

Full Length Research Paper

Food and feeding habits of three main fish species in Lake Baringo, Kenya

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The diets of three fish species of commercial importance in Lake Baringo, *Protopterus aethiopicus*, *Clarias gariepinus* and *Oreochromis niloticus*, were determined using frequency of occurrence and volumetric methods between April 2008 and March 2010. Seine and gill nets were used to catch a total of 430 fish specimens. The diet of *P. aethiopicus* was 94.3% molluscs with a frequency of occurrence of 98.6% of stomachs with food. Adult *C. gariepinus* fed mainly on fish with 75% of the stomachs with food containing fish remains and mean of 49.2% contribution by volume. *C. gariepinus* also fed on zooplankton, especially the cladoceran *Daphnia barbata*. The food items in the stomachs of *O. niloticus* consisted mainly of algae, detritus and zooplankton. Algae was consumed by *O. niloticus* of all length classes in proportions ranging from 26.5 to 88.1%. The importance of zooplankton as food for *O. niloticus* decreased with size of fish. The study reveals the importance of zooplankton as food for *O. niloticus* and *C. gariepinus* in Lake Baringo. There is need to rehabilitate the catchment of Lake Baringo so as to improve the water quality thus improve productivity.

Key words: Diet, Omnivorous, Algae, zooplankton, food web.

INTRODUCTION

Lake Baringo lies in a closed drainage basin of the Kenyan East African Rift Valley system at an altitude of 965 m above sea level with a surface area of approximately 130 km² and a mean depth of 3.5 m. Besides being a source of fish, water for drinking, irrigation and transport, the lake is also a repository of fauna and flora biodiversity. The lake's water quality has deteriorated in the recent past mainly due to sedimentation from its catchment arising from poor agricultural practices, deforestation and overgrazing. Consequently, these have led to a decline in fish catches. Since the 1980s, frequent lake closures to fishing activities have not alleviated the problem.

The fish community of Lake Baringo comprises seven species. These include *Aplocheilichthys* sp, *Barbus*

intermedius australis, *B. lineomaculatus*, *Clarias gariepinus*, *Labeo cylindricus*, *Oreochromis niloticus baringoensis* and *Protopterus aethiopicus* (Britton et al., 2006). Of these, four species, namely *C. gariepinus*, *O. n. baringoensis* and *P. aethiopicus*, are economically exploited. The fishery of the lake was once dominated by the endemic *O. n. baringoensis* but is presently dominated by *P. aethiopicus*, which was introduced in 1975. Annual catches of *O. n. baringoensis* exceeded 600 t in the 1960s but this decreased to mean annual catches of below 12 t in 2006 despite a prolonged period of fishery closure (Britton et al., 2006).

Lungfishes, *Protopterus* spp have been classified as omnivores feeding mainly on fishes besides other items like insects, crustaceans, annelids, mollusks, fish, detritus

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and plant material (Corbet, 1961; Mlewa and Green, 2004; Oniye et al., 2006; Adeyemi et al., 2009). *C. gariepinus* is a benthopelagic fish which is known to be voracious with a wide range of diet (Yalcin et al., 2002). Fish has been reported to be the most important food item among other materials like insects, shrimps, snails, detritus and macrophytes (Skelton, 1993; Dadebo, 2000, 2009; Yalcin et al., 2001; El Gamal and Ismail, 2005; Potts et al., 2008; David et al., 2010). Earlier studies in various lakes showed that *O. niloticus* is capable of using a wide range of food resources including algae, detritus, higher plant material, chironomids, zooplankton and fish (Getabu, 1994; Njiru et al., 2004; Shalloof and Khalifa, 2009).

Studies on natural feeding of fish could provide useful information on the trophic relationships in aquatic ecosystems (Abdel-Aziz and Gharib, 2007), which could be used in formulating management strategy options in a multi species fishery. Pius and Benedicta (2002) also reported the use of stomach content in reducing intra and inter specific competition for ecological niche. Apart from studies on the feeding biology of the marble fish, *P. aethiopicus* and *O. niloticus* by Mlewa and Green (2004) and Busienei (2003), respectively, there has been no comprehensive investigation on the diet of fish species of commercial importance in Lake Baringo. This study investigated the diet and the trophic inter-relationships of *P. aethiopicus*, *C. gariepinus* and *O. niloticus* in Lake Baringo.

MATERIALS AND METHODS

Study area

Lake Baringo (Figure 1) is a freshwater lake in the eastern arm of the Great Rift Valley in Kenya. It is located between latitude 0°30' N and 0°45' N and longitude 36° 00' E and 36° 10' E and lies approximately 60 km north of the equator at an altitude of 975 m above sea level (Kallqvist, 1987). The lake has a surface area of approximately 130 km² and a catchment of 6,820 km². It has a mean depth of 3 m with the deepest point being about 7 m at high water levels.

Stratified random design was used in this study. The lake was divided into five different sectors, based on proximity to river mouths and based on this, stations S2, C2 and N2 lying on the S-N transects while C3, C2 and C1 lying on the E-W transects were chosen (Figure 1 and Table 1). Stations S2 and C3 have the influence of rivers Molo and Mukutan respectively. Station C2 is at the centre of the lake, C1 in the west adjacent to rocky shores while N2 lies in the north.

Fish was caught quarterly between April 2008 and March 2010 by seining in the lake using a 5 mm mesh size of 30 m in length and 2 m depth seine net. Gillnets of various meshes were also used especially for larger fish specimens. Captured fishes were sorted into different species, the total length of each fish was noted to the nearest centimetre and gut content was removed and preserved in 4% formaldehyde solution. For fishes less than 5 cm total length, however, whole specimens were preserved.

In the laboratory, the stomach contents were emptied into a Petri dish and each food item sorted under x 50 magnification of a binocular microscope. The gut contents were analysed using two

methods, frequency of occurrence and volumetric method based on Hynes (1950). In the frequency of occurrence method, the occurrence of food items was expressed as the percentage of the total number of stomach containing food while in volumetric method, percentage volume contribution of each food item was visually assessed relative to all of the food items present in the gut.

The contents were analysed separately for two length classes in *C. gariepinus* and six length classes for *O. niloticus*. Additionally, for stomachs with zooplankton, the percentage contribution of each species in the diet of *O. niloticus* was determined.

RESULTS

In this study, gut content of a total of 430 fishes were analysed. Of these, 142, 72 and 216 were *P. aethiopicus*, *C. gariepinus* and *O. niloticus*, respectively. The total length for the three fish species were in the range of, 17.3-97.5, 19.6-63.0 and 2.4-28.0 cm, respectively. Juveniles of *P. aethiopicus* and *C. gariepinus* were not obtained from the lake during the study.

The diet of *P. aethiopicus* was dominated by molluscs with a mean composition of 94.3% (Table 2) with a frequency of occurrence of 98.6% of stomachs with food. Fish was also an important component of the species stomach contents with a mean contribution of 4.9% and a frequency of occurrence of 39.4% of the stomachs with food. Other food items recorded included detritus (1.0%), insects (0.10%) and higher plant materials (0.1%). Insects found in the stomachs were of the order Odonata while the higher plant materials belonged to the families Ceratophyllaceae and Poaceae.

The diet of *C. gariepinus* consisted of mainly fish, detritus and zooplankton (Table 3). Fish was the dominant prey item. The frequency of occurrence for the prey was 75% with a mean contribution of 49.2% by volume. The other important components of the diet of the species were detritus and zooplankton. This food items contributed 28.3 and 19.6% of the diet by volume, respectively. The numbers of zooplankton recorded in the stomachs were, however, high with the highest being 85,300 organisms in a stomach of a 43.5 cm fish. Higher plant materials were also recorded in the stomach, albeit in small proportions.

Among the zooplankton prey, *C. gariepinus* preferred the cladoceran *D. barbata* as its prey. The percentage contribution of the item in the *C. gariepinus* stomachs ranged from 33 to 94%. Other zooplankton taxa in the diet included copepods (nauplii, adult cyclopoids and calanoids), cladocerans *D. excisum*, and *Ceriodaphnia cornuta* while *Filinia opoliensis* was the only rotifer recorded in the stomachs. The proportion of *D. barbata* in the diet of *C. gariepinus* above 40 cm in length was higher (96.1%) compared to those in the fishes below 40 cm with a proportion of 30.5% of the diet by volume (Table 4).

The food items in the stomachs of *O. niloticus* consisted mainly of algae, detritus and zooplankton (Figure 2). Other stomach components were higher plant materials,

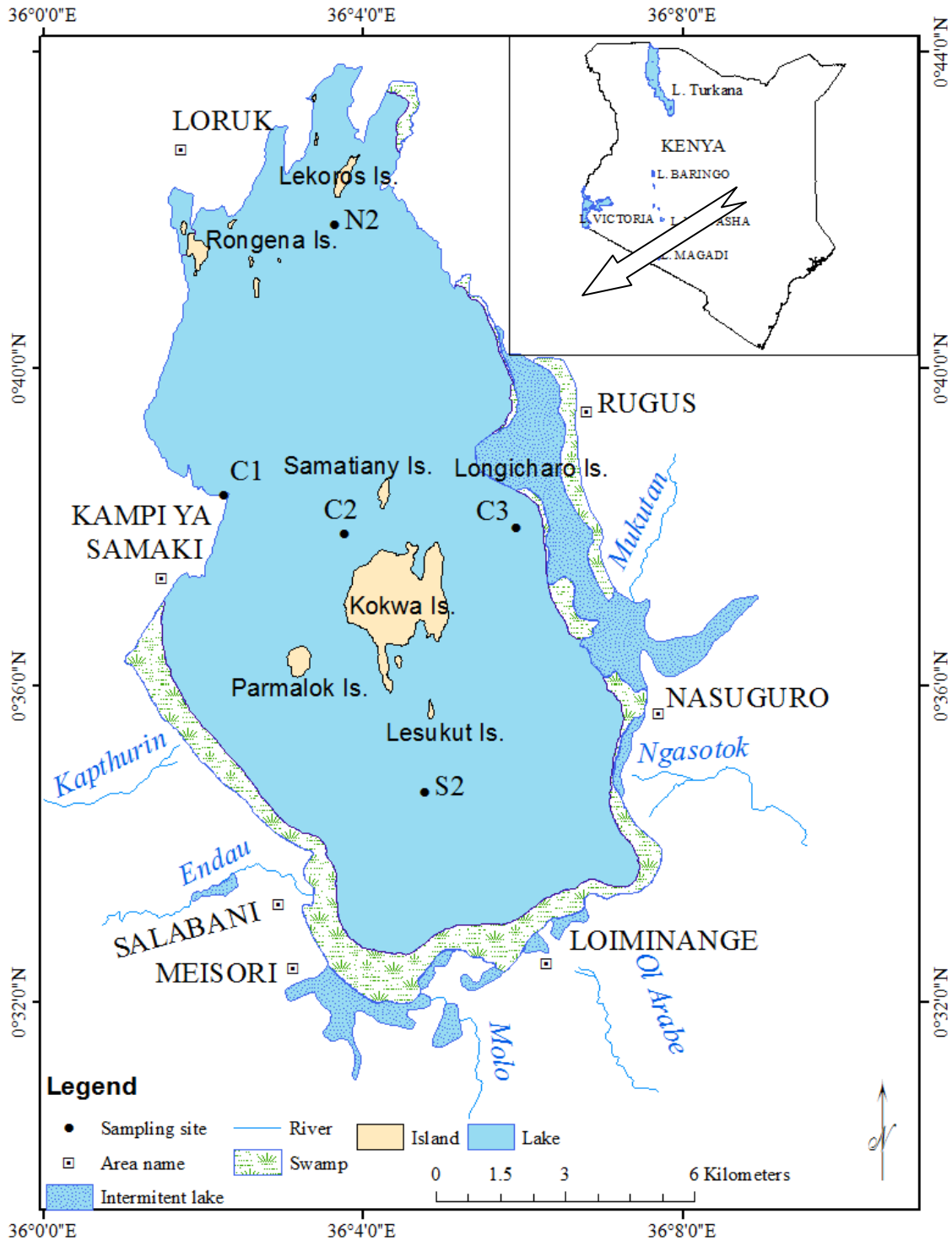


Figure 1. A map of Lake Baringo showing the sampling stations.

fish and insects. Algae were predominantly consumed by *O. niloticus* of all size classes in high proportions between 26.5 and 88.1% of the diet. While the importance of zooplankton decreased with size of fish, the reverse trend occurred for detritus with the proportion ingested increa-

sing with size of *niloticus*. Insects, fish and higher plant materials on the other hand were hardly utilized by *O. niloticus* over 15 cm in length. The fish found in the few stomachs were probably accidentally swallowed by the mouth brooding females as all the stomachs where they

Table 1. The geographical positions of the sampling stations in Lake Baringo.

Station	Position	
S2	00° 34'38. 7" N	036° 04' 47.3" E
C1	00° 38'13. 0" N	036° 02' 42.1" E
C2	00° 38' 0.1" N	036° 03' 53.2" E
C3	00° 37'59. 0" N	036° 05' 54.4" E
N2	00° 41'33. 4" N	036° 03' 27.2" E

Table 2. Summary of the percentages of food items of *P. aethiopicus* in Lake Baringo.

Parameter	Frequency of occurrence	Volume
Insects	2.8	0.10
Molluscs	98.6	94.29
Fish remains	39.4	4.88
Detritus	7.0	0.59
Higher plant materials	4.2	0.13

Table 3. Summary of the percentages of food items of *C. gariepinus* in Lake Baringo.

Parameter	Frequency of occurrence	Volume
Fish remains	75	49.17
Detritus	75	28.33
Plant materials	50	2.92
Zooplankton	50	19.58

Table 4. Percentage contribution of different prey items in the diet of different size classes of *C. gariepinus* in Lake Baringo during the study period.

Parameter	Size Class (cm)	
	10.0 - 39.9	40.0 - 69.9
Nauplii	27.1	
Cyclopoida	13.6	1.8
Calanoida		1.5
<i>Diaphanosoma excisum</i>	27.1	
<i>Daphnia barbata</i>	30.5	96.1
Others	1.6	0.6

occurred were females. Insects were found in only the stomachs of fishes in the size class of 5.0-9.9 cm with a proportion of 1.9% and these were terrestrial insects which could have been taken from the water surface.

Among the zooplankton species forming the main diet of *O. niloticus* are the cladocerans *D. excisum*, *M. micrura* and *D. barbata*. Important rotifer species were *Brachionus patulus* and *Keratella tropica*. The importance

of copepods as food for the species was negligible as only nauplii were recorded in a few stomachs in low proportions. *M. micrura* and *D. excisum* were the dominant prey items ingested by fish less than 10 cm in length occurring in proportions of 13.8 to 66.5% in the stomachs of fishes below 10.0 cm respectively (Table 5). The two species were also found in the diet of the largest size class, 25.0-29.9 cm, in the proportions of 72.0 and

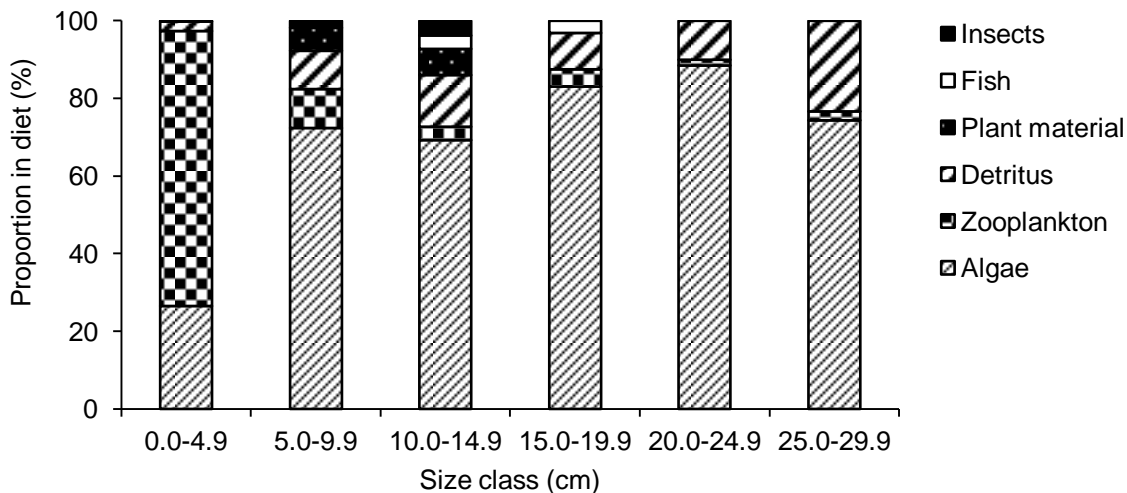


Figure 2. Diet composition of different size classes, by volume, of *O. niloticus* in Lake Baringo during the study period.

Table 5. Proportions of various zooplankton species in the diet of *Oreochromis niloticus* in Lake Baringo between April 2008 and March 2010.

Parameter	Size classes (TL cm)					
	2.4-4.9	5.0-9.9	10.0-14.9	15.0-19.9	20.0-24.9	25.0-29.9
<i>Moina micrura</i>	66.5	45.4			2.7	72.0
<i>Diaphanosoma excisum</i>	33.2	13.8		11.5	2.4	16.0
<i>Daphnia barbata</i>	0.3		74.6	40.5	81.3	12.0
<i>Brachionus patulus</i>		13.8	4.5	15.7	2.7	
<i>Keratella tropica</i>		13.1	5.4	19.9	6.2	
<i>Filinia opoliensis</i>			10.5		2.1	
Nauplii		8.5				
Others		5.4	5.0	12.4	2.4	

16.0% respectively.

The results exhibited a clear ontogenic shift with lower length groups feeding predominantly on *M. micrura* and *D. excisum* while larger classes feeding mainly on *D. barbata*. 56% of the lowest length class fed on the smallest prey, *M. micrura* which averaged 627 μm in length while 23.4% of the class fed on medium sized *D. excisum* with a mean length of 790 μm . These proportions decreased with increase in size of *O. niloticus* juveniles and in the 10.0-19.9 cm and 20.0-29.9 cm length classes the fishes were predominantly feeding on *D. barbata* which is a bigger prey. The mean length of *D. barbata* in the lake was found to be 1347 μm . It was also evident from the results that the smallest size group of *O. niloticus* had the narrowest spectrum of diet with *M. micrura* being the only selected zooplankton in the diet.

DISCUSSION

The absence of juveniles of *P. aethiopicus* in the fish

catches of Lake Baringo is not unique. Earlier studies in Lake Victoria basin revealed that small sizes of the species are rarely encountered in the open waters of lakes (Graham, 1929; Okedi, 1971; Mosille and Mainoya, 1988). The juveniles of the fish are believed to be found in matted roots of papyrus and may be limited to these habitats (Graham, 1929; Greenwood, 1966). While an earlier investigation in the lake had reported that *P. aethiopicus* show selective preference for fishes as food (Mlewa and Green, 2004), the present study shows that *P. aethiopicus* prefer feeding on molluscan diet. This corroborates the findings of Corbet (1961) in Lake Victoria. *P. aethiopicus*, which was introduced into Lake Baringo in 1975 and presently dominates the fish community, is mostly a benthic feeder and probably has no competitor. Moreover, while *O. niloticus* feeds by sight in the pelagic zone and is probably affected by the lake's high turbidity, *P. aethiopicus* feeds by groping at the bottom of the lake which molluscs inhabit. The success of *P. aethiopicus* may be as a result of the widespread dis-

tribution, albeit in low abundance, of molluscs in the lake (Muli et al., 2007).

Like *P. aethiopicus*, *C. gariepinus* also feeds by feeling and as such would be expected not to be affected much by the turbidity of Lake Baringo water. The species probably lacks strong jaws to utilize the available molluscs in the lake. Predation on zooplankton by adult *C. gariepinus* has also been reported by Dejen et al. (2004) in Lake Tana in Eritrea. The use of zooplankton as food by adult *C. gariepinus* in Lake Baringo is probably a pointer that the lake lacks alternative larger prey for the fish. Its wide, subterminal mouth enables it to suck in large amounts of water which is flushed through the gills for filter feeding. Efficiency of zooplankton capture is ensured by the large number of gill rakers which increase with size (Bruton, 1977). Dependence on zooplankton by the larger *C. gariepinus* results in competition with small-ler fish and *O. niloticus* which could result in the reduction of forage success. However, being a non-visual filter feeder, it is probable that the fish fed in areas with high density of the prey. In Lake George, Burgis (1973) found high densities of *D. barbata* just above the surface of mud, a habitat they probably also occupy in Lake Baringo.

That cladocerans are favoured, than the more abundant copepods, as prey by fish predators in Lake Baringo corroborates earlier studies. Zaret (1980) and O'Brien (1987) reported that zoopanktivorous fish often take cladocerans in preference to copepods perhaps because the latter have a more erratic mode of motion and are, as such, not easy to capture, a fact that could also explain the results of this study.

O. niloticus exhibited a richer floral and faunal dietary assemblage than the other species with algae being utilized in all the length classes. The general low numbers of zooplankton in the stomachs of *O. niloticus* could probably be attributed to turbidity of the lake water (Omondi et al., 2011) which reduces visibility of the predators and on feeding rythms. The lack of clear zooplankton species selectivity pattern could be due to importance of other food items. In the present study, it is suspected that due to the high turbidity, the species could heavily be relying on algal matter which dominated the diet of *O. niloticus*.

Conclusions and recommendations

The study reveals the importance of algae, mollusks, fish and higher plants as food for fish in Lake Baringo. It further showed that zooplankton forms an important item in the diets of *O. niloticus* and *C. gariepinus* with possible competition for the item, especially between adult *C. gariepinus* and juveniles of *O. niloticus*. The catches of *O. niloticus*, which once dominated Lake Baringo, have declined due to deteriorating water quality especially increasing turbidity. Besides reduction of the euphotic zone, the turbid water also reduces feeding efficiency of the fish which feeds by sight. *C. gariepinus* in the lake, on the other hand, lack suitable food due to low densities of

macroinvertebrates. The fish, particularly the adults, have thus taken to feeding on zooplankton especially *D. barbata* thus competing for prey with its juveniles and other fish species especially *O. niloticus* leading to reduced growth. *P. aethiopicus* which was introduced into the lake has flourished due to occurrence of mollusc in the lake for which there is no competition.

There is need to reduce siltation into the lake by rehabilitation of soil cover in the catchment of Lake Baringo. This would reduce turbidity in the lake with a result of increased productivity due to increased light penetration. Reduced turbidity would also culminate in increased macrophytic community, hence further increase in the lake's productivity. Considering the development projects coming up around the lake, there is also need to control pollution into the lake to prevent eutrophication.

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