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FEEDING HABITS OF FISH AND SOME WATER QUALITYFEATURES OFLAKE MAYBAR, SOUTH WOLLO, ETHIOPIA

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ABBREVIATIONS

ANOVA	Analysis of variance
DO	Dissolved Oxygen
EC	Electrical Conductivity
FAO	Food Association Organization
FCF	Fulton Condition Factor
FL	Fork Length
LFDP	Lake Fisheries Development Program
IFP	Index of Food Preponderance
LWR	Length Weight Relationship
PH	Power of Hydrogen
SCRP	Soil Conservation Research Program
SL	Standard Length
T	Temperature
TL	Total Length
TW	Total Weight

ABSTRACT

Oreochromis niloticus and *Cyprinus carpio* are the two fish species in Lake Maybar. Even though these species are economically important, there is no data on the feeding ecology. The present study aims to investigate food and feeding habit and some selected water quality features. Fish samples were collected from three different sampling sites using different mesh size of gill nets. A total of 140 (70 *O.niloticus* and 70 *C .carpio*) fishes ranging from 13 to 32 cm and 14 to 45 cm were examined that have a total weight (TW) 133 to 327gand 110 to 1000 g , respectively. Among the total number of *Oreochromis niloticus* 4 (5.71%) fish samples had empty stomach while 66 (94.23%) were with foods. Regarding *Cyprinus carpio,* 6 (8.6%) had empty guts and the remaining 64 (91.43%) guts were observed with food; both of them were analyzed using the frequency of occurrence and volumetric analysis methods. The major food items found in the stomach of *C. carpio* were detritus (84.37%), phytoplankton (64.06%) and macrophyte (59.4%) in frequency of occurrence. Volumetrically *C. carpio* fed on detritus (43.09%), macrophyte (17.06%) and phytoplankton (5.6%). The dominant food items identified from the gut contents of *O. niloticus* were phytoplankton (75.5%), macrophyte (72.2%) and detritus (68.18%) occurring in, and of the gut contents and comprising 10.28%, 24.97% and 41.55% of the total volume of food items, respectively. Some selected physiochemical features of the lake such as temperature, pH, dissolved oxygen (DO) and conductivity showed optimum levels for fish growth. The relationship between TL and TW of *C. carpio* was linear and strong (R^2=0.946), with regression coefficient value of 2.91 which is closer to isometric growth value (3). Similarly, the length-weight relationship of *O. niloticus* was also linear and strong (R^2=0.966), and showed isometric growth (regression coefficient =2.923). The contributions of animal origin food categories were important in the diet of juveniles of both species whereas, food of plant origin were more important in the diet of adults of both species. However, there were no significant variations in the diet of individuals within the different size classes of *C.carpio* and *O.niloticus*. Based on the results, it was concluded that *C.carpio* and *O.niloticus* were omnivorous in its feeding habits in Lake Maybar and there were no significant ontogenetic shifts in its diet.

1. INTRODUCTION

1.1. Background

Fish require nutrients for growth, reproduction and other normal physiological functions. In a natural aquatic environment, phytoplankton, zooplankton, plant materials, insects, insects' larvae, worms and smaller fish are the major food types of fish (Ndirmbita, 2014).Fish tend to show a preference for particular food items within their environment. The availability of food in any aquatic environment determines the well-being and reproductive potential of fish (Keyombe, 2015). The weight and size of fish are a reflection of food availability in the aquatic ecosystem (Bolarinwa, 2015). Many environmental factors, such as water temperature, food availability, stocking density and other environmental conditions, influence the food selection behavior of fish (Houlihan, 2001). The size of food items and the size and age of fish can also determine their food selection behavior (Otieno, 2014). Mainly, fish feed on items that can fit into their mouth and that their stomach can digest. As fish grow, the stomach becomes longer and their digestive system becomes more developed (Abebe Getahun, 2015). However, the feeding rate relative to bodyweight decreases, whereas the absolute rate of food consumed increases (Ndirmbita, 2014).

Common carp, native to Eastern Europe and Central Asia, was introduced to Ethiopia in 1936 for aquaculture purpose (Welcome, 1988; Henning *et al*., 2008; Troca, 2012). Since then, it has been stocked in various reservoirs and natural lakes to enhance fish yield by filling the available niche (Shibru Tedla and Fisha Haile-Meskel, 1981). However, *C.carpio* (common carp) has been nominated as one of the 100 of the "World's Worst" invaders (Lowe *et al*., 2000).

Common carp has a versatile feeding behavior, characterized by opportunistic omnivorous feeding behavior (Colautti and Remes, 2001). Studies have reported that common carp feeds on a variety of food items including molluscs, zooplankton, aquatic vegetation, detritus, phytoplankton, insects, fish parts and ostracods (Maitland, 1992; Magalhaes, 1993; Colautti and Remes, 2001; Rahman *et al*., 2006; Saikia and Das, 2008; Elias Dadebo *et al*., 2015). Its diet composition may vary within a wide range of seasonal and spatial condition of the environments

(Ali *et al*., 2010; Elias Dadebo *et al*., 2015). The food composition may also vary depending on the size of the fish, environmental condition and habitat types (Chakrabarti and Jana, 1991).

Oreochromis niloticus (Nile tilapia), on the other hand, is a native fish to Africa and it is the most dominant and the most preferred species in Ethiopia (Petra *et al*., 2008). It is distributed in almost all inland water bodies of Ethiopia and accounted about 60% of the capture fishery in the country (LFDP, 1997; Demeke Admassu, 1998). Several studies indicated that phytoplankton is the most consumed food item over the other food items in the diet of Nile tilapia (Zenebe Tadesse, 1988, 1999; Yirgaw Teferi *et al*., 2000; Alemayehu Negassa and Prabu, 2008; Filipos Engdaw *et al*., 2013; Workye Worie and Abebe Getahun, 2015). However, Tadesse Fetahi *et al*. (2018) recently reported that 64% of Nile tilapia diet originated from macrophytes in Lake Ziway, indicating the absence of consensus on the food and feeding habits of Nile tilapia as well as the possibility of diet competition between common carp and Nile tilapia. Kassahun Asaminew (2005) has also reported that there was a clear food competition between common carp and Nile tilapia in Lake Koka.

Studies on natural feeding of fish provide useful information on the trophic relationship on aquatic ecosystem (Abdel-Aziz and Gharib, 2007), which could be used in formulating management strategy options in multispecies fishery. Food and feeding habit of fish are important biological factors for selecting a group of fish for culture in ponds to avoid competition for food among themselves and live in association and to utilize all the available food (Dewan and Saha, 1979). Similarly, introducing non-native fish species for higher economic gain is common among developed and developing countries. These practices often threaten native fish species towards extinction. A crucial factor to the native fish species encountering is the introduction of a non-native fish which results in the overlapping of trophic niches (Olden *et al*., 2006). Avoidance of competition for food or management of niche partitioning may lead to successful co-habitation of the species (Banaduc, 2008).

It is virtually impossible to gather sufficient information of food and feeding habit of fish on their natural habitat without studying its gut content. The general practice of identification and quantification of gut content in fishes mostly addresses undigested parts of the ingested diet. In the case of plankton feeders, soft bodied zooplankton (e.g. protozoa, some rotifers) are often skipped off the counting procedure for their rapid digestibility. There is a clear differentiation of the enzymatic activity among fishes from different trophic status as well as food habits. For example, herbivorous and omnivorous species have been reported to have more amylase activity than carnivorous species (Fish, 1960; Vonk and Western, 1984; Sabapathy and Teo, 1993). Thus, it is obvious that some food items from the gut in those fishes would be missed resulting in variation of their quantitative data on food. Another physiological factor is the gut retention time that may, directly or indirectly, influence enzyme activity on the digestion of the food. Information from the gut contents is, therefore, biased and never gives reliable basis for generalization on the feeding habit of fish. The feeding habit of different fish varies from month to month. This variation is due to changes in composition of food organisms occurring at differ seasons of the year. In nature fishes feed on a great diversity of food items such as phytoplankton, zooplankton, benthic and non-benthic invertebrates, benthic deposits, other fish and aquatic macrophytes (Flipos*et al*., 2013).

Ethiopia is uniquely rich in water resources. It has numerous water bodies including ponds, lakes, rivers, reservoirs and wetlands .Gashaw Tesfaye and Wolff (2014) reported that the surface area of major lakes and reservoirs is 713000 km^2 and the length of rivers is 8065 km. Numerous studies have been conducted on the feeding habit of fish in many lakes and upstream rivers of the country which are used as site of migration for the fish during reproduction (Desta *et al*., 2006; Dadebo *et al*., 2013). However, information on the fish feeding habit, and water quality of Lake Maybar, which constitutes two species is diminutive. In addition, area specific information is critical to create trophic model that can be used in fisheries management and designing conservation strategies for sustainable utilization of fishery resource of the lake.

The multiple activities in aquatic and wetlands ecosystems have created threat to the ecosystems and the services they provide to us. Major challenges of such systems include pollution by silt load, water level fluctuation, over-exploitation of specific fish species, conflict of interest in the use of the water catchment deforestation and degradation, water logging, flooding, over grazing, and population. Continuous studies and producing up to date data on the health status of a particular water body are crucial for sustainable management of such ecosystem to ensure its ecological integrity and benefits.

Lake Maybar is located in the north eastern part of the central Ethiopian high lands and situated within the Albuko Woreda, with an altitude of 2463 m above sea level. Besides being a source of fish, the lake is also important for irrigation purpose. However, it is heavily influenced by human activities especially irrigation, fluctuation of water level and water quality degradation. This in turn affects natural feeding habits of fish. Therefore, the present study aimed at studying the feeding habits of *C. carpio* and *O.niloticus* and some selected water quality parameters in the lake, and this study produced vital baseline data for proper management and utilization of the fish in the future.

1.2. Statement of the problem

Over one billion people worldwide depend on fish as their main source of animal protein (Throp *et al*., 2006). Fishes play an important role in the economy of developing and developed countries by contributing to animal protein intake, employment generation, household incomes and foreign exchange earnings. To fill the gap in food limitations, the aquatic ecosystem can serve as an inexpensive source of fish protein. Aiming at increasing the fish production of water bodies, introductions of exotic freshwater fishes have been made to several man-made and natural water bodies in Ethiopia.

On the other hand, invasive species pose one of the greatest threats to the biotic integrity of aquatic ecosystems, even though their effects on native fauna are highly variable and extremely difficult to predict (Moyle and Cech, 1996). This is because environmental conditions vary and the processes by which species coexist are complex (Huisman and Weissing, 1999). Introduced species compete for space and food with native species. Hence, there could be diet overlap between exotic and native species, resulting in diet and habitat shifts with potentially negative consequences for native species. To sustain the development of fishery in Lake Maybar knowledge on the feeding habit of fish is crucial. However, there are no studies focusing on the feeding habit of fish and water quality features of Lake Maybar. This study was therefore proposed to provide new insights on feeding habit of fish and assess some water quality features in Lake Maybar.

1.3. Objectives of the study

1.3.1. General objectives

To study feeding habit of fish and some water quality features to provide data for sustainable management and conservation of the fish resources in Lake Maybar.

1.3.2. Specific objectives

- To assess water quality parameters of Lake Maybar using some selected physicochemical features.
- To determine the length-weight relationship and body conditions of *O. niloticus* and *C. carpio* in Lake Maybr.
- To identify prey organisms and examine dietary importance of prey items of *O. niloticus* and *C. carpio* using gut content analysis in Lake Maybar
- Determine the feeding strategies (ontogenetic dietary shifts) of *O. niloticus* and *C. carpio carp* of Lake Maybar.

1.4. Research questions

The specific research questions dealt with were:

1. What is the status of physicochemical water quality of Lake Maybar?
2. How is length-weight relationship of the two species in the lake?
3. What are the dietary components of the two fish species of the lake?

1.5. Significance of the study

The aim of this study was to explore feeding habit of fish and some water quality features in Lake Maybar. Knowledge on the natural feeding of fish provides useful information on the trophic relationship in the aquatic ecosystem, which can be used in formulating management strategies in multi-species fishery. Introducing non-native fish species for higher economic gain is common among developed and developing countries. These practices are based on the knowledge of feeding habit of fish in order to avoid the overlapping of trophic niche and prevent the native fish from extinction. Feeding of fish represents an integration of important ecological components that include behavior, condition, habitat use, energy intake and inter- and intra-specific interaction. Fish population needs adequate quantities of usable resources to sustain. Gut content analysis provides important insight in to fish feeding pattern. In general, this study may produce good data on feeding habit and water quality on the less known and unstudied Lake Maybar and such information are of paramount importance to ecological management of the lake and sustainable use of its resources.

2. LITERATURE REVIEW

2.1. Food and feeding habits of fish

The study of fish feeding, characteristics of their feeding behavior, effects of various environmental factors and physiological status on feeding efficiency is the basic directions of ichthyological research (Moyle and Cech, 2000). Fishes are characterized by very high diversity of species adaptations, including feeding adaptations (Wooton, 1990). The composition of the consumed food, the width and variability of the food spectrum, the way of obtaining the food and dynamics of feeding may differ. Food habits of fish are highly variable and depend on a wide range of factors including the species and age of the fish, the availability of preferred food and the combination of fish species (Antony *et al*., 2014).

Studies on natural feeding of fishes are permit to identify the trophic relationships present in aquatic ecosystems, identifying feeding composition, structure and stability of food webs (Abdel-Aziz, and Gharib, 2007). Food and feeding habit of fish are also important biological factors for selecting a group of fish for culture in ponds to avoid competition for food among themselves and live in an association and to utilize all the available food (Dewan and Saha, 1979).

The study of the feeding habits of fish and other animals based on analysis of stomach content has become a standard practice (Hyslop, 1980; Zacharia and Abdurahiman, 2004). Stomach content analysis is widely used in the study of fish feeding habits and provides an important means of investigating trophic relationships in aquatic communities (Zacharia and Abdurahiman, 2004). An understanding of how a species utilizes its food resource and how that changes ontogenetically is prerequisite to any examination of the impact of a predator on the structure of a prey assemblage (Adeyemi *et al*., 2009). Ontogenetic shifts in diet are very common in fish (Mohammad, 2015). Many factors are also responsible for these changes in diet, and can be divided into two categories: external factors (e.g. habitat, food supply, predation risk) and internal factors (e.g. anatomical structures, behavior, physiological demands). In many species, dietary changes are associated with habitat shifts (Mohammad, 2015). The type and size of food item consumed changes with age and size of the fish (Mohammad, 2015). This is mainly because fish can only feed on food items that can fit into their mouth and what their gut can digest.

The food habit of different fish also varies from month to month (Shukla and Patel, 2013). This variation might be due to changes in the composition of food organisms occurring at different seasons of the year. It has been documented that natural food material is not available in equal quantity throughout the year, and there is a clear fluctuation in it (Bhuiyan *et al*., 1999). It is important to emphasize that the effect of seasonality should always be considered in the studies on natural feeding of fish, because the temporal changes of biotic and abiotic factors alters the structure of the food web along the year and, as a consequence, the fish often shows temporal and seasonal diet shifts (Wootton,1990).

2.2. Length-weight relationship of fishes

Length-weight relationship is an integral component in the study of fisheries science (Moata *et al*., 2005) and it is fundamental to understand life history and undergoing morphological comparisons between different fish species or between fish populations from different habitats (Mehmet *et al*., 2007). Gulland (1983) reported the importance of length-weight relationship as a factor in the biological study of fishes such as stock assessment and management. The establishment of length-weight relationship is fundamental for estimation of production and biomass determination of a fish population (Moata *et al*., 2005).

The relationship between weight (W) and length (L) typically takes the curvilinear form: $W = aL^b$ or in the linear form: Log W=Log a + b Log L, where a and b are constant parameters estimated by regression analysis. According to Pauly (2005), "b" values may range from 2.5 to 3.5. If fish retains the same shape, it grows isometrically and the length exponent "b" has the value b=3.0 (Pauly, 2005) and a value significantly larger or smaller than b=3.0 shows allometric growth pattern. A value less than b = 3.0 shows that the fish becomes lighter for its length and if greater than b = 3.0, indicates that the fish becomes heavier for its length as it grows.

2.3. Common carp (*Cyprinus carpio*)

Carp are widespread across the world, but the extensive environmental damage that they cause makes them a part of the "100 World's Worst Invasive Species" by the International Union for the Conservation of Nature (IUCN) (Lowe *et al*., 2000). Carps are known to be an ecosystem engineer, which means that they modify and alter the state of the water bodies they inhabit (Weber and Brown, 2009). Common carp is native to Europe but has been widely introduced and is now found worldwide except for the poles (Froese and Pauly, 2002). It is probably the first fish species whose distribution was widely extended by the human introduction, since its introduction by the Romans from the River Danube throughout Europe (Balon, 1995). It also accounts for the world's highest farm fish production (Abdelhamid *et al*., 2017).

Common carp exploit large and small manmade and natural reservoirs, and pools in slow or fast moving streams. However, they prefer larger, slower-moving bodies of water with soft vegetated sediments but they are tolerant and hardy fish that thrive in a wide variety of aquatic habitats (Pauly, 2005). They normally live in a preferred temperature range of around 15–32ºC, but are able to survive in a wide range of temperatures, including ice-covered lakes (at about 2ºC) and much warmer ponds (up to about 40ºC) (Koehn *et al*., 2016). Carps are also able to tolerate poor quality water with low oxygen levels and water that is slightly salty (Banarescu and Coad, 1991). Juvenile carp are usually found strongly associated with aquatic plants in marsh areas or river backwaters for the first year of their life (McCrimmon, 1968).

Ecosystem alterations induced by common carp have great potential to influence native fish populations, but direct empirical evidence is limited. By reducing or eliminating aquatic macrophytes and disrupting substrates, common carp may indirectly reduce the abundance of other fishes through reductions in spawning and nursery habitats (Paukert *et al*., 2002). Additionally, increased turbidity, commonly associated with common carp populations, may alter piscivore and planktivore foraging behavior and reduce success (Reid *et al*., 1999), affecting fish condition, growth and survival. Thus, common carp may interact with and have effects on native fishes through multiple complex mechanisms.

On the basis of qualitative and quantitative analysis of gut contents, common carp is an omnivorous fish that can consume a wide range of food items like worms, molluscs, zooplankton, aquatic vegetation, plant debris, detritus, and insects (Colautti *et al*., 2001). The diversity of its diet makes this species resistant to food web change and capable of inhabiting a wide variety of habitats (Weber and Brown, 2011).

Rahman *et al*. (2009) stated that common carp primarily feeds on benthic macro-invertebrates (chironomids) and zooplankton, but the bulk of its diet consists of detritus. Common carp generally ignores phytoplankton, strongly selects benthic macro-invertebrates and weakly selects zooplankton (Mohammad, 2015). Cherry and Guthrie (1975) reported that detritus and zooplanktonic organisms such as cladocera, copepod and diptera constituted the large part of the monthly and annual food of common carp in waters they investigated. Karaca (1995) reported that the majority of the food found in the digestive tracts of common carp constitutes Chrysophyta from algae with 55.46% followed by benthic organisms with 16.17 % and copepod from zooplankton with 8.49 %. Among the animal based organisms which constitute 33.77 % of the total food consumed 56.72 % was zooplanktonic and 43.28 % was benthic organisms in Hirfanli dam, Turkey (Karaca, 1995). Hana and Manal (1988) found eggs of other fish and small fish in the digestive tract of common carp.

The feeding habit of common carp showed seasonal differences based on its diet availability (Mustafizur *et al*., 2010). Elias Dadebo *et al*. (2015) also reported that common carp mainly feed on detritus and macrophytes during the wet months whereas insects accounted the largest food volume in the dry months. However, the presence of benthic organisms and detritus in its digestive tract throughout the year confirms that the species feeds at the bottom of the water body (Mustafizur *et al*., 2010).

Diet of common carp also varies between adult and juvenile fish, with juveniles consuming more plankton and larger carp consuming more bottom-dwelling food (Chakrabarti and Jana, 1991; Adamek *et al*., 2003; Rahman *et al*., 2009). According to Rahman *et al*. (2009), common carp of up to 15.4 cm total length preferentially select zooplankton, while common carp larger than 18.9 cm total length avoid zooplankton. But, size of common carp has no significant effect on phytoplankton (Mohammad, 2015).

The allometric and isometric growth pattern of common carp was reported in different water bodies such as Almus Dam lake (Tokat- Turkey) (Mehmet *et al*.,2007) and in Morocco (Moata *et al*., 2005) and they reported a "b" value of 3.319 and 3.412, respectively, and showed that common carp had a positive allometry growth pattern. Daniela *et al*. (2009) in Brazil and Elias Dadebo *et al*. (2015) in Lake Koka, Ethiopia, also reported a "b" value of 3.002 and 3.018, respectively, and showed that common carp had isometric growth pattern.

2.4. Nile tilapia *(Oreochromis niloticus*)

Tilapia is considered to be the most important and second cultured fish species next to carp around the world (Abdelhamid *et al*., 2017). These fishes were found throughout the Nile River basin (Njir *et al*., 2004; Shipton *et al*., 2008). In Ethiopia it is widely distributed in the lakes, rivers, reservoirs and swamps, and contributes about 60% of total landings of fish (LFDP, 1997; Demeke Admassu, 1998), but currently reduced to 49% (Gashaw Tesfaye and Wolff, 2014).

Due to its suitability to aquaculture, this species was introduced in many parts of Asia, Europe, North America and South America (Alemayehu Negassa and Prabu, 2008). Nile tilapia is an important fish in the ecology of tropical waters as well as aquatic systems in other subtropical regions (Offem and Omoniyi, 2007). This is mainly because it feeds mainly on algae and other plant materials as well as detritus making it a link between lower and upper trophic levels in the aquatic food webs. However, Nile tilapia has been observed to diversify its diet under different conditions to include detritus, small insects as well as some fish parts (Zaganini *et al*., 2012). In addition the fish is capable of filter feeding by capturing food particles in the water column.

Depending on the food source, Nile tilapia feed either via suspension filtering or surface grazing, trapping plankton using mucus excreted from their gills (Fryer and Iles, 1972). It is reported that Nile tilapia from Lakes Hawassa, Ziway and Chamo mainly feed on phytoplankton, macrophytes and detritus (Todurancea *et al.*, 1988; Zenebe Tadesse, 1988; Yirgaw Teferi *et al*., 2000; Alemayehu Negassa and Prabu, 2008).

The food composition differs depending on the season and also lake type (Getachew Tefera and Fernando, 1989). Nile tilapia feeds on both types of food, plant material and animal material; the proportion of phytoplankton was higher during dry months and macrophyte was higher in wet months (Zenebe Tadesse, 1988, 1998; Yirgaw Teferi *et al.*, 2000; Shalloof and Khalifa, 2009; Flipos Engdaw *et al.*, 2013). The seasonal variation on the feeding habit of Nile tilapia due to a seasonal succession of phytoplankton in some rift valley lakes of Ethiopia was also well explained (Yirgaw Teferi *et al*., 2000).

Fish tend to show a preference for some food items over others within their environment. Selection of food items of fish also depends on the age or size of the fish, since smaller fish tend to select smaller food items and vice versa (Flipos Engdaw *et al*., 2013). Adult Nile tilapia was reported to feed on variety of food items including phytoplankton, macrophytes, planktonic and benthic invertebrates and detritus (Yirgaw Teferi *et al*., 2000; Oso *et al*., 2006; Alemayehu Negassa and Prabu, 2008) whereas juveniles are generally omnivorous feeding on zooplankton, insect larvae (Todurancea *et al*., 1988; Zenebe Tadesse, 1988; Flipos Engdaw *et al*., 2011) and phytoplanktons of which diatoms were the major dietary component (Zenebe Tadesse, 1988; Witte and Winter, 1995).

The slope of the regression line (b) of Nile tilapia in different water bodies was indicating isometric growth pattern of the fish; where its shape and specific gravity do not change as the fish grows in size (Elias Dadebo *et al*., 2014). The isometric growth pattern of Nile tilapia was reported in rift valley lakes of Ethiopia such as in Lake Hayq (b=2.95; Workye Worie and Abebe Getahun, 2002), Lake Hawassa (b=3.01; Demeke Admassu (1998), Lake Koka (b= 3.0541; Flipos Engdaw *et al*., 2013).

2.5. Feeding behavior and environmental requirements of tilapia

Nile tilapia (*O. niloticus*) is the most important fish species in tropical and Subtropical freshwater (Amal, 2011). It is of great importance, often forming the basis of commercial fisheries in many African countries (Uraguchi, 2013). High tolerance to environmental conditions and its ability to accept formulated and natural feeds make it economically viable (Bankole, 2009). It has a versatile feeding behavior and is characterized by a generalist and opportunistic omnivorous feeding behavior (Canonico, 2005). Its diet composition may vary within a wide range of temporal and spatial conditions of the environment (Houlihan, 2001).

According to Popma and Masser (1999), tilapia ingests a wide variety of natural food organisms including plankton, some aquatic macrophytes, planktonic and benthic aquatic invertebrates, larval fish, detritus, and decomposing organic matter. Tilapia is often considered filter feeders because they can efficiently harvest plankton from the water. However, tilapia does not physically filter the water through gill rakers as efficiently true filter feeders such as gizzard shad and silver carp. The gills of tilapia secrete a mucous that traps plankton. The plankton-rich mucous, or bolus, is then swallowed. Digestion and Assimilation of plant material occurs along the length of the intestine (Popma and Masser, 1999). Tilapia is more tolerant than most commonly farmed freshwater fish to high salinity, high water temperature, low dissolved oxygen and high ammonia concentrations.

2.5.1. Water temperature

Tilapia does not thrive in low temperature but are very tolerant to high temperature (Table 1). Optimum usually is at 28 to 32 ºC (FAO, 2005). Growth declines with decreasing temperature. The intolerance of tilapia to low temperatures is a serious constraint for Commercial culture in temperate regions (Tiechert *et al*., 1997).

Table 1.Environmental conditions favorable for tilapia growth (Source: Trewavas, 1983)

Parameter	Level	Comment
Temperature(ºC)	8-42	Survival range
	25-33	Optimum for reproduction and growth
DO (mg/L)	3	Minimum for optimum growth
Ph	6.5-9.0	Optimum for primary productivity
	6.8-8.0	Optimum for enhanced growth

2.5.2. Dissolved oxygen concentration

Tilapia survive routine dawn dissolved oxygen (DO) concentrations of less than 0.3 mg/L, considerably below the tolerance limits for most other cultured fish. In research studies, Nile tilapia grew better when aerators were used to prevent morning DO concentrations from falling below 0.7 to 0.8 mg/L (compared with unaerated control ponds) (Popma and Masser, 1999). Growth was not further improved when additional aeration kept DO concentrations above 2.0 to 2.5 mg/L. Although tilapia can survive acute low DO concentrations for several hours, tilapia ponds should be managed to maintain DO concentrations above 1 mg/L. Metabolism, growth and, possibly disease resistance are depressed when DO falls below this level for prolonged periods (Popma and Masser, 1999).

2.5.3. PH

In general, tilapia can survive in pH ranging from 5 to 10 but do best in a pH range of 6 to 9. The pH of pond water may increase above 9 during periods when photosynthesis is high (Tiechert *et al.*, 1997).

2.6. Freshwater bodies and fishes of Ethiopia

Like most countries of Sub-Saharan Africa, fish production in Ethiopia is far below the estimated yield and the pattern of production is by no means uniform; only capture fisheries. The country is endowed with a number of natural lakes, reservoirs and large rivers containing substantial qualities of fish stock (Table 1). Water bodies of Ethiopia have a surface area estimated at 7,334 km2 of major lakes and reservoirs, and 275 km2 of small water bodies, with 7,185 km of rivers within the country (Shibru Tedla, 1973). According to Abebe Getahun, (2003), the country has about 153 indigenous and additional 10 exotic fish species (among these, six species are commercially most important ones and belong to the following families: Centropomidae (*Lates niloticus*), Cichlidae (*O. niloticus*), Clariidae (*Clarias gariepinus*), Bagridae (*Bagrus dockmak*), and Cyprinidae (*Labeobarbus spp. and Labeo sp*.). *Oreochromis niloticus* is the most exploited species constituting about 80 % of the total fish capture in Ethiopia (Breuil, 1995). It is one of the most important species in the ecology and fisheries of almost all Ethiopian inland waters (Shibru Tedla, 1973). Consequently, fish resources became depleted from time to time because of overexploitations of capture fisheries (FAO, 2008).

Table 2.Ethiopian water bodies and their fish potential and production status (Source: Gashaw Tesfaye and Wollf, 2014)

Water bodies types	Area(km^2)	Length(km)	Fishery potential(ton/year)
Major Lakes	7740	-	39262
Major reservoirs	1447	-	7879
Small water bodies	4450	-	25996
Rivers	-	8065	21405
Total	13637	8065	94541

2.6. Threats to the fish diversity

Throughout Africa fishes are the major source of food account for some 25% to 30% of the total animal protein consumed (Rene and Kinadijan, 1994) .However this is not the case in Ethiopia where people do not include fish in their daily diet. Although no precise data are available, it appears that most Ethiopians prefer beef to fish even though much more it is expensive and hence not easily obtained. Even those who would eat fish were it readily available cannot since market supply is poor. The development of aquaculture is also limited (Kutty, 1986), and some previous attempts have been doomed to failure. According to FAO report (FAO, 1973) only about 3% of the potential Ethiopian fishery is being exploited, and despite a chironic food shortage in the country this trend appears to have changed little since the early 1970's. Therefore, while there is a growing but localized trend in some lakes (e.g., Lake Hawassa, Lake Chamo, and the southern part of Lake Tana) over-exploitation of fish resource is not at present a significant problem in most of Ethiopia (Lake Fisheries Development Project Reports, 1978and Personal Communication with Fisheries Department Personal).Needless to say proper management studies and measures should be taken now, before this become a real threat. Similarly, chemical pollution which is a critical problem in developed nations is only treating to the fish fauna of Ethiopia in highly localized regions at this point in time.

Alteration of rivers and stream courses for various human benefits (e.g., hydroelectric project and channeling for irrigation) has deleterious effect on the biota of freshwater system (Robertes, 1993).This brought about trough reduction of water levels thereby altering temperature, PH nutrient regimes and sediment level. In addition to the negative aspects they have in spreading disease and aquatic weeds (Fernando, 1981) dams unless carefully designed affect most migratory fish thereby hindering reproduction. In Ethiopia there are past, present, and future plans to divert freshwater bodies for various human use. There are major projects currently under implementation or due to take place in the future in the Omo-Gibe, Baro-Akobo and the Blue Nile (Mengistue Wube, 1994) .This and the widespread medium irrigation projects like the once seen in the Wollo region should be closely examine to determine the ecological imbalance that may be caused by such undertakings, in addition to their political, economic and social ramification. Nevertheless most important in Ethiopia, as elsewhere, could be the combined effects of deforestation and the introduction of alien species. Many workers including Mayer (1984) confirm that these two factors have disastrous consequence on aquatic ecosystems throughout the globe.

Deforestation

Forest destruction in Ethiopia is known to be one of the highest ,probably comparable to the country identified 'hotspots' of forest destruction in Tropical Africa, and Asia(Goldammer,1990) The Ethiopian highlands ,especially the northern ones, inhibited by traditional agricultural populace, have already striped off much of their natural vegetation. For much of the region very small patches of forest around churches are all that remains of the ones densely forested highlands. As have been well documented in many other countries , the negative impact of , deforestation on aquatic system are manifold and result in major perturbations of nutrient availability, water temperature, turbidity, pH,and water levels of associated water bodies(Groombrige,1992). Sediment accumulations as a result of erosion covers benthic organism depress oxygen levels, and reduce light penetration, and photosynthesis (Young, 1996). Damage to forest cover is exacerbated by poor regeneration due to overgrazing by high densities of cattle, sheep and goat.

2.7. Water quality

United states geological survey (2006) defines water quality as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics.

The addition of various kinds of pollutants and nutrients through the agency sewage, industrial effluents, agricultural runoff etc. into the water bodies brings about a series of changes in the physicochemical and biological characteristics of the water, which has been the subject of several investigations (Mahananda *et al*., 2010). Boyd (1998) also defines water quality as all physical, chemical and biological factors that influence the beneficial use of water. He continued by saying that, where aquaculture is concerned, any characteristic of water that affect the survival, reproduction, growth and management of fish or other aquatic creatures in any way is a water quality variable. It is done to determine the suitability of the water body for the intended use.

2.7.1. Physicochemical factors

The biological attributes of water quality refer to the number and types of organisms that inhabit a waterway. The poorer the quality of water, the fewer the number and types of organisms that can live in it. The most basic physical attribute of a stream is the path along which it flows. Most streams are classified as "meandering" or S-shaped. Meandering streams have many bends and they are characterized by deep pools of cold water along the outside banks where faster-moving water scours the

Natural stream-channel patterns, with their bends and pools, are essential to decreasing flooding as well as providing a suitable habitat for certain aquatic plants and animals. Measurements of a stream's physical attributes can also serve as indicators of some forms of pollution. For example, changes in temperature may indicate the presence of certain effluents, while changes in stream width, depth, and velocity, turbidity, and rock size may indicate dredging in the area.

2.7.2. Turbidity

According to Moyle (1990), turbidity refers to how clear the water is. The greater the amount of total suspended solids in the water, the higher the measured turbidity. The major source of turbidity in the open water lakes is typically phytoplankton, but closer to shore, particulate may also be clay and silts from shoreline erosion (Moyle, 1990). As particulate of silt and clay and other organic materials settle to the bottom, they can suffocate newly hatched larvae and fill the spaces between rocks which could have used by aquatic organism as habitat. Fine particulate materials can also damage sensitive gills structures, decrease their resistance to diseases, prevent proper eggs and larval development and potential interfere with particle feeding activities. Increased turbidity also affects the rate of photosynthesis which causes the reduction of oxygen levels in daytime. This can lead to the state of anoxia which can result in the death of the fish (Moyle, 199). Resource Information Standards Committee (1998) reported that turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. It was further explained that some of these are sediments from erosion, suspended sediments from the bottom, waste discharge and algae growth.

Boyd (1998) reported that, concentration of dissolved oxygen can fall so low that creatures in ponds die. However, adverse effects of low dissolved oxygen more often are expressed as reduced growth and greater susceptibility to disease. In ponds with chronically low dissolved oxygen concentrations, creatures will eat less and they will not convert food to flesh as efficiently as in ponds with normal dissolved oxygen concentration (Boyd, 1998). Boyd (2002) reported that, Dissolved oxygen concentration in intensive tilapia culture unit may be quite low at times. He noted that, tilapia are rather tolerant to low dissolved oxygen, and concentrations of 3 to 4mg/l apparently are not extremely harmful to them even with long-term exposure. The dissolved Oxygen concentration also fluctuates daily in ponds, and water released during the night or early in the morning may be particularly low in this variable. Thus, effluents from tilapia culture may have less than minimum concentrate ion of 5 to 6mg/l DO usually recommended for the protection of aquatic life in natural water bodies according to (Boyd, 2002). Again, a report from Boyd (1998) proved that, feed applied for aquaculture species results in pollution of pond waters by organic and inorganic metabolic wastes. Uneaten feed also decomposes, releasing nutrient into the water. Consequently, phytoplankton becomes abundance and problems with low dissolved oxygen increase as a function of increasing feeding rate (Boyd, 1998).

2.7.3. Temperature and pH

Boyd (1998) reported that, warm water species grow best at temperatures between 25 and 32 ºC. Water temperatures are in this range year-round at low altitude in the tropics, but they are too low in winter in temperate regions for rapid growth of warm water aquaculture species and their food organism (Boyd, 1998). Water temperature is sensitive to atmospheric temperature. It is influenced by the Sun's energy, water depth, water circulation, pump motor heat and heat from other mechanical devices. Water temperature directly impacts the level of dissolved oxygen retention. According to Stevens (2011), another temperature-related phenomenon is water stratification. This occurs in deeper ponds as increased ambient temperature causes a warm, less dense layer of water to stratify over a cool, dense layer of water. Most of the oxygen is produced in the warm surface layer of water and over time oxygen can be depleted in the cooler layer. These layers may not mix for a long period until a cold front or thunderstorm cools the surface layer allowing the two layers to mix. This is often referred to as "turn-over." The result is a sudden. pH is a measure of whether water is acidic or basic (Boyd,1998). Fish have an average blood pH of 7.4, so pond water with a pH close to this is optimum. An acceptable range would be 6.5 to 9.0. Fish can become stressed in water with a pH ranging from 4.0 to 6.5 and 9.0 to 11.0. Fish growth is limited in water pH less than 6.5, and reproduction ceases and fry can die at pH less than 5.0. Pond water pH fluctuates throughout the day due to photosynthesis and respiration by plants and vertebrates. Typically pH is highest at dusk and lowest at dawn. This is because night time respiration increases carbon dioxide concentrations that interact with water producing carbonic acid and lowering pH. This can limit the ability of fish blood to carry oxygen (Russell, 2011).

2.7.4. Nutrients

Phosphorus (P) and nitrogen (N) are the primary nutrients that in excessive amounts pollute our lakes, streams, and wetlands. Nitrogen is essential to the production of plant and animal tissue. It is used primarily by plants and animals to synthesize protein. Nitrogen enters the ecosystem in several chemical forms and also occurs in other dissolved or particulate forms, such as tissues of living and dead organisms. Nitrate, compound containing nitrogen, can exist in the atmosphere or as a dissolved gas in water, and at elevated levels can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and domestic animals. Common sources of excess nitrate reaching lakes and streams include septic systems, animal feed lots, agricultural fertilizers, manure, industrial waste waters, sanitary landfills, and garbage dumps. Phosphorus fuels algae growth and it is a vital nutrient for converting sunlight into usable energy, and essential to cellular growth and reproduction.

2.8. Biological factors

2.8.1. Competition

Competition either within or among species, for limited food supplies may slow growth. Moyle and Joseph (1988) reported that bluegill, a species in which the adults and young both eat virtually the same aquatic invertebrates and are not cannibalistic, become stunted when the population size reaches a particular level. Fertilization of the pond will increase the invertebrate food base and consequently bluegill total biomass. However, the average size of the bluegill remains small as growth slows and some reproduction continues. Biological constraints to the development of commercial tilapia farming are their inability to withstand sustained water temperatures below 50 to 52 ºC and early sexual maturity that results in spawning before fish reach market size (Popma and Masser, 1999).

2.8.2. Food availability

Food availability also interact with other factors as well, particularly temperature, to affect the growth of fishes on a seasonal basis. For example, Moyle and Joseph (1988) found marked seasonal differences in growth (length increases) in northern Indiana bluegill populations. Bluegill growth was accelerated during the warmer months of plentiful food. Striped mullet (Mugilcephalus) from south Texas coastal waters show cycles of seasonal growth similar to those of bluegills, except that growth virtually ceases during the warmest.

3. MATERIALS AND METHODS

3.1. Description of the study area

3.1.1. Location, and some biological and morphometric features

Lake Maybar (Fig. 1 and 2) is one of the many water bodies of Ethiopia and is situated in the north eastern part of the central Ethiopian highlands within the Albuko Woreda, South Wollo, some 20 km south-east of Dessie town. It is located at 10^0 59'13.7''N latitude and $39^0$39'10.9''E longitude with an altitude of 2463m above sea level. The area of Lake Maybar is 52.77 hectares and its perimeter is 3.14 km (soil conservation research program, 2010).

Anna (2007) described the name Maybar as May- bar means ‘water lake’, i.e. May means water in Tigrigna and Bahr means lake in Amharic. Another given translation was ‘water in a small plate’, i.e. May means water in Tigrigna and Bar means small plate in Amharic language. The legend about the lake says that it was given to one of the earlier religious leader for cleaning during praying, which was explained by some elderly to show the link of the lake with the spirit. There is difference between opinion of the elderly and youths on the issue. The religious leaders clean demons from sick people by directly dipping people in the lake on the opposite side of the pump side. In the lake, there are two commercially important fish species of *O. niloticus* and *C. carpio*.

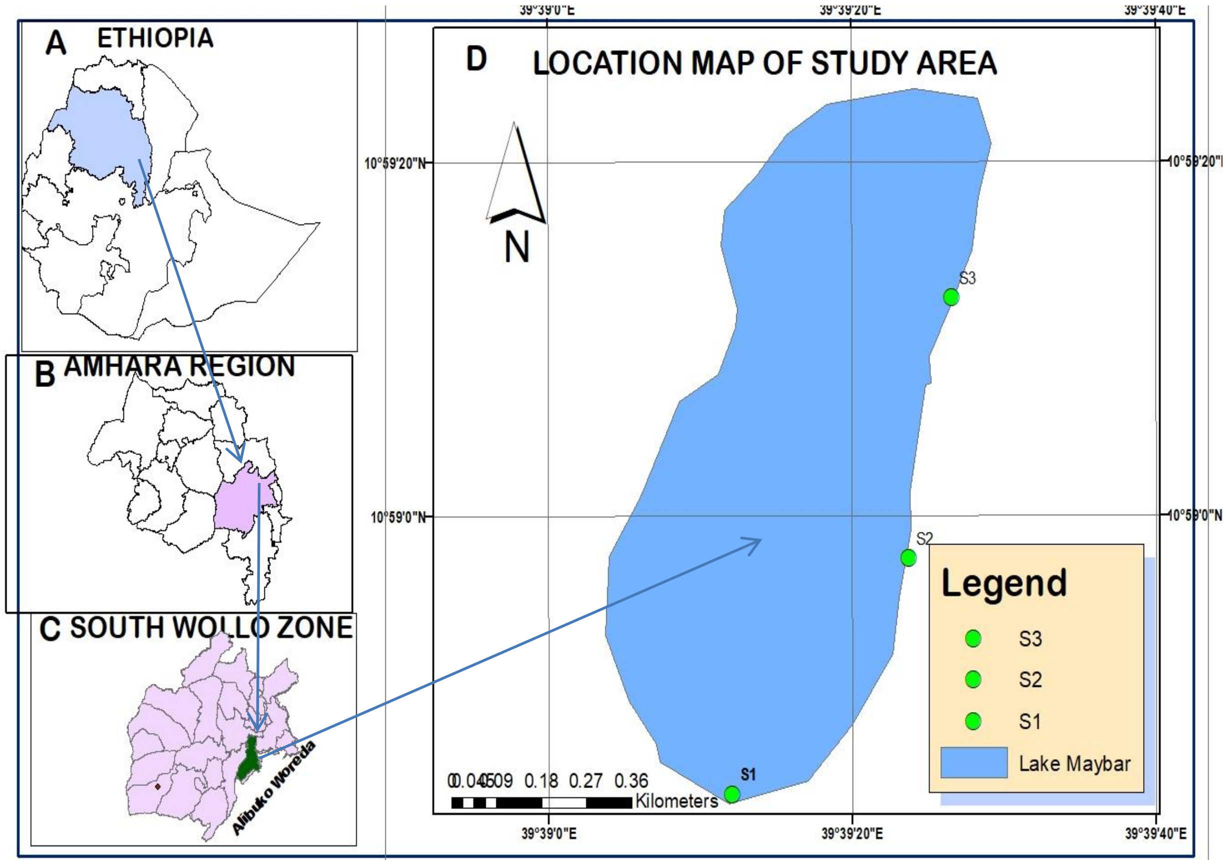


Fig.1.Map of Lake Maybar indicating sampling sites

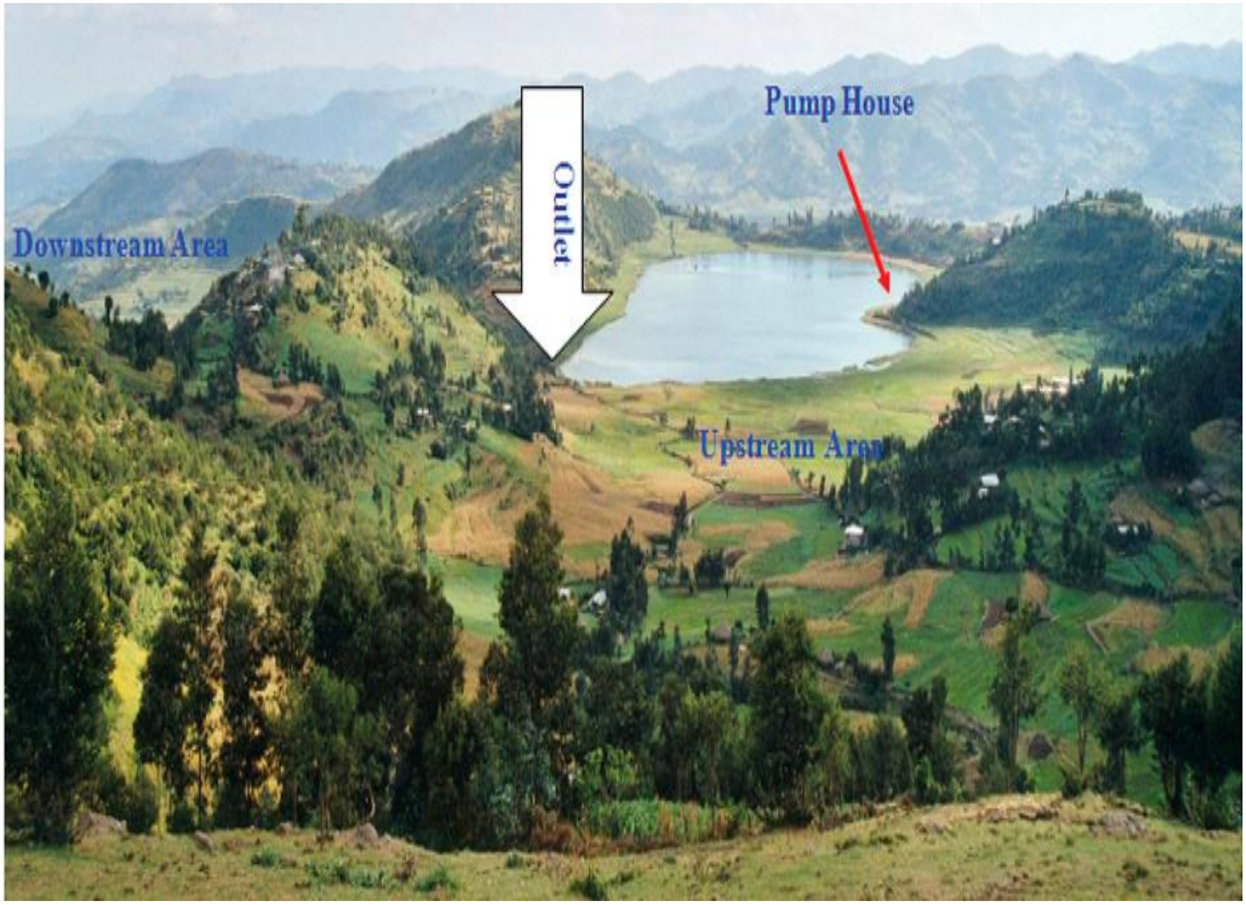


Fig.2.Photographic view of Lake Maybar with its surrounding catchment (Source: Anna, 2007)

Table 3.Some morphometeric and catchment features of Lake Maybar (Source: SCRP, 2010)

Morphometric features	**Values**
Area of the lake (ha)	52.77
Area of its watershed (ha)	397.5
Perimeter of the lake (km)	3.14
Perimeter of its watershed (km)	9.11

3.1.2. Catchment soil type, climate and livelihood of the community

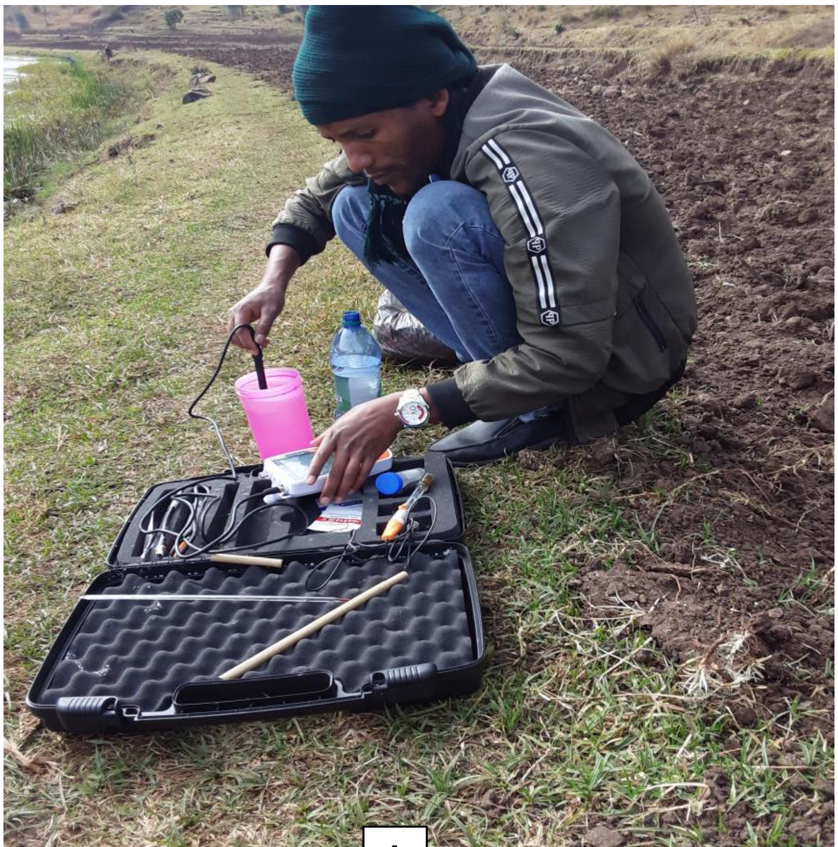
The soil of the study area ranges from very shallow soil associated with Lithosols to very deep soil. The former are found on steep slopes and the latter are developed from colluviums or alluviums in valley bottoms. In these plain areas, hydromorphic soils (Mollic Gleysols) with very high water tables, often waterlogged and swampy, are also found. In some parts of the territory, Fluvisols, along river gullies, and Regosols are reported to be found (Weigel, 1986 as cited in Habtamu Kebede, 2009). In the Lake Maybar area, a bimodal rainfall regime is dominant; Belg (March to May), the minor rainy season, and Kiremt (July to September), the major rainy season. Meanannual rainfall is 1500 mm. Mean daily air temperature ranges from 6.7°C up to 25.1°C which results in an annual mean of 16.0°C.

The main livelihood of the local community is agriculture. The mainly cultivated crops in the catchment area are maize, cereals (teff, barley, emmer wheat and wheat) and pulses (horse beans, field pea and lentils). Cereals are mainly planted in Belg rainy season, whereas pulses are dominant in Kiremt rainy season. Maize is grown in Belg.

3.2. Fish sampling and measurement, and water physicochemical parameters

Three sites were selected by considering Lake Region where common carp and Nile tilapia can dwell. The sampling sites were located in the littoral zone of the lake, site 2 and site 3 at the eastern end and site 1 at the south eastern end. Some selected water quality parameters were measured on fish sampling sites using appropriate measuring methods (Fig. 3A). Water temperature, dissolved oxygen, conductivity and pH were measured using multimeter measuring probe.

A total of one hundred forty (140) fish samples, seventy (70) individual of *C. carpio* and seventy (70) individuals of *O. niloticus,* were obtained from fishermen for the assessment of length–weight relationship and food and feeding habits of the two fish species in Lake Maybar. The fishermen caught the fishes using the commercial gillnets with different mesh size (6cm and 12cm stretched mesh size).Fishermen set gillnets overnight and collected the fish caught on the following day morning. After capture, the fish were serially tagged on the landing site; the total length (TL), fork length (FL), standard length (SL), and total weight (TW) of each specimen were measured (Fig. 3B, Fig. 4). The total length (TL) and total weight (TW) of all specimens were measured and weighted to the nearest value of 0.1 cm and 0.1 g, respectively. The collected fish samples were dissected and the sexes were determined by inspecting the gonads. Then, the digestive tracts were opened and the gut contents were taken out and preserved in 5% formalin in vials and brought to the laboratory of biology department of DebreBerhan University for gut content analysis.



A

Fig.3.Measurement of physicochemical parameter (A) and weight and length of fish (B) at the fishing site

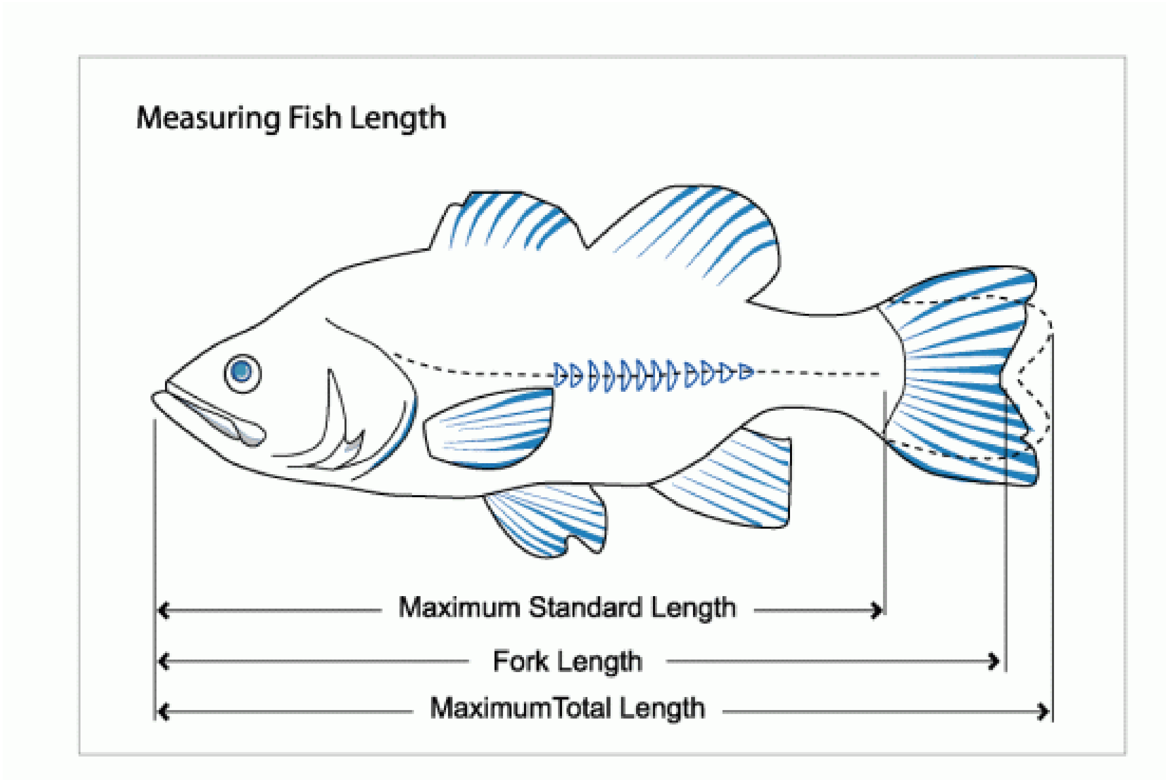


Fig.4.Standard length, fork length and total length in fish

3.3. Food and feeding habit

3.3.1. Gut content analysis

According to Chipps and Gravey (2007), gut contents can be collected either from the live or fresh died or preserved fish. Irrespective of the method, investigators should ensure that the gut removal technique effectively samples all food items in the gut or else data will be distorted toward food items that are more easily displaced from the stomach. Instead, live fish can also be forfeited and gut contents removed for analysis. When diet samples are not analyzed forthwith, fish should be preserved immediately either by freezing or by fixing formalin to avoid continued digestion of food contents (Chipps and Gravey, 2007).In present study, after body parameter measurement, guts were collected by dissecting the fish on its ventral side using scissors. The contents were preserved in sampling vials containing 5% formalin solution and brought to the laboratory for analysis (Fig. 5). In the laboratory, the guts were opened in a Petri-dish and prepared on a slide for microscopic examination. Examination was conducted under a dissecting microscope (magnification 40X) and a hand lens. The observed food items were carefully grouped in to different categories and identified to the lowest taxonomic level possible using identification keys (Edmondson, 1959; Pennak, 1978). The relative importance of each food items identified was determined using the methods of frequency of occurrence and volumetric analysis:

Fig.5.The collected gut samples of the fish species ready for gut content analysis in laboratory

3.3.2. The relative importance of food items

3.3.2.1. Frequency of occurrence

The number of gut samples in which a given food item was found was expressed as a percentage of all non-empty guts examined. This method gives an estimate of the proportion of the population that feeds on a particular food item (Hyslop, 1980).

$$\%FO = \frac{\text{The number of stomach in which a given food is found}}{\text{The number of non-empty stomach examined}} \times 100$$

3.3.2.2. Volumetric analysis

Food items that are found in the guts were grouped into different taxonomic categories and the water displaced by a group of items in each category was measured in a partially filled graduated cylinder as developed by Hyslop (1980). The volume of the water displaced by each category of food items was expressed as a percentage of the total volume of the gut contents (Bowen, 1983). In case of microscopic food items, the estimated average volume of an individual organism was multiplied by the total number of organisms counted in the gut samples.

$$\%\text{v}= \frac{\text{volume of one food item found in all specimen}}{\text{The volum of all food items in all specimen}} \times 100$$

3.4. Length-weight relationship and fish condition factor

Organisms generally increase in size (length, weight) during development. The key factors that influence the growth of fish are the quantity of food available, the number of fish utilizing the same food sources, temperature, oxygen and other water quality factors besides the size, age, and sexual maturity of the fish. The length-weight relationships (LWRs) of each individual fishes were examined based on the method of Bagenal and Tesch (1978).

$$\mathbf{TW=aTL^{b}}$$

Where, TW=total weight in grams; TL=total length in centimeters. The prefix '**a** 'is the intercept and the exponent '**b**' is the regression coefficient value of the exponent 'b' provide information on fish growth (Le Cren, 1951); when **b** =3, increase in weight is isometric and if the value of '**b'** deviates from 3, weight increase is allometric (Bagenal and Tesch, 1978).

Fish condition or well-being (fatness of the fish) has large influence on growth, survival, and reproduction on fish population (Lambert and Dutil, 2000). The average fish condition factor (CF) was estimated for both sexes to assess body condition of individual fish (Bagenal and Tesch, 1978). CF was computed using the following formula:

$$\text{FCF (\% in gram/cm}^3 = \frac{TW}{(TL)^b}\text{x}100$$

Where FCF fish condition factor, TW =total weight, TL =total length

3.5. Ontogenetic dietary shifts

For ontogenetic dietary shifts, the fish samples of *C. carpio* were divided into four classes (I- 14-20 cm TL, II- 21-30 cm TL, III- 31-40 cm TL and IV->40 cm TL). For ontogenetic dietary shifts, the fish samples of *O. niloticus* were divided in to three classes (I- 13-20 cm TL, II- 21-30 cm TL, III- >30 cm TL).

3.6. Data analysis

The data generated from the stomach contents were expressed using descriptive statistics. Physico-chemical parameters were analyzed using one way ANOVA. In addition, the results obtained from LWR were interpreted using linear regression method.

Dietary overlap within the different size class of *C. carpio* and dietary overlap within the different size class of *O. niloticus* was calculated using Schoener Diet Overlap Index (SDOI) (Schoener, 1970).

α=1-0.5 ($\sum_{i=}^{n} 1\ |pxi - pyi|$)

Where α is percentage overlap, SDOI, between length class x and y, pxi and pyi are proportions of food category (type) i used by x and y, and n is the total number of food categories. Values range from 0(no food overlap) to 1(complete overlap) with values greater than 0.6 being considered as biologically significant (Mathur, 1997).

4. RESULTS

4.1. Physicochemical parameters of water

Physicochemical parameters such as water temperature (T), pH, dissolved oxygen (DO) and conductivity of the study lake are indicated in Table 4. The mean values (±SD) of dissolved oxygen (mgL^{-1}) ranged from 6.59±0.37 at S3 to 7.89±0.37 at S1and there is significant variation in the value of DO among sampling sites ($p<0.05$).Similarly, the variation in pH and temperature among sites was significant ($p<0.05$) (table 4). The mean (±SD) value of electrical conductivity (EC)ranged from 129±5.26μScm^{-1} at S2 to 570±9.19μScm^{-1}at S1. There was statistically significant difference in EC among the three sites. Site1 showed significantly higher value of specific conductivity than S2 and S3 ($p<0.05$).

Table 4.Some physicochemical parameters measured in selected sites of Lake Maybar

Physico-chemical parameter	Sites		
	S1	S2	S3
DO(mgL^{-1})	7.89±0.37^{b}	6.9±0.28^{a}	6.59±0.37^{a}
Temperature (°C)	19.8±0.43 ^{a}	18.9±0.75^{a}	20.26±0.099 ^{b}
PH	8.45±0.28^{b}	7.5±0.0.23^{a}	7.89±0.0.143 ^{a}
EC(μScm^{-1})	570±9.19^{b}	129±5.26 ^{a}	340.4±13.3 ^{a}

Mean in the same row with different superscript are significantly different ($p<0.05$).

4.2. Length –weight relationship and condition factor of fish

4.2.1. Length–weight relationship

The total length of the fish ranged from 14 to 45 cm for common carp and 13 to 32 cm for Nile tilapia. The corresponding total weight ranged from 110 to 1000 grams for common carp, and from 133 to 327 gram for Nile tilapia. With regard to sex, the minimum and maximum total lengths of male and female individuals of *C. carpio* were 21cm and 45cm, and14cm to 33cm, respectively (Table 5).The minimum and maximum total weights of male individuals were 110 g and 1000 g whereas minimum and maximum total weight of female individuals were 125 g and 420 g, respectively.

Table 5. The total length and total weight for males and females of *C. carpio* in Lake Maybar (female = 40 and male =30)

Sex	N	TL(cm)			TW(g)		
		Min	Max	Range	Min	Max	Range
Male	30	21	45	24	110	1000	890
Female	40	14	33	19	125	420	295

With regard to sex, the minimum and maximum total lengths of male individuals of *O. niloticus* were 13cm and 31cm whereas minimum and maximum total lengths of female individual's of *O. niloticus* were 13cm and 32cm, respectively (Table 6). The minimum and maximum total weight of male individuals of *O. niloticus* was 140 g and 320 g whereas minimum and maximum total weight of female individuals were 133g and 327 g, respectively.

Table 6. The total length and total weight for males and females of *O. niloticus* in Lake Maybar (female =34 and male =36)

Sex	N	TL(cm)			TW(g)		
		Min	Max	Range	Min	Max	Range
Male	36	13	31	18	140	320	180
Female	34	13	32	19	133	327	194

Length-weight relationship of common carp is shown in Fig. 6 and it was curvilinear, which shows that common carp has isometric growth. Length-weight relationship of Nile tilapia is presented in Fig. 7 and it was curvilinear, which shows that Nile tilapia had an isometric growth.

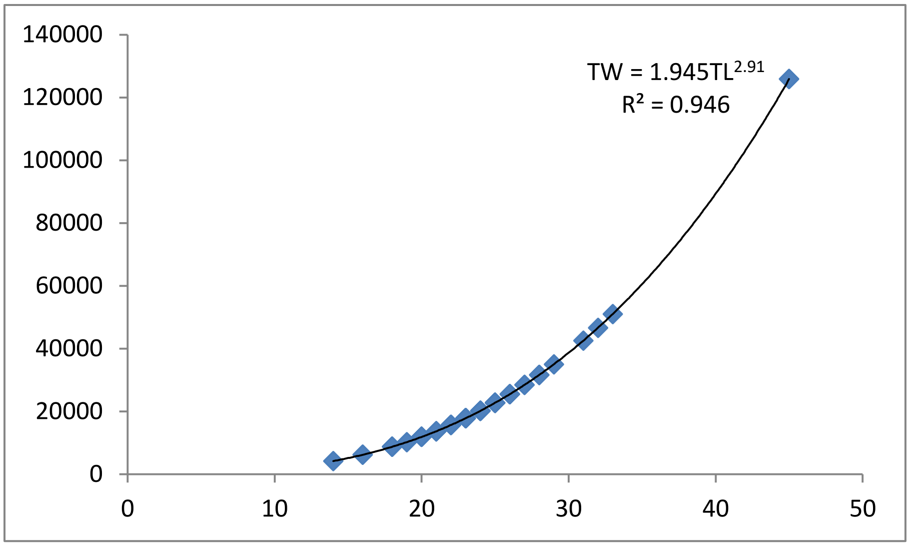


Fig.6. Total length and total weight relationships (sexes combined) for *C. carpio*

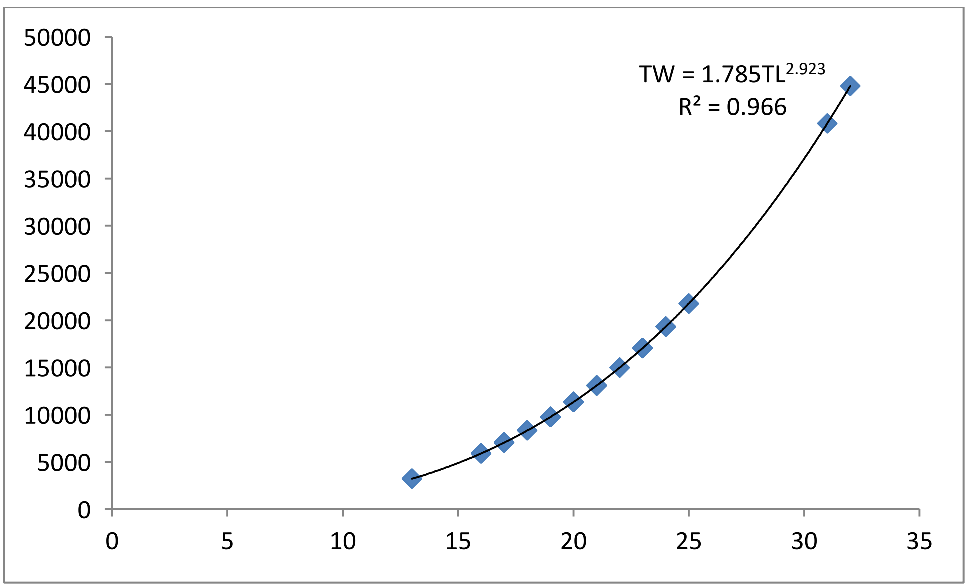


Fig.7. Total length and total weight relationships (sexes combined) for *O. niloticus*

4.2.2. Condition factor

Table7shows the number of specimen, maximum and minimum length, maximum and minimum weight and condition factor for the two fish species. The highest and lowest condition factor (K) recorded for *C. carpio* were 4.55 and 0.713, respectively. The average condition factor for male and female *C. carpio* was 1.95 and 1.94, respectively. Condition factor for almost all samples of both male and female were greater than one (K>1) and this indicates that almost all the fishes are in good conditions. For *O. niloticus*, the highest and lowest Kof6.37and 0.99, respectively, were recorded. The average K for male and female *O. niloticus* was 1.85 and 1.72, respectively. The condition factor of almost all samples of both sexes of this fish was greater than one (K>1) and this indicates that almost all samples the fishes are in good conditions.

Table 7. Condition factor of *C. carpio* and *O. niloticus*in Lake Maybar

Fish species	Sex	N	TL(cm)		Weight (gm)		$K=W/TL^3 *100$
			Max	Min	Max	Min	
C. carpio	Male	30	45	21	1000	110	1.95
	Female	40	33	14	420	125	1.94
O. niloticus	Male		31	13	320	140	1.85
	Female		32	13	327	133	1.72

4.3. Food and feeding habits of fish

C.carpio

Out of the total number of 70 *C. carpio* sample collected, 64 (91.4%) were non-empty while the remaining 6 (8.6%) were completely empty gut. The food items identified from the gut contents of *C. carpio* were detritus, phytoplankton, zooplankton, macrophyte, insect, sand and mud, fish scale, fish larvae, egg and nematode (Table8).Detritus (43%), macrophyte (17%) and phytoplankton (5%) constituted the bulk (65.75%) of the food consumed by volume (Table8).Detritus occurred in 84.37% of the guts and accounted for 43.09% of the total food volume (Table 8). Phytoplankton occurred in 64.06% of the guts and constituted 5.6% the total food volume. Among the phytoplankton groups, blue green algae constituted the largest proportion of the diet of *C. carpio*(4.25% by volume) compared to the other phytoplankton taxa

(Table 8). Macrophytes occurred in 59.4% of the guts examined and accounted for 17.06% of the total volume of food categories.

Table 8. Frequency of occurrence and volumetric contribution of different food items in the diet of C. *carpio* (n = 64)

Food items	**Frequency of occurrence**		**Volumetric analysis**	
	Number	**Percent**	**Volume (ml)**	**Percent**
Phytoplankton	**41**	**64.06**	**8**	**5.6**
• Blue green algae	37	57.8	6.02	4.25
• Diatoms	12	18.75	1.56	1.1
Zooplankton	**30**	**46.87**	**6.5**	**4.6**
• Rotifers	12	18.75	1.8	1.27
• Copepods	11	17.2	1.51	1.05
• Daphnia	14	21.9	1.93	1.36
Insect	**4**	**6.25**	**1.2**	**0.85**
• Coleopteran	3	4.7	0.27	0.19
• Plecoptera	1	1.56	0.47	0.33
• Unidentified animal	3	4.7	2.7	1.9
Root hairs	**3**	**4.7**	**3.5**	**2.47**
Sand and mud	**23**	**35.93**	**15.07**	**10.6**
Nematode	**4**	**6.25**	**2.5**	**1.76**
Macrophyte	**38**	**59.4**	**24.19**	**17.06**
Fish scale	**27**	**42.2**	**17.7**	**12.48**
Egg	**3**	**4.7**	**1.2**	**0.85**
Fish larvae	**1**	**1.56**	**0.3**	**0.21**
Detritus	**54**	**84.37**	**61.08**	**43.09**

Table 9. Index of preponderance of *C. carpio* in present study

Food item	F	%F	V	%V	%F%V	%IFP
Phytoplankton	41	64.06	8	5.6	358.736	5.820837
Zooplankton	30	46.87	6.5	4.6	215.602	3.49835
Insect	4	6.25	1.2	0.85	5.3125	0.0862
Sand$mud	23	35.93	15.07	10.6	380.858	6.179787
Sand	3	4.7	3.5	2.47	11.609	0.188367
Nematode	4	6.25	2.5	1.76	11	0.178486
Macrophyte	38	59.4	24.19	17.06	1013.364	16.44281
Fish scale	27	42.2	17.7	12.48	526.656	8.5455
Egg	3	4.7	1.2	0.85	3.995	0.064823
Fish larvae	1	1.56	0.3	0.21	0.3276	0.005316
Detritus	54	84.37	61.08	43.09	3635.503	58.98954
Total						100

According to the index of preponderance detritus and macrophyte constitute first and second ranks whereas fish scale, sand and mud, and phytoplankton held third, fourth and fifth ranks in the feed of C. *carpio* (Table 9).

O. niloticus

Out of the total number of 70 *O. niloticus* sample collected, 66 (94.28 %) were non-empty gut while the remaining 4 (5.71 %) were completely empty. The food items identified from the gut contents of *O. niloticus* were detritus, phytoplankton, zooplankton, macrophyte, insect, sand and mud, fish larvae and annelida (Table10). Detritus (21.55%), macrophyte (32.9%) and phytoplankton (22.8%) constituted the bulk (77.32 %) of the food consumed by *O. niloticus* by volume (Table10). The remaining food items accounted for only 22.68% of the total volume of the food items. Phytoplankton occurred in 75.5% of the guts and accounted for 22.8% the total food volume. Among the phytoplankton group blue green algae constituted the largest portion of the diet of *O. niloticus* (12.14% by volume) compared to the other phytoplankton taxa (Table 10). Macrophytes occurred in 72.2% of the guts examined and accounted for 32.97% of the total volume of food categories. Detritus occurred in 68.18% of the guts and accounted for 21.55% of the total food volume.

Table 10. Frequency of occurrence and volumetric contribution of different food items in the diet of *Orieochromis niloticus (*n=66)

Food items	Frequency of occurrence		Volumetric analysis	
	Number	Percent	Volume(ml)	Percent
Detritus	**45**	**68.18**	**50.9**	**21.55**
Macrophyte	**48**	**72.2**	**30.6**	**32.97**
Phytoplankton	**50**	**75.5**	**12.6**	**22.8**
• Blue green algae	39	59.09	14.91	12.14
• Diatom	20	30.03	5.6	4.56
• Green algae	17	25.75	7.5	6.10
Zooplankton	**35**	**53.03**	**2.75**	**2.24**
• Rotifer	2	3.03	0.75	0.61
• Copepod	4	6.06	1.2	0.98
• Daphnia	3	4.54	0.8	0.65
Unidentified animal	**8**	**12.12**	**4.5**	**3.67**
Fish larvae	**15**	**22.72**	**6.5**	**5.3**
Sand and mud	**17**	**25.75**	**11.1**	**9.06**
Annelida	**4**	**6.06**	**3.2**	**2.61**
Insect	**3**	**4.54**	**0.37**	**0.3**
Diptera	3	4.54	0.35	0.28

Table 11. Index of preponderance of *O. niloticus* in Lake Maybar in present study

Food item	**F**	**%F**	**V**	**%V**	**%F%V**	**%IFP**
Detritus	45	68.18	50.09	40.8898	2787.94	47.23
Macrophyte	48	72.72	30.6	24.97959	1816.69	30.78
Phytoplankton	50	75.75	12.6	10.28571	779.22	13.20
Zooplankton	35	53.03	2.75	2.244898	119.04	2.01
Fish larvae	15	22.72	6.5	5.306122	120.59	2.04
Annelida	4	6.06	3.2	2.612245	15.83	0.26
Insect	3	4.54	0.37	0.302041	1.37	0.02
Sand and mud	17	25.75	11.1	9.061224	233.3	3.95
Unidentified	5	7.57	4.5	3.673469	27.82	0.47
Diptera	3	4.54	4.54	3.706122	16.84601	0.28462

4.4. Ontogenetic dietary shifts

C.carpio

Schoener Diet Overlap Index (SDOI) revealed no significant variation in the diet of the different size-classes (I&II-85%, I&III-66.3%, I&IV-61%, II&III-81%, II&IV-63.8% and III&IV-89.2%).The contribution of prey items consumed by the different size classes of *C. carpio* is shown in Fig. 8. In the first size class (14-20 cm TL), insects constitute almost half (50.5%) of the gut content, while the contribution of detritus and macrophyte accounted for 25.7% and 6.5%, respectively (Fig. 8). In the size class 21cm TL-30 cm TL the contribution of insects (41%) declined slightly, while the contribution of detritus (31.7%) and macrophyte (10.6%)

increased slightly. The contribution of other food items was relatively low. In the size class 31-40 cm TL detritus (44.97%), insect (27.5%), and macrophytes (12.3%) were the most important food items. Other food items were of low importance. In the largest size class (>40 cm TL), detritus (51.3%), insect (18.5%) and macrophyte (14.7%) were dominant food items while the contribution of other food items was insignificant. Generally, the contribution of foods of animal origin such as insect and zooplankton declined with size of fish while the contributions of food of plant origin, namely detritus, macrophyte and phytoplankton increased with size of fish.

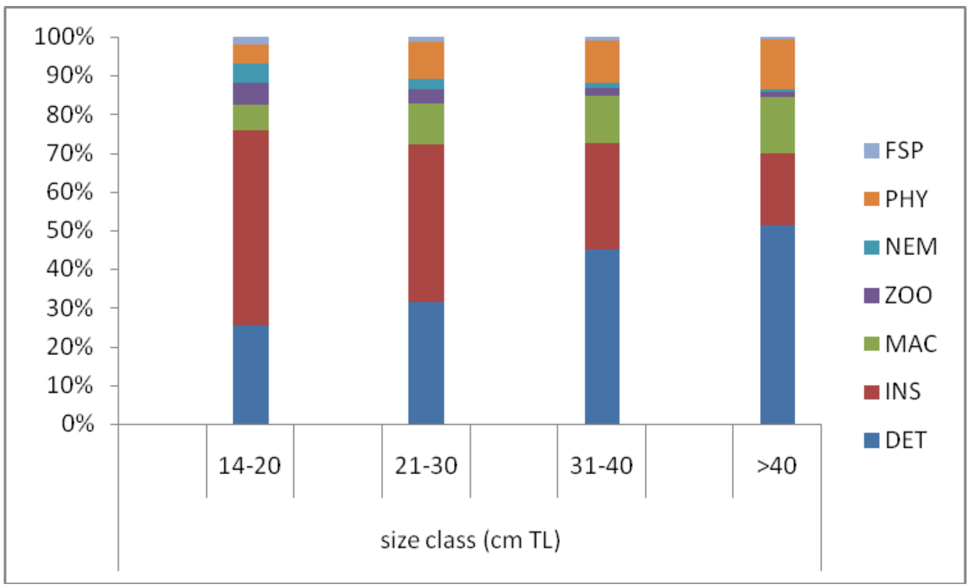


Fig.8. The percentage mean volumetric contribution of prey organisms consumed by different size classes of *C. carpio* (n=64) in Lake Maybar (FSP=fish part, PHY=phytoplankton, NEM=nematode, ZOO=zooplankton, MAC=macrophyte, INS=insect and DET=detritus)

O.niloticus

SDOI revealed no significant variation in the diet of the different size-classes (I&II-86.3%, I&III-69.3%, I&IV-61% and II&III-86.2%). The contribution of food items consumed by the different size classes of *O. niloticus* is shown in Fig. 9. In the smallest size class (13-20 cm TL), the diet was dominated by phytoplankton (28%), zooplankton (22.11%) and detritus (20.1%). The contributions of other food items such as insect (11.3%) and macrophyte (4.2%) were relatively low. In the size class 21cm TL-30 cm TL, the contribution of detritus (31.1%) and phytoplankton (28.9%) increased slightly, while the contribution of zooplankton (18.2%)

declined slightly. The contribution of other food items was relatively low. In the largest size class (>30 cm TL), detritus (40.2%), phytoplankton (30.75%) and macrophyte (13.2%) were dominant food items while the contribution of other food items was low. Generally, the contribution of foods of animal origin such as insect and zooplankton declined with size of fish while the contributions of food of plant origin, namely detritus, macrophyte and phytoplankton increased with size of this fish species.

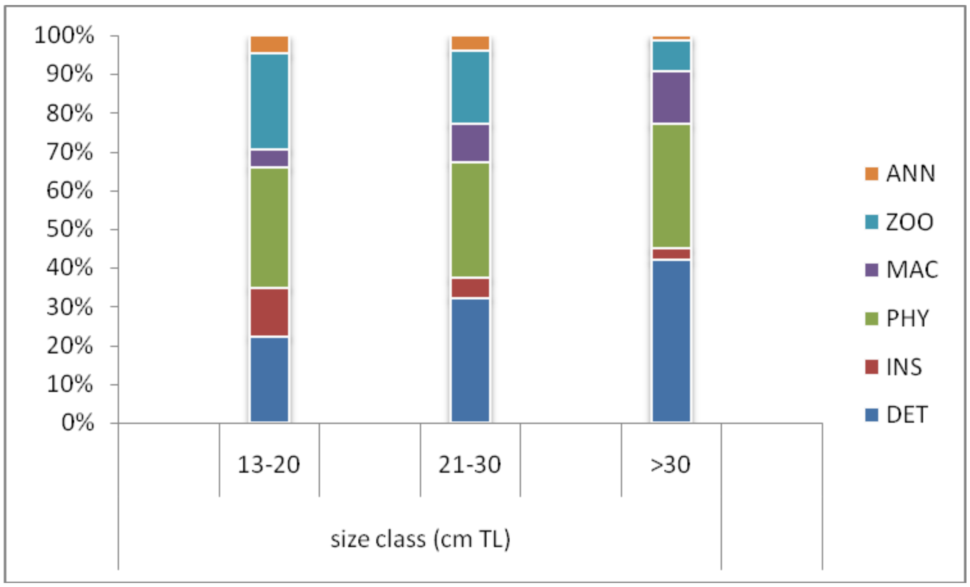


Fig.9.The percentage mean volumetric contribution of prey organisms consumed by different size classes of O. *niloticus* (n=66) from Lake Maybar (PHY=phytoplankton, ANN=annelida, ZOO=zooplankton, MAC=macrophyte, INS=insect and DET=detritus)

5. DISCUSSION

5.1. Physicochemical parameters

The physicochemical parameters of water are important factors and have a great influence on growth, survival and reproduction of fish population. The physicochemical parameters of the water of the lake differed markedly among the three sampling stations. Site 1 was characterized by having higher DO, pH and conductivity. Site 2 was characterized by having low level of EC, andS3 was again characterized by having lower DO, and higher temperature. Conductivity is generally a very good predictor of both total cations and salinity in Ethiopian water bodies (Zinabu Gebre-Mariam *et al*., 2002).Just like, metal water can conduct (transport) electricity. This is because there are salts dissolved in the water.

For aquatic animals including fish, pH level plays an important role (Zaniboni, 2008). An increase or decrease in pH disturbs the acid base balance, ion regulation and ammonia execration (Wood, 2001).Although the optimum pH range differs among species, the pH range 6.5-9.0 is generally accepted for fish growth (Sophin, 2001). The pH values of water of the Lake Maybarin the present study is suitable for normal biological activity as it was found within the range of 6.5-8.5 that is set by the European Economic Community (1980).According to Trewavas (1983), tilapia is capable of tolerating water temperatures ranging from 8°C to 42°C, and shows better growth performance at water temperature in between 25°C to 33°C(Guerrero,1985).Common carp is active in feeding when the water temperature is over 18°C -20°C.Though common carp tolerates high water temperature (around 28°C -30°C) the optimum temperature for growing is between 20°C and 25°C.The result of the current study showed that the measured physicochemical parameters are at a good condition for growth and survival of common carp and Nile tilapia that exist in the lake.

5.2. The LWRs and condition factor

5.2.1. The LWRs and condition factor of common carp

The length-weight relationship of common carp in Lake Maybarwas found to be curvilinear and highly significant. The estimated length weight coefficient (b) value of common carp in the study area is within the range of b values (2-4) in fishes in general (Bagenal and Tesch, 1978) and in tropical fishes (b=2.5-3.5) in particular (Gayannilo and Pauly, 1997). The slope of the regression line (b) indicated isometric growth pattern of the fish, where its shape and specific gravity do not change as the fish grows in size (Elias Dadebo *et al*., 2014). It means that growth occurs at the same rate for all parts of the fish (Flipos Engdaw *et al*., 2013).

The value of b for *C. carpio* (b=2.91) in the present study is slightly lower than the other studies conducted on same fish species. For common carp, Elias Dadebo *et al*. (2015) reported 3.018valueof the slope of the line (b) in Lake Koka (Ethiopia), James *et al*. (2000) reported the ”b” value of 3.010 and Daniela *et al*. (2009) reported 3.002 in Brazil. The other study done by Moata *et al*. (2005) in Morocco reported that the growth pattern of common carp was found to be 3.412, which is considerably positive allometry. However, the value of b in the present study is higher than the value of b (2.3) that was reported by Otieno *et al*. (2014) from Lake Naivasha, Kenya. Such differences in length-weight relationship coefficient are not unexpected and may result from differences in sampling size, sampling time, food availability and habitats (Froes, 2006). The study by King and Udo (1998) also showed that the functional regression value of “b” represents the body form and is directly related to the weight affected by ecological factors such as temperature, habitat selection as well as sampling vessels.

The condition factor ,k, is a measurement that involves the length and weight for a particular fish. The k value of male and female *C.carpio* in this lake was 1.95 and 1.94, respectively. These k values of the present study indicate that condition factor of *C. carpio* in Lake Maybar is very well. According to Nehemia *et al*. (2012), better body condition is correlated with high values of condition factor. The condition of the fish is poor, long and thin when k value is less than 1 but very well if it is greater than 1(Gubta *et al*., 2011).Therefore, in the present study, the average condition factor for both male and female fishes of *C.carpio* was greater than 1.94, which indicates a good condition. According to Ujjani *et al*. (2012) the higher condition factor of the fish indicates the wellbeing of the fish level in relation to feeding, reproduction condition and fat accumulation. The difference in condition factor could be due to the availability of food organism at a particular time as well as the difference of gonad development (Gupta *et al*., 2011). The present study also indicated that most of female fish gonad developed egg, showing good condition factors for *C.carpio* in this lake.

5.2.2. The LWRs and condition factor of Nile tilapia

The length-weight relationship of Nile tilapia in the study lake was found to be curvilinear and highly significant. The "b" value of Nile tilapia is found within the range of b values (2-4) in fishes in general (Bagenal and Tesch, 1978) and in tropical fishes (b=2.5-3.5) in particular (Gayannilo and Pauly, 1997). The value of b for Nile tilapia in this study is comparable to the value of b calculated for the same species in Lake Hawassa (b=2.91) (Demeke Admassu, 1990) and Lake Hayq (b=2.95) (Workye Worie and Abebe Getahun, 2014).The variation in the value of"b" occurs due to season, habitat, gonad maturity, sex, diet, stomach fullness, health, gear selectivity and differences in environmental conditions. The regression co-efficient value (b) of the present study was also within the expected range of 2-4, appropriate for freshwater fishes (Anani and Nunoo, 2016).

The k values of male and female *O. nililiticus* were 1.85 and 1.72. These k values of the present study also indicate that condition factor of *O. niloticus* in Lake Maybar is very well. Therefore, in the present study, the average condition factor for both male and female fishes of O. *niloticus* were greater than 1.78, which indicates a good condition. It also indicates that most of female fish gonad developed egg, showing good condition factors for *O. niloticus* in this lake.

5.3. Food and feeding habit

Gut content analysis provides important insight in to fish feeding patterns. Feeding of fish represents an integration of many important ecological components that includes behavior, condition, habitat use, energy intake and inter and intra interaction. The gut content analysis makes possible to answer questions such as determining the relative importance of different food items to fish nutrition, quantifying the consumption rate of individual prey items (Pikitch *et al.*, 2004; Chipps and Garvery, 2007). Out of the total of 140 fish samples (70 *C. carpio* and 70 *O.niloticus*), the guts of 6 (9.6%) of common carp and 4(6.7%) of *O. niloticus* were found as empty and the remaining 64(91.4%) of *C. carpio* and 66(94.28%) of *O.niloticus* were observed as non-empty, containing different food items. The small amount of empty stomach observed may be due to the short period of time between capture and the least probability of food loss through digestion.

5.3.1. Feeding habits of *O.niloticus*

The stomach contents analysis of *O. niloticus* indicated that this fish species feeds on a variety of food categories in Lake Maybar, including foods from plant origins, such as phytoplankton, macrophyte and detritus as well as food from animal origins such as zooplankton, insect, annelid, unidentified animal and sand and mud. The types of food items found in the stomachs of Nile tilapia were quite similar to what has been reported by several authors in different lakes of Ethiopia. Nile tilapia was reported to feed on variety of food items including phytoplankton, macrophytes, benthic aquatic invertebrates and detritus (Getachew Tefera, 1987; Todurancea *et al*., 1988; Getachew and Fernando, 1989; Zenebe Tadesse, 1988, 1998, 1999; Yirgaw Teferi *et al*., 2000; Oso *et al*., 2006; Alemayehu Negassa and Prabu, 2008; Flipos Engdaw *et al*., 2013; Yirga Enawgaw and Brook Lemma, 2018).

The present work showed that Nile tilapia in Lake Maybar consumed large quantities of macrophytes. However, different authors have reported that phytoplankton was found to be the most important food item than macrophytes in lakes for which data are available (Getachew Tefera, 1987; 1993; Zenebe Tadesse, 1988, 1998, 1999; Yirgaw Teferi *et al*., 2000; Alemayehu Negassa and Prabu, 2008; Mulugeta Wakijira, 2013; Filipos Engdaw *et al*., 2013; Workye Worie and Abebe Getahun, 2015; Yirga Enawgaw and Brook Lemma, 2018).The variation in diet composition is affected by many factors such as season, spatial variation, and ontogenetic dietary shift of fish (Bozza,2010).Availability, composition and abundance of prey item also determine the dietary composition of fish(Meurer, 2012). The dominance of macrophytes to the diet of Nile tilapia in the present study is also in agreement with the finding reported by Tadesse Fetahi *et al*. (2018) who found the high contribution of macrophytes (64%) in the diet of Nile tilapia in Lake Zeway. Furthermore, Rao *et al*. (2015) reported the high contribution of macrophytes (54%) in the diet of Nile tilapia in South Lake, China. The occurrences of macrophytes were also found slightly high in the diet of Nile tilapia in other rift valley lakes (Zenebe Tadesse, 1999; Filipos Engedaw *et al*., 2013; Yirgaw Teferi *et al*., 2000).

In addition to phytoplankton and macrophytes, detritus were also consumed in large quantities. Zenebe (1999) and Yirgaw Teferi *et al*. (2000) reported the importance of detritus in the diet of Nile tilapia in Lake Langano and Lake Chamo (Ethiopia), respectively. Bowen (1980) also reported the presence of large quantities of detritus in the diet of Nile tilapia in Lake Valencia (Venezuela). Several authors provided similar findings on the importance of detritus in different parts of Africa (Getabu, 1993; Shipton *et al*., 2008; Oso *et al*., 2006; Flipos Engdaw *et al*., 2013; Mulugeta Wakijira, 2013).In addition, rotifers, cladocereans, and copepods contributed an appreciable amount of the food composition of *O.niloticus* in Lake Maybar. Zenebe Tadesse (1999) also reported the presence of rotifers and copepods in the food of *O.niloticus* in Lake Langano.

5.3.2. Feeding habits of *C. carpio*

In the present study, the examination of the feeding biology of *C. carpio* in Lake Maybar indicated that this species feeds on a wide range of food items. *C. carpio* was found to be omnivores in its diet everywhere for which data are available (Rahmane *et al*., 2006). The finding of the present study also showed that *C. carpio* is omnivores in its diet in Lake Maybar and consumed varieties of food items which include phytoplankton, zooplankton, insect, macrophyte, root hairs, sand and mud and fish parts. The quantitative analysis of food items indicated the importance of various for items such as detritus (43.9%), macrophytes (17.06%), and fish scale, (12.48%), sand and mud (10.6%), phytoplankton (5.6%), zooplankton (4.6%), root hairs (2.47%) in the diet of this fish species. This findings contradicts with the report of Elias Dadebo *et al* (2015), who found that dipteral constituted the largest proportion of the diet of *C. carpio* (26.7%) among the insect group by volume'; there was no dipteral food item at all in gut content of *C. carpio*in Lake Maybar in the present study. Other studies also reported the finding differing from the present result. For example, Philip (2006) reported that *C. carpio* consumed large quantities of mollusks and annelids in addition to other food categories; the present study findings did not showed large quantities of such food items (mollusks and annelids) in the gut contents of *C. carpio*.Elias Dadebo *et al*.(2015) found several food items such as euglenoid, hemipetra, and diptera in the guts of *C. carpio* in Lake Koka. However euglenoid, hemipetra, and diptera were not identified in the diet of C. *carpio* from Lake Maybar. The result of the present study showed that *C. carpio* fed on multilateral food items. Even though no dipteral and hemiptera were found in the gut contents of *C. carpio*in Lake Maybar, several food items such as detritus, phytoplankton and macrophytes were the major bulk contents which were frequently identified food items in the present study, which agrees with thefindings of Girma Tilahun *etal.* (2015).

5.4. Variation of food compositions with fish sizes

Slight ontogenetic dietary shift was observed in the present study in both species and it demonstrates that smaller fishes mainly focused on animal based items such as insects and zooplankton whereas larger fish mainly feed on detritus, phytoplankton and macrophyte. Different factors may be responsible for the ontogenetic dietary shifts in fish. Settlement into the foraging areas (McCormick, 1997; Sivadas and Bhaskaran, 2009) and age-specific changes in the use of habitats (Brett, 2002) are some of these factors. For example, in *C. carpio* the juveniles generally prefer shallow vegetated parts of the water body and they feed on benthic invertebrates and mud (Christopher, 2008). As the fish grows older, changes occur in the physiology and body structures and these changes result in changes in the feeding behavior of the fish. These changes may include increase in length of the alimentary canal and gape size of the mouth (McCormick, 1997). Ontogenetic diet shift has been shown to occur during the life history of many fish species, and prey size is generally positively correlated with fish size. A fundamental characteristic of fish in their feeding is that the individuals increase considerably in size which is usually associated with changes in food resource use (Zerihun Desta *et al*., 2007).

The result of the present study is in agreement with the reports of Todurancea *et al*. (1988) in Lake Hawassa, Zenebe Tadesse (1988) in Lake Zeway, Flipos Engdaw *et al*. (2013) in Lake Koka, all of themreported the significant contribution of zooplankton to smaller sized*O. niloticus*.Larger fish greater than 30cm TL instead relied on food from plant origins such as macrophytesand detritus. Fish change their feeding behavior from primarily omnivorous to herbivorouswith the high-energy demands as they grow (Benavides, 1994; Flipos Engdaw, 2013; Workiye Worie, 2015). The growing energy demand of the fish cannot be met by feeding only on zooplankton and benthic invertebrates. This enables them to shift their feeding behavior from eating only zooplankton and benthic invertebrates to generalist behavior. In addition, the bigger fish are more capable of digesting cell wall material, and therefore can be less selective in their feeding pattern (German, 2009).

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The result of the current study showed that the measured physicochemical parameters are at a good condition for growth and survival of common carp and Nile tilapia that exist in the lake. The length-weight relationship of common carp and Nile tilapia was found to be curvilinear. The slope of the regression line for common carp and Nile tilapia indicate isometric growth pattern of the fish. Foods of both plant and animal origins were identified in the diets of the two species. *C. carpio* and *O.niloticus* in Lake Maybar had good condition factors and had proportional length-weight relationship. The major food categories in the gut content of *C. carpio* and *O.niloticus* in Lake Maybar were detritus, macrophyte and phytoplankton, whereas minor food groups were zooplankton (cladocerance), root hairs and sand. The gut content analysis provided *that C.carpio* and *O.niloticus* were characterized by omnivorous feeding habits that showed length-based variation of food composition. Slight ontogenetic diet shift was observed in the present study in both species and it demonstrates that smaller fishes mainly focused on animal based items whereas larger fish depend on plant items. The size-related shifts in food item preferences of *O.niloticus* and *C.carpio* in the lake seem to depend upon physiological requirements.

6.2. Recommendations

The following recommendations are forwarded based on the study conducted on feeding habit of common carp and Nile tilapia, and some water quality features in Lake Maybar.

- ✓ The present work was carried out by taking short period of time due to time and budget constraints. Therefore, further research is recommended to examine the feeding habit by taking year round data so as to show seasonal variations.
- ✓ In this study it was attempted to generate crucial data on some aspects of feeding biology of common carp and Nile tilapia. Other aspects like fertilization and growth rate should be studied to give useful information on the ecology of both species.
- ✓ Dietary overlap between common carp and Nile tilapia should be studied
- ✓ In this study it was attempted to show some water quality features, such as dissolved oxygen, temperature, pH and conductivity. Studies which integrate biological and other physicochemical features should be conducted to give adequate information on the water quality of Lake Maybar.

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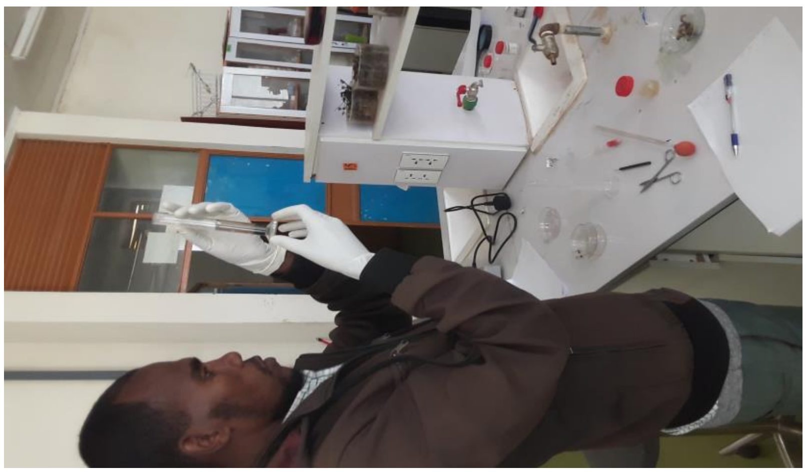
APPENDIX

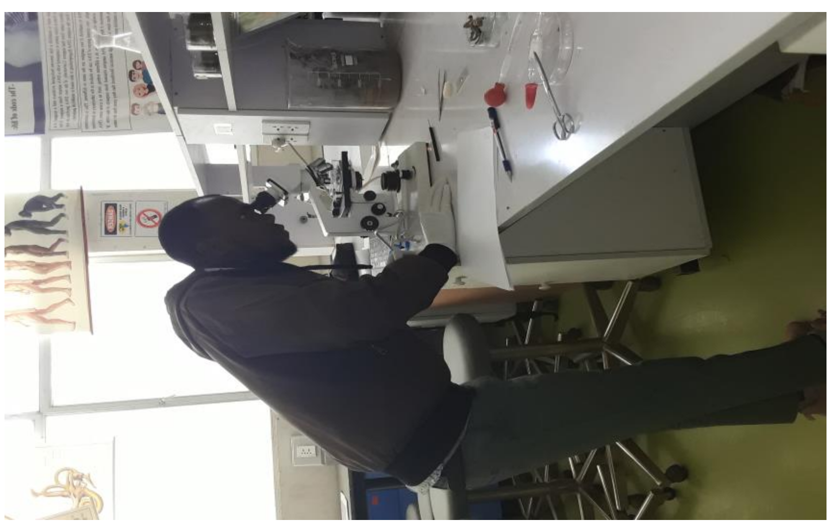
Appendix1. Measurement of physiochemical parameter at the fishing site

Appendix 2. Images of the fish species from Lake Maybar

Appendix 4. Volumetric analysis in the laboratory



Appendix5.Microscopic examination



Appendix 6. Measuring the fish length

Appendix 7. Measuring the fish weight

Appendix : 8 one way ANOVA for analysis of the water quality in all sampling sites

Parameter		Sum of Squares	df	Mean Square	F	Sig.
Do	Between Groups	4.571	2	2.285	19.254	.000
	Within Groups	1.424	12	.119		
	Total	5.995	14			
Temperatures	Between Groups	4.518	2	2.259	8.793	.004
	Within Groups	3.083	12	.257		
	Total	7.602	14			
PH	Between Groups	2.287	2	1.144	22.833	.000
	Within Groups	.601	12	.050		
	Total	2.888	14			
EC	Between Groups	486043.733	2	243021.867	2.510E3	.000
	Within Groups	1162.000	12	96.833		
	Total	487205.733	14			

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
dissolved oxygen	site1	5	7.8900	.37483	.16763	7.4246	8.3554
	site2	5	6.9180	.28057	.12548	6.5696	7.2664
	site3	5	6.5900	.36993	.16544	6.1307	7.0493
	Total	15	7.1327	.65438	.16896	6.7703	7.4950
temperature	site1	5	19.8000	.43012	.19235	19.2659	20.3341
	site2	5	18.9360	.75887	.33938	17.9937	19.8783
	site3	5	20.2600	.09975	.04461	20.1361	20.3839
	Total	15	19.6653	.73687	.19026	19.2573	20.0734
PH	site1	5	8.4500	.27839	.12450	8.1043	8.7957
	site2	5	7.4980	.22819	.10205	7.2147	7.7813
	site3	5	7.8940	.14381	.06431	7.7154	8.0726
	Total	15	7.9473	.45419	.11727	7.6958	8.1989
Electrical conductivity	site1	5	5.700000E2	9.1923882	4.1109610E0	558.586143	581.413857
	site2	5	1.292000E2	5.2630789	2.3537205E0	122.665024	135.734976
	site3	5	3.404000E2	13.3529023	5.9715995E0	323.820182	356.979818
	Total	15	3.465333E2	186.5486787	4.8166662E1	243.226118	449.840548

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APPROVAL SHEET I

This is to certify that the thesis entitled **"-----------------------"** submitted in partial fulfillment of requirements of Degree of ---------------- in -----------**,** College of ------------------**,** Debre Berhan University and is a faithful record of original research work carried out by ----------- under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

It is further assures that the various sources used during the course of investigation has been duly acknowledged. Therefore, I recommend it be accepted as fulfilling the thesis requirements.

-------------------- (-------.) --------------------- -------------------

Major Advisor Signature

Date

APPROVAL SHEET II

We, the undersigned members of the board of the examiners of the final open defense by ---------------------------have read and evaluated his thesis entitled "--" and examined the candidate performance. This is, therefore, to certify that the thesis has been accepted in partial fulfilment of the requirements for the degree of Master of Science in Biology.

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Name of Internal examiner	Signature	Date
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Name of Department Chairman	Signature	Date