

**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES**

**FISH ABUNDANCE AND SOCIO-ECONOMIC ASPECTS OF LAKE JIPE
FISHERIES, KENYA/TANZANIA BORDER**

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BY

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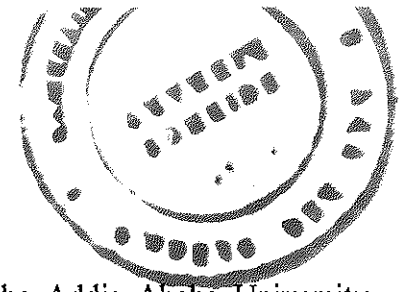
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Dedication

To my parents Linus Mukuru and Janet Mukuru for ensuring that I have quality education

and

The late Dr. Luc De Vos who was my mentor, teacher and friend and who introduced me to the field of Ichthyology



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ABSTRACT

Lake Jipe is a lake that is shared by two countries, Kenya and Tanzania, and is one of the water bodies where both human and natural activities have had great impacts both on the fish and fisheries. This study was aimed at identifying all the fish species found in the lake, determining the relative abundance of each of the species at selected sites and to assess the socio-economic aspects of fisheries in the lake. Fish sampling was done using gill nets of size 20 – 60 mm and fish identified to give a species inventory of the lake. Relative abundance was estimated using Catch Per Unit Effort (CPUE). A questionnaire was used to gather information on the socio-economic aspects. Nine species were identified from the lake. Catch Per Unit Effort (CPUE) showed that the introduced *Oreochromis esculentus* was the most abundant in both seasons and also in all the sites, both in numbers and weights. Analysis of Variance (ANOVA) indicated a significant difference in weight of specimens between the two seasons. The length-weight relationship for *Barbus. Paludinosus*, *O. esculentus* and *O. jipe*, which were the most common species in the lake, were found to be curvilinear. The mean seasonal Fulton condition factor was 2.0, 2.1, 1.3 and 0.9 for *O. jipe*, *O. esculentus*, *B. paludinosus* and *R. tangensis*, respectively. There were no significant differences in the water parameters between the sampling sites, but there were significant differences for BOD, electrical conductivity and temperature between seasons. Gill nets were the most commonly used fishing gear by the local fishermen and a mesh size of 30mm was most preferred. Fish caught by the fishermen were both for commercial and subsistence purposes. Fish preservation methods included smoking and sun drying. This study realized that the challenges facing Lake Jipe are a complex mixture of socio-economic and ecological factors some of which include increased siltation, decreasing water quality and quantity, shrinking fishery, advancing water plants, agricultural expansion and expanding irrigation.

KEYWORDS: Lake Jipe fisheries, Relative abundance, Socio-economic aspects, Kenya/Tanzania border

1. INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

Estimate of global decline in species richness and decline in processes that lead or contribute to the stability and resilience of ecosystems have aroused a lot of concern about the future of the biotic potential of the earth (UNEP, 1992 *cited in* Bruce and Brett, 1996). Fragmentation of natural habitats affects biodiversity at greater scales conventionally (Saunders *et al.*, 1991). Species loss and rarity in freshwater ecosystems of Kenya is particularly dramatic. Successful conservation of native fish communities, whether in protected areas or in managed landscapes requires the maintenance of interaction among organisms as well as between organisms and their environment. A successful strategy requires improvements in the management of protected areas.

Fish communities are the products of interaction among water quality and quantity, condition of the watershed and the species themselves (Jack and Gary, 1996). Any alterations of these might alter landscapes and create habitat mosaics hence shaping associated communities. Human activities and natural disturbances affect the interaction among the watersheds, riparian communities and aquatic habitats. The riparian zone, which is one of the most dynamic and productive portions of the landscape, reflects the consequences of these interactions (Gregory *et al.*, 1991). Floods and droughts are often critical and essential forces shaping fish communities (Jack and Gary, 1996). Floods might be necessary, for example to remove fine sediments from spawning areas, introduce large wood debris to stream channels and to scour new pool habitats (Swanston, 1991). Droughts shape fish communities whereas some fish species are adapted to survive complete desiccation (Léveque, 1997).

Water chemistry is also a very important factor influencing fish communities. The water level fluctuations are a key factor influencing the composition and abundance of fishes in water bodies. Storm events and seasonal variation in freshwater input alters salinity and thereby control the structure and location of fish communities in areas of tidal influence (Jack and Gary, 1996).

The presence of non-native species affects native species of fishes especially in areas of modified habitats (Courtenary and Stauffer, 1984). Non-native fishes often are predators that are introduced for other purposes but often cause decline or extinctions of native species (Moyle, 1976). Introduced fish might also be the source of diseases that depress the native fish (Heckmann *et al.*, 1986). The structure of fish communities can also be altered by the selective removal of certain species. When the efforts shift from one species to the other, as stock is depleted, a process of serial depletions occurs. Intense fishing reduces abundance, alters population, age structure and can also alter community structure all of which lead to clear signs of over-fishing (Polovina and Ralston, 1984).

Stresses on aquatic communities attributable to human activities include toxic metals and organic compounds, limnological changes due to excessive nutrients enrichment, acid rain, mortalities at water intakes by impingements and entrainment, losses of natural littoral habitats, depreciation of streams and bays and in many places pressure from exotic species and overexploitation (Johnson, 1984).

Eutrophication often causes enormous growth of higher aquatic plants and algae. Presently,

control of mass development of water plants presents a grave environmental problem because it requires substantial economic costs to combat them. Lake Jipe is such a good example bearing in mind the big masses of papyrus reeds and bulrushes encroaching the it from all directions owing to the high levels of siltation from the surrounding catchment areas (Mutonya, 1999). Abundant growth of submerged aquatic plants causes a rise in water levels, and a simultaneous reduction of the flow rate and of the mass of water flowing out (Welse and Jorga, 1981). As a result, water losses from evapotranspiration occur.

The species composition, distribution and percentage cover of aquatic plants may determine the fish species composition, diversity of fish population, fish production, access to fish stocks by fishermen, fishing gear and sometimes boat access and transport possibilities getting the fisheries products to the market (Petr, 1981). Aquatic macrophytes can also be efficient indicators of water quality and their presence may enhance water quality due to their ability to absorb excessive loads of nutrients (Petr, 1981).

Lake Jipe is a shallow basin at the foot of Mount Kilimanjaro and the Pare Mountains of Tanzania. According to Lowe (1951 *cited in* Dadzie *et al.*, 1988), the Lake was about 19 km long and 2 km wide. It is now estimated that the grip of the papyrus weeds and the bulrushes have captured 50% of its surface in the past 40 years (Mutonya, 1999). Until recently the lake contained two native species, which are *Oreochromis jipe* Lowe, 1955 and *O. girigan girigan* Lowe, 1955 (Dadzie *et al.*, 1988). According to Dadzie *et al.* (1988), *O. esculentus*, Graham, 1928, *Tilapia rendalli*, Boulenger, 1897 and *O. pangani pangani* Lowe, 1955 were introduced to the lake from the Tanzanian side either deliberately or by migration up the Ruvu River. Non-tilapiine species also present in the lake according to Dadzie *et al.* (1988),

include *Clarias gariepinus* Burchell, 1822, *Barbus paludinosus* Peters 1852 and *Rhabdalestes tangensis* Lonnberg, 1907.

The lake supports a considerable fishery. Dugout canoes are the only crafts used and gill nets of stretched mesh 2 inches to 3.5 inches are used (made of nylon thread of 2, 3 or 4 ply). The usual catch consists of tilapiines and some *Clarias*. The same species are caught by hook and line, using hooks of size 14", 16", and 18". Traditional traps (called Migono by the local people) are set at the shallow edges of the lake and catch all species (Dadzie *et al.*, 1988). Lake Jipe is one very important waterbody both to Kenya and Tanzania. For one, it is a reservoir of the Ruvu River in Tanzania, which has the hydro-electric power plant serving parts of the country. It supports lives of many people who are fishermen both on the Kenyan and the Tanzanian side. The lake is also a very important source of water for wild animals inhabiting Tsavo West National Park in Kenya.

Unlike the Lake Victoria water hyacinth, which is a floating mass of vegetation, the *typha* weed has its roots on the solid ground. According to a report by the Coast Development Authority (*cited* in Mutonya 1999), the proliferation of the papyrus is due to the high level of siltation from Kilimanjaro mountain complex. Fishermen in the area may lose their source of livelihood unless action is taken to curb siltation in the lake.

The impact of the introduced species of fish on the endemics is not known. According to Biley *et al.* (1978 in Dadzie *et al.* 1988), *O. esculentus* comprise of 24% of all the tilapiines in the commercial catches. Payne (1980, in Dadzie *et al.* 1988), observed that *O. esculentus* constituted the major part of the catch even in the shallow northern part of the lake but those

measured did not exceed 17.5 cm in total length, and may be they were sexually immature. Changing of ontogenic states to the atricial state of *O. esculentus* would endanger the endemic species because nets of mesh size small enough to catch juveniles of *O. jipe* and *O. girigan* before they reach sexual maturity are used. *O. esculentus* may also compete with the native species for breeding sites.

Fishing in Lake Jipe is for marketing as well as subsistence. The fields are therefore of legitimate concern and a factual knowledge about the status and potential of the lake is relevant to the economy of the local people as well as science.

1.2 Literature Review

1.2.1 Fish diversity

There are about 25,000 species of fishes worldwide, nearly half of which live in fresh waters (Williams, 1995). The most diverse families are the minnows (Cyprinidae: 272 species), Perches (Perchidae, 146), Suckers (Castomidae, 68) Killifishes (Cyprinodontidae: 65) and livebearers (Poeciliidae: 63). About 790 of these species occur in the United States (Williams, 1995).

1.2.2 African fish diversity

As elsewhere, Ostariopsian fish dominate the freshwater fish fauna of Africa, but the families are unequally represented. Over 2000 non-cichlid species belonging to 340 genera and 75 families (freshwater and brackish waters) have been recorded according to the checklist of freshwater fishes of Africa (CLOFFA) (Daget *et al.*, 1991). Cyprinidae, Characidae and a few Siluriform families constitute the bulk of the riverine fish fauna with Cyprinodontidae and Mormyridae (Skelton *et al.*, 1991). Cichlids are by far the most dominant species with some 870 species and 143 genera recorded, most of them being endemic to East African lakes (Daget *et al.*, 1991).

1.2.2.1 Ichthyological provinces of Africa

Roberts (1975) recognized ten ichthyological provinces in Africa. These are;

- The Maghreb which has extremely poor fish fauna;
- The Nilo- Sudan that extends from the Atlantic coast to the Indian Ocean and includes the major drainage basins of the Nile, Chad, Niger, Volta and Senegal;
- The upper Guinea province which includes coastal rivers from south of the Kogon River in Guinea to Liberia and exhibits faunistic affinities with the lower Guinea

province and the Zaire;

- The Lower Guinea which covers the coastal rivers from Cameroon to the mouth of the Zaire;
- The Zaire province which includes Lakes Kivu and Tanganyika;
- The Quanza which covers the Angolan coastal drainages;
- The Zambezi which includes the river basins of the Cunene, Ovambo, Okavango, Zambezi and Limpopo as well as Lake Malawi;
- The East Coast province which covers the coastal drainages from the Juba in the north to the Zambezi in the south; and
- The Southern province includes the basins of the Orange-Vaal and all the systems to the south.

The Malagasy, is not an ichthyofauna province recognized by Roberts, but is a part of the African continent.

1.2.2.2 Kenyan fish fauna

Kenya's hydrography is dominated by a series of lakes, rivers, floodplains and swamps. The lakes fall into two; L. Victoria and rift valley lakes. Riverine drainage systems of Kenya are largely influenced by the Great Rift Valley and six major drainage basins are evident. Kenyan fishes are approximately 700 species (>250 species freshwater) and currently, 206 species belonging to 38 families are known in the fresh waters (Seegers, *et al*, in press). The Kenyan coast harbors many species of marine fish.

With at least 50 species, Cyprinidae are far the largest fish family followed by Cichlidae, Mormyridae, Characidae and Alestidae represented by 28, 15, 15 and 12 species,

respectively. Taxonomic status of several Kenya fishes is currently unresolved and several still await formal description (Seegers, *et al*, in press). At least 18 fish species were introduced, deliberately or after escaping from fish farms, such as the rainbow trout and black bass. However, present taxonomic status of L. Victoria haplochromines is not accurately known given that 6% of the lake lies in Kenya and haplochromines have a lake-wide distribution (Ogutu-Ohwayo, 1990). Haplochromines of satellite lakes of Victoria such as Kanyaboli are currently unfully studied. An ecological change in L. Victoria after the upsurge of Nile perch has destabilized fish species composition in the region (Ogutu-Ohwayo, 1985; Ogutu-Ohwayo *et al.*, 1997).

1.2.3 Threats to fish biodiversity

Courses of declines of fish diversity are numerous and complex. In a survey of the extinctions on North American fishes during the past century, more than one factor contributed to 82% of the extinctions (Williams, 1995). There are various anthropogenic impacts on fish diversity some of which are discussed below.

1.2.3.1 Physical habitat alteration

Some of the activities that physically alter the habitat of fish include dam construction, water diversion, stream channelization, bank riprap, dredging and other projects that change the natural course or flow of aquatic habitats. Fishing Gear can reduce habitat complexity by smoothing bedforms, removing emergent epifauna and removing species that produce structures such as burrows (Auster, 1998).

World-wide, wetlands are rapidly being lost to drainage, mainly to increase agricultural production. In many areas, the traditional practices of flood recession agriculture on the floodplains have extended in response to increase in human population (Léveque, 1997). The destruction of aquatic habitats is a major consequence of deforestation and the possible disappearance of endemic species adapted to the clear forest waters (Léveque, 1997).

1.2.3.2 Pollution and eutrophication

Pollution in the form of point sources from industrial outfalls and sewage treatment plants, as well as non-point sources such as runoff from agriculture, rangelands, and urban areas, is a serious problem. Depending on the level of increased acidity, some fish communities have lost diversity and individual populations have decreased in size or have been eliminated altogether (Auster, 1998).

One of the most obvious direct effects on a lake of a net increase in nutrition is an increase in the abundance of phytoplankton which might cause a conspicuous reduction in transparency. The macrophyte species with weak root systems that absorb nutrients from the water increase with enhanced nutrient supply, large quantities of which can entangle boat propellers and swimmers. Plants with well developed root systems get much of their nutrition from the mud, and so recycle nutrients that otherwise would be permanently buried. An increase in the photosynthetic organisms provides food for an increase in the abundance of certain invertebrates and fish (Welse and Jorga, 1981).

1.2.3.3 Fishery management

Certain fishery management practices have adverse side effects on fish diversity. Some of these include stream and lake poisoning projects designed to eliminate “rough” or “trash” fish in favour of certain more “desirable fishes”. Some hatchery practices and poorly managed commercial and sport fishery harvests have had detrimental effects on fish diversity (William, 1995). Other problems include the release of large numbers of artificially propagated fish that compete or hybridize with remaining wild fish.

1.2.3.4 Introduction of non native species

The introduction and establishment of non-native species is a pervasive problem for fresh water fish conservation. Many species react in unexpected ways when introduced into established communities and novel environments. Problems resulting from introductions include competition with, predation upon, or hybridization with the native species and a disruption of the food webs that can affect even terrestrial species. Introduced species may also carry non native parasites and diseases and spread them to the native species (William, 1995)

The Nile perch (*Lates niloticus* Linnaeus, 1758), *Oreochromis leucostictus* Trewavas, 1933, *Tilapia zilli*, Gervais, 1948 and *Tilapia melanopleura* Dumeril, 1859, were introduced into Lakes Victoria and Kyoga to improve the declining fisheries of large species (Ogutu-Ohwayo, 1990). Stocks of Nile perch started to increase rapidly in 1965, in Lake Kyoga and in 1977, 1981 and 1983 respectively in Lake Victoria. This led to the decline of the haplochromines and upsurge of the Nile perch.

1.2.4 Fish as indicators of environmental quality.

The use of fishes as indicators of environmental health or biological integrity is based on the tenet that fish species or fish communities are sensitive indicators of the relative health of an aquatic ecosystem (Naiman, 1992). According to Lowe-McConnell (1993), structurally and functionally diverse fish communities provide evidence of water quality in that they incorporate all the local environmental perturbations into the stability of the communities themselves.

Fish are used as biological indicators because they utilize a wide variety of habitats both in marine and fresh water environments. These habitats and consequently the fish assemblages associated with them are potentially affected by a number of anthropogenic influences (Lowe-McConnell, 1977). As water flows from mountain tops to valleys and ultimately to lakes and oceans, it collects runoff, sediments, nutrients, and pollutants. Point and non point sources of pollution are synergized and often form complex and lethal compounds as they accumulate downstream. Fishes are the best known species of the aquatic world which reflect the health and dysfunction of aquatic habitats (William, 1995). Certain fish or fish guilds may be utilized as indicators of environmental degradation. For example, the presence of certain introduced fishes, such as the common carp and mosquito fish, may indicate poor quality habitats because of their broad tolerance to degraded environmental conditions (Williams, 1995).

In addition, some of these potential impacts can have a direct influence on the food resources distribution, abundance, growth, survival and behavior of fishes in aquatic environments. Within South Africa, many groups of organisms have been proposed as indicators of

ecosystem health, although no single group is favored by all biologists. It appears that fish and micro- invertebrates have received the most attention (Naiman, 1992). Fish have numerous advantages as indicator organisms for biology monitoring programmers. These include:

- they are typically present in all aquatic systems except in highly polluted waters;
- there is extensive life –history information available for most species;
- easy to identify compared to invertebrates and most samples can be processed in the field with the fish being returned to the waters;
- comparatively long-lived and therefore provide a long term record of environmental stress; and
- acute toxicity and stress effects can be evaluated in the lab using selected species some of which may be missing from the study systems.

Some of the difficulties and problems encountered when using fish as environmental indicators include:

- the selective nature of sampling gear for certain sizes and species of fish;
- sometimes substances physically or chemically harmful to other organisms do not have a detrimental effect on fishes; and
- the mobility of fishes on seasonal and due time scales can lead to sampling bias.

1.2.4 Role of papyrus in wetlands

Wetlands dominated by papyrus (*Cyperus papyrus* L. Cyperaceae) are extensively distributed in East and Central Africa. However, the use of papyrus swamps by fishes is limited to species that can tolerate the low oxygen conditions that prevail in the dense

swamp interior (Olowo and Chapman, 1996). The dense canopy of papyrus limits mixing of the water column and incident light, which in combination with high rates of organic decomposition of huge amounts of vegetation, produces extremely low oxygen conditions in the water (Beadle and Lind, 1960; Chapman and Liem, 1995).

The extreme hypoxia that characterizes the dense interior of papyrus swamps may limit the dispersal of non-air breathing fishes (Olowo and Chapman, 1996). Papyrus swamps may be important to the maintenance of variation among population of some water breathing fishes through selection for low oxygen tolerance and their patchy distribution in rivers and lakes of East and Central Africa (Beadle and Lind, 1960).

1.2.5 Fish production and marketing

Kenya's fish industry is a source of income and food for many Kenyans (Ogotu, 1992). It also earns foreign exchange through export of fish products. The government policy on the fish industry aims at increasing fish production by ensuring high remunerations to fishermen. It also intends to promote fish consumption by making fish more available to consumers at affordable prices (Kenya Government, 1989). Marketing of fish starts as soon as it is landed and continues as the fish is passed down a clearly defined marketing channel until it reaches the market outlet. The marketing sector is the link between the fisherman and the consumer and its performance has a major impact on fish production, pricing and consumption.

All fisheries are finite in their production. Many traditional fisheries are probably already over-fished in those areas of easy access along the shores of lakes. Once permissible yields

have been determined by stock assessment personnel, those responsible for the continuance of the fishery must determine the best way to ensure that over-fishing does not occur. For full control all those participating in the fish catching and marketing process should be registered and licensed, with the eventual aim being to issue a quota of licenses to a particular type of fishing in each area under consideration when the fishing pressure becomes excessive (Willoughby, 1979).

One of the major problems in tropical Africa is that of preserving the catch (Willoughby, 1979). Two traditional methods of preservation are used throughout Africa; sun drying for smaller fish and smoking, usually a hot smoking or roasting process, for larger ones. Salting and brining fish is a rather more restricted technique, as in some areas, salt is scarce, while in others, customers may reject the product (Willoughby, 1979). The use of ice for short term preservation of the catch during transit from the place of capture to the retail market is now becoming common in several countries. Freezing and canning plants have also been introduced in several countries such as Kenya and Malawi but these must obviously be sited in locations where regular supply of good quality fish can be guaranteed. Distribution methods vary considerably according to the location and size of the supply source in relation to the market. In more isolated areas, and for most of the traditional fisheries, the only people able to obtain fresh fish are the villagers in the immediate area. Fish in excess of the requirement of these people must be smoked or dried as soon as possible after catching

1.3 Objectives

1.3.1 General objective.

The main objective was to assess the present status of fish and the socio-economic aspects of fisheries of Lake Jipe.

1.3.2 Specific objectives

The specific objectives were the following:

- 1 Identify the fish species found in Lake Jipe;
- 2 Determine the relative abundance of each of the species at selected sites; and
- 3 Highlight some socio-economic aspects of the fishery.

1.3.3 Research questions.

- What species of fish are found in Lake Jipe both native and introduced other than those identified by earlier researchers?
- What is the relative abundance of each fish species in the Lake?
- What are the current socio-economic aspects of the fishery on the lake?

2. STUDY AREA AND METHODS

2.1 Study area

2.1.1 Size and location

Lake Jipe lies at the western side of Tsavo West National Park in the Coast province of Kenya. It is a shallow basin at about 3° 40' S 37° 40' E east of the north Pare mountains, Tanzania. The lake is bisected by the Kenya-Tanzania border and is at the foot of Mount Kilimanjaro. The Lake is about 10 km long and 3 km wide and only a few meters deep and is about 720 m above sea level. Its northern end is a swamp into which flows a stream, known in Kenya as Lumi, from Mount Kilimanjaro. The Ruvu river flows from the North East corner of Lake Jipe to Nyumba ya Mungu in Tanzania.

2.1.2 The Jipe drainage basin

Lake Jipe is fed by Lumi River that is fed by subsurface drainage, which results from snowbelt and rainfall around Mount Kilimanjaro. Some of the subsurface water reaches the river through springs. The slopes of Mount Kilimanjaro are all in Tanzania while Lumi River runs through the Kenyan territory, past the town of Taveta to the lake.

The Lumi enters Jipe through a large *typha* swamp, which may exceed 20 km² in area and blends into the swamps of the Ruvu River, the exit of the lake waters. However, intensive diversion of the Lumi River for irrigation at present has caused drying of the part of the river entering the lake; hence no water enters the lake from the river. The other main source of water for Lake Jipe is the Pare Mountains in Tanzania. There is virtually no inflow from the western side of the lake where the Serengeti plains in Kenya's Tsavo West National Park are arid and very flat. Several small hills on the Kenyan shore produce occasional runoff to the

lake via stream beds that are dry, red, sandy channels for most of the year.

The level of the Lake is partly regulated by the outflow from the Ruvu river, which passes through a very extensive swampy area with almost no slope before becoming a true River near Kifaru. This swamp which is dominated by papyrus, covers around 35 km² and is both in Kenya and Tanzania as the river channel is the international border. The Ruvu then flows westwards to Nyumba ya Mungu reservoir where it joins with waters from the southern and western sides of Mount Kilimanjaro and Mt Meru to become the Pangani River.

2.1.3 Climate

Data for annual rainfall of the area shows great variability between the maximum and the minimum annual rainfall. The average rainfall is 700 mm with a bimodal pattern. The short rains in November are much more intense than the March - May long rains.

2.1.4 Vegetation

The vegetation of the Lake and the fringing swamps is dominated by the bulrush (*Typha domingensis* Pers. Typhaceae) which grows out from the lakeshore and forms floating islands as well as lining the lake edges. This plant thrives very well in the Lake Jipe waters despite their sodic content as it grows over 5 m high and is very dense. The swards of *Cyperus laevegatus* L. Typhaceae (the soda-tolerant sedge) on the lowland side of the rushes and the abundance of the soda tolerant grasses *Spolobolus spicatus* Kunth Poaceae and *S. macranthus* further attest to the presence of sodium carbonate in the water and soil. While *Typha* predominates, many other wetland plants are present, especially at the northern end where the Ruvu River exits through extensive papyrus swamps. Lake Jipe's swampy ends

are surrounded by semi - aquatic grasses and reeds and patches of water weeds (*Najas* and *Potamogeton*) spread their leaves and flowers on its surface. Acacia wooded grasslands cover the surrounding area on the Kenyan side with *Acacia xanthophloea* Benth, Mimosaceae, being the dominant *Acacia* species.

2.1.5 Bird fauna

Some of the piscivorous birds found in the lake include; Lesser Jacana, Purple Gallinule, Madagascar Squacco Heron, Black Heron, African Darter, African Skimmers and Kingfishers. Other non piscivorous birds seen include; raptors, rollers, Starlings, Weaver birds, Hornbills, Secretary birds and stocks. The double banded courser, which is a bird of short grass plains or desert, often far from water has also been seen between large piles of hippo dung at Lake Jipe (Pers com).

2.1.6 Other vertebrates

The lake is important to the aquatic and terrestrial fauna both wild and domestic of wide area around it because it is a permanent source of water and green vegetation throughout the dry seasons. Lake Jipe being at the western side of the Tsavo West National Park serves as the watering and feeding resource for aquatic and terrestrial animals from the adjacent dry plains. The lake also harbors crocodiles and hippopotamus.

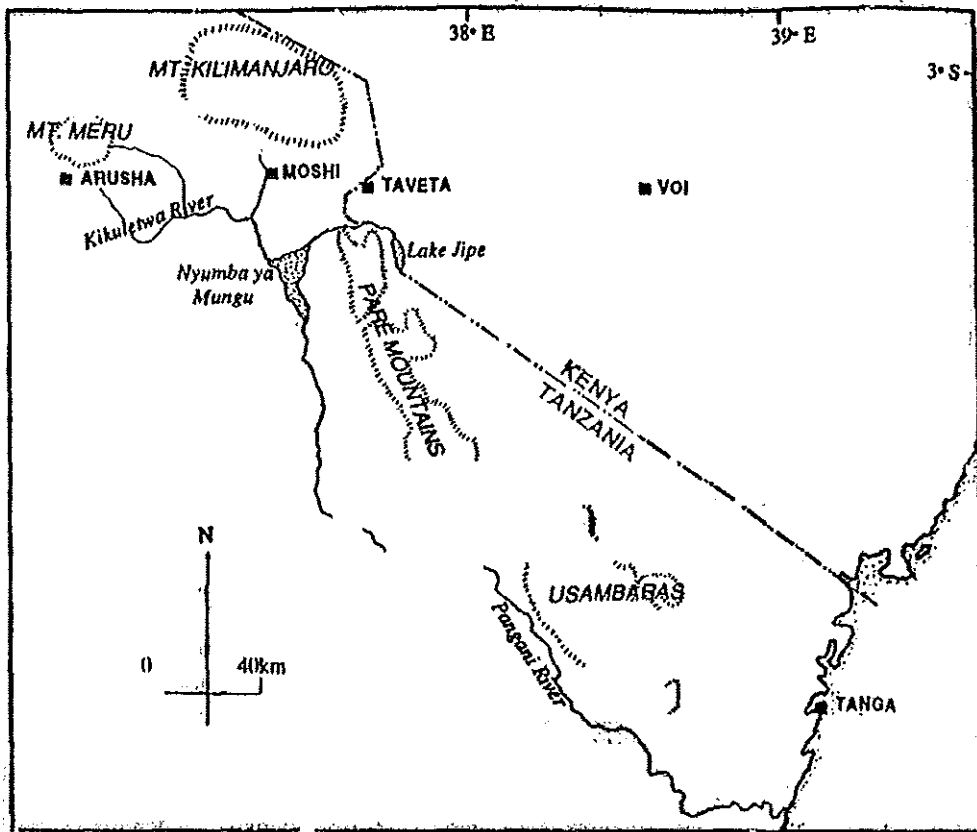


Figure 1: Location of Lake Jipe in relation to major geographic features

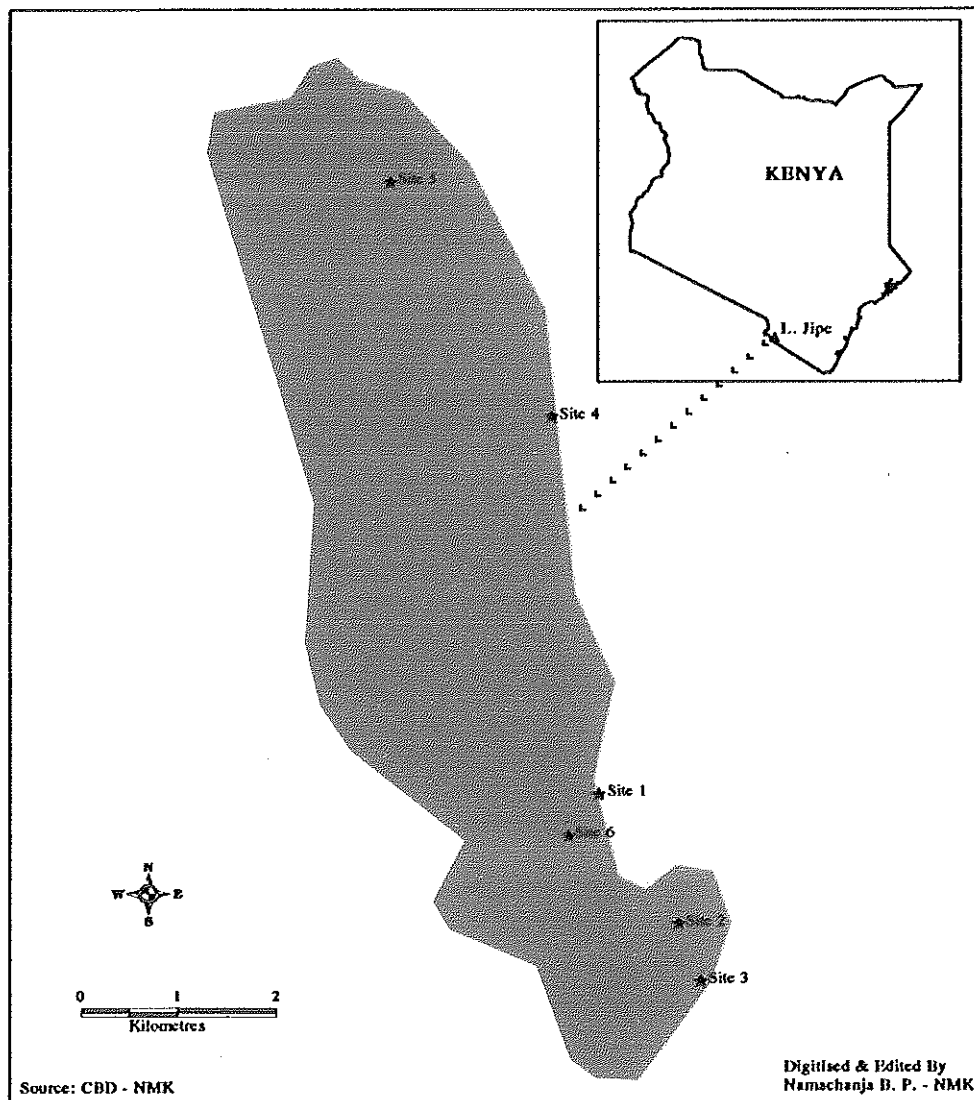


Figure 2: Map of Lake Jipe showing the sampling sites (Inset: Map of Kenya showing the location of Lake Jipe)

2.2 Methods

Data was collected in two consecutive seasons; the dry season (August to October, 2003) and the wet season (November, 2003 to January, 2004). Six sampling sites were selected, three on the shore and three in the interior. Fish samples were collected at the selected sites using stretched gill nets of sizes 20 mm, 30mm, 40mm and 50 mm. Total length (T.L) and total weight (T.W) of all the fish specimens were measured to the nearest 1mm using a vernier caliper and 0.1g using a weighing balance, respectively. The fish were then put in plastic jars containing 10% formalin and labeled with dates of collection and the locality (sampling site). The depth of the lake was taken at the sampling sites and transparency measured using a secchi disc. Temperature of the lake was taken with a mercury thermometer placed directly into the water for few minutes. Conductivity was measured using a conductivity meter according to Talling and Talling (1965). Oxygen measurements were made with a YSI model 57 oxygen meter.

Water samples were collected in polythene bottles (soaked in dilute nitric acid and rinsed with distilled water) as recommended in APHA (1985) from the six sampling sites. A portable digital pH meter model 818 (Scholl, Germany), placed at a depth of 30cm, was used to measure pH. Biological Oxygen Demand (BOD) was measured using a Hach manometric BOD meter kept at 20°C for 5 days in the dark. This was done in order to determine how much oxygen was being used to decompose organic matter and if there was enough left for fish and other organisms that rely on oxygen. Fish specimens were then transported to the National Museums of Kenya (NMK). In the laboratory, specimens were tagged, catalogued and stored in the NMK ichthyology department's collection room.

2.2.1 Identification of specimens

This was done by the use of taxonomic keys (Copley, 1958; Eccles, 1992; Skelton 1993, Seegers *et al.*, in press). The specimens were also compared with other previously identified specimens from the same lake available at the National Museums of Kenya, Ichthyology collection. Identified fish were then sorted into species.

2.2.2 Determination of relative abundance

The relative abundance at the sampling sites was estimated by Catch Per Unit Effort (CPUE) method. CPUE was recorded as the number and weight of fish of each species caught per net set during the sampling occasions. The nets were left in the water for three hours in every site on each sampling occasion.

2.2.3 Socio-economic aspects

A questionnaire was administered to determine the socioeconomic aspects of the fishery (see appendix 1). Other information was obtained by direct observation. The mesh sizes of gill nets used by the local fishermen were measured using a vernier caliper.

2.3 Data analysis

Data was analysed using the STATISTICA software (StatSoft, Inc., 2000). Data for the relative abundance was analyzed by computing weights and numbers of each fish species occurring in each of the sampled site for both the dry and the wet season. Analysis of Variance (2-way ANOVA) was used to compare if there were significant differences in the weight and numbers of specimens between sites and seasons.

Data for length-weight relationships for the most common species in the lake were analyzed by fitting a regression equation, $TW=aTL^b$ (Le Cren, 1951; Bagenal and Tesch, 1978). Data for socio-economic aspects were reported and length frequency of the most common species determined. Well being of a fish was assessed by computing the Fulton condition factor for each sample of the most common species (Le Cren, 1951; Bagenal and Tesch, 1978) as follows:

$$\text{Fulton Condition Factor (FCF)} = 100TWTL^{-3}$$

3. RESULTS

3.1 Fish species found in Lake Jipe

A total of nine species were identified during the study period. All the nine species were reported by earlier scientists. The species identified were; *Oreochromis esculentus* Graham, 1928, *O. jipe* Lowe, 1955, *Barbus paludinosus* Peters, 1852, *Clarias gariepinus* Burchell, 1822, *Haplochromis bloyeti* Sauvage, 1883, *Tilapia rendalli* Boulenger, 1899, *Synodontis zanzibaricus* Peters, 1868, *Rhabdalestes tangensis* Lonnberg, 1907 and *Barbus lineomaculatus* Boulenger, 1903. Fish species identified by earlier scientists Lowe (1951 in Dadzie *et al* 1988) but not found in the present study include *O. girigan* Lowe, 1955, and *O. pangani* Lowe, 1955.

3.2 Relative abundance

A total number of 3926 fish specimens were caught during the study period of which 3478 were caught during the dry season whereas 448 were caught during the rainy season. In the dry season *O. esculentus* had a total of 2665 specimens in all the sites thus being the most abundant of all the other species. Other species in the dry season had the following number of specimens: *O. jipe* 94, *T. rendalli* 25, *B. paludinosus* 653, *B. lineomaculatus* 2, *S. zanzibaricus* 1, *C. gariepinus* 21, *R. tangensis* 31 and *H. bloyeti* 21 (see appendix 4). In the wet season, the numbers of specimens were 326, 73, 1, 15, 0, 1, 7, 23 and 0 respectively (see appendix 5). *O. esculentus* which is an introduced species was therefore the most abundant in all the sites both during the dry and the wet seasons thus forming the highest percentages of the catches (see appendices 4 and 5). The same species also dominated the fishermen catches (F.C) in both seasons (see appendices 4 and 5). For the six sites in the dry period *B. paludinosus* came second in number of specimens and *O. jipe* which is the native tilapiine in

the Lake came third. However, *O. jipe* was more abundant than *B. paludinosus* both in number and weight in the wet season. *C. gariepinus* also formed considerable amount of the fishermen catches. *B. lineomaculatus* showed very low abundance in number and weight and not being present in the catches at all during the wet season and only two specimens caught during the dry season (see Figures 3 and 4, Appendices 4 and 5).

O. esculentus had total lengths ranging from 42.9 mm –160.5 mm with a mean±SD length of 80.2 ± 24.45 mm. Others species had ranges and means as shown in table 1 below.

Table 1: Range and means±SD of weights (g) and lengths (mm) of specimens sampled in Lake Jipe.

Fish species	N	Range of weights	Mean±SD	Range of lengths	Mean±SD
<i>O. jipe</i>	117	2.9 - 350	35.1±32.2	11.6 - 296.8	122.3±30.5
<i>O. esculentus</i>	2999	2 - 79.7	12.2±9.7	42.9 - 160.5	80.2±24.45
<i>B. paludinosus</i>	679	4 - 75.8	6.2±5	60 - 96.3	75.9±7.5
<i>T. rendalli</i>	31	14.4 - 82.5	43.9±25.7	93.5 - 169.6	125.6±26.99
<i>H. Bloyeti</i>	23	2.6 - 4.3	3.3±0.5	49 - 58.9	52.6±2.7
<i>R. tangensis</i>	55	0.9 - 2.3	1.4±0.3	38.7 - 67.8	54.2±7.7
<i>C. gariepinus</i>	28	440 - 545	477.9±440	255-360	293.8±30.9

There were variations in the abundance of fish species found in different sites but *O. esculentus* featured in all the sites. *O. jipe* was more abundant in the sites near the shores and very inshore. *B. paludinosus* appeared in all the sites during the dry season but appeared in only one site during the wet season. However, it featured in the fishermen catches. *R. tangensis* appeared in almost all the sites in both seasons.

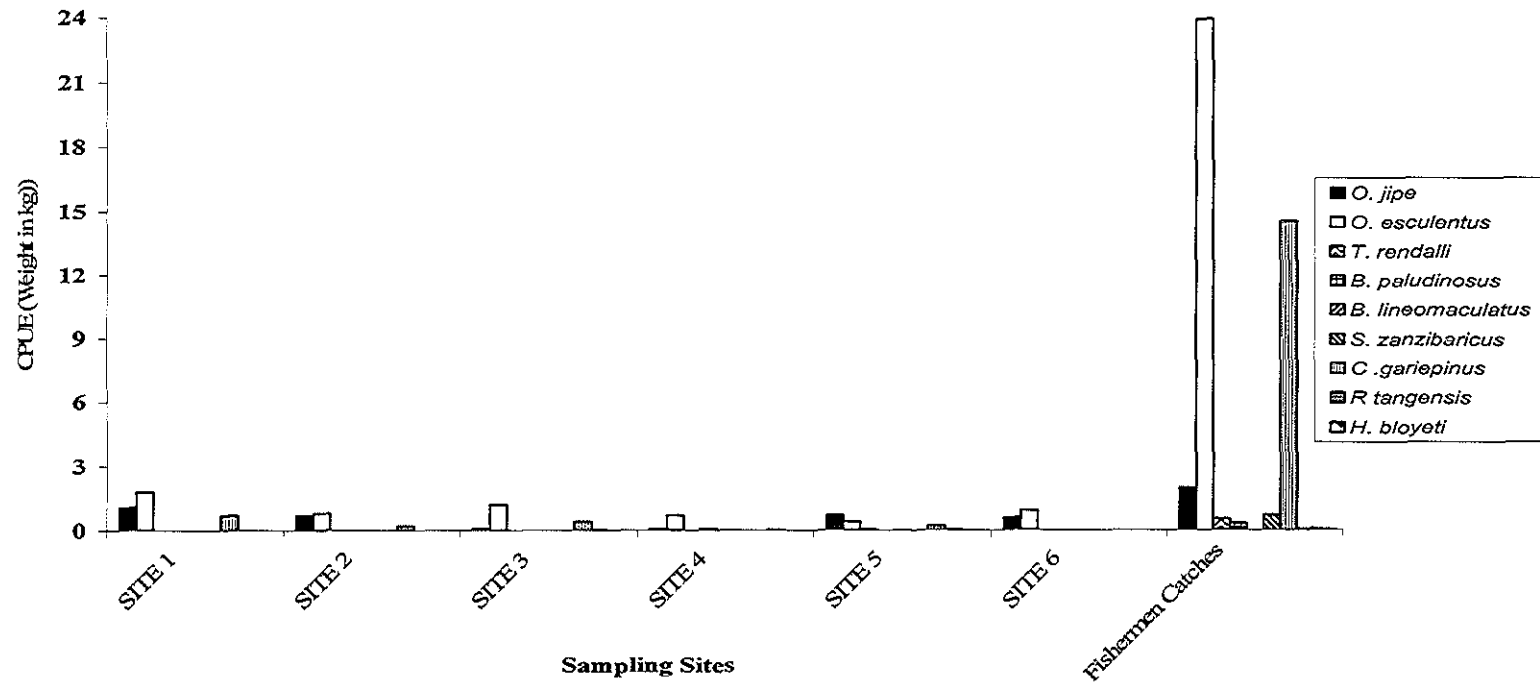


Figure 4: CPUE by weight during the wet season in Lake Jipe

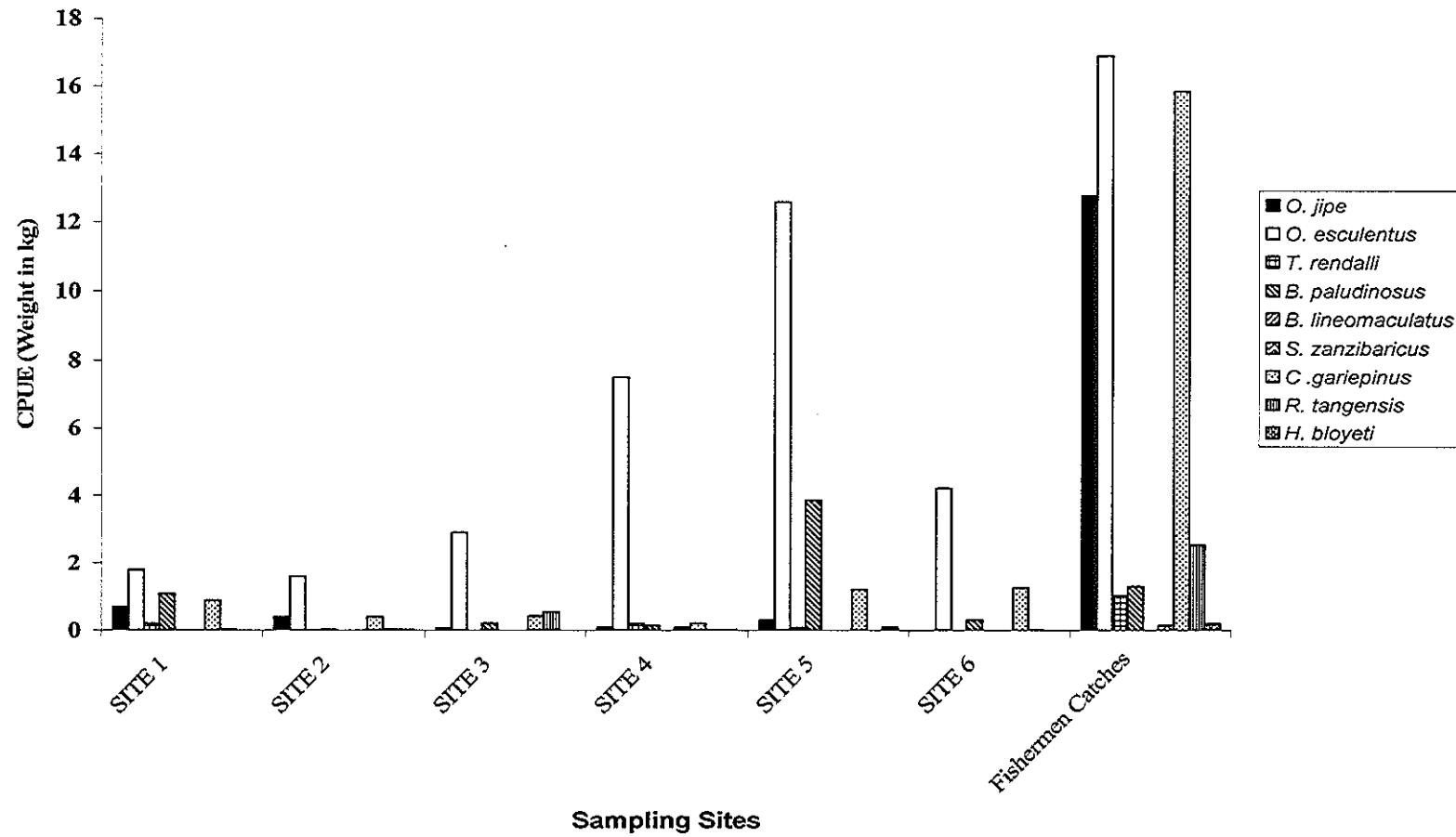


Figure 2: CPUE by weight during the dry season in Lake Jipe

3.2.1 Number of specimens at the sampling sites

There were more number of specimens in the dry season than in the wet season. The fishermen catches and site 5 had the highest number of specimens in the dry season. In the wet season all the sites had small number of specimens (see Figure 5).

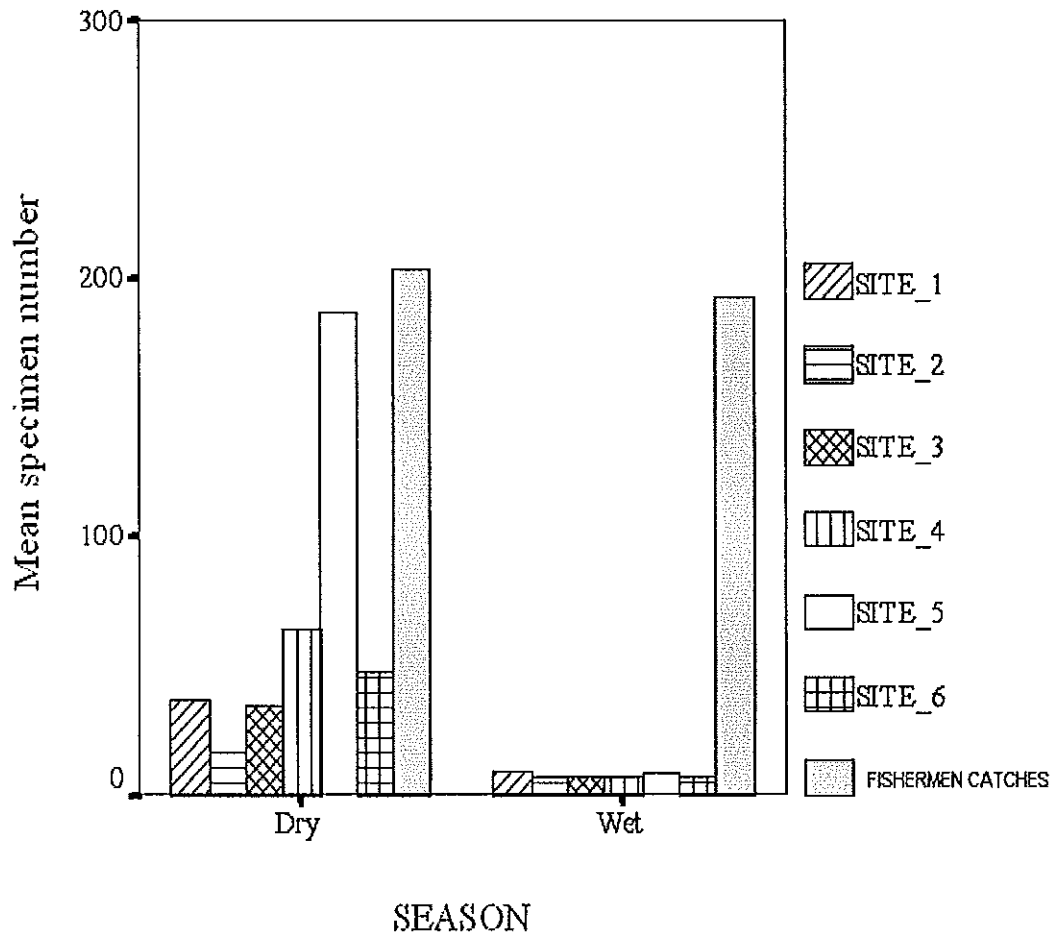


Figure 5: Mean number of all species in the two seasons at different sites.

3.2.2 Weight of specimens at the sampling sites

There was more weight of specimens during the dry season than in the wet season at the sampling sites (see Figure 6, appendix 2 and 3). There were no significant differences between the mean weights of specimens at the sampling sites except for *O. esculentus* (see Table 2). However, *T. rendalli* did not appear in some of the sites.

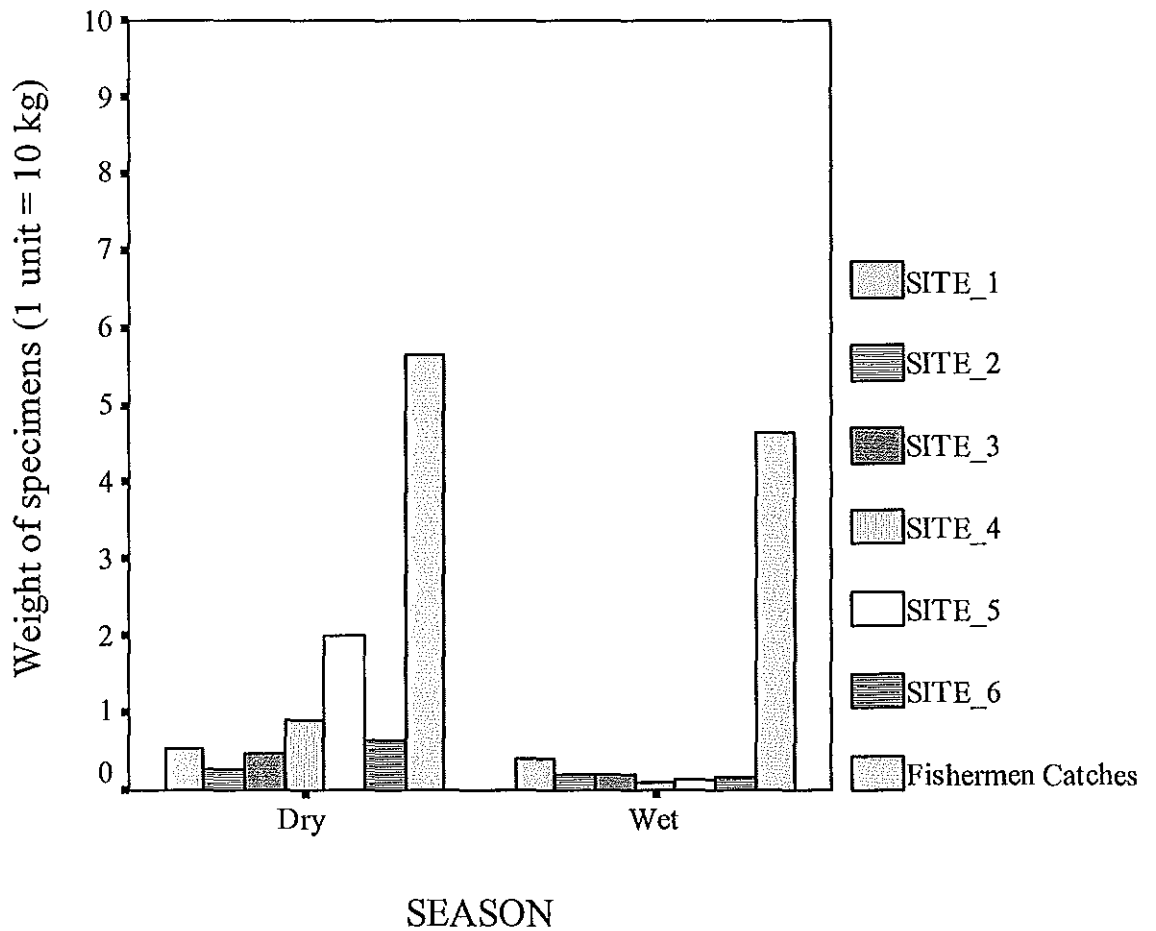


Figure 6: Weight of all species in the two seasons at different sites

Table 2: Mean±SD of weight of specimens at different sites for the most common species in Lake Jipe

Fish species	Sampling sites						F	P
	1	2	3	4	5	6		
<i>O. jipe</i>	33.1±16	22.8±14.3	32.1±13.8	29.8±23.7	37.8±16.5	73.3±11.2.	1.89	0.13
<i>O. esculentus</i>	11±9.2	15±8.3	12.8±11.3	14.9±10.6	10.9±9	12.1±10.5	6.65	0.00 ^(S)
<i>B. paludinosus</i>	9.8±14.5	9.1±7.2	5.3±0.9	6.3±1.8	9.1±10.5	8.2±11	1.4	0.22
<i>T. rendalli</i>	23.1±21.2	2.4±0.2	-	20.9±13.3	17±0	-	1.36	0.27
<i>R. tangensis</i>	2.8±2.1	2.2±0.9	1.6±0.3	6.4±16.2	2.2±1.5	1.3±0.8	0.41	0.84
<i>C. garipepinus</i>	475.7±27.1	489.3±46.7	503±50.3	450±0	463.3±24.5	477.3±18.6	1.63	0.921

^(S)- Significant, - No specimens

3.2.3 Weight of specimens in different seasons for the most common species in Lake Jipe.

Only *O. esculentus* and *C. gariepinus* showed significant differences in weights between the two seasons. Others; *B. paludinosus*, *O. jipe* and *R. tangensis* showed no significant differences (see Table 3).

Table 3: Mean±SD weight of specimens in different seasons for the most common species in Lake Jipe.

FISH SPECIES	SEASON				F	P
	DRY	N	WET	N		
<i>O. jipe</i>	32.1±20.7	47	37.2±40	70	0.07	0.79
<i>O. esculentus</i>	11.8±50	2570	15.2±8.6	329	33.9	0.00 ^(s)
<i>B. paludinosus</i>	8.8±10.8	663	6.3±0.9	16	0.00	0.99
<i>C. gariepinus</i>	468.3±20.5	21	505.5±42.5	7	18.12	0.00 ^(s)
<i>R. tangensis</i>	3.7±9	32	1.9±1.2	23	0.003	0.95

^(s)-Significant

3.2.4 Length frequency distribution for the most common species in Lake Jipe

O. esculentus had most specimens with total lengths ranging from 41 – 50 mm. *B. paludinosus* had most specimens with total lengths ranging from 61 – 70 mm. The others *O. jipe* and *R. tangensis* had most specimens with total lengths ranging from 101 – 120 and 41 – 50 mm respectively (see Figures 7, 8, 9 and 10).

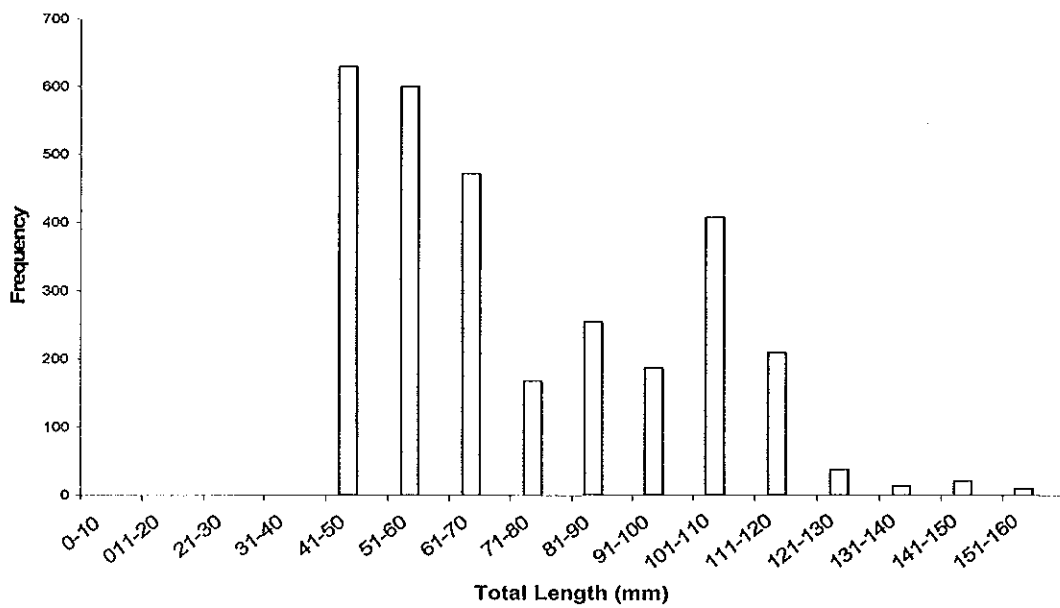


Figure 7: Length frequency distribution for *O. esculentus* in Lake Jipe (n = 2899)

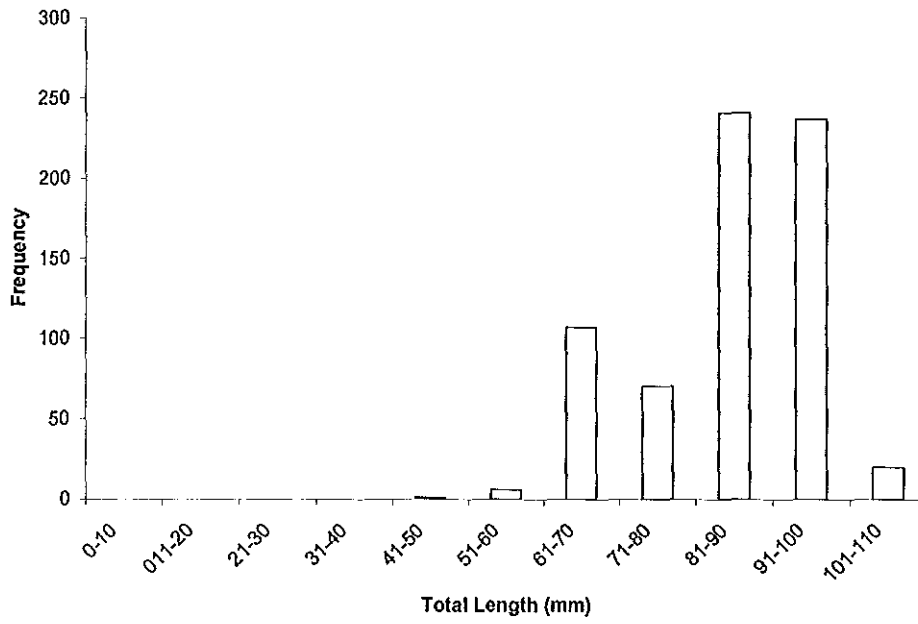


Figure 8: Length frequency distribution for *B. paludinosus* in Lake Jipe (n = 679)

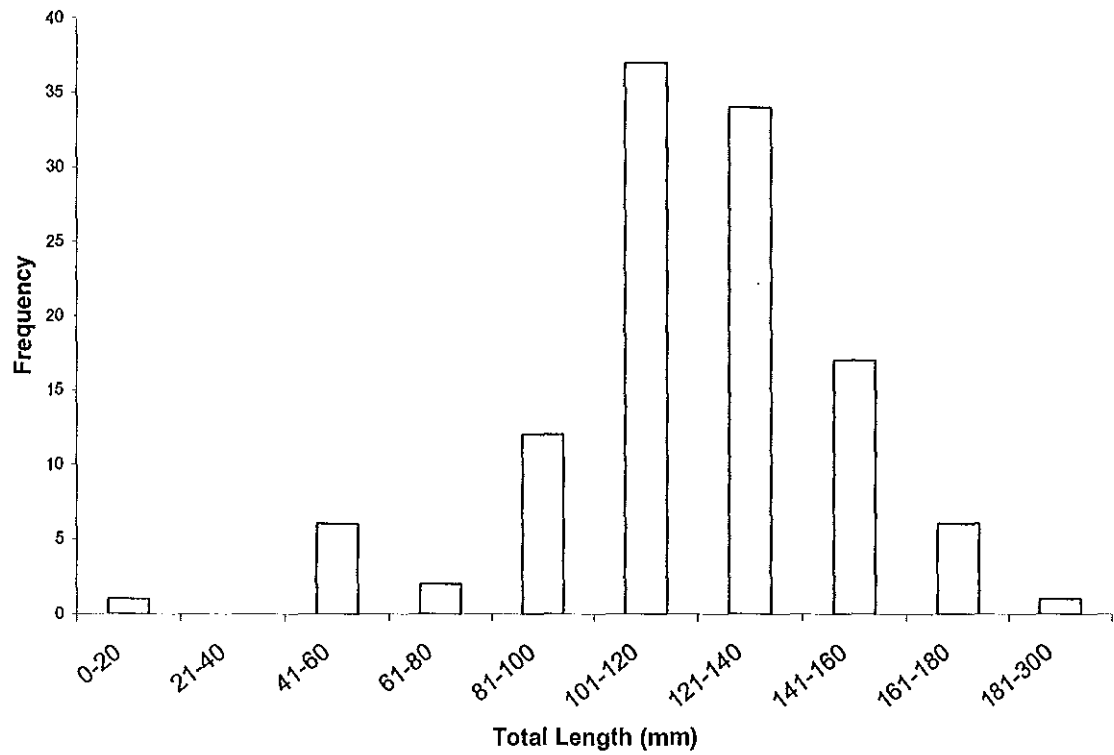


Figure 9: Length frequency distribution of *O. jipe* in Lake Jipe (n = 117)

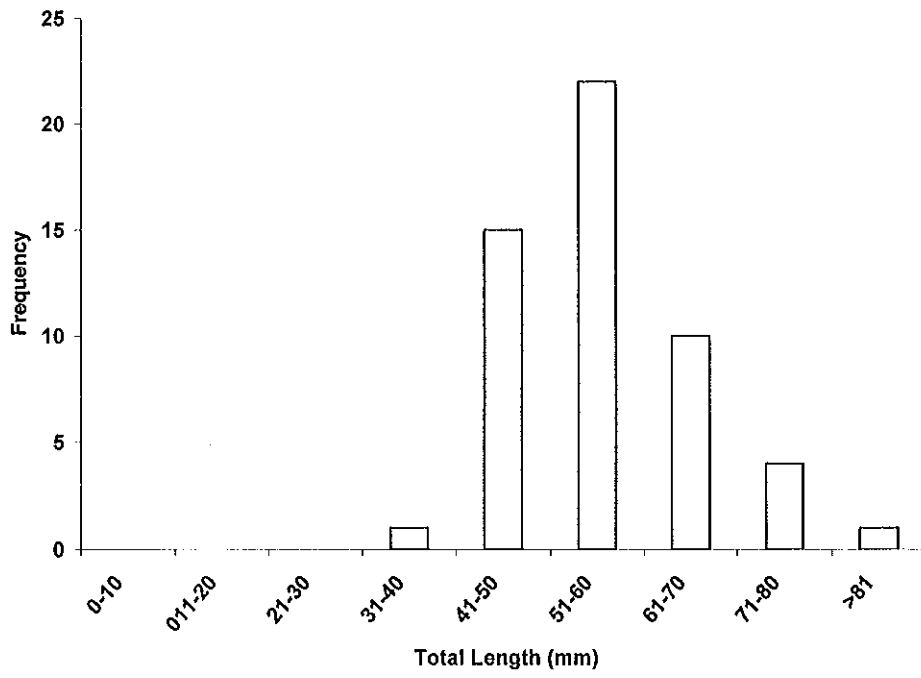


Figure 10: Length frequency distribution for *R. tangensis* in Lake Jipe (n = 55)

3.2.5 Length – weight relationships of the most common species in Lake Jipe

The length weight relationship of *B. paludinosus*, *O. jipe* and *O. esculentus* in Lake Jipe determined separately were curvilinear and best described by the following regression equations (see Figures 11, 12 and 13).

$$B. paludinosus \quad TW = 0.0252TL^{2.7}, R^2 = 0.83, n = 679$$

$$O. jipe \quad TW = 0.1385TL^{2.2}, R^2 = 0.77, n = 118$$

$$O. esculentus \quad TW = 0.0696TL^{2.4}, R^2 = 0.86, n = 2899$$

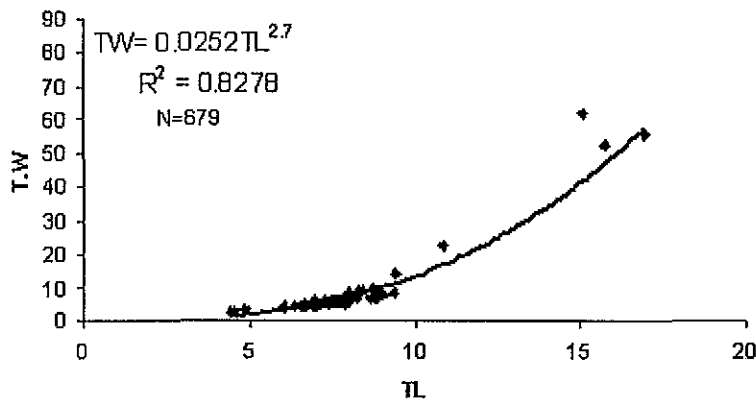


Figure 11: Length – weight relationship for *B. paludinosus* in Lake Jipe

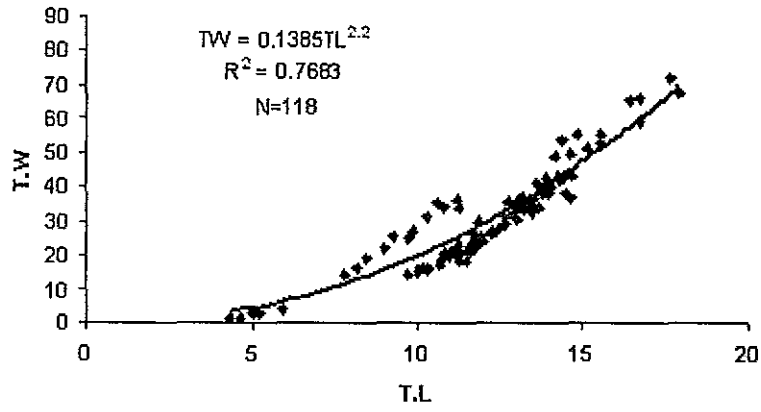


Figure 12: Length- weight relationship for *O. jipe* in Lake Jipe

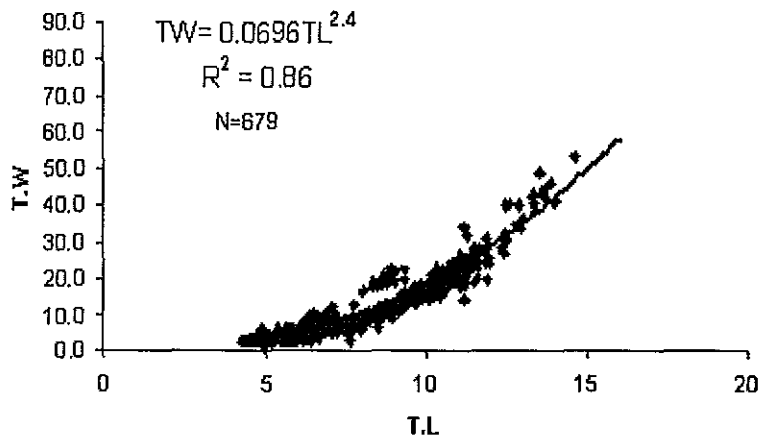


Figure 13: Length – weight relationship for *O. esculentus* in Lake Jipe