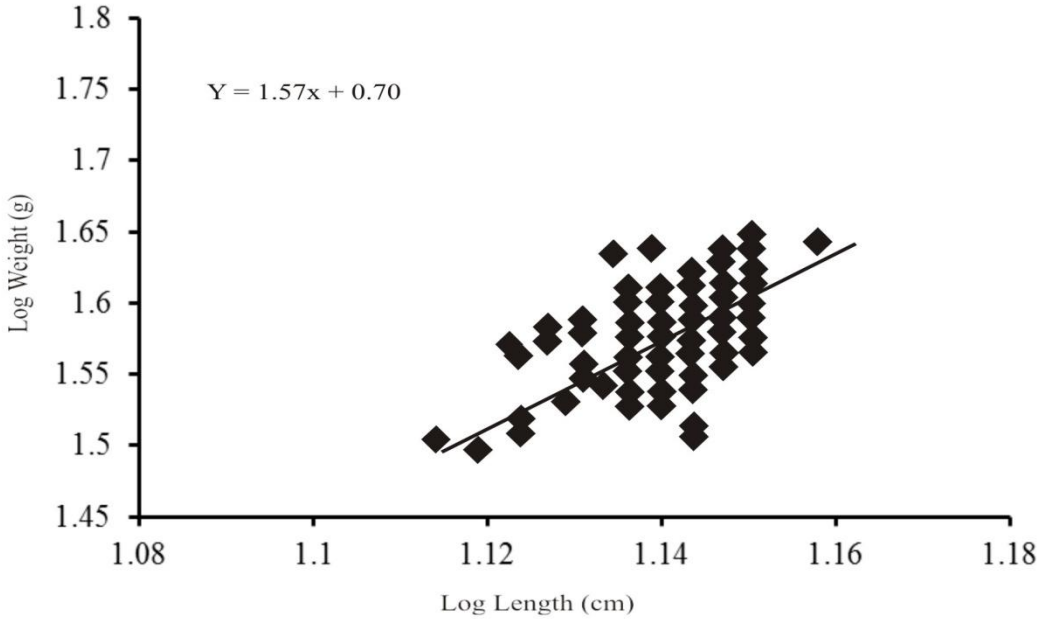


Fig. 4.13: Scatter Diagram of Length-Weight Relationship of *Schilbe mystus*

The condition factor ('K') for the 12 species of fish recorded, ranged between 0.59 and 7.42. *Oreochromis niloticus* had the highest range of condition factor ('K') (2.56–6.12), *Tilapia zillii* (1.74–3.20) and the lowest was *Clarias gariepinus* (0.59–3.64). The mean condition factor ('K') value for all the fish species was greater than one (Table 4.7), indicating that all of them were in good condition.

4.9 Sex Ratio of Fish Species

The sex ratios of the twelve fish species are given in Table 4.8.

The total number of female fish caught (1121, 51.87%), irrespective of species was numerically higher than the number of male fish (1040, 48.13%). The difference between the number of male and female was significant ($P<0.05$) (Table 4.8). The highest mumber of females to a single male was 1.21 in *Mormyruis rume* (Mormyridae), next to which was 1.18 in *Hippopotamyrus psittacus* (Mormyridae) and the lowest was 1 in *Hydrocynus vittatus* (Alestiidae).

4.10 Seasonal Weight of Fish Species in Dogon Ruwa

Comparison of the weight between the wet and dry seasons showed significant differences (P□0.05) in the weight of all the fish. The average weight of 209.47g was observed in *Clarias gariepinus* during dry season, while in the rainy season it was 324.34g. Also, *Mormyrops anguilloides* weighed 117.27g in dry season and 174.38g in the rainy season. No significant difference was observed in the standard length and total length between the seasons (dry and rainy season) in all the fish species. (Table 4.9).

Table 4.7: Condition Factor and sizes of the Fish Species in Dogon Ruwa water body

Species	No Caught	'K' range	Mean 'K' value	Weight (g)	Mean Standard Length (cm)	Mean Total Length (cm)
Clarias gariepinus	164	0.59–3.64	1.41±0.11	266.91±17.17^{a}	23.82±0.37^{a}	27.36±0.38^{a}
Clarias anguillaris	172	0.61–4.06	1.70±0.13	235.88±13.99^{a}	20.83±0.30^{b}	23.79±0.31^{b}
Brycinus nurse	134	0.99–4.48	2.36±0.20	174.72±17.27^{bc}	16.95±0.37^{e}	19.38±0.39^{e}
Hydrocynus vittatus	169	0.62–6.23	1.26±0.09	175.09±17.44^{de}	22.17±0.37^{c}	24.25±0.39^{c}
Marcusenius abadii	142	1.45–7.42	1.20±0.10	168.19±19.68^{cde}	21.97±0.42^{c}	23.98±0.44^{c}
Mormyrus rume	115	0.77–3.75	2.14±0.20	205.38±14.54^{bcd}	11.60±0.31^{g}	13.74±0.32^{h}
Hippotamyrus psittacus	135	1.97–3.75	2.81±0.24	194.26±18.03^{bc}	17.35±0.39^{e}	18.95±0.40^{f}
Mormyrops anguilloides	154	0.75–2.69	1.66±0.13	145.82±19.11^{bcde}	18.99±0.41^{d}	21.19±0.43^{d}
Oreochromis niloticus	310	2.56–6.12	2.29±0.13	168.18±13.95^{e}	11.97±0.30^{g}	14.04±0.31^{h}
Tilapia zilli	321	1.00–2.75	2.10±0.12	181.31±11.40b^{cde}	12.20±0.24^{f}	14.28±0.25^{g}
Synodontis budgetti	168	1.74–3.20	1.85±0.14	178.85±18.32^{bcd}	18.98±0.39^{d}	21.21±0.41^{d}
Shilbe mystus	177	0.94–3.56	2.02±0.15	188.56±17.26^{b}	13.44±0.37^{f}	15.45±0.38^{g}
Total	**2161**					

Table 4.8: Fish Species in Dogon Ruwa and Their Sex Ratios

	Sex		Ratio
Fish species	**Male**	**Female**	**M : F**
Clarias gariepinus	79 (7.60)	86 (7.67)	1 : 1.09
Clarias anguillaris	85 (8.17)	87 (7.76)	1 : 1.02
Brycinus nurse	69 (6.63)	73 (6.51)	1 : 1.06
Hydrocynus vittatus	84 (8.08)	84 (7.49)	1 : 1
Marcusenius abadii	67 (6.44)	77 (6.87)	1 : 1.15
Mormyrus rume	52 (5.00)	63 (5.62)	1 : 1.21
Hippopotamyrus psittacus	65 (6.25)	77 (6.87)	1 : 1.18
Mormyrops anguilloides	73 (7.02)	83 (7.40)	1 : 1.14
Oreochromis niloticus	145 (13.94)	149 (13.29)	1 : 1.03
Tilapia zillii	148 (14.23)	156 (13.92)	1 : 1.05
Synodontis budgetti	82 (7.88)	91 (8.12)	1: 1.11
Shilbe mystus	91 (8.75)	95 (8.47)	1 : 1.04
Total	**1,040 (48.13)**	**1,121 (51.8)**	**1 : 1.08**

P value = 0.00

Table 4.9: Seasonal variation in the sizes of fish species in Dogon Ruwa water body

Fish Species	Weight (g)		Standard Length (cm)		Total Length (cm)	
	Dry	**Rainy**	**Dry**	**Rainy**	**Dry**	**Rainy**
Clarias gariepinus	209.47±27.19	324.34±20.98	22.29±0.58	25.35±0.45	25.71±0.61	29.01±0.47
Clarias anguillaris	166.42±19.48	305.34±20.09	18.71±0.42	22.95±0.43	21.96±0.43	25.61±0.45
Brycinus nurse	127.26±26.66	222.18±21.95	14.24±0.57	19.67±0.47	16.78±0.59	21.97±0.49
Hydrocynus vittatus	165.37±27.31	183.18±22.47	22.05±0.58	22.27±0.48	24.04±0.61	24.42±0.50
Marcusenius abadii	161.81±29.22	174.58±26.38	21.79±0.62	22.15±0.56	23.82±0.65	24.14±0.59
Mormyrus rume	253.42±19.06	173.36±20.63	12.22±0.41	11.19±0.44	14.26±0.43	13.39±0.46
Hippopotamyrus psittacus	160.54±22.52	222.37±27.22	16.44±0.48	18.12±0.58	17.94±0.50	19.79±0.61
Mormyrops anguilloides	117.27±27.85	174.38±26.16	17.94±0.59	20.04±0.56	20.24±0.62	22.15±0.58
Oreochromis niloticus	138.21±14.85	198.15±23.61	12.20±0.32	11.74±0.50	14.26±0.33	13.83±0.53
Tilapia zillii	162.81±13.96	199.82±18.02	11.51±0.30	12.88±0.39	13.56±0.31	15.00±0.40
Synodontis budgetti	155.65±29.66	202.05±21.52	17.74±0.63	20.22±0.50	19.74±0.66	22.68±0.48
Shilbe mystus	162.04±32.79	206.24±18.69	13.32±0.70	13.52±0.40	15.30±0.73	15.56±0.42
P value	**0.369**		**0.376**		**0.396**	

4.11 Seasonal Abundance of Fish Species in Relation to Sex

Data on fish species according to sex revealed no significant difference between the seasons in abundance of fish species. The overall numerical abundance of male and female fish was similar in both the dry and rainy season (Table 4.10).

4.12 Physico-Chemical Parameters of Dogon Ruwa Water Body

The mean temperature value showed no significant difference ($P>0.05$) between both the dry and rainy seasons: 26.86°C versus 26.93°C in the rainy season.

The mean DO also showed no significant difference ($P>0.05$) between the seasons, mean DO of dry season was 6.53mg/l and 6.91mg/l in the rainy season.

The mean of pH ($P<0.05$) of dry season (6.80) is significantly different from pH of rainy season (7.45). Likewise, the mean EC of the dry season was 205.92µS, which is significantly different from 60.83µS of EC of rainy season. The TDS of dry season was 102.92ppm and it is significantly different from the TDS of rainy season (30.42ppm) (Table 4.11).

4.13 Correlation Matrix of the Physico-chemical Parameters of the Water Body

Table: 4.12 shows a strong negative correlation between temperature and dissolved oxygen (-0.869), temperature and electrical conductivity (-0.641), temperature and total dissolved solids (-0.640) and a strong positive correlation between electrical conductivity and total dissolved solids (1.000).

Table 4.10: Seasonal Abundance of different Fish Species in relation to sex

Fish Species	Rainy			Dry Season		
	Male	**Female**	**Total**	**Male**	**Female**	**Total**
Clarias gariepinus	40 (6.82)	41 (6.46)	**81de (6.63)**	39 (8.61)	45 (9.26)	**84^{b} (8.95)**
Clarias anguillaris	52 (8.86)	50 (7.87)	**102^{c} (8.35)**	33 (7.28)	37 (7.61)	**70^{bcd} (7.45)**
Brycinus nurse	32 (5.45)	34 (5.35)	**66^{e} (5.40)**	37 (8.17)	39 (8.02)	**76^{bc} (8.09)**
Hydrocynus vittatus	48 (8.18)	48 (7.56)	**96^{cd} (7.86)**	36 (7.95)	36 (7.41)	**72^{bcd} (7.67)**
Marcusenius abadii	37 (6.30)	42 (6.61)	**79de (6.46)**	30 (6.62)	35 (7.20)	**65^{cde} (6.92)**
Mormyrus rume	28 (4.77)	37 (5.83)	**65^{e} (5.32)**	24 (5.30)	26 (5.35)	**50^{f} (5.32)**
Hippotamyrus psittacus	41 (6.98)	46 (7.24)	**87^{cd} (7.12)**	24 (5.30)	31 (6.38)	**55^{ef} (5.86)**
Mormyrops anguilloides	42 (7.16)	49 (7.72)	**91^{cd} (7.45)**	31 (6.84)	34 (7.00)	**65^{cde} (6.92)**
Oreochromis niloticus	79 (13.46)	87 (13.70)	**166^{a} (13.58)**	66 (14.57)	62 (12.76)	**128^{a} (13.63)**
Tilapia zilli	80 (13.63)	88 (13.88)	**168^{a} (13.75)**	68 (15.01)	68 (13.99)	**136^{a} (14.48)**
Synodontis budgetti	47 (8.01)	48 (7.56)	**95^{cd} (7.77)**	35 (7.73)	43 (8.85)	**78^{bc} (8.31)**
Shilbe mystus	61 (10.39)	65 (10.24)	**126^{b} (10.31)**	30 (6.62)	30 (6.17)	**60^{def} (6.39)**
Total	**587 (48.04)**	**635 (51.96)**	**1222 (56.55)**	**453 (48.24)**	**486 (51.76)**	**939 (43.45)**

	P value
Sex and the Rainy Season	0.578
Species and the Rainy Season	0.000
Sex and the Dry Season	0.625
Species and the Dry Season	0.000

Table 4.11: Seasonal Physico-chemical Parameters of Dogon Ruwa water Body of Kamuku National Park

Season	Months	Temp (°C)	DO(mg/L)	pH	EC (µS)	TDS (ppm)
Dry	November	24.55^{bc}±0.78	7.30^{a}±0.14	7.18^{a}±0.14	287.00^{a}±1.41	143.50^{a}±0.71
	December	23.00^{c}±1.41	7.10a±0.00	7.20^{c}±0.14	296.00^{a}±2.83	148.00^{a}±1.41
	January	20.50^{d}±0.71	7.06^{a}±0.92	6.20^{a}±0.14	289.50^{a}±0.71	144.50^{a}±0.71
	February	27.00^{b}±0.50	6.74^{b}±0.78	5.90^{b}±0.71	209.00^{b}±1.41	104.50^{b}±0.71
	March	31.50^{a}±1.00	5.90^{c}±0.14	7.05^{a}±0.71	98.00^{c}±0.00	49.00^{c}±0.00
	April	33.50^{a}±0.05	5.05^{b}±0.07	7.25^{a}±0.28	56.00^{d}±11.31	28.00^{d}±5.65
		26.68±0.25	**6.53±0.04**	**6.80±0.04**	**205.92±3.69**	**102.92±0.78**
	May	32.00^{a}±0.00	5.50^{b}±0.14	7.70^{ab}±0.14	37.00^{b}±1.41	18.50^{b}±0.71
Rainy	June	25.95^{bc}±0.71	7.46^{a}±0.36	7.49^{b}±0.32	37.00b±1.41	18.50^{b}±0.71
	July	26.65^{b}±0.71	7.05^{a}±0.71	8.02^{a}±0.03	77.00^{a}±1.41	38.50^{a}±0.71
	August	26.00^{bc}±1.41	7.15^{a}±0.71	7.12^{c}±0.08	71.00^{a}±9.90	35.50^{a}±4.95
	September	26.40^{bc}±0.85	7.09^{a}±0.12	7.10^{c}±0.14	71.00^{a}±7.07	35.50^{a}±3.54
	October	24.55^{c}±0.64	7.20^{a}±0.14	7.28^{c}±0.11	72.00^{a}±5.66	36.00^{a}±2.83
		26.93±0.25	**6.91±0.04**	**7.45±0.04**	**60.83±3.69**	**30.42±0.78**
P value		**0.916**	**0.427**	**0.043**	**0.008**	**0.008**

Key:

Temp (°C) – Temperature DO (mg/L) – Dissolved oxygen

pH - Hydrogen ion concentration EC (µS) – Electrical conductivity

TDS (ppm) – Total dissolved solids

Table 4.12: Correlation matrix of the Physico-Chemical Parameters of Dogon RuwaWater Body of Kamuku National Park

	TEMP	**DO**	**pH**	**EC**	**TDS**
TEMP	1				
DO	-0.869*	1			
pH	0.326	-0.104	1		
EC	-0.641*	0.348	-0.558	1	
TDS	-0.640*	0.348	-0.558	1.000*	1

***** Significant

Key:

Temp (°C) – Temperature

DO (mg/L) – Dissolved oxygen

pH - Hydrogen ion concentration

EC (µS) – Electrical conductivity

TDS (ppm) – Total dissolved solids

CHAPTER FIVE

5.0 DISCUSSION

A total of up to 12 fish species belonging to 11 genera from 6 families were caught using experimental gill nets of 9 different stretched mesh sizes (although only first four were responsive) set across the Dogon Ruwa water body of Kamuku National Park. This shows the versatility of gill nets in being able to snare fish of any size and shape. Sikoki *et al.* (1998) were also able to catch up to 25 fish species belonging to 15 families in Lower Nun River using gill nets. Sikoki *et al.* (1998) noted that gill nets had the capacity to catch fish of all sizes, shapes and species in all water habitats.

Gill nets can be used in lakes of any size; in deep or shallow water (river), under ice in winter, and over bottom that is too rough for seines and trawls and they can be used on a large or small scale; they are also passive gear to which fish swim and become stuck (Hamley, 1975). Gill net catches during the day and at night indicate that in shallow rivers such as in the present study, activity patterns are not clear-cut and a fishery could operate effectively throughout 24 hours as observed by Petr (1969) in Volta Lake, Ghana.

The twelve fish species identified in the Dogon Ruwa water body have also been observed by several fisheries' workers and researchers (Ita *et al.*, 1984; 1985; Akinyemi, 1987; Sikoki *et al*., 1998; Allison and Okadi, 2013; Oguntade *et al*., 2014) including species in other families, and found to constitute the major fisheries of inland waters in Nigeria, due to their ability to adapt to the physico-chemical parameters of the water bodies.

The occurrence of fish species and their abundance in Dogon Ruwa could be on account that the water body is part of Kamuku National Park, where fishing activities are supposed to be restricted or almost non-existent. The relatively low fish species composition in Dogon Ruwa water body (12 species in 6 families) compared with Nun River, in which Sikoki *et al*. (1998) recorded up to 25 species belonging to 15 families, can be attributed to the small size of Dogon Ruwa water body (<10 ha). Furthermore, rivers are known to typically support more fish species than their associated reservoirs, often as a result of large scale changes in regimes of temperature, turbidity, flow, allochthonous nutrient inputs and availability of food resources (Williams *et al*., 1998).

Large carnivorous fish species such as *Lates niloticus* and *Gymnarchus niloticus* were conspicuously absent in Dogon Ruwa water body; this is likely due to the relatively small size of the water body compared with a big one, such as River Benue. Fagade (1992) stated that large fish species such as *Lates niloticus* and *Gymnarchus niloticus* were not commonly found in small water bodies (>2 - <10 ha).

The fact that fish species in the six families were common throughout the study period in Dogon Ruwa water body is likely due to the relative abundance of these species in northern Nigeria, as indicated by Ita (1993) and Adeosun *et al*. (2011), who noted that the Mormyridae, Cichlidae, Mochokidae, Characidae, Bagridae and Clariidae were more common in northern Nigeria. Allison and Okadi (2013) also reported that these six families of fish were common during their study on the Lower Nun River; they suggested that variation in mesh size may have influenced the catches.

The dominance of cichlids by number and mormyrids by weight observed in this study is similar to the observations of Akinyemi (1987) on Eleiyele River and Olaniran (2003) on IITA water body; they both reported Cichlidae as the dominant family and suggested that this could be due to their ability to utilize a wide range of foods at the lower trophic level as herbivores, as well as their high fecundity and prolific nature. Food and high reproductive efficiency, as reported by Komolafe and Arawomo (2007), might be responsible for abundance of the cichlids. Moses (1974) suggested that the dominance of cichlids in Lower Nun River may be attributed to gear selectivity. I also agree with the remarks made by the authors.

The abundance of cichlids and mormyrids could be due to the environment, because Dogon Ruwa water body is located in an environment that has features which make these fish thrive better. Wuraola and Jenyo (2011) found that River Oni had abundance of Mormyridae due to the environment of Oni River, which has thick vegetation cover and fallen tree branches. According to Reed (1967) and Jenyo and Wuraola (2011), these species prefer to live around fallen trees in water, where the current is less swift, and worms and detritus abundant.

The abundance of fish species showed that *Tilapia zillii* was the dominant species, followed by *Oreochromis niloticus,* then *Clarias gariepinus*. This agrees with the findings of Akinyemi (1987) in Eleiyele River, that the families Cichlidae and Clariidae were dominant and occurred throughout their study period. The cichlids *Oreochromis niloticus* and *Tilapia zillii* were dominant in similar studies conducted in Lakes Kainji and Tatabu, in Niger State, by Daddy *et al.* (1991) and Ita (1993), respectively. Daddy *et*

al. (1991) and Ita (1993) suggested that their great numbers could be attributed to their high reproductive ability.

The ‘b’ values in length-weight relationships determine the growth pattern of the fish species. When b is equal to 3 or close to 3, growth in the fish is said to be isometric i.e. fish becomes more robust with increasing length (Bagenal and Tesch, 1978). Similarly when b is far less or greater than 3, growth in the fish is allometric which may be positive if >3 or negative if <3, i.e. the fish becomes thinner with increase in length (King, 1996). The result of the present study showed that the growth of the fish species in the Dogon Ruwa water body was allometric, that the fish become thinner with increase in length (Tesch, 1968; King, 1996). This was similar with documented works from Inland water bodies in Nigeria. Notable among them are; the findings of Olatunde (1984) in commercial fish landings in Zaria central market, Abowei and Hart (2009) in an investigation of some morphometric parameters of 10 fin fish species of Lower Nun River in Niger Delta, Ibrahim *et al*. (2009) in fish species of Kontagora Reservoir, also Ude *et al*. (2011) made similar findings in an evaluation of length-weight relationship of fish species of Ebonyi River and Alex Nehemia *et al*., 2012 in length-weight relationship and condition factor of tilapia species grown in marine and fresh water ponds.

The fish species in the present study had ‘b' value range of between 1.44 and 2.75 which indicate that they become thinner with increase in length. This was similar with the findings of Imam *et al*. (2010) with a recorded range of between 1.42 and 2.56 in Wasai Reservoir in Kano. However the ‘b’ values recorded for all the fish species in the present

study is below the documented values of 2.5 to 3.5 for tropical fish species (Gayannilo and Pauly, 1997).

The relationship of length-weight can be use in the estimation of condition factor (K) of fish species. In fisheries science, the condition factor is used in order to compare the condition, fatness or wellbeing of fish (Ahmed *et al*., 2011). It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition (Bagenal and Tesch, 1978).

Condition factor is also a useful index for monitoring of feeding intensity, age and growth rates in fish (Ndimele *et al*., 2010). It is strongly influence by both biotic and abiotic environmental conditions and can be use as an index to assess the status of the aquatic ecosystem in which fish live (Anene, 2005). The condition factors (K) of the twelve species in the present study range between 0.59 and 3.56, which is similar to what was obtained in other tropical water bodies. For example in Nigeria, a range of between 0.49 - 1.48 was recorded by Nwadiaro and Okorie (1985) in Oguta Lake. Also Kumolu-Johnson and Ndimele (2011) obtained a K-value of between 0.91 and 8.46 from Ologe Lagoon in Lagos. But Ibrahim *et al*. (2012) recorded a mean K-value of 1.98 ± 0.35 in Kontagora Reservoir in Niger State. While in Sudan Ahmed *et al*. (2011) recorded a K-value range of 0.506 and 3.415. The mean K-values of species sampled had there value greater than 1 which was an indication that the fish species were doing well in the water body, even though is less than the 2.9 to 4.8 reported by Bagenal and Tesch (1978) for mature fresh water fish, which was attributed to variation in weight of individual fish sampled.

The sex ratio of fish in Dogon Ruwa showed that there was significant difference between the number of male and female fish among all the fish species, the number of female fish was higher than the number of male fish. Omotosho (1997) made the same observation in Asa Reservoir and remarked that this was indicative of reproductive efficiency. Obodai and Waltia (2003) made a similar observation in the Tono water body of Upper east Ghana, where they obtained a male to female ratio of 1:1.2 in *Schilbe mystus*. However, much higher numbers of females per male fish have been reported for *Gnathonemus cyprinoides* and *Hepsetus odoe* with male to female ratios of 1:1.4 and 1:2 respectively, in Osinmo Reservoir by Komolafe and Arawomo (2008)

The observed seasonal variation in fish population size, being higher in the rainy season than in the dry season, concurs with the reports of Mosess (1987) and Abowei (2000) in Lower Nun River of the Niger Delta. Moses (1987) and Abowei (2000) noted that during floods, some fish species could move to another water body or migrate to a favourable habitat for food and breeding, causing the increase in population that they observed in the rainy season. Nevertheless, this report is contrary to the observations of Chinda and Osuamkpe (1994) in Lower Bony River, Niger Delta; Otobo (1995) in Southern Nigeria; Allison *et al*. (1997) in Lower Nun River; Sikoki *et al*. (1998) in Lower Nun River; Nweke (2000) in Elechi Creek and Ebere (2002) in Okrika Creek. They reported a higher population of fish in the dry season than in the rainy season, which they attributed to low volume and clarity of the water.

The physico-chemical parameters obtained in this study revealed that the mean range of the physico-chemical factors of Dogon Ruwa are within the limits for fish tolerance, survival and production, according to Boyd (1979); the values obtained are indicative of good water quality according to APHA (1998).

There were no significant differences in the temperature and dissolved oxygen between the seasons, but significant differences was observed in pH, electrical conductivity and total dissolved solid between the dry and rainy season months in Dogon Ruwa water body during the period of study. This Stability in physico-chemical parameters may be attributed to flow of water from surrounding streams, especially in the rainy season, wind movement (Harmattan) in the dry season, small size of Dogon Ruwa water body, in which thermal stratification (temperature discontinuity) probably does not occur, but mixing, which ensures a uniform distribution of dissolved substances. Stabillity is said to enhance reproductive activities and feeding. Akinbuwa (1999); Obodai and Waltia (2003) and Komolafe and Arawomo (2008) made similar observations on physico-chemical parameters. The authors noted that high water stability resulted in better reproductive activities and subsequent development of the fisheries resources in most rivers and streams; they remarked that turbulent mixing ensures a uniform distribution of dissolved substances, but temporary temperature discontinuities could occur in pools and deep water bodies.

Though the temperature of Dogon Ruwa water body was optimal during the period of study, the slightly higher mean water temperatures observed during the rainy season (May-October) than mean water temperatures in the dry season (November-April) may

likely be due to the geographical area of the study, rainy season in the northern part of Nigeria last for only three to four months (June–September). The rest of the year is hot and dry with temperatures climbing as high as 40 °C (104.0 °F) (Mandi, 2014). The slight variation observed in dissolved oxygen may be due to seasonal variation of temperature as revealed in the negative correlation between DO and temperature. Ita (1993) observed on Kainji Lake that the higher the temperature, the lower the DO of the water body.

The mean pH of 7.3 during the rainy season and 6.9 in the dry season were an indication that the river was moderately alkaline and was within the range of pH known for most lakes and streams of the world (Welch, 1952; Komolafe and Arawomo, 2008). Horne and Goldman (1994) reported that moderate alkaline pH favoured fish abundance. The electrical conductivity and total dissolved solids were also optimal during the time of study.

Since the water parameters recorded in Dogon Ruwa (protected area) were at optimal levels for fish abundance and growth, more adult fish than recorded should have been caught; however, the fact that more juveniles and sub-adults than adults were recorded in this study shows that the area is not probably well protected. During the period of study, poachers were caught at different times using gill nets of less than 1inch mesh size. The gill nets of 1 inch mesh size or less would catch all sizes of fish. Power Bratton (1985) and Muth and Bowe (1998) observed that it is not known exactly how much poachers kill, but its quite probable that they can illegally take just as much as legitimate

hunters/fishers do in some areas (i.e drastically reducing the fish population) during regular hunting season.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

At least a total of 12 species belonging to 6 families occur in Dogon-Ruwa water body of Kamuku National Park. The most numerically abundant fish families in descending order are the Cichlidae, Mormyridae and the Mochokidae.

The growth patterns of all the fish species in Dogon Ruwa water body of Kamuku National Park were negatively allometric with 'b' values range of 1.44 - 2.75 and the mean condition factor ('K') of separately and together in all the fish species was more than one (1), showing that all the fish species were generally in good condition.

The water quality of Dogon-Ruwa water body of Kamuku National Park was optimal between April, 2013 and March, 2014.

6.2 Recommendations

The authorities of the National Park should intensify the protection of this resources by enforcing existing laws and sanctioning/penalizing poachers i.e arresting and prosecuting offenders (LFN, 2004).

The findings of this study should serve as base line information in assisting the National Park Service in the management and conservation of the fish and fisheries resources of the Park's water body.

Further survey of fish species diversity and abundance should be carried out for a longer period on a larger scale for a thorough assessment of the water body and its fishery potential.

REFERENCES

Abowei, F. N. and Hart, A. I. (2009). Some morphometric parameters of 10 finfish species from the lower Nun River, Niger Delta, Nigeria. *Research Journal of Biological Sciences*, **4**(3): 282-288.

Adeniji, H. A. (1986). Some Limnological Precautions for Fish Farmers. *Kainji Lake Research Institute Annual report*, **4:** 54-56.

Adeniji, H. A. and Ovie, S. I. (1990). A Simple Guide to Water Quality Management in Fish Ponds. National Institute for Freshwater Fish Research (NIFFR), New Bussa. *Technical Report Series*, **23:**1-10.

Adeosun, F. I., Omoniyi, Y., Akegbejo-Samson, Y. and Olujimi, O. O. (2011). The fishes of Ikere Gorge drainage system in Ikere, Oyo State, Nigeria. *Asiatic Journal of Biotechnology Resources*, **2**(4): 374-383.

Ahmed, E. O., Ali, M. E. and Aziz, A. A. (2011). Length-weight Relationships and Condition factors of six fish species in Atbara River and Khashm el- girba Reservoir, Sudan. *International Journal of Agricultural Sciences*, **3**(1): 65-70.

Akinbuwa, O. (1999). The Rotifers Fauna and Physico-Chemical Condition of Erinle Lake and Its Major Inflows at Ede, Osun State, Nigeria. Ph. D. Thesis, Obafemi Awolowo University, Ile-Ife, Nigeria. 327pp.

Akinyemi, O. (1987). Fishing Activities and Fish Species Diversity Assessment in Eleiyele River, Ibadan, Nigeria. *African Journal of Livestock Extension*, **2**: 72-74.

Akinyemi, O., Ita, E. O. and Sado, E. K. (1985). A Preliminary Assessment of the Post-Impoundment Fisheries of Lake Asejire, Oyo State, Nigeria. *Kainji Lake Research Institute Annual report*, **6**: 44-50.

Alex, N., Justin, D. Mganira, A. and Cyrus, R. (2012). Length-weight relationship and condition factor of tilapia species grown in marine and fresh water ponds. *Agriculture and biology journal of North America*, **4**(1): 117- 124.

Allison, M. E. and Okadi, D. (2013). Gill Net Selectivity, Seasonal, Tidal and Photoperiod Variation in Catch in Lower Nun River, Niger Delta, Nigeria. *Science Resources Essays*, **8**:108-114.

Allison, M. E., Gabriel, U., Inko-Tariah, M. B., Davies, O. A. and Udeme-Naa, B. (1997). The Fish Assemblage of Elechi Creek, Rivers State, Nigeria. *Niger Delta Biological Science Journal*, **2**: 53-61.

Alphonse, A. and Rudi, V. T. (1995). Ecology and Fish Catches in Natural Lakes of Benin, West Africa. *Environmental Biology of Fishes*, **43:** 381-391.

Anene, A. (2005). Condition factor of four Cichlid species of a man-made Lake in Imo State, South-eastern Nigeria. *Turkish Journal of Fisheries and Aquatic Sciences*, **5**: 43-47.

APHA (American public Health Association) (1998). Standard methods for the examination of water and waste water. 20th, edition. American public Health Association Inc, New York. 1193pp.

Asiwaju, A. A. (2011). Catch assessment, fish species diversity and abundance in Ogun estuary, Ogun State, Nigeria. M.Sc. Thesis. University of Agriculture, Abeokuta, Nigeria. 122pp.

Auta, J. (1993). Water Quality Management in Fish Ponds. *Proceeding of National Workshop on Fisheries Extension Delivery.* 20pp.

Awachie, J. B. E. (1976). Fish Culture Possibilities on Flood-plains of Niger-Benue Drainage System. Central Institute of Freshwater Aquaculture. *Technical paper*, **5**: 170-184.

Bagenal T. B. and Tesch, F. W. (1978). Methods of Assessment of Fish Production in Fresh Waters. IBP Handbook No 3, 3rd edition. Oxford Blackwell Scientific Publication, London. pp. 101-136.

Bagenal, T. B. (1978). Egg and Early Life History Part 1: Fecundity in: method of assessment of fish production in freshwaters. Integrated Business Planning Handbook. Pp. 160-169.

Balogun, J. K. (2005). Fish Distribution in a Small Domestic Water Supply Reservoir: A Case Study of Kangimi Reservoir, Kaduna, Nigeria. *Journal of Applied Science of Environmental Management*, **9**(1): 93-97.

Balogun, J. K. (2006). Basic Fisheries Biology and Management For tertiary Institutions. Ayo-Sule (NIG) Printers & Publishers, Zaria, Nigeria. Pp. 3-33.

Banks, J. W., Holden, M. J. and McConnell, R. M. (1967). Phyletic Studies of Teleostean Fishes with a Provisional Classification of Living forms. *Bulletin of the American Museum of Natural of Natural History, New York*. **4**(4): 55-77.

Banks, J. W., Holden, M. J. and McConnell, R. M. (1966). Fishery Report. In: White E (Ed). *The first scientific report of the Kainji Biological Research Team.* University of Ile-Ife, Nigeria. p. 88.

Bolger, T., P. L. Connolly, P. L (1989). The suitable indices for the measurement analysis of fish condition. *Journal of Fish Biology*, 34:171-182.

Boyd, C. E. (1979). Water Quality in Warm Water Fish ponds. Agricultural Station, Auburn University, Alabama, 35pp.

Branco, C. W. C. and Senna, P. A. C. (1996). Relationship among Heterotrophic Bacteria Chlorophyta, Total Phytoplankton, Total Zooplankton and Physical and Chemical Features in the Paranoa Reservoir, Basilia. *Brazil Hydrobiologia*, **334**: 171-181.

Bukar, T. A. and Gubio, A. K. (1985). The Decline in the Commercially Important Species of Fish and Predominance of *Clarias lazera* in Lake Chad, *Fisheries Society of Nigeria 1985 Conference Proceedings*, pp. 35-51.

Charles, B. P. S. M. and Alan, B. (1998). *Fisheries Notes*: March, 1998 publication. FN005 (ISSN 1440-2254).

Chidi, A. U. (1993). The Yankari Fishes. *An Identification Guide to One Hundred and Fifty Nigerian Fish Species*, Kobi press, Bauchi, Nigeria, 64pp.

Chindah, A. C. and Osuamkpe, A. (1994). The Fish Assemblage of the Lower Bony River, Niger Delta, Nigeria. *African Journal of Ecol*ogy, **32**: 58-65.

Chude, L. A. (1979). Fish and Fisheries of Lake Ndalokwu. *A Flood Plain Downstream of Kainji Dam, Kainji Lake Research Institute Report*, p. 10.

Countant, C. C. (1987). Thermal Preference: When Does an Asset Become a Liability? *Environmental Biology of fishes*, **18:** 161-164.

Daddy, F. M., Osuamkpe, A. and Mohammed, A. (1991). Wetland Studies. Natural Resources Evaluation of Lake Tatabu (Ndakolowu), New-Bussa, *Nigeria National Institute for Freshwater Fisheries Research Report*, pp. 50-60.

Dupree, J. M. and Hunner, O. (1993). Some Simple Methods for the Assessment of Tropical fish Stocks. FAO. *Fisheries Technical paper,* **234:** 42-45.

Ebere, N. (2002). The Impact of Oil Refinery Effluents on the Distribution, Abundance and Community Structure of Macro-benthos in Okrika Creek. Ph.D Thesis, Dept of Biological Sciences, Rivers State University of Science and Technology, Port Harcourt, Nigeria. Pp. 30-383.

Egborge, A. B. M. (1992). Problems of Aquatic Resources Conservation. A Case Study of Nigerian Fishes. *Proceedings of the National Conference on Aquatic Resources Calabar,* 11 – 14th May, 1992. P 27.

Ekanem, S. B. (2000). Some Reproductive Aspects of *Chrysichthys nigrodigitatus* (Lacepe) from Cross River, Nigeria. The International Centre for Living Aquatic Resources Management (ICLARM), **23**(2): 24-28.

Fafioye, O. O. and Oluajo, O. A. (2005). Length-weight relationship of five fish species in Epe Lagoon, Nigeria. *African Journal of Agricultural Research*, **4**: 42-46.

Fagade, S. O. (1992). The food and feeding habits of *Sarotherondon galileaus* from a small lake. *Hydrobiology*, **93**(2): 256-263.

Falaye, A. E. and Jenyo-Oni, A. (2009). Aquatic biodiversity and the implication in artisanal fishing production. *African journal of livestock extension*, **7**: 39-43.

Federal Department of Fisheries (FDF) (2003). Presidential Forum on Fisheries and Aquaculture (Status and Opportunities). *Federal Department of Fisheries Report*, Abuja, Nigeria. P. 49.

Federal Department of Fisheries (FDF) (2007). Fisheries statistic of Nigeria, fourth edition 1995-2007. 49pp.

Federal Department of Fisheries (FDF) (2008). Fisheries statistic of Nigeria projected human population; fish demand and supply in Nigeria, 2000-2015. 56pp.

Froese, R. and Pauly, D. (Eds) (2014). FishBase. World Wide Web Electronic publication. Available at www.fishbase.org. (Version August, 2014)

Gayannilo, F. C. and Pauly, D. (1997). FAO International Center for Living Aquatic Resources Management (ICLARM) stock assessment tools (FISAT): *References Manual, FAO Computerized Information Series (Fisheries)*, **8**: 240-252.

Gomiero, L. M., Braga, F. M. S (2005). The condition factor of fishes from two river basins in Sao Paulo State, Southeast of Brazil. *Acta Scientiarum*, 27:73-78.

Hamley, C. E. (1975). *Biology of Fishes.* Sounder college, Philadelphia. Pp. 462-463.

Holden, M. and McConnell, R. H. (1965). West African Freshwater Fish. Longman. London. 67pp.

Hopson, A. J. (1967). The Fishes of Lake Chad. *In*: *Fish and Fisheries of Northern Nigeria*, Reed *et al.* (Eds.), Ministry of Agriculture, Northern Nigeria, Gaskiya, Zaria. 98pp.

Hubbell, S. P. (2001). The Unified Neutral Theory of Biodiversity and Biogeography. Princeton University Press, Princeton, United States of America. 275pp.

Hynes, H. B. N. (1974). The Biology of Pollutant Water. Liverpool University Press. Cambridge. 202pp.

Ibrahim, B. U., Auta, J. and Balogun, J. K. (2009). An assessment of the physico-chemical parameters of Kontagora Reservoir, Niger State, Nigeria. *Bayero Journal of Pure and Applied Sciences*, **2**(1): 64 – 69.

Ibrahim, B. U., Auta, J. and Balogun, J. K. (2012). Survey of Fish Biodiversity of Kontagora Dam, Niger State, Nigeria. *Nigerian Journal of Fisheries Science and Technology,* **1:** 47-54.

Idodo-Umeh. G. (2003). *Freshwater fishes of Nigeria* (*taxonomy, ecological notes diet and utilization*). Idodo Umeh publishes limited, Benin City, Nigeria. 112pp.

Ikomi, R. B. (1996). Studies on the Growth Pattern, Feeding Habits and Reproductive Characteristics of the *Mormyrid brienomyrus longianalis* (Boulenger 1901) in Upper Warri River. *Nigeria Fisheries Research,* **26**: 187-198.

Ikomi, R. B. and Odum, O. (1998). Studies on Aspects of the Ecology of the Catfish *Chrysichthys auratus* Geoffroy St. Hilaire (Osteichthyes; Bagridae) in River Benin. *Nigeria Fisheries Research,* **35**: 209-218.

Ikusemiju, K. and Olaniyan, C. I. O. (1997). The Food and Feeding Habits of the Catfish *Chrysichthys walkeri* (Gunther), *Chrysichthys filamentosus* (Boulenger) and *Chrysichthys nigrodigitatus* (Lacepede) in Lekki Lagoon, *Nigeria Journal of Fisheries and Aquaculture,* **10**: 105-112.

Imam, T. S., Bala, U., Balarabe, M. L. and Oyeyi, T. I. (2010). Length-weight relationship and condition factor of four fish species from Wasai Reservoir in Kano, Nigeria. *African Journal of General Agriculture,* **6** (3): 125-130.

International Union on Conservation of Nature and Natural Resources (IUCN). (2004). Managing Protected Areas in the Tropics. IUCN commission on National Parks and Protected Areas. P. 48.

.

Ita, E .O. (1993). Inland Fishery Resources of Nigeria. *Central Insitute of Freshwater Aquaculture Occassional Paper,* **20**: 120-126.

Ita, E. O. and Mohammed, A. (1979). A Preliminary Report of Expeditions to Inlet and Outlet Channels of Lake Ndakolowu (Tatabu) and a Proposal for Refilling the Lake: *Report submitted to Kainji Lake Research Institute,* 13pp.

Ita, E. O. and Pandogari, A. (1987). A Preliminary Investigations on the Fish and Fisheries of Some Randomly Selected Reservoirs in Kano State. *Kainji Lake Research Institute. Annual Report,* **10**: 38-43.

Ita, E. O., Mohammed, A., Omorinkoba, W. S., Bankole, N. O. and Awojodu, S. (1982). A Preliminary Report on the Immediate Post Impoundment Fishery of Shiroro Reservoir, Niger State, Nigeria. *Kainji Lake research institute, Annual report*, Pp. 25-29.

Ita, E. O., Sado, E. K., Balogun, J. K., Pandogari, A, and Ebitoye, R. (1984). A Preliminary Checklist of Inland Water Bodies in Nigeria with References to Ponds, Lakes, Reservoir and Major Rivers. *Kainji Lake research institute, Technical Report*, **14**: 51-60.

Ita, E. O., Sado, E. K., Balogun, J. K., Pandogari, A. and Ibitoye, B. (1985). Inventory Survey of Nigeria Inland in Nigeria with Special Reference to Pounds, Lakes, Reservoirs and major rivers. *Kainji Lake research institute, Technical Report*, **14**: 62-68.

Khaironizam, M. Z. and Norma-Rshid, Y. (2002). Length-weigth Relationshiop of Mudskipper in the Coastal Areas of Scangor, Malaysia. International Centre for Living Aquatic Resources Management. *World Fish Centre Quarterly Repor*t, **25**: 20-22.

King, R. P. (1995). Fisheries Biology, Assessment and Management, 1st Edition Fishing News Book, London, 118pp.

King, R. P. (1996). Length-weight relationship of Nigeria Freshwater Fishes. FAO *International Center for Living Aquatic Resources Management (ICLARM) Quaterly Report*, **19**(3): 49-52.

King, R. P. (1997). Length-fecundity Relationship of Nigeria Fish Population, *International Centre for Living Aquatic Resources Management (ICLARM)*, **20**(1): 29-33.

Komolafe, O. O. and Aramowo, G. A. O. (2007). Reproductive Strategy of *Oreochromis niloticus* (Cichlidae) in Opa Reservoir, Ile-Ife, Nigeria. *Journal of Tropical Biology*, **55**(2): 595-602.

Komolafe, O. O. and Aramowo, G. A. O. (2008). Preliminary Observation on Fish Species in a Newly impounded Osinmo Reservoir. *Turkish Journal of Fisheries and Aquatic Sciences*, **8**: 289-292.

Krohne, D. T. (2001). General ecology. 2nd edition. Brooks/Cole, London. 512pp.

Kumolu-Johnson, C. A. and Ndimele, P. E. (2011). Length-weight relationships of nine fish species from Ologe Lagoon, Lagos, Nigeria. *African Journal of Biotechnology*, **10** (2): 241-243.

Kutty, M. N. (1968). Respiratory Quotient in Gold Fish (Rainbow Trout). *Journal of Fisheries Society Research Canada,* **25:** 1689-1728.

Lagler, K. F., Bardach, J. E., Miller, R. R. and May Passino, D. R. (1977). Ichthyology, 2nd edition. John Wiley and Sons Inc., Florida, USA, pp. 129-163.

Law of Federation of Nigeria (LFN). (2004). National Park Service Act, Cap N65

Lawan, B. Marguba, (2002). National Parks and their Benefits to Local Communities in Nigeria. *Nigeria Parks Services Publication, Abuja*, Nigeria. 48pp.

Lawson O .E. (1969): Fish Diversity in Three Tributaries of River Ore, South-West, Nigeria. *Journal of Fish Science,* **2**(6): 524-531.

Lawson O .E. and Olusanya, M. O. (2010). Fish Diversity in Three Tributaries of River Ore, South-West, Nigeria. *Journal of Fish Science*, **2**(6): 524-531.

Lawson, O. T. (1969). A HandBook of Common Methods of Water Analysis for Limnology. Moshy Publishers, St. Louis, United State America. P. 69.

Le Cren, E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology*, **20**: 201-219.

Lelek, D. S. C. (1972). Fish Population of Kainji Lake (Trends in their development and utilization). Rome: FAO. *Technical report*, **2:** 23-26.

Lewis, D. S. C. (1974). The Effects of the Formation of Lake Kainji upon the Indigenous Fish Population. *Hydrobiogy,* **45**: 281-301.

Lima-Junior, S. E., Cardone I. B., Goite, R (2002). Determination of a method for calculation of Allometric Condition Factor of fish in Sao Paulo State, Southeast of Brazil. *Acta scientiarum*, **24**:397- 400.

Lowe-McConnell, R. H. (1987). Ecological Studies in Tropical Communities.1st Edition. Cambridge University Press, Cambridge. 337pp.

Mandi, T. (Eds) (2015). Nigeria weather. World Wide Web Electronic publication. Available at www.Cometonigeria.com. (Version August, 2015)

Martinez-Placious, C. A., Sanchez, C. C. and Olvera, M. A. (1993). The Potential for Culture of the American Cichlidae with Emphasis on *Cichlas maurophthalmus*. In: Muir, J.F. and Roberts, R.J. (Eds): Recent Advances in Aquaculture. Blackwell Scientific Publications, Oxford. 208pp.

Matthes, H. (1990). Report on the Fisheries Related Aspects of the Hadejia-Nguru Wetlands Conservation Project, Nguru, Nigeria. *Report to the Hadejia-Nguru Wetlands Conservation Project*, P. 42.

McGill, B. J., Etienne, R. S., Gray, J. S., Alonso, D., Anderson, M. J., Benecha, H. K., Dornelas, M., Enquist, B. J., Green, J. L., He, F., Hurlbert, A. H., Magurran, A. E., Marquet, P. A., Maurer, B. A., Ostling, A., Soykan, C. U., Ugland, K. I. and White, E. P. (2007). Species Abundance Distributions: Moving Beyond Single Prediction Theories to Integration within an Ecological Framework. *Ecology Letters*, **10**: 995–1015.

Mora, C. Sale, P. (2011). Ongoing global biodiversity loss and the need to move beyond protected areas: A review of the technical and practical shortcoming of protected areas on land and sea. *Marine Ecology Progress Series*, **434**: 251–266.

Moses, O. O. (1974). Aspect of the Biology of Asejire Reservoir. Ph. D. Thesis, University of Ibadan, Nigeria. 301pp.

Moses, O. O. (1987). Production, Utilization and Marketing in Fishery Status and Opportunities. Keynote address. *10th Annual conference of Fisheries Society of Nigeria Abeokuta, Nigeria.* Pp. 17-18.

Moss, B. (1993). Ecology of Freshwater. 2nd edition. Blackwell Scientific Publication. London. 417pp.

Motwani, M. P. and Kanwai Y. (1970). Fish and Fisheries of the Coffer Dammed Right Channel of the River Niger at Kainji. *Nigerian Institute of Social Economic Research report*, **1**: 27-48.

Murphy, B. (2009). General information on solids. Water quality monitoring. Pp. 24-36.

Mustapha, M. K. (2003). Fish Fauna of Oyun Reservoir, Offa, Nigeria. *The Nigerian field*, **50**: 75-78.

Muth, R. M., Bowe, J. R. (1998). Illegal Harvest of Renewable Natural Resources in North America: Toward a Typology of the Motivations for Poaching. *Society & Natural Resources*, **11**(1): 9–24.

Ndimele, P. E., Kumolu-Johnson, C. A., Aladetohun, N. F. and Ayorinde, O. A. (2010). Length-weight relationship, condition factor and dietary composition of *Sarotherodon melanotheron*, Ruppell, 1852 (Pisces: Cichlidae) in Ologe Lagoon, Lagos, Nigeria. *Agricultural and Biological Journal North America*, **1**: 584-590.

Nwadiaro, C. S. and Okorie, P. U. (1985). Biometric characteristics: length weight relationships and condition factors in *Chrysichthys filamentosus*, Pisces, Bagridae from Oguta Lake Nigeria. *Africa Biology*, 2: 48-56.

Nwadiaro, C. S. (1984). The Longitudinal Distribution of Macro Invertebrates and Fish in Lower Niger Delta River (River Sombrerio) *Nigeria Hydrobiology Bulletin*, **18**: 13-40.

Nweke, A. N. (2000). Impact of Organic Wastes Pollution on the Macro-benthos and Fish Fauna of Elechi Creek. *Ph. D. Thesis,* Department of Biological Sciences, Rivers State University of Science and Technology, Port Harcourt, Nigeria. Pp. 24-287.

Obasohan, E. E., Oransaye, J. A. O. (2006). Biodiversity and Sustainability of Freshwater Fishes of Nigeria. *Fisheries Society of Nigeria Proceeding*, **12**: 230-237.

Obeng, A. (1969). The Effect of Water Level Fluctuations on the Biology of Kainji, Nigeria. *Nigerian Field*, **41**: 156-165.

Obodai, E. A. and Waltia, S. C. (2003). Preliminary Observation on Fishing Activities in the Tono Reservoir, Upper-East Region, Ghana. *Journal of the Ghana Science Association*, **5**: 69-76.

Odusanya, A. S. (2008). Fisheries Livelihood in Ogun State. *Seminar Report*, Department of Aquaculture and Fisheries management, University of Agriculture Abeokuta. Nigeria. 49pp.

Offem, B. O., Samson, Y. A. and Omoniyi, I. T. (2008). Reproductive Aspects of Common Freshwater Fishes in the Cross river, Nigeria. *Journal of animal plant scienc*e, **18**(4): 130-138.

Ogbe, F. G., Obande, R. A. and Okayi, R. G. (2006). Age, Gowth and Mortality of *Bagrus bayad* from Lower Benue River, Nigeria. *Journal for the Tropics*, **3**(2): 103-109.

Ogun-Osun River Basin development authority (OORBDA). (1997). Distribution, Abundance and Food of Commercial Fish in the Black Volta and the Volta man-made lake in Ghana during its period of filling (1964-1968). *Hydrobiologia*, **32**: 417-485.

Oguntade, O. R., Oketoki, O. T., Ukenye, E. A., Usman, B. A. and Adeleke, M. T. (2014). Survey of the Present and Fast Disappearing Fish Species along Two Rivers in Niger Delta, Nigeria. *Journal of Fisheries and Aquatic science*, **9**(5): 352-358.

Olaniran, T. S. (2003). Fishing Activities and Fish Species Diversity Assessment in Eleiyele Lake, Ibadan, Nigeria. *African Journal of Livestock Extension*, **2**: 72-74.

Olaosebikan, B. D. and Raji, A. (1998). Field Guide to Nigeria Freshwater Fishes. Federal College of Freshwater Fisheries Technology Publication. Decency printers, Ilorin, Nigeria. 110pp.

Olatunde, A. A. (1977). The Distribution, Abundance and Trend in the Establishment of the Family Schilbeidae in Lake Kainji, *Journal of Nigeria Hydrobiology*, **56**: 69-80.

Olatunde, A. A. (1980). The Biochemical Composition and Nutritional Value of Eutropius niloticus, Schilbe mystus and Physailia pellucida. Family Schilbeidae (Osteichthyes: Siluriformes) from Lake Kainji, Nigeria. *Journal of Nigeria Hydrobiology*, **88**: 500 – 504.

Olurin, K. B. and Aderibigbe, O. A (2006). Length-Weight Relationship and Condition Factor of Pond Reared Juvenile Oreochromis niloticus. *Journal of Zoology*, **1**:82-85.

Olusola, O. K. and Arawomo, G. O. A. (2008). Preliminary Observations on Fish Species in a Newly Impounded Osinmo Reservoir. *Turkish Journal of Fisheries and Aquatic Science*, **8**: 289-292.

Omotosho, J. S. (1997). Ichthyofauna Diversity of Asa Reservoir, Ilorin, Nigeria. *Bioscience Research Communications*, **10**: 75-81.

Oniye, S. J., Adebote, D. A., Usman, S. K. and Makpo, J. K. (2006). Some Aspects of the Biology of *Protopterus annectens* (Owen) in Jachi Dam, Katsina State, Nigeria. *Journal of Fisheries and Aquatic Sciences*, **2:** 136-141.

Orchutt, J. D. and Porter, G. (1983). Dual Vertical Migration by 200 Plankton.Constant and Fluctuant Temperature Effects on Life History Parameters of *Daphnia. Journal of Limnology and Oceanography*, **28**: 720-730.

Otobo, A. J. (1995). Fish Communities of a Perturbed Stream, Southern Nigeria. *Journal of Tropical Ecology*, **4**: 12-15.

Parker, J. O. and Haswell, A. (1964). Age, Growth and Mortality of *Bagru bayad Macropetrus* (Foskalis, 1775) From Lower Benue River, Nigeria. *Biological and Environmental Sciences Journal for the Tropics*, **3**(2): 103-109.

Pauly, D. (1993). Linear Regressions in Fisheries Research. *Journal of the fisheries research*, Canada, **30**: 409-434.

Peter, U. Okorie, P. U. (1994). Fisheries Resources Surveys: Beyond Length-weight Relationship Models. *Nigeria Journal of Bioscience Research Commission*, **5:** 24-25.

Petr, T. (1969). Fish population changes in the Volta Lake, Accra, Ghana over the Period January, 1965 - September, 1966. Universities press for Ghana Academic of Science, pp. 220-234.

Power, B. S. (1985). Effects of Disturbance by Visitors on Two Woodland Orchid Species in Great Smoky Mountains National Park, United States of America. *Biological Conservation,* **31**(3): 211–227.

Reed, W., Burchard, J., Hopson, A. J., Jenness, J. and Ibrahim, Y. (1967). Fish and Fisheries of Northern Nigeria. Ministry of Agriculture, Northern Nigeria. Gaskiya, Zaria. 226pp.

Riedel, R. Caskey, L. M. and Hulbert, S. H. (2007). Length-weigth Relationship and Growth Rates of Dominant Fishes of the Salton Sea: Implications for Predation by Fish-eating Birds. *Lakes and Reservoirs Management report*, **23**: 528-535.

Ryder, P., Ross, E. and Howarth, K. (1974). The Ecology of Running Water. Liverpool University Press. London. 318pp.

Ryder, R. A. (1965). A Method for Estimating the Potential Fish Production of North Temperate Lakes. *Transactions American Fisheries Society*, **94**(3): 214-218.

Sikoki, F. D., Hart, A. I. and Abowei, J. F. N. (1998). Gill Net Selectivity and Fish Abundance in the Lower Nun River, Bayelsa State, Nigeria. *Journal of Applied Science and EnvironmentalManagement*, **1**: 13-19.

Soutullo, A. (2010). Extent of the Global Network of Terrestrial Protected Areas. *Conservation Biology*, **24**(2): 362-363.

Steele, R. G. O. and Torrie, J. H. (1980). Principle and Procedure of Statistics. McGram-Hill, New York, United States America. 633pp.

Stone, N. M. and Thomforde, H. K. (2006). Understanding Your Fish Pond. *Water Analysis Report*, Co-operative Aquaculture/Fisheries Extension Programme. University of Arkansas. Pine Bluff, Department of Agriculture and County Governments, United State of America. 88pp.

Tesch, F. W. (1968). Age and growth. In: Methods for Assessment of fish production in freshwater (Ricker, W. E. ed.). Blackwell Scientific Publication, Oxford. Pp. 93-123.

Thomas, J., Vena, S. and Kuruo, B. M. (2003). Length Weight Relationship of Some Deep Sea Fish Inhabiting the Continental Slope Beyond 250m Depth Along the West Coast of India. *World Fish Centre Quarterly Report*, **26**: 17-21.

Tobor, J. G. (1973). A Survey on the Fisheries of the Lower Yobe in the North Western Basin of Lake Chad, Nigeria. *Annual Report of the Federal Department of Fisheries*, **3**: 82-89.

Turner, J. L. (1970). The Fish Population of the newly impounded Kainji Lake, Nigeria. *Journal of West Africa Science Association*, **16**: 49-58.

Ude, E. F., Ugwu, L. L. C., Mgbenka, B. O. and Nwani, C. D. (2011). Evaluation of length-weight relationship of fish species of Ebonyi River, Nigeria. *Nigerian Journal of Fisheries*, **8**(1): 136-144.

Weatherly, A. H. and Gill, H. S. (1987). *The biology of fish growth*, London, academic Press. Pp. 433-443.

Welch, P. S. (1952). *Limnology*. 2nd edition, McGraw Hill Book Company inc. London. 538pp.

Welcome, R. L. (1985). River Fisheries. FAO. *Fisheries Technical Paper,* No.262, FAO, Rome. 40pp.

Welman, J. B. (1948). Preliminary Survey of the Freshwater Fisheries in Nigeria. Government printer, Lagos, Nigeria. Pp. 60-68.

Welman, J. B. (1984). The Physico-chemical Hydrology of a Tropical Seasonal River, Upper Ogun River. *Journal of Nigeria Hydrobiology,* **79**: 157-165.

White, E. (1965). The First Scientific Report of the Kainji Biological Research Team. University of Ife, Ile-Ife, Nigeria. P. 72.

White, M. (1965). Man-made Lakes in Tropical Africa and their Biological Potentials. *Archive Hydrobiology*, **4**: 219-224.

William, R. M., Halwart, T. and Barig, H. (1998). Integrating Fisheries and Agriculture to Enhance Fish Production and Food Security. *FAO Aquaculture newsletter*, **20**: 3-8.

Willoughby, L. G. (1976). *Freshwater Biology*. Hutchinson and Co., London, Great Britain. 410pp.

Wootton, R. J. (1990). *Ecology of Teleost Fishes*, 1st Edition Chapman and Hall, London, 718pp.

Word Conservation on Protected Areas (WCPA) (2000). Protected Areas: Benefits Beyond Boundaries. *International Union on Conservation of Nature* (IUCN), Pp. 42-52.

Worthington, G. H. and Richardo, C. K. (1930). Scientific results of the Cambridge expedition to the East African lakes No15: the fish of Lake Rudolf and Lake Baningo. *Journal Limnology Soiety of Zoology,* **267**:353-389.

Wuraola, O. B. and Jenyo, A. (2011). Assessment of Fish Biodiversity in Oni River, Ogun State, Nigeria. *International Journal of Agricultural Management and Development (IJAMAD),* **10:** 107-113.

Young, G. L. (1962). Fundamentals of Ecology, W. B. Saunders, Philadephia, Pennsylvania, United States of America, pp. 52-80.