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Morphometric Relationships and Feeding Habits of Nile Tilapia *Oreochromis niloticus* (L.) (Pisces: Cichlidae) From Lake Koka, Ethiopia

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Abstract: The study aimed to check morphometric relationships and feeding habits of the Nile tilapia *Oreochromis niloticus* (L.). A total 573 fish samples from 4.7 cm to 35.2 cm Total Length (TL) and from 1.67 g to 780.0 g Total Weights (TW) were collected from Lake Koka during dry (May) and wet (August) months of 2011. The relationship between TL and Standard Length (SL) was linear (SL = 0.8482TL-0.8674) and the relationship between TL and TW was curvilinear (TW = 0.0153TL3.0541). From the total number of fishes 488 (85.2%) stomach was observed with food and remaining 85(14.8%) was empty. The major food items found in the stomach content was phytoplankton, macrophytes and detritus. Phytoplankton occurred in 80.1% of the stomach contents examined and contributed 47.45% of the total volume of food items. Macrophytes and detritus was found in 61.1 and 75.2% of the stomach contents and contributed 26.2 and 15.5% of the total volume of the diet, respectively. Zooplankton and insects was recorded in 54.1 and 19.9% of the stomach and volumetrically accounted for 7.06 and 2.43% of the bulk, respectively. During the dry month phytoplankton was observed in 96.4% of the stomach and constituting 66.1% of the total volume of the diet. During wet month macrophytes was the most important food items found in 98.1% of the stomach contents and constituting 79.1% of the total volume of the food items. Ontogenetic dietary shift was observed during the present study. Small sized fish (<10 cm) fed mainly on insects and zooplankton. When the fish size increased phytoplankton, macrophytes was increased in their food contents and zooplankton, insects and ostracods declined.

Keywords: Lake koka, morphometric, ontogenetic dietary shift, *Oreochromis niloticus*, phytoplankton, stomach contents, volumetric analysis, zooplankton

INTRODUCTION

The Nile tilapia *Oreochromis niloticus* (L) is native to the Lake Chad basin and Lakes of Tanganyika, Albert, Edward and Kivu which is widely distributed in tropical and subtropical Africa. These fishes were found throughout the Nile River basin (Shipton *et al*., 2008; Njir *et al*., 2004). In Ethiopia inland water bodies covers 8,800 km^2 which contains diverse aquatic ecosystems (Mesfin, 2009). There are different economically and ecologically important species of fishes found in those water bodies in which *O. niloticus* is important for fisheries production of the country in general and traditional fishery of Lake Koka in particular (Alemayehu and Prabu, 2008; Yirgaw *et al*., 2000). Due to its suitability to aquaculture, this species was introduced in many parts of Asia, Europe, North America and South America (Mark *et al*., 2005; Alemayehu and Prabu, 2008; El-Wakil *et al*., 2010). The worldwide harvest of farmed *O. niloticus* have been reported to increase above 800,000 metric tons per year in recent times (Popma and Masser, 1999; Kamal *et al*., 2010; El-Wakil *et al*., 2010). Due to fast growth rate, ability to reproduce in artificial conditions, high salinity tolerance, able to survive in low dissolved oxygen concentrations, survive in poor water quality and wide range of feeding habits favoured to produce large quantities in a small area within the short period of time (Mark *et al*., 2005; Alemayehu and Prabu, 2008; El-Wakil *et al*., 2010).

In Ethiopia it is widely distributed in the lakes, rivers, reservoirs and swamps which contribute about 60% of total landings of fish (LFDP, 1997; Demeke, 1998). It is reported that *O. niloticus* from Lakes of Hawassa, Ziway and Chamo mainly feeds on phytoplankton, macrophytes and detritus (Getachew, 1993; Yirgaw *et al*., 2000; Todurancea *et al*., 1988; Alemayehu and Prabu, 2008). However, food composition differs depending on the season (dry or wet) and also Lake type (Getachew and Fernando, 1989; Kamal *et al*., 2010). There is paucity of detailed information on the feeding habits of this species

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particularly seasonal variation in the diet and ontogenetic dietary shift from Lake Koka. Therefore, this study reports morphometric relationships, seasonal variation in diet composition and ontogenetic dietary shift.

MATERIALS AND METHODS

Study area: Lake Koka is selected for collection of fish which is located in the northern part of Main Ethiopian Rift, Misraq-Shewa Zone of Oromia Region with latitude and longitude of 08°24'N and 39°01'E (FAO, 2011). The Lake surface area is approximately 250 km^2 which receives additional water from Awash River and Mojo River. This reservoir supports fishing industry for the society due to wide variety of fishes in which *O. niloticus* is commercially important (Mesfin, 2009; Peder, 2009).

Sampling and measurements: *Oreochromis niloticus* was collected from Lake Koka during May, 2011 for dry month and August, 2011 for wet month. A total of 573 fishes were collected from fishermen catch. In addition, fingerlings were also collected by using beach seine (20 m long and 3 m wide with a mesh size of 0.6 mm) in the shallow parts of the lake. Sampling was done two times until sufficient fishes were collected for stomach content analysis. Total Length (TL), Standard Lengths (SL) and Total Weight (TW) of all fishes were measured to the nearest millimeter and gram. The sex and gonad maturity stage of each fish was recorded by observing visually using five point maturity scales (Holden and Raitt, 1974).

Length-weight relationships: Length-weight relationship of *O. niloticus* was calculated using least squares regression analysis (Bagenal and Tesch, 1978).

$TW = a\ XTL^b$ Whereas, TW = Total Weight, TL= total length, a and b = Y intercept and slope of the equation, respectively.

Food and feeding observation: The stomach content analysis was carried out in the laboratory by using preserved stomach contents in 5% formalin. The stomach contents were examined using dissection microscope (Leica MS5) and also compound microscope (Leica DME). The relative importance of different food items found in the stomach contents was determined (Windell and Bowen, 1978).

Frequency occurrence of food items: The number of stomach samples contains 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 particular food item was estimated and the frequency of occurrence was calculated (Hyslop, 1980; Bowen, 1983):

$$Fi = 100^* \, ni/n$$

where,

- F*i* : Frequency of occurrence of the *i* food item in the sample
- n*i* : Number of stomachs in which the *i* item is found
- n : Total number of stomachs with food in the sample

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

Data analysis: The data generated from the stomach content analysis was summarized by converting in to percentage compositions. In addition, least squared regression analysis was used to establish length-weight and length-length relationships.

RESULTS

Morphometric relationships: A total of 573 fish samples from 4.7 to 35.2 cm in TL and 1.67 to 780.0 g in TW were used to determine length-length and length-weight relationships. The relationship between TL and SL of *O. niloticus* was linear and highly significant ($p<0.001$) (Fig. 1) whereas the relationship between TL and TW was curvilinear and also significant ($p<0.001$) (Fig. 2). The "b" value of 3.054 was very close to three and it indicates isometric growth pattern of the species. The intercept "a" was 0.015; this indicates the average condition factor index of *O. niloticus*.

Food composition: Among the 573 stomach content used to analyze the food composition in dry (May) and

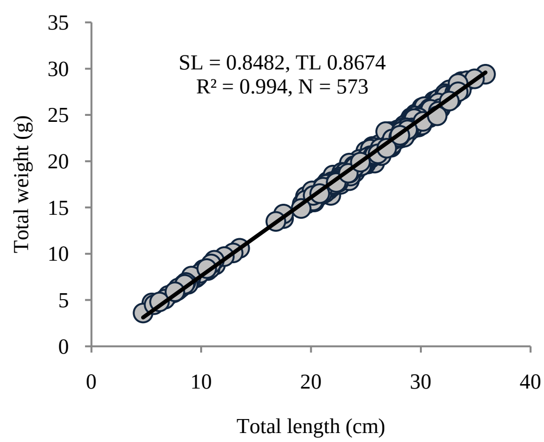

Fig. 1: Length-length relationships

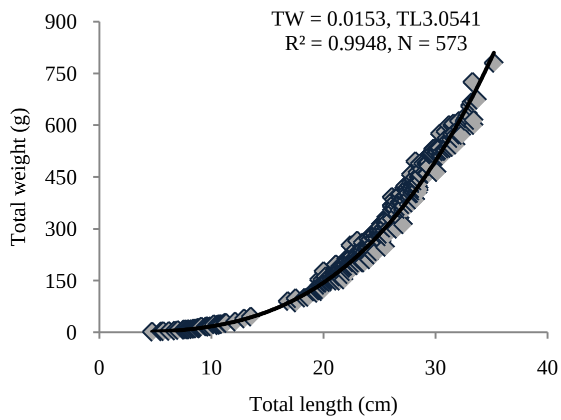

Fig. 2: Total length and total weigth relatioships

wet (August) months, 85(14.8%) were completely empty and 488 (85.2%) observed with phytoplankton, detritus, macrophytes, zooplankton, insects, ostracods and nematodes. Phytoplankton and macrophytes were dominant in majority of the samples; detritus and zooplanktons were intermediate; insects and ostracods were low. Phytoplankton constituted largest component of the diet occurred in 80.1% and volumetrically constituted 47.45% of the total volume of food items (Table 1). Among the phytoplanktons, blue green algae such as *Microcystis*, *Planktolyngbya*, *Anabaena*, *Chroococcus* and *Lyngbya* were dominant in 69.9% and constituting 35.2% of the total volume of food items. Green algae such as *Spirogyra*, *Botryococcus*, *Scenedesmus*, *Closterium* and *Pediastrum* was observed in 59.6% of the stomachs and constituted 8.0% of the total volume (Table 1). Macrophytes were the second important food items in the diet of *O. niloticus* that occurred in 61.1% of the stomach examined and it constituted 26.2% of the total volume of the food items consumed. Detritus occurred in 75.2% and accounted for 15.5% of the total volume. Zooplankton occurred in 54.1% and volumetrically their contribution was 7.06% (Table 1). The frequency of insect's occurrence was 19.9% and their volumetric contribution was 2.43% of the total volume of food items. The small sized zooplankton (*Branchionus* and *Keratella*) were the most important groups in the diet of *O. niloticus*. Percentage occurrences of ostracods were 17.0% and their volumetric contribution was 1.3% of the total volume of food items (Table 1).

Seasonal variation in the diet of *O. niloticus:* The result clearly demonstrates seasonal variation, during dry month phytoplanktons were dominantly occurred in 96.4% of the stomachs contents and comprising 66.1% of the total volume of food items. However, during wet month declined sharply (46.1%) and constituting 3.51% of the total volume. The contribution of detritus was comparable during dry and wet months. It occurred in 72.8 and 80.8% of the stomachs during dry and wet months, respectively. Volumetrically it constitutes 14.72 and 14.32% of the total volume of food items during dry and wet months respectively (Table 2 and 3). Zooplankton was observed in 74.3% of the stomach contents and comprised 9.77% of total volume of food items during the dry month. But their contribution declined during wet month (11.5%) and accounting

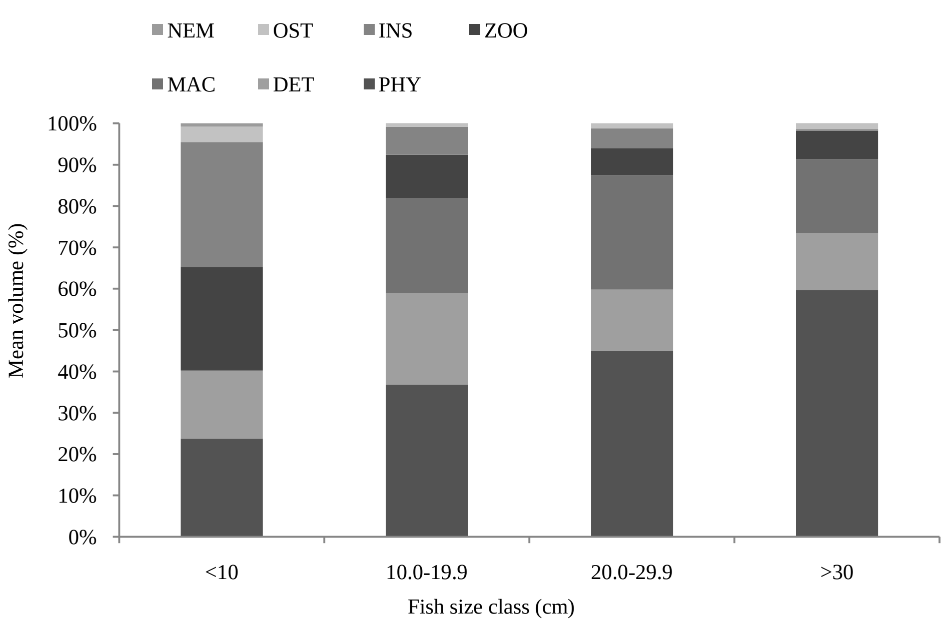

Fig. 3: Volumetric contributions of different food items in the diet of different size class of *O. niloticus* (PHY-phytoplankton, DET-detritus, MAC-macrophyte, ZOO-zooplankton, INS-insect, OST-ostracode and NEM-nematode)

Table 1: Frequency of occurrence and volumetric contribution of food items consumed by *O. niloticus* from Lake Koka

	Frequency of occurrence		Volumetric analysis	
Food items	Number	%	Volume	%
Phytoplankton	391	80.1	773.9	47.45
Blue green algae	341	69.9	574.0	35.20
Green algae	291	59.6	130.5	8.00
Diatoms	254	52.0	57.90	3.50
Euglenoids	7 0	14.3	11.50	0.70
Zooplankton	264	54.1	115.2	7.06
Rotifers	221	65.8	51.20	3.10
Copepods	207	42.4	39.70	2.40
Cladocerans	131	26.8	24.20	1.50
Insects	97	19.9	39.58	2.43
Diptera	98	20.1	34.60	2.12
Ephemeroptera	15	3.10	2.410	0.15
Hemiptera	17	3.50	2.300	0.14
Plecoptera	6	1.20	0.160	0.01
Macrophytes	298	61.1	430.7	26.2
Detritus	367	75.2	253.3	15.5
Ostracods	83	17.0	20.50	1.30
Nematodes	14	2.90	0.800	0.05

Table 2: Frequency of occurrence and volumetric contribution of different food items consumed by *O. niloticus* in Lake Koka during dry month

	Frequency of occurrence		Volumetric analysis	
Food items	Number	%	Volume	%
Phytoplankton	319	96.4	756.2	66.1
Blue green algae	307	92.7	568.2	49.7
Green algae	275	83.1	129.4	11.0
Diatoms	195	58.9	48.30	4.20
Euglenoids	62	18.7	10.40	0.90
Zooplankton	246	74.3	111.8	9.77
Rotifers	181	54.5	52.75	4.61
Copepods	137	61.0	38.43	3.36
Cladocerans	90	34.4	20.60	1.77
Insects	88	26.6	35.00	3.06
Diptera	68	27.7	28.60	2.50
Ephemeroptera	14	4.20	2.100	0.20
Hemiptera	14	4.20	1.600	0.13
Plecoptera	17	5.20	2.600	0.22
Macrophytes	144	43.5	51.60	4.50
Detritus	241	72.8	168.5	14.72
Ostracods	75	22.7	19.80	1.72
Nematodes	13	3.90	0.800	0.70

1.12% of the total volume of food items (Table 3). The macrophytes contribution was very low during the dry month. They were found in 43.5% of the stomach contents and constituted 4.5% of the total volume of food items (Table 2). However, during wet month most important food items in the diet of *O. niloticus* were macrophytes (98.1%) and constituting 79.56% of the total volume of food items (Table 3). Comparing the two months, the contribution of insects was relatively high during the dry month occurring in 26.6% of the stomach contents examined and accounting for 3.06% of the total volume of the bulk. During the wet month the contribution of insects was insignificant, because they occurred in few numbers and their volumetric contribution was also very low. The contributions of ostracods and nematodes were negligible because of their low occurrence and small volumetric contributions (Table 2 and 3).

Ontogenetic diet shift: Ontogenetic dietary shift was evident during the present study. Foods of animal origin, namely insects and zooplankton was most important food items of the fish below 10 cm of TL contributing 30.2 and 24.9% of the total volume of food items, respectively. Ostracods were another food source of animal origin relatively important in the diet. Their volumetric contribution was 3.7% of the food items in that particular size class. The contribution of nematodes was insignificant. Food of plant origin was also relatively important in the diet. Phytoplankton and detritus accounted for 23.8 and 16.3% of the total volume of food items (Fig. 3).

In 10.0-19.9 cm TL of fishes, foods of plant origin were most important. Phytoplankton, macrophytes and detritus comprised 36.7, 22.7 and 22.3% of the total volume of the food items consumed respectively. On the other hand the contributions of animal origin foods declined sharply. Zooplankton and insects accounted for 10.5 and 6.8% of the total volume of the diet, respectively (Fig. 3).

In the size class of 20.0-29.9 cm of TL, foods of plant origin constituted about 90% of the bulk food

Table 3: Frequency of occurrence (%) and volumetric contribution (%) of different food items eaten by *O. niloticus* from Lake Koka during wet month

	Frequency of occurrence		Volumetric analysis	
Food items	Number	%	Volume	%
Phytoplankton	72	46.1	17.20	3.51
Blue green algae	34	21.8	5.500	1.10
Green algae	59	37.8	9.400	1.90
Diatoms	16	10.3	1.700	0.30
Euglenoids	8	5.10	0.600	0.18
Zooplankton	18	11.5	5.500	1.20
Rotifers	3	1.90	0.300	0.06
Copepods	5	3.20	1.300	0.30
Cladocerans	17	10.9	3.900	0.76
Insects	9	5.80	4.500	0.92
Diptera	6	3.80	4.000	0.81
Ephemeroptera	1	0.60	0.300	0.06
Hemiptera	2	1.30	0.250	0.05
Macrophytes	154	98.1	388.9	79.1
Detritus	126	80.8	77.00	14.32
Ostracods	9	5.80	0.760	0.200
Nematodes	1	0.60	0.020	0.004

consumed. Phytoplankton, macrophytes and detritus comprised 46.4, 28.6 and 15.3% of the bulk food consumed, respectively. The contribution of foods of animal origin was low in this size class. Zooplankton and insects comprised 5.2 and 3.4% of the total volume of food items, respectively. The contributions of ostracods and nematodes were negligible (Fig. 3).

In the largest size class (>30 cm TL), contribution of phytoplankton, macrophytes and detritus were 59.2, 17.8 and 13.7% of the total volume of food items respectively. Compared to lower size classes, contribution of phytoplankton was increased considerably and macrophytes and detritus contribution was declined. Zooplankton accounted for 6.8% of the bulk food items in this size class, the contributions of other foods of animal origin were relatively low (Fig. 1).

DISCUSSION

The highly significant linear relationship indicates that either of the length measurement could be converted to the other easily because of their strong relationship. The relationship between TL and TW was curvilinear and highly significant and slope of the regression line indicates isometric growth pattern of *O. niloticus* in Lake Koka. It may be due to the growth that occurs at same rate for all parts of the organisms. Several authors have reported isometric and allometric growth pattern of *O. niloticus* from different water bodies. The isometric growth pattern observed in the present study was in agreement with the earlier findings (Olurin and Aderibigbe, 2006; Offem *et al*., 2007; Abowei *et al*., 2009; Zenebe, 1998).

Adult *O. niloticus* was reported to feed on variety of food items including phytoplankton, macrophytes, planktonic and benthic aquatic invertebrates, insects and detritus (Getachew, 1987; Todurancea *et al*., 1988; Getachew and Fernando, 1989; Yirgaw *et al*., 2000; Oso *et al*., 2006; Alemayehu and Prabu, 2008) whereas juveniles are generally omnivorous feeding on zooplankton, insect larvae (Todurancea *et al*., 1988) and phytoplanktons of which diatoms was the major dietary component (Witte and Winter, 1995). The types of food items found in the stomachs of *O. niloticus* collected from Lake Koka were quite similar with above findings.

In addition to phytoplankton, detritus and aquatic macrophytes were also considerable importance in the diet of *O. niloticus* due to some nutritional benefits. Several authors have provided similar interpretations about the importance of detritus and macrophyte in different parts of Africa (Zenebe, 1988; Getabu, 1993; Shipton *et al*., 2008; Oso *et al*., 2006; Kamal *et al*., 2010).

In the present study, proportion of phytoplankton was higher during dry month and macrophyte was higher in wet month. Among the phytoplanktons, blue green algae dominated in dry month and diatoms in wet month. This is quite similar with the findings of other investigators in the Ethiopian rift valley lakes (Zenebe, 1988, 1998; Yirgaw *et al*., 2000). The composition differences and relative contribution of food items may partly explained by difference in micro habitat occupied by the fish. During wet month fish moves to shallow parts of the lake for reproduction and stays for longer period of time by feeding macrophytes and vegetations. In addition, during wet month due to high flooding from the catchment area may cause fluctuations in water level and increasing turbidity of the lake. This decreases the penetration of light in the lake and thereby affecting the growth and abundance of phytoplankton in the water (Getachew, 1987a, b, 1993). During dry month fish may move to pelagic region of the lake and feeding mainly on suspended phytoplankton. During this period phytoplankton production may be high due to increased light penetration into the photic zone of Lake. The seasonal variation on the feeding habit of *O. niloticus* due to seasonal succession of phytoplankton in some rift valley lakes of Ethiopia was well explained (Yirgaw *et al*., 2000).

It is a well established fact that the composition of different food items utilized by *O. niloticus* changes as the fish grows older. Even though, nutritive quality of foods of animal origin consumed by early stages of the fish was high, the energy demands of growing fish cannot be met by particulate feeding on zooplankton and benthic invertebrates. As the fish changes it's feeding from primarily omnivorous diet to herbivorous diet may be due to energy demands, because of this large volumes of phytoplankton are filtered out from the water column as mentioned by earlier researchers (Shipton *et al*., 2008; Alemayehu and Prabu, 2008).

The ontogenetic dietary shift of *O. niloticus* in Lake Victoria highlights zooplankton were most important food items for fish less than 5 cm TL and little importance for larger than 10 cm TL (Njir *et al*., 2004). In the present study fish <10 cm TL mainly fed on zooplankton and insects and declined sharply as the size of fish increased above 10 cm TL. These findings are in corroborating well with earlier findings (Njir *et al*., 2004; Todurancea *et al*., 1988; Abdel-Tewwab and El-Marakby, 2000; Yirgaw *et al*., 2000; Alemayehu and Prabu, 2008). The reason for taking less zooplankton during adult life may be the fish change its mode of feeding by gulping the water within its area. The zooplanktons may detect feeding current and swim away to avoid being swallowed by the fish. The possible reason for juveniles feeding early larval stages of insects and zooplanktons may be due to small volume of the stomach that may not support big macrophyte and detritus and again the volumes of the stomach are not large enough to make filter feeding energetically.

CONCLUSION

Generally *O. niloticus* in Lake Koka was found to be an herbivorous fish mainly feeding on phytoplankton, detritus and macrophytes. In addition, zooplankton and insects constituted minor portion of the diet of *O. niloticus* in Lake Koka.

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