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Food and feeding habits of juvenile and adult Nile tilapia, *Oreochromis niloticus* (L.)(Pisces: Cichlidae) in Lake Ziway, Ethiopia

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ABSTRACT: *Oreochromis niloticus* (Nile tilapia) is an important fish in the ecology of tropical and subtropical aquatic ecosystems. The fish is commercially the most important fish species in Ethiopian water bodies including Lake Ziway. In recent years, the fish community structure and ecosystem dynamics of Lake Ziway have changed, but no studies have been carried out to assess whether the fishes have altered their diets in the lake. This study investigated the food and feeding habits of Nile tilapia from April to August 2017 in Lake Ziway, Ethiopia. A total of 365 Nile tilapia specimens (170 adults and 195 juveniles) were collected ranging from 2.5 to 30 cm TL and 0.5 to 459.7 g TW. Adult fish samples were obtained from the catches of fishermen, while the juveniles were collected from three sampling sites which were located in the shallow part of the lake. Guts of 165 (85%) juveniles and 115 (73.5%) adults that contained food items in their stomachs were analyzed using the frequency of occurrence and volumetric methods. Volumetrically, the major diets of juveniles were zooplankton (33.79%), phytoplankton (25.44%), insect (18.69%), and detritus (14.02%) while the diet of adults were mainly macrophytes (36.2%) followed by phytoplankton (34.36%) and detritus (18.41%). Nile tilapia, which was a phytoplanktivorous fish, has now consumed predominately macrophytes even though phytoplankton is the second dominant food item. Juvenile Nile tilapia depends on zooplankton and insect larvae. The study demonstrates that juveniles mainly fed on animal-based food items whereas the adult fed primarily on macrophytes followed by phytoplankton food items. We have discussed the possible causes of macrophytes as a major diet of adult Nile tilapia. This study contributes to the sustainable utilization of Nile tilapia and for the development of the aquaculture industry.

Keywords/phrases: Diet composition, dietary shift, Nile tilapia, temporal variation

INTRODUCTION

Nile tilapia is native to Central and North Africa and has been introduced to many parts of Asia, Europe, North America, and South America due to its suitability to aquaculture (Alemayehu Negassa and Prabu, 2008). It is also an important fish in the ecology of tropical and subtropical aquatic ecosystems (Offem and Omoniyi, 2007). The fish 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. In Ethiopia, Nile tilapia is widely distributed in lakes, rivers, reservoirs, and swamps, and contributes about 60% of the total landings of fish (LFDP, 1997; Demeke Admassu, 1998), but currently reduced to 49% (Gashaw Tesfaye and Wolff, 2014), and in Lake Ziway particularly its contribution has declined from 89.3% in 1994 to 27% in 2014 (Lemma Abera, 2016). As a result of the declining contribution of Nile tilapia in Lake Ziway, around 70% of the annual catch of the lake is covered by exotic fish species (*Cyprinus carpio*, *Carassius carassius* and *Clarias gariepinus*) (Lemma Abera, 2016).

The dramatic decline of Nile tilapia in the lake could be related to food availability, overfishing and selectivity for fishing in the lake. Among these, food availability could be the main reason for the decline of Nile tilapia stock in Lake Ziway. Because, Lake Ziway is located in the vicinity of a growing town, where human population pressure has been increasing; agriculture and floriculture are expanding in the drainage basin. Accordingly, land degradation, soil erosion, and nutrient runoff have increased. As a result, the turbidity of the lake is very high, and primary productivity is light rather than nutrient-limited (Girma Tilahun, 2006; Lemma Abera, 2016). Hence, phytoplankton biomass is declining,

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which is a diet of Nile tilapia. It has also been reported that the presence of a high load of suspended sediments had made it difficult for the filter-feeding behavior of tilapia (Tadesse Fetahi *et al*., 2017).

Studies in Ethiopian water bodies reported that adult Nile tilapia feeds primarily on phytoplankton (particularly diatom) whereas juveniles are generally omnivore feeding on zooplankton and insect larvae (Todurancea *et al*., 1988; Zenebe Tadesse, 1988; Witte and Winter, 1995; Yirgaw Teferi *et al*., 2000; Alemayehu Negassa and Prabu, 2008; Flipos Engdaw *et al*., 2011; Workye Worie and Abebe Getahun, 2015). However, Tadesse Fetahi *et al*. (2018) have recently reported that 64% of the Nile tilapia diet originated from macrophytes in Lake Ziway using stable isotope analysis, indicating the absence of consensus on the food and feeding habits of Nile tilapia. The stable isotopes studies should be supported by the well-established traditional gut content method. Furthermore, the study conducted by the latter authors did not include juvenile Nile tilapia in their study. Therefore, updated information on the feeding habits of juvenile and adult Nile tilapia is currently mandatory to clarify these controversies as the fish is the most commercially important and preferred fish species in Ethiopia. To this end, the study aimed to determine whether Nile tilapia has changed its feeding habits with ecosystem and fish community structure changes in the lake. The study also assessed temporal variation in the diet of Nile tilapia in Lake Ziway. The information would be useful to create a trophic model that can be used in fisheries management and designing conservation strategies for sustainable utilization of the fishery resources of the lake. The study also provides data for the commercial Nile tilapia feed formulation.

MATERIALS AND METHODS

Study area

Lake Ziway (70 52′ to 80 8′ N latitude and 70 52′ to 380 56′ E longitude) is one of the freshwater Rift Valley Lakes of Ethiopia (Makin *et al*., 1975) and is situated at an altitude of 1636 meters above sea level with a surface area of 434 km^2 (Wood and Talling, 1988). It is found at about 160 km south of Addis Ababa. Two main rivers, Meki from the north-west and Katar from the east are flowing into the lake and it has an outflow through Bulbula River, draining into Lake Abijata (Fig.1). The lake supports seven indigenous and six introduced fish species (Lemma Abera, 2016) of these the native *Oreochromis niloticus* and the exotic *Cyprinus carpio, Carassius carassius,* and *Clarias gariepinus* were the most important commercial fish species in the lake.

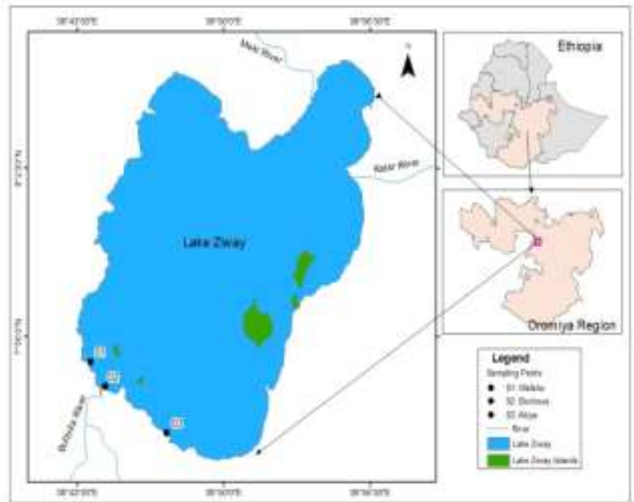

Figure 1. Map of Ethiopia and Lake Ziway with sampling sites.

Field procedures

Adult fish samples were obtained from fishermen. The commercial gillnets of the fishermen consist of different mesh sizes (6cm, 8cm, 10cm and 12cm stretched mesh sizes). Fishermen set Gill nets overnight and collected them on the following day morning. In order to obtain juveniles, a beach seine (3 cm mesh size) was used. The sampling sites are also located in the littoral zone of the lake, site 1 (Wafeko) and site 2 (Bochessa) at the southwestern end and site 3 (Abiye) at the southern end (Fig. 1). Fish samples were identified using keys developed by Golubtsov *et al*. (1995) and Redeat Habtesilassie (2012). Total length (TL) and total weight (TW) of all specimens were measured using a measuring board and a sensitive balance to the nearest value of 0.01 cm and 0.01g, respectively. Each fish was dissected and the maturity stage of each sample was determined by visual examination of gonads using 5 points maturity scale (Holden and Raitt, 1974). Each fish was dissected and stomach containing food were transferred to a labeled plastic bag containing 4% formaldehyde solution and then brought to the fishery laboratory of Addis Ababa University for furtheranalysis.

Lab analysis

In the laboratory, the content of each stomach of Nile tilapia was transferred into a petri-dish to identify food items either visually and/or microscopically. Smaller food items were examined under a dissecting microscope (LEICAMS5, LEICADME, magnification 40X) and identified to the lowest possible taxa using descriptions and illustrations in the literature (Edmondson, 1959; Whitford and Schumacher, 1973; Pennak, 1978; Komarek, 1989; Fernando, 2002). Then, the relative importance of each food item to the diet of the fish was estimated using the frequency of occurrence and volumetric methods.

Frequency of Occurrence

Stomach samples contain one or more of a given food item was expressed as a percentage of all non-empty stomachs examined. The proportion of the population that feeds on a particular food item was estimated and the frequency of occurrence was calculated (Hyslop, 1980; Bowen, 1983):

$$\frac{Thenumberofstomachsinwhichagivenfooditemisfound}{Numberofstomachsexamined} * 100$$

Volumetric Analysis

Food items that were found in the stomachs were sorted into different taxonomic categories. The water displaced by a group of items in each category was measured in a partially filled graduate cylinder and expressed as a percentage of the total volume of the stomach contents (Bowen, 1983).

$$\frac{Volumeofonefooditemfoundinallspecimens}{Thevolumeofallfooditemsinallspecimens} * 100$$

Temporal variation in feeding habit of juvenile and adult Nile tilapia

The monthly difference in the feeding habit of juvenile and adult Nile tilapia was studied by plotting the relative importance (percentage of frequency of occurrence and volume) of major food items against sampling months (from April to August).

Data analysis

Frequency of occurrence and volume of the food items were used to determine the percent contribution of the food items in the diet of both juvenile and adult Nile tilapia. Sigma Plot Version 10 was used for Graphical representation.

RESULTS

Diet composition of juvenile and adult Nile tilapia

The size of the juvenile and adult stage of Nile tilapia was determined depending on their gonad development and size in the present study. Fishes (≤10cm TL) had a thread like (very thin) and flesh-colored gonads. Such features characterize immature gonad (Babiker and Ibrahim, 1979). Therefore, juvenile fishes in the present study ranged from 2.5-10 cm TL, whereas the adult Nile tilapia include all fish whose size is >10 cm.

Visual and microscopic examination of gut contents of juvenile and adult Nile tilapia showed diverse items of plant-based food items (phytoplankton and macrophyte) and animal-based food items (zooplankton, insects, nematodes, and fish scale) and detritus. Among phytoplankton blue-green algae, green algae, diatom, and euglena were the major groups that are found in both juvenile and adult Nile tilapia. Some species like *Anabaenopsis sp*. from blue-green algae, *Coelastrum sp*. from green algae, and *Nitzschia sp*. from diatom groups were found in guts of adult Nile tilapia but not in the gut of juveniles. Zooplankton like Rotifer, Copepods, ostracods, and Cladocerans groups was also found in guts of juveniles and adult Nile tilapia. Among these, some species like *Keratella sp*. from rotifer, *Ceriodaphnia cornuta* and *Alona sp*. from Cladocerans and ostracods, and similarly, some insect larvae (Plecoptera and Hemiptera) were found in the guts of juvenile Nile tilapia but not found in the guts of adult Nile tilapia.

The relative contribution of food items in the diet of juvenile and adult Nile tilapia

The frequency and volumetric contribution of different food items in juveniles and adults of Nile tilapia in Lake Ziway are given in Table 1. In juveniles of < 10 cm TL, the major food items in terms of frequency of occurrence were phytoplankton that constituted the largest component of the diet occurring in 85.29% followed by zooplankton (83.53%) and detritus (72.65%). Insects contributed moderately and occurred in 66.80% of the stomachs examined. Volumetrically, the major portion was zooplankton (33.79%) followed by phytoplankton (25.44%), insect (18.69%), and detritus (14.02%) (Table 1). Other than the four major food items, macrophytes, nematodes, ostracods, and unidentified animals made up a relatively lower portion of the diet of juvenile Nile tilapia. In adults (11-30 cm TL), phytoplankton constituted the largest component of the diet occurring in 89% followed by detritus (82%) and macrophytes (79%). Volumetrically, macrophytes were dominant making up 36.2% followed by phytoplankton (34.36%) and detritus (18.55%) (Table 1). Accordingly, macrophytes, phytoplankton, and detritus were the most important food items of adult Nile tilapia in Lake Ziway. On the other hand, food items such as nematodes, ostracods, and unidentified animals made up a minor portion of the diet of adult and juvenile Nile tilapia, with a relatively higher portion in juvenile Nile tilapia (Table 1).

Table 1. Frequency of occurrence and volumetric contributions of different food items consumed by Nile tilapia (n=365) from Lake Ziway.

Food items	Juvenile		Adult	
	Frequency of occurrence (%)	Volumetric contribution (%)	Frequency of occurrence (%)	Volumetric contribution (%)
Phytoplankton	**85.29**	**25.44**	**89**	**34.36**
Blue green algae	55.10	5.79	81	13.76
Green algae	48.35	3.45	62	9.85
Diatoms	72.75	15.39	75	10.01
Euglena	4.80	0.81	7	0.74
Zooplankton	**85.58**	**35.58**	**58**	**6.52**
Rotifers	60.78	3.28	45	1.42
Copepodes	79.41	22.29	42	3.24
Cladocerans	54.90	8.22	31	1.86
Ostracods	9.80	1.79	-	-
Insect	**66.8**	**18.69**	**24**	**2.28**
Diptera	61.67	12. 68	22	1.63
Ephemeroptera	34.91	1.68	10	0.28
Hemiptera	20.59	1.08	-	-
Plecoptera	16.67	1.09	-	-
Coleoptera	38.63	2.24	13	0.37
Nematodes	**19.61**	**3.64**	**16**	**1.32**
unidentified animal fragments	**11.76**	**1.57**	**7**	**0.77**
Macrophytes	**32.35**	**1.06**	**79**	**36.20**
Detritus	**72.65**	**14.02**	**82**	**18.55**

Temporal variation in the diet composition of Nile tilapia

The result clearly shows a temporal variation in the diet of juvenile and adult Nile tilapia. The contribution of phytoplankton was high from April to May occurring in 91.67% to 92.86% of the total stomach and constituted 49% to 51% of the total volume of food items and low from June to August occurring from 85.71% to 54.28% and constituting 32.51% to 12.22% of the total volume of food items (Fig. 2). Conversely, the volumetric contribution of detritus was high in August (30%) and low in May (13 %) (Fig. 2). The contribution of macrophytes was low in May occurring in 61.16% of the total stomach and constituting 23.4% of the total volume of the stomach and high in August occurring in 89% of the total stomachs and constituting 52.81% of the total volume of the stomachs (Fig. 2). Similar to adult Nile tilapia, juvenile Nile tilapia mainly feed on phytoplankton from April to May occurring from 84.57% to 88% of the stomach and comprising 35.72% to 37.04% of the total volume of food items, while decreased from June to August occurring from 63.16% to 41% and comprising 23.94% to 11.97% of the total volume of food items, respectively (Fig. 2). The contribution of zooplankton was comparable among months and their volumetric contribution ranged from 33% in May to 38.43% in July (Fig. 2). Similarly, the contribution of insect showed little variation among months in which their volumetric contribution ranged from 16.96% in August to 20.27% in June.

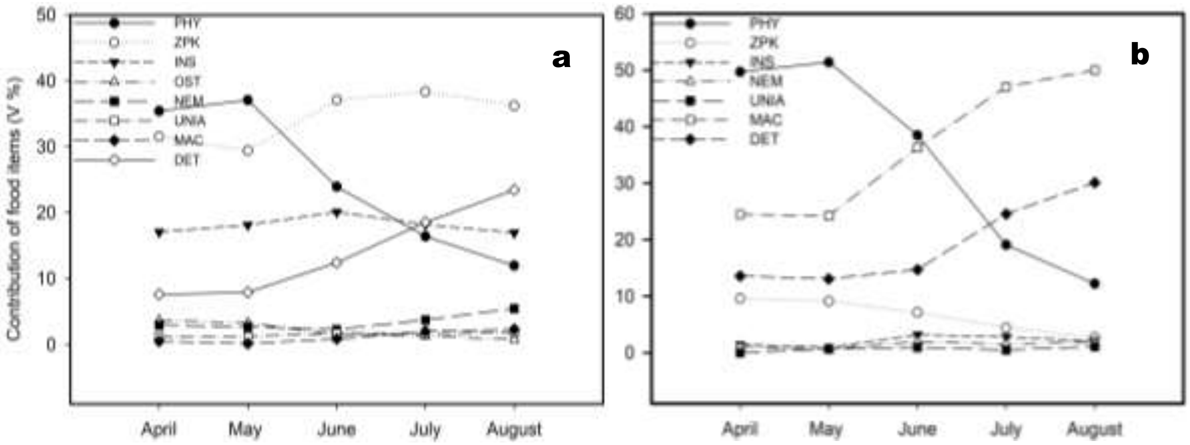

Figure 2. Monthly variation in the diet of Nile tilapia from Lake Ziway from April-August 2017 (a) Juvenile Nile tilapia and (b) Adult Nile tilapia. Abbreviations: PHY=phytoplankton, ZPK=zooplankton, INS=insects, OST=ostracoda, NEM=nematode, UNIA= unidentified animal, MAC=macrophytes and DET=detitus.

DISCUSSION

Feeding habit of juvenile and adult Nile tilapia

Nile tilapia fed on phytoplankton, macrophytes, detritus, zooplankton, insects, and nematodes. Among these food items, macrophytes followed by phytoplankton and detritus were the dominant diets of adult Nile tilapia in Lake Ziway. Earlier studies carried out in some rift valley lakes (e.g. Lake Ziway by Zenebe Tadesse, 1988; Getachew Teferra and Fernando, 1989; Alemayehu Negassa and Prabu, 2008; Koka Reservoir by Flipos Engdaw *et al*., 2013) have indicated that phytoplankton was the most consumed food item by adult Nile tilapia. The relative dominance of macrophytes in the present diet of Nile tilapia could be due to declining phytoplankton biomass in Lake Ziway (Girma Tilahun, 2006) and the presence of a high load of suspended sediments that is difficult for filter-feeding behavior of the tilapia (Tadesse Fetahi *et al*., 2017). The other most probable reason is that most sampling months of the present study were wet months that provide nutrient inputs to the littoral region for high production of macrophytes compared to the pelagic phytoplankton, which is light-limited due to turbidity.

The predominance of macrophytes to the diet of adult Nile tilapia in the present study is in agreement with the report by Tadesse Fetahi *et al*. (2017) that indicated the high contribution of macrophytes (64%) in the diet of Nile tilapia for the same lake. Similarly, Rao*et al*. (2015) have also reported the high contribution of macrophytes (54%) in the diet of Nile tilapia in South Lake, China. In addition to phytoplankton and macrophytes, detritus was also consumed in large quantities. Zenebe Tadesse (1999) and Yirgaw Teferi *et al*. (2000) have reported the importance of detritus in the diet of Nile tilapia in Lake Langano and Lake Chamo (Ethiopia), respectively. Bowen (1980) has also reported the presence of large quantities of detritus in the diet of Nile tilapia in Lake Valencia (Venezuela). Several authors have also provided similar interpretations about the importance of detritus in the diet of tilapia in different parts of Africa (Oso*et al*., 2006; Shipton *et al*., 2008; Flipos Engdaw *et al*., 2013; Mulugeta Wakijira, 2013). However, the contribution of animal origin (zooplankton, insect, and nematodes) was low to the diet of adult Nile tilapia of Lake Ziway. This is also in line with the study by other authors (Yirgaw Teferi *et al*., 2000; Alemayehu Negassa and Prabu, 2008, Flipos Engdaw *et al*., 2013). A major reason why zooplankton is not the primary diet of adult Nile tilapia is the low abundance and biomass of zooplankton particularly large size cladocerans in the system that cannot satiate its daily requirement

(Adamneh Dagne *et al.*, 2008). Furthermore, the zooplankton may detect the feeding current of Nile tilapia and swim away from the fish (Flipos Engdaw *et al.*, 2013). On the other hand, the dominance of plant-based food items (particularly macrophytes) and detritus over animal origin in the diet of adult Nile tilapia could be attributed to wider mouth gapes and their developed digestive system in terms of having more developed digestive enzymes, coupled with longer and larger gut length (Sayed *et al.*, 2014; Chemandwa *et al.*, 2016). This makes it possible for the fish to digest more complex food items like plant materials which cannot be digested at younger ages. Unlike the adults, juvenile Nile tilapia mainly fed on zooplankton followed by phytoplankton and insects. This is also in agreement with other reports (Todurancea *et al.*, 1988 in Lake Hawassa; Zenebe Tadesse, 1988 in Lake Ziway; Flipos Engdaw *et al.*, 2013 in Lake Koka).

In Lake Koka Nile tilapia of <10 cm TL mainly fed on zooplankton (25%) and insects (30%) and this trend declined sharply as the size of fish increased above 10 cm TL (Flipos Engdaw *et al.*, 2013). Zooplankton were the most important food items for fish less than 5 cm TL and little importance for larger than 10 cm TL of Nile tilapia in Lake Victoria (Njir *et al.*, 2004). Similarly, zooplankton (46%) were the most important food items for fish less than 10 cm TL and of little importance for fishes larger than 10 cm TL in Lake Tinishu Abaya (Ethiopia) (Yirga Enawgaw and Brook Lemma, 2018). The result of the present study is also in agreement with Todurancea *et al.* (1988); Zenebe Tadesse (1988) and Yirgaw Teferi *et al.* (2000) who reported the significant contribution of zooplankton to smaller sized Nile tilapia. The possible reason for juveniles feeding on zooplankton and larval stages of insects over plant materials (macrophytes and phytoplankton) and detritus might be due to the small volume of the stomach that may not support big macrophytes and detritus (Flipos Engdaw *et al.*, 2013). Furthermore, Benavides *et al.* (1994) hypothesized that since juvenile fish have higher mass protein demand due to their higher specific growth rate and greater mass-specific metabolism, they may not satisfy this demand by consuming a plant-based diet. Thus, younger fish tend to feed more on animal origin including zooplankton and insect larvae and shift to plant-based foods as they grow. In addition to zooplankton and insect larvae, juvenile Nile tilapia mainly feeds on phytoplankton particularly diatoms. This is also in agreement with Zenebe Tadesse (1988). The high contribution of diatom in the diet of juvenile Nile tilapia might be associated with the small size of diatom and its high nutrition value when compared with filamentous algae (Nesara and Bedi, 2018). The type and size of food items consumed changes with the age and size of the fish. This is mainly because fish can only feed on food items that can fit into their mouth and what their gut can digest (Otieno *et al.*, 2014). The importance of phytoplankton, macrophytes, and detritus was higher in adults than in juveniles whereas the importance of zooplankton, insects, and other animal origin food was higher in juveniles than in adults. Similar results were also reported by Yirga Enawgaw and Brook Lemma (2018) who reported that there was no significant dietary overlap between juvenile and adult Nile tilapia in Lake Tinishu Abaya, Ethiopia. Zerihun Desta *et al.* (2007) also reported that the ontogenetic diet shift has been shown to occur during the life history of many fish species as prey size is generally positively correlated with fish size.

Temporal variations in the diet of juvenile and adult Nile tilapia

The temporal changes of biotic and abiotic factors alter the structure of the food web along the year and as a consequence, the fish often shows temporal and seasonal diet variation. In the present study, the proportion of phytoplankton was higher from April to May and low from July to August (Fig. 2). Among the phytoplankton, blue-green algae were dominant in April and May, and diatoms were also dominant from June to August. The reason might be the high availability of blue-green algae in Lake Ziway relative to other algal groups, because, Ziway is the shallow and most wind-exposed turbid lake contained the largest amount of non-algal particles that contributed to 91% of the total light extinction (Girma Tilahun and Ahlgren G., 2010). This is also preferred filamentous blue-green algae which are mainly dominant on the surface of water bodies as it can compete for light over other algal groups. The same result also reported by other investigators in the Ethiopian rift valley lakes (Zenebe Tadesse, 1998, 1999; Yirgaw Teferi *et al*., 2000; Flipos Engdaw *et al.,* 2013) who reported that blue-green algae are dominant in dry months and diatoms are dominant in wet months. According to Flipos Engdaw *et al*. (2013), the contribution of phytoplankton to the diet of Nile tilapia was high (66.1%) in the dry month (May) and very low (3.51%) in a wet month (August). On the contrary, the contribution of macrophytes was high from July to August and low from April to May. The differences in composition and the varying relative contribution of food items may be due to the difference in microhabitat occupied by the fish. During dry months fish may move to the pelagic region of the lake and feed mainly on suspended phytoplankton because, phytoplankton production may be high due to increased light penetration into the photic zone of the lake (Flipos Engdaw *et al*., 2013). That is why the contribution of phytoplankton was higher in dry months than in wet months as the primary production of Lake Ziway is light rather than nutrient-limited (Girma Tilahun, 2006; Tadesse Fetahi *et al*., 2017). On the other hand, during wet months high flooding from the catchment area may cause fluctuations in water level and increase the turbidity of the lake. This decreases light penetration in the lake, thereby affecting the growth and abundance of phytoplankton in the water (GetachewTefera, 1993). Since the biomass of phytoplankton in the lake is low in wet months, Nile tilapia has to rely on any plant material available in the lake that is why macrophytes and detritus constitute the bulk of its diet during July and August. Besides, during wet months fish moves to shallow parts of the lake for reproduction and stays for a longer period by feeding macrophytes. In addition to macrophytes, the contribution of detritus to the diet of Nile tilapia was high in July and August. The high contribution of detritus in these wet months could be associated with plant materials coming with runoff during the wet months (Zenebe Tadesse, 1999; Workye Worie and Abebe Getahun, 2015). The contribution of zooplankton to the diet of adult Nile tilapia was low in July and August, and relatively high in April and May, and moderate in June (Fig. 2). This is in line with Flipos Engdaw *et al* (2013) who reported that the contribution of zooplankton was higher in a dry month (May) (9.7%) than a wet month (August) (1.2%) in Lake Koka. In the case of juveniles of Nile tilapia, the contribution of zooplankton was high in all months with a peak in July and low in May (Fig. 2). The highest proportion of zooplankton during the July and August months might be associated with the low availability of phytoplankton which is the second important food item for juvenile Nile tilapia. In contrast, the contribution of phytoplankton was high in May and low in August (Fig. 2). The reverse is true for the contribution of detritus to the diet of juvenile Nile tilapia in Lake Ziway (Fig. 2). A similar result was also reported by Flipos Engdaw (2013) from Lake Koka. However, the contribution of insects to the diet of juvenile Nile tilapia was comparable among months with relatively higher in June.

CONCLUSIONS

Nile tilapia has a diverse feeding habit that includes macrophytes, phytoplankton, zooplankton, fish scale, insects, and detritus. Macrophytes and phytoplankton was the dominant food item consumed by the adult Nile tilapia while juvenile mainly depends on zooplankton and insect larvae. The study demonstrating juveniles mainly feeding on animal-based food items whereas adults depend on plant origin. However, diet temporal variation was observed in both juveniles and adults, which are omnivores feeding on different levels of plant and animal origin food items. The present work was carried out by considering only five months of data due to time and budget constraints, and further research is recommended to examine the diet of juvenile and adult Nile tilapia using year-round data to show seasonal variations. Besides, the impact of sedimentation and other anthropogenic activities on the feeding habit of Nile tilapia should be studied.

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