

# Food and Feeding Habits of the Common Carp (*Cyprinus carpio* L. 1758) (Pisces: Cyprinidae) in Lake Koka, Ethiopia

Elias Dadebo<sup>1\*</sup>, Alamrew Eyayu<sup>2</sup>, Solomon Sorsa<sup>1</sup> and Girma Tilahun<sup>1</sup>

<sup>1</sup>Department of Biology, College of Natural and Computational Sciences, P. O. Box 5, Hawassa University, Hawassa, Ethiopia (\*edadebo@yahoo.com).

<sup>2</sup>Department of Biology, College of Natural and Computational Sciences, P. O. Box 445, Debre Berhan University, Debre Berhan, Ethiopia.

## ABSTRACT

Feeding habits of *Cyprinus carpio* was studied in Lake Koka, Ethiopia, in April and May (dry months) and July and August (wet months), 2011. The objective of the study was to identify the diet composition, seasonal variation in diet and ontogenetic dietary shift. Gut contents of 435 fish were analyzed using frequency of occurrence and volumetric analysis. In frequency of occurrence method the number of gut samples was expressed as a percentage of all non-empty stomachs examined while in volumetric method the volume of each food category was expressed as a percentage of the total volume of the gut contents. Detritus, insects and macrophytes were the dominant food categories occurring in 97.0%, 85.2% and 53.3% of the guts and comprising 39.8%, 36.4% and 12.4% of the total volume of food items, respectively. The remaining food categories were of low importance in the diet. The frequency of occurrence and volumetric contributions of the different food categories of *C. carpio* significantly varied (U-test,  $p < 0.05$ ) during the dry and wet seasons. During the dry season, insects and detritus were important food categories, occurring in 94.4% and 98.6% of the guts and comprising 42.3% and 36.1% of the total volume of food, respectively. During the wet season, detritus was the most important food category. It occurred in 93.9% of the guts and accounted for 48.8% of the total volume of food. Insects and macrophytes were also important during the wet season, occurring in 68.2% and 74.3% of the guts and comprising 23.6% and 22.6% of the total volume of food, respectively. The contributions of animal origin food categories were important in the diet of juveniles whereas, food of plant origin were more important in the diet of adults. However, there were no significant variations in the diet of individuals in the different size classes. Based on the results, it was concluded that *C. carpio* was omnivorous in its feeding habits in Lake Koka with considerable seasonal variation but insignificant onto genetic change in its diet.

**Keywords:** *Cyprinus carpio*, Lake Koka, Seasonal and Ontogenetic Variation in Diet, Ethiopia.

## 1. INTRODUCTION

The common carp *Cyprinus carpio* (L. 1758) is a freshwater fish widely distributed in eutrophic waters of Europe and Asia (Kottelat and Freyhof, 2007). The native distribution of *C. carpio* covers a large area from Eurasia eastward across Russia and China (Christopher, 2008) in still or slowly flowing waters, lakes, reservoirs and permanent wetlands, commonly with silt bottoms (Kottelat and Freyhof, 2007). *C. carpio* was one of the first species to be introduced into other countries from its native origin of Asia and Europe (Henning et al., 2008). The introduction of *C.*

*carpio* in African freshwater ecosystems began in South Africa in its largest impoundment of Lake Gariep (Henning et al., 2008). This species was also introduced to Ethiopia in Lake Koka by a Catholic priest Aba Samuel from Italy in the late 1960s. The species is an omnivorous bottom feeder fish. Since it disturbs the bottom sediment while feeding, it is known to increase water turbidity (Magalhaes, 1993; Ali et al., 2010; Mustafizur et al., 2010). In Lake Koka the species contributes about 16% of the total landings (LFDP, 1997).

Various investigators have studied the food and feeding habits of *C. carpio* in its area of native distribution (Hana and Manal, 1988; Magalhaes, 1993; Adamek and Sukop, 2003; Ali et al., 2010; Mustafizur et al., 2010). According to Mustafizur et al. (2010), the feeding condition of *C. carpio* showed differences based on its diet and seasonal feeding activities. This variation in the types of organisms consumed could be due to the fact that it changes its location in certain periods for feeding purposes (Ali et al., 2010). The presence of benthic organisms, detritus, and mud in its digestive tract throughout the year confirms that the species feeds at the bottom of the water body (Magalhaes, 1993; Ali et al., 2010; Mustafizur et al., 2010). Even though the fish is commercially important in Ethiopia, very little information is available on its biology and ecology (Fasil Degefu et al., 2012, Mathewos Hailu, 2013). Kassahun Assaminew (2005) studied distribution, abundance and feeding biology of *C. carpio* together with other commercially important fish species in Lake Koka. LFDP (1997) reported the types of food consumed by *C. carpio* in Lake Koka. Apart from this limited information on the population and diet of the fish in the lake, no published information is available on the feeding habits of the species in Ethiopia. Therefore, the present work was intended to study the feeding habits of *C. carpio* in Lake Koka, and this information is vital to produce baseline data for proper management and utilization of the fish in the future.

## **2. MATERIALS AND METHODS**

### **2.1. Description of the Study Area**

Lake Koka (Latitude 08°24'0"N and Longitude 39°35'0"E) is an artificial lake formed as a result of damming of the Awash River for the purpose of hydropower in the late 1960's. The surface area of the lake is 250km<sup>2</sup> with a maximum and mean depth of 14m and 9m, respectively (LFDP, 1997). The lake is located at an altitude of 1,590m above sea level and about 90km southeast of Addis Ababa, the nation's capital. The region around Lake Koka has a total average annual

rainfall of about 630mm and an average surface water temperature of 19°C (averaged for the period between 1998 and 2009) (Mesfin Mengesha, 2009).

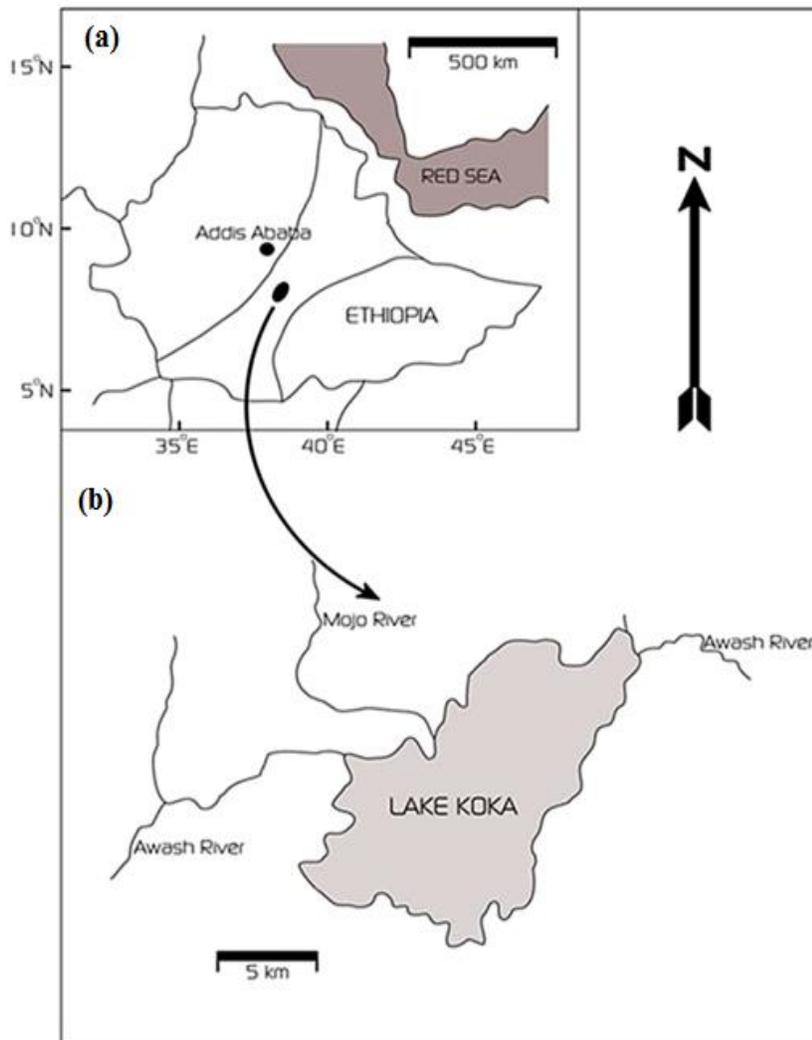


Figure 1. (a) Map of Ethiopia with the relative position of Lake Koka and (b) map of Lake Koka.

The water of the lake is turbid because of suspended inorganic materials and supersaturated with oxygen to a depth of about 8 m and displays pronounced conductivity stratification, probably due to the incomplete mixing of two inflows (Melaku Mesfin et al., 1988). The phytoplankton in the lake is dominated by blue green algae *Microcystis*. Other blue green algae commonly found in the lake include: *Planktolyngbya*, *Lyngbya*, *Chroococcus*, *Merismopedia* and *Coelosphaerium* (Melaku Mesfin et al., 1988). The zooplankton are of low diversity but abundant and include major groups such as rotifers, copepods and cladocerans (Melaku Mesfin et al., 1988). Large

populations of benthic invertebrates are also found in the lake (Melaku Mesfin et al., 1988). Large commercial farms are present downstream the lake irrigated by the regulated flow of the Awash River which drains through the east African rift valley starting from the central highlands of Ethiopia (Tenalem Ayenew, 2003). The Awash (major) and Modjo (minor) Rivers are the main effluents (Fig 1) and Awash River is the outlet of the dam.

In addition to its use for hydropower and irrigation, the lake supports an estimated fish yield of 625 tons per year (Sitotaw Ferede, 1983). The commercial fish landings are composed of four species: *C. carpio*, the Nile tilapia (*Oreochromis niloticus* L.1758), the African catfish (*Clarias garpienus* Burchell 1822) and the African big barb (*Labeobarbus intermedius* Rüppell 1836) (Mesfin Mengesha, 2009). *O. niloticus* is the dominant species constituting about 59% of the total landings in the lake (LFDP, 1997).

## **2.2. Fish Sampling and Measurements**

Two hundred and forty five and 142 individuals of *C. carpio* were caught in the dry (April and May) and wet (July and August) months of 2011, respectively. Furthermore 48 fingerlings were sampled during the dry months. The adult fish were purchased from the landings of the fishermen of Lake Koka. The commercial gillnets of the fishermen consist of different mesh sizes (80mm, 100mm, 120mm, 140mm and 160mm stretched mesh sizes). The fingerlings were caught in the shallow areas of the lake using a beach seine. Total length (TL) of the fish samples was measured to the nearest millimeter using a measuring board. Total weight (TW) was weighed using a digital balance (Scaltech, Germany) to the nearest 0.1g. The collected fish samples were dissected and the sexes were determined. The sexes and maturity stages were determined by visual examination of the gonads and using a five point maturity scale as of Holden and Raitt (1974). Then, the digestive tracts were opened and the gut contents were preserved in 5% formalin and brought to the laboratory of Biology Department of Hawassa University, Ethiopia.

## **2.4. Stomach Content Analysis**

Since, *C. carpio* has no distinct stomach, food contents of sampled fish were taken from the first quarter of the gut and preserved in 5% formalin solution and brought to 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 (LEICA MS5, magnification 40X) and a compound microscope (LEICA DME, magnification 400X). 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 following methods:

#### **2.4.1. 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).

#### **2.4.2. 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.

#### **2.5. Seasonal Variation and Ontogenetic Dietary Shifts**

The seasonal variations in the types of the food consumed by *C. carpio* were analyzed separately during the dry and wet months using frequency of occurrence and volumetric method of analysis. For ontogenetic dietary shifts the fish samples were divided into four classes (I- < 20cm TL, II- 20- 29.9cm TL, III- 30- 39.9cm TL and IV- > 40cm TL) and percentage mean volume of different food items was calculated as of Wallace (1981).

#### **2.6. Statistical analysis**

Chi-square test was used to compare frequency of occurrences of the different food categories during the dry and wet seasons (Sokal and Rohlf, 1995). Similarly, the non-parametric Mann-Whitney's U-test was used to compare the volume of the different food categories consumed during the dry and wet seasons since the data did not satisfy the assumption of equal variance to employ a parametric test.

Dietary overlap between fish of different size-classes was calculated using Schoener Diet Overlap Index (SDOI) (Schoener, 1970; Wallace, 1981):

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

Where  $\alpha$  is percentage overlap, SDOI, between length classes  $x$  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. Overlap in

the index is generally considered to be biologically significant when  $\alpha$  value exceeds 0.60 (Mathur, 1977).

### 3. RESULTS

#### 3.1. Diet Composition

A total of 435 non-empty fish samples were used to conduct the gut content analysis. The fish samples ranged in size from 2.6cm TL and 0.3g TW to 78.0cm TL and 5,200g TW. The food items included detritus, insects, macrophytes, phytoplankton, ostracods, zooplankton, and gastropods (Table 1). Detritus, insects and macrophytes were the dominant food items (39.9%, 36.4% and 12.4% by volume, respectively), while phytoplankton, ostracods, zooplankton and gastropods were of low importance (Table 1).

Table 1. Frequency of occurrence and volumetric contributions of different food items consumed by *C. carpio* (n=435) in Lake Koka.

Food items	Frequency of occurrence		Volumetric analysis	
	Number	Percent	Volume (ml)	Percent
<b>Detritus</b>	<b>422</b>	<b>97.0</b>	<b>477.4</b>	<b>39.8</b>
<b>Insects</b>	<b>372</b>	<b>85.5</b>	<b>440.1</b>	<b>36.4</b>
Diptera	417	95.9	319.3	26.7
Ephemeroptera	100	23.0	41.9	3.5
Hemiptera	90	20.7	31.9	2.7
Plecoptera	62	14.3	29.2	2.2
Coleoptera	32	7.4	2.9	1.3
<b>Macrophytes</b>	<b>232</b>	<b>53.3</b>	<b>147.7</b>	<b>12.4</b>
<b>Phytoplankton</b>	<b>74</b>	<b>40.0</b>	<b>49.9</b>	<b>4.4</b>
Blue green algae	124	28.5	20.2	1.8
Diatoms	137	31.5	17.9	1.5
Green algae	101	23.2	17.0	1.1
Euglenoids	3	0.7	0.1	0.01
<b>Ostracods</b>	<b>143</b>	<b>32.9</b>	<b>44.8</b>	<b>3.8</b>
<b>Zooplankton</b>	<b>135</b>	<b>31.0</b>	<b>23.6</b>	<b>2.2</b>
Copepods	114	26.2	15.7	1.3
Cladocerans	55	12.6	7.6	0.9
Rotifers	2	0.5	0.3	0.02
<b>Gastropods</b>	<b>38</b>	<b>8.7</b>	<b>11.3</b>	<b>1.0</b>

Detritus occurred in 97.0% of the guts and accounted for 39.8% of the total food volume (Table 1). Insects occurred in 85.2% of the guts and constituted 36.4% of the total food volume. Among

the insect groups, Diptera constituted the largest proportion of the diet of *C. carpio* (26.7% by volume) compared to other insect taxa (Table 1). Macrophytes occurred in 53.3% of the guts examined and accounted for 12.4% of the total volume of food categories (Table 1). The details of the contributions by other minor food items such as phytoplankton, zooplankton, ostracods and gastropods can be seen in table 1.

Table 2. Relative contributions of different food items in the diet of *C. carpio* during the dry (n= 293) and wet (n= 142) seasons in Lake Koka. Note that the volume of the major food categories in bold adds up to 100%.

Food items*	Frequency of occurrence (%)		Volumetric contribution (%)	
	Dry season	Wet season	Dry season	Wet season
<b>Detritus</b>	<b>98.6<sup>a</sup></b>	<b>93.9<sup>a</sup></b>	<b>36.1<sup>a</sup></b>	<b>48.8<sup>a</sup></b>
<b>Insects</b>	<b>94.4<sup>b</sup></b>	<b>68.2<sup>a</sup></b>	<b>42.3<sup>b</sup></b>	<b>23.6<sup>a</sup></b>
<i>Diptera</i>	88.2	62.9	30.9	16.0
<i>Ephemeroptera</i>	25.8	17.6	3.6	3.2
<i>Coleoptera</i>	13.9	18.9	0.2	3.3
<i>Plecoptera</i>	20.2	2.7	3.8	0.6
<i>Hemiptera</i>	28.6	5.4	3.8	0.5
<b>Macrophytes</b>	<b>42.5<sup>a</sup></b>	<b>74.3<sup>b</sup></b>	<b>8.3<sup>a</sup></b>	<b>22.6<sup>b</sup></b>
<b>Phytoplankton</b>	<b>53.7<sup>b</sup></b>	<b>13.5<sup>a</sup></b>	<b>5.6<sup>b</sup></b>	<b>0.6<sup>a</sup></b>
Diatoms	41.1	12.8	1.9	0.4
Blue green algae	41.5	3.4	2.3	0.1
Green algae	34.2	2.0	1.4	0.1
Euglenoids	0.4	1.4	0.01	0.02
<b>Ostracods</b>	<b>45.0<sup>b</sup></b>	<b>9.5<sup>a</sup></b>	<b>5.0<sup>a</sup></b>	<b>0.7<sup>a</sup></b>
<b>Zooplankton</b>	<b>33.5<sup>a</sup></b>	<b>26.4<sup>a</sup></b>	<b>2.2<sup>a</sup></b>	<b>1.6<sup>a</sup></b>
<i>Copepods</i>	28.6	21.6	1.5	0.9
<i>Cladocerans</i>	14.3	8.8	0.7	0.7
<i>Rotifers</i>	0.7	-	0.03	-
<b>Gastropods</b>	<b>5.2<sup>a</sup></b>	<b>15.5<sup>b</sup></b>	<b>0.5<sup>a</sup></b>	<b>2.1<sup>a</sup></b>

(Note: \*Values of respective food categories under the same category given different superscript letters are significantly different ( $\alpha < 0.05$ )).

### 3.2. Seasonal Variation in the Diet of *C. carpio*

The frequency of occurrence of the different food items consumed by *C. carpio* varied significantly ( $\chi^2$ -test,  $p < 0.05$ ) with season (Table 2). In the same manner, the volumetric contributions of the different food items varied significantly (U-test,  $p < 0.05$ ) with season. The contribution of insects was the highest during the dry months occurring in 94.4% of the guts and

comprising 42.3% volumetrically (Table 2). However, the contribution of insects declined during the wet months occurring in 68.2% of the guts and constituting 23.6% of the total volume of the food categories (Table 2). Except Coleoptera, all other insect groups were more important during the dry season than the wet season (Table 2). Among the insect groups, Diptera constituted the largest proportion (30.9% by volume during the dry months and 16.0% by volume during the wet months) compared to the other insect taxa (Table 2).

Detritus was the most important food item both during the wet season (occurring in 93.9% of the guts and accounting for 48.8% volumetrically) and during the dry season (occurring in 98.6% of the guts and accounting for 36.1% of the total volume of food items)(Table 2). Macrophytes were relatively less important during the dry months occurring in 42.5% of the guts examined and constituting 8.3% of the total volume of food items (Table 2). However, the contribution of macrophytes increased during the wet months occurring in 74.3% of the guts and comprising 22.6% of the total volume of food items (Table 2). The seasonal variations of the other food categories such as ostracods, phytoplankton, zooplankton and gastropods can be seen in table 2.

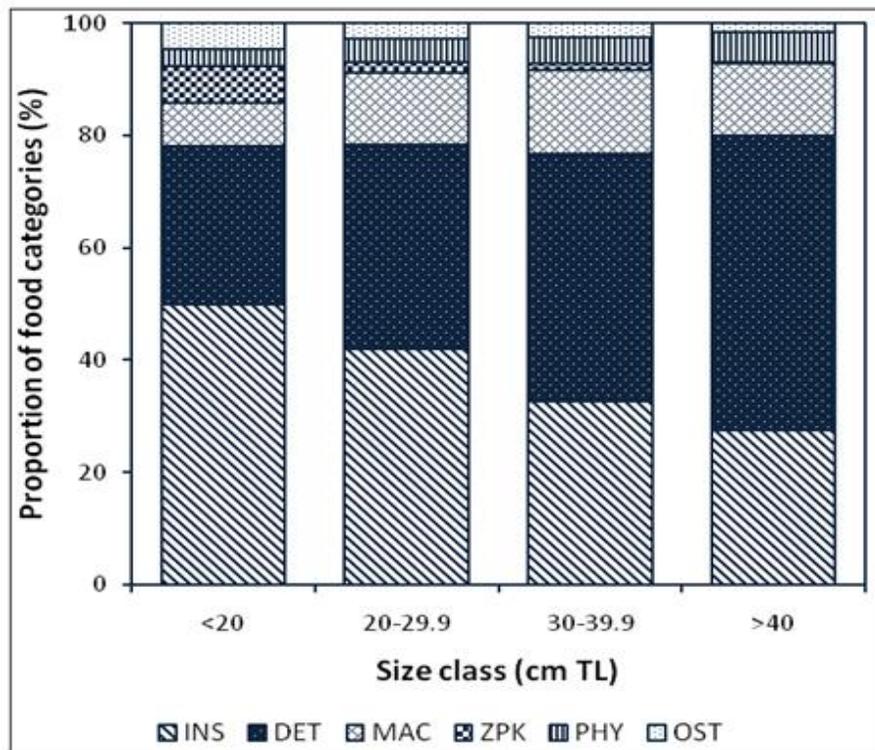


Figure 2. The percentage mean volumetric contributions of prey organisms consumed by (n=435) *C. carpio* at different size classes from Lake Koka (INS=insects, DET=detritus, MAC=macrophytes, ZPK=zooplankton, PHY=phytoplankton and OST=ostracods)

### 3.3. Ontogenetic Dietary Shifts

SDOI revealed no significant variation in the diet of the different size-classes (I & II- 88.1%, I & III- 77.9%, I & IV- 71.0%, II & III- 89.9%, II & IV- 83.0% and III & IV- 91.3%) (Fig 2). In the smallest size class (<20cm TL) percent mean volume of the diet was dominated by insects (49.9%) and detritus (28.3%). The contributions of other food items such as macrophytes (7.7%) zooplankton (6.4%), ostracods (4.7%) and phytoplankton (3.0%) were relatively low. In the size class 20cm TL-29.9cm TL the contribution of insects (42.0%) declined slightly, while the contributions of detritus (36.3%) and macrophytes (12.9%) increased slightly (Fig 2). The contribution of other food items was relatively low. In the size class 30-39.9cm TL detritus (44.2%), insects (32.6%), and macrophytes (14.8%) were the most important food items (Fig2). Other food items were of lower importance. In the largest size class (>40cm TL), detritus (52.4%), insects (27.5%) and macrophytes (13%) were dominant food items while the contribution of other food items was insignificant (Fig 2). Generally, the contribution of foods of animal origin such as insects, zooplankton and ostracods declined with size of fish while the contributions of food of plant origin, namely detritus, macrophytes and phytoplankton increased with size of fish.

## 4. DISCUSSION

A study on stomach content analysis is important in providing useful taxonomic information of fish diets, role of fish in their environment and to draw stock assessment models and provide knowledge of maintaining (replenishing) more exploited species in a sense of mono-poly culture systems (Vander et al., 1997; Sivadas and Bhaskaran, 2009). Therefore, the examination of the feeding biology of *C. carpio* (one of the commercially important fish species in Ethiopia) is very important for proper utilization of the stock in Lake Koka. *C. carpio* was found to be omnivorous in its diet elsewhere for which data are available (Lammens and Hoogenboezem, 1991; Maitland, 1992; Magalhaes, 1993; Rahman et al., 2006; Saikia and Das, 2008). In line with these reports, the results of the present study also, confirmed that *C. carpio* is omnivorous in its diet in Lake Koka, and consumed a wide range of food items including detritus, insects, macrophytes, phytoplankton, ostracods, zooplankton, and gastropods. Furthermore, Saikia and Das (2008) reported that the gut contents of *C. carpio* in Indian lakes largely contain algae, zooplankton (Cladocera, Copepoda, Rotifera), benthic organisms (Diptera mainly Chironomidae larvae), plant

residues and mud. Magalhaes (1993) found zooplankton, phytoplankton, detritus and mud in the digestive tract of *C. carpio* in the Iberian stream. The same author also reported that the most common zooplanktonic organisms observed in the gut contents of the fish were Cladocera (35.7%), Copepoda (23.8%), Rotifera (4.3%) and non zooplanktonic ostracods (3.8%) by volume. According to Magalhaes (1993), the most frequently observed benthic organisms in the gut were Diptera and Oligochaeta.

Ali et al. (2010) reported that zooplankton, phytoplankton and benthic organisms were apparent in the gut of *C. carpio* from Hirfanli Dam, Turkey. According to the same authors, out of the animal based organisms that constituted 33.8% of the total volume food consumed 56.7% was due to zooplankton while 43.3% was composed of benthic organisms. Likewise, in the present study, the contribution of animal based food categories was largely dominated by benthic organisms (36.6% of the total volume) but unlike the report of Ali et al. (2010) zooplankton contributed only 1.9% of the total volume of food items in this study. The differences in the volumetric contribution of zooplankton may be due to the difference in sampling period and the productivity of the lakes that create conducive environmental condition for the seasonal reproductive cycle of the groups.

There are some differences between the present study and previous studies as related to the feeding habits of *C. carpio*. For example, Philip (2006) reported that, in addition to other food categories, *C. carpio* consumed large quantities of mollusks and annelids. The same author also stated that when animal based food is limited *C. carpio* was forced to eat the seeds of water grown plants such as rice and the seeds of wheat, oat and maize. However, in the present study mollusks, annelids, and seeds of water plants were not encountered. This could be due to the selective feeding habit of *C. carpio* on easily available benthic organisms and zooplankton rather than seeds of aquatic plants, mollusks and annelids. Hana and Manal (1988) found fish eggs in the guts of *C. carpio*. Eggs of other fishes were not identified in the diet of *C. carpio* from Lake Koka and this may be due to the unavailability of fish eggs in the open water systems where adult *C. carpio* mostly inhabit. Saikia and Das (2008) reported that although plant based feeding rate is high in Apatani Plateau reservoir they observed 1-5 small fish in the digestive tract of 17 *C. carpio* and the Chironomidae larvae were seldom seen. However, in the present study, fish prey was not observed in the gut contents of *C. carpio*. The presence of a more competitive piscivorous fish such as *C. garpienus* that normally feeds on *O. niloticus* and *L. intermedius* in

the lake, unavailability of smaller prey fish species in the open water systems, the cost of energy in capturing the prey and the issues of preference could all be possible reasons for the absence of prey fish in the gut of *C. carpio*.

Detritus was present almost in all guts during the present study. Digestibility and nutritive quality of detritus increase when the fish consumes large quantities of this food item together with the associated heterotrophic and autotrophic microorganisms (Bowen, 1979). Bowen (1979) also pointed out that *C. carpio* does not have a true detritus recycling stomach (lacking in gastric glands) and this would suggest that this food item could be consumed while the fish was foraging on zoo-benthos.

According to Saikia and Das (2008), the gut content of *C. carpio* composed large quantities of Diptera (*Chironomus*) and small amounts of Cladocera (*Ceriodaphnia*), Copepod (*Diaptomus*), Oligochaeta, Rotifera and Ostracoda. Ali et al. (2010) reported that Oligochaeta were immediately digested by *C. carpio* because they were soft bodied animals. That is why it was rarely observed in the digestive tract of the species. In the present work and in Kassahun Assaminew (2005) there were no Oligochaeta in the gut contents of *C. carpio* in Lake Koka. Rather detritus, insects (mostly Diptera) and macrophytes constituted the bulk of the diet of *C. carpio* in Lake Koka.

Maitland (1992) stated that *C. carpio* feeds on detritus, plants and benthic organisms. The species also feeds on aquatic plants and insects from the surface (Njiru et al., 2008). Kassahun Assaminew (2005) also reported that phytoplankton, zooplankton, insects, water bugs, nematodes, fish eggs, fish scales, detritus, macrophytes and mud were found in the gut of *C. carpio* from Lake Koka. The same author also stated that macrophytes, insects and groups of zooplankton genera dominated the gut contents of *C. carpio*. The present study is in agreement with the report of Kassahun Assaminew (2005) that stated the bulk of the food categories of *C. carpio* as detritus, insects and macrophytes.

In the present study, the diet composition of *C. carpio* showed some seasonal variations both in frequency of occurrence and volumetric contributions. The fact that the diet of *C. carpio* exhibited seasonal variations may be attributed to the changes of its location in certain periods for feeding purposes (Ali et al., 2010).

The reason for the higher proportion of insects, phytoplankton and ostracods in the diet of *C. carpio* in this study could be the favorable environmental condition in tropics that provides a

suitable reproductive cycle in the dry months for the above food items as a result of the increase in temperature that can lead to the abundance of the food items. On the other hand, the higher contribution of detritus and macrophytes during the wet months could be due to the fact that large quantities of plant materials and debris are carried into the lake by runoff during the rainy season.

Ontogenetic dietary shift was slight during the present study. The most notable change observed was that smaller sized fish (<20cm TL) predominantly fed on foods of animal origin such as insects, zooplankton and ostracods whereas adults mainly fed on detritus, macrophytes and phytoplankton. 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).

## 5. CONCLUSION

The results of the present study have clearly shown that the most important food categories of *C. carpio* in Lake Koka were detritus, insects and macrophytes. Foods of minor importance were phytoplankton, ostracods, zooplankton and gastropods. The gut content analysis suggested that *C. carpio* is an omnivorous fish in its feeding habits. The fish also showed seasonal change and slight ontogenetic dietary shift in its feeding habits. Among the major food items detritus was largely consumed during the wet months whereas insects accounted the largest food volume in the dry months. Volumetric contribution of macrophytes was high during the wet months. Phytoplankton and ostracods were more important during the dry months but gastropods were more important during the wet months. The slight ontogenetic dietary change observed in this study was that the relative importance of insects, zooplankton and ostracods was high in the diet

of juveniles (<20 cm TL) while adults mainly consumed macrophytes, detritus and phytoplankton. Generally, the consumption of animal origin food decreased with size of fish whereas, the consumption of plant origin food increased with fish size.

## 5. ACKNOWLEDGMENTS

We thank fishermen Kecha Fiche and Abbu Geleta for their assistance during the field work. Yirgashewa Bekele is acknowledged for her assistance during gut content analysis in the laboratory. Dr. Andargachew Gedebo, coordinator of NORAD Project is acknowledged for providing a vehicle for sample collection. Department of Biology of Hawassa University provided laboratory space and fishing gears for sample collection. Financial support for the second author was provided by Ministry of Education, Addis Ababa, Ethiopia.

## 6. REFERENCE

- Adamek, Z & Sukop, I. 2003. The role of supplementary feeding in food competition between common carp (*Cyprinus carpio*) and perch (*Perca fluviatilis*) in a pond polyculture. *Journal of Zoology*, **43**: 175-184.
- Ali, G., Mehmet, Y., Ayse, K & Semra, B. 2010. Feeding properties of common carp (*Cyprinus carpio* L. 1758) living in Hirfanli Dam Lake, Ankara, Turkey. *Aquatic Ecology*, **18(2)**: 545-556.
- Bowen, S.H. 1979. A nutritional constraint in detritivory by fishes: the stunted population of *Sarotherodon mossambicus* in Lake Sibaya, South Africa. *Ecological Monographs*, **49**: 17-31.
- Bowen, S.H. 1983. Quantitative description of the diet of fish. In: L.A. Nielsen and D.L. Johnson (eds.), *Fisheries Techniques*, Bethesda, Maryland, pp 325-336.
- Brett, J.M. 2002. Tracking trophic interactions in cold water reservoirs using naturally occurring stable isotopes. *Ichthyologia*, **23(4)**:211-227.
- Christopher, P.R. 2008. Seasonal distribution, aggregation and habitat selection of common carp in clear lake, Iowa. *Transactions of American Fisheries Society*, **137**:1050-1062.
- Edmondson, W.T. 1959. *Fresh-water biology*. 2<sup>nd</sup> ed. John Wiley & Sons Inc., NY, 1248p.
- Fasil Degefu, Gashaw Tesfaye & Fikadu Tefera. 2012. Study on the adaptability status and reproductive success of *Oreochromis niloticus* L. (Pisces: Cichlidae) and carp (*Cyprinus*

- carpio* L. 1758) in a tropic reservoir (Fincha, Ethiopia). *International Journal of Aquaculture*, **2(10)**: 67-71.
- Hana, H.M & Manal, M.A. 1988. Limnological investigation on the Al-Iatifiyah common carp (*Cyprinus carpio*) pond (Baghdad-Iraq) and food and feeding habits of *Cyprinus carpio* L. 1758. *Environmental Science and Health*, **23(6)**: 513-524.
- Henning, W., Wely, O., Booth, J & Ellender, B. 2008. Understanding the role of carp in South Africa's largest impoundment, Rhodes. *Ichthyologia*, **24**: 117-128.
- Holden, M & Raitt, D. 1974. Manual of fisheries science part 2: method of resource investigation and their application. *FAO Fisheries Technical Paper Review*, **115**: 1-24.
- Hyslop, E.J. 1980. Stomach content analysis: a review of methods and their application. *Journal of Fish Biology*, **17**: 411-429.
- Kassahun Assaminew. 2005. Distribution, abundance and feeding biology of the fish species in Koka reservoir and the associated Awash River floodplain, Ethiopia, M.Sc thesis. UNESCO-IHE Institute for Water Education, Delft, Amsterdam.
- Kottelat, M & Freyhof, J. 2007. Handbook of European freshwater fishes. Cornol, Switzerland.
- Lammens, E.N.R & Hoogenboezem, W. 1991. Diets and feeding behavior. In: I.J. Winfield and J.S. Nelson (eds.), *Cyprinid Fishes: Systematics, Biology and Exploitation*. Chapman and Hall, London, pp 353-376.
- LFDP. 1997. Lake Management Plans. Phase-II, Working paper 23, MOA, 27p.
- Magalhaes, M.F. 1993. Feeding of an Iberian stream *Cyprinid* assemblage: seasonality of resources in a highly variable environment. *Oecologia*, **96**: 253-260.
- Maitland, H. 1992. A comparative study of the feeding mechanisms of some African Cyprinidae (Pisces: Cypriniformes). *Bijdragen Journal of Ecology*, **33**: 12-35.
- Mathewos Hailu. 2013. Reproductive aspects of common carp (*Cyprinus carpio* L. 1758) in a tropical reservoir (Amerti: Ethiopia). *Journal of Ecology and the Natural Environment*, **5(9)**: 260- 264.
- Mathur, D. 1977. Food habits and competitive relationships of Bandfin shiner in Halawakee Creek, Alabama. *American Midland Naturalist*, **97**: 89-100.
- McCormick, M. 1997. Ontogeny of diet shifts by a micro-carnivorous fish, *Cheilodactylus spectabilis*: relationship between feeding mechanics, microhabitat selection and growth. *Marine Biology*, **132**: 9-20.

- Melaku Mesfin., Tudorancea, C & Baxter, R.M. 1988. Some limnological observations on two Ethiopian hydroelectric reservoirs: Koka (Shewa Administrative District) and Fincha (Wollega Administrative District). *Hydrobiologia*, **157**: 47-55.
- Mesfin Mengesha. 2009. Heavy metal pollution in the rift valley Lakes of Hawassa and Koka, Ethiopia. MSc thesis, Bremen University of Aquatic Tropical Ecology, Bremen, 78p.
- Mustafizur, R., Shusaku, K., Balcombe, S & Abdul, W. 2010. Common carp (*Cyprinus carpio* L. 1758) alters its feeding niche in response to changing food resources: direct observations in simulated ponds. *Journal of Biological Sciences*, **22**: 405-431.
- Njiru, M., Ojuok, E., Ngugi, C., Morara, G & Mugo, J. 2008. Does seasonal closure have an effect on fishery? In: M. Sengupta & R. Dalwani (eds.), The case of common carp, *Cyprinus carpio* L. 1758 in Lake Naivasha, Kenya. Kenyan Marine Fisheries Research Institute, Nairobi, pp 137-140.
- Pennak, R.W. 1978. Fresh-water invertebrates of the United States. 2<sup>nd</sup> ed. John Wiley & Sons, New York, 803p.
- Philip, B. 2006. Gustatory and olfactory feeding responses in Japanese Koi carp (*Cyprinus carpio*). PhD thesis, University of Stellanbosch, Germany.
- Rahman, M.M., Nagelkerke, L.A., Wahab, M.A., Milstein, A & Verreth, J. 2006. Growth, production and food preference of rohu *Labeo rohita* (H.) in monoculture and polyculture with common carp *Cyprinus carpio* (L. 1758) under-fed and non-fed ponds. *Aquaculture*, **257**: 359-372.
- Saikia, S.K & Das, D.N. 2008. Feeding ecology of common carp (*Cyprinus carpio* L. 1758) in a rice–fish culture system of the Apatani Plateau (Arunachal Pradesh, India). *Aquatic Ecology*, **23(6)**: 513-524.
- Sitotaw Ferede. 1983. Review of fishery development potential in Ethiopia. *Trade Focus*, **2(4)**: 29-36.
- Sivadas, M & Bhaskaran, M. 2009. Stomach content analysis of the Indian mackerel *Rastrelliger kanagartha* (Cuvier) from Calicut, Kerala, India. *Indian Journal of Fisheries*, **56(2)**:143-146.
- Schoener, T.W. 1970. Non-synchronous spatial overlap of lizards in patchy habitats. *Ecology*, **51**: 408-418.

- Sokal, R.R & Rohlf, F.J. 1995. *Biometry: The principles and practices of statistics in biological research*. 3<sup>rd</sup> edition, Freeman and Company, New York, 859p.
- Tenalem Ayenew. 2003. Some improper water resources utilization practices and environmental problems in the Ethiopian Rift. *African Water Journal*, **1(1)**: 80-105.
- Vander, M.J., Cabana, G & Rasmussen, J.B. 1997. Comparing the trophic position of littoral fish estimated using stable nitrogen isotopes ( $d^{15}N$ ) and dietary data. *Canadian Journal of Fisheries and Aquatic Sciences*, **54**: 1142-1158.
- Wallace, R.K. 1981. An assessment of diet-overlap indexes. *Transactions of American Fisheries Society*, **110**: 72-76.
- Zerihun Desta. 2007. Food web structure and mercury transfer pattern in fish community of Lake Hawassa, Ethiopia. PhD thesis, Norwegian University of Life Science, Ås, 196p.