

Spatial Variation in Food selection, Feeding Habits, and Ontogenetic Diet Shift of *Labeobarbus altianalis* (Boulenger, 1900) along River Nyando, Kenya

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Abstract

The food and feeding habits of *Labeobarbus altianalis* (Boulenger, 1900) was studied based on 170 gut samples collected along River Nyando, Kenya. This study was aimed at determining the spatial variation in feed and feeding habits of *L. altianalis*. Three sites S1 at upper region; S2 at mid region and S3 at lower region closer to the river mouth were sampled. Fish sampling was done using an electrofisher and identified in the field. The length and weight of *L. altianalis* were taken in the field to the nearest 0.1 g. The stomachs were gutted and then preserved in vials in 5% formalin for later examination of dietary components. Ten dietary groups were identified from the guts. There were significant variations in the proportion of the plant materials among the three sampling sites (Chi-square; $\chi^2 = 129.12$, $df = 20$, $P < 0.0001$). At S1, ephemeroptera, cladocera and detritus were the dominant food items because of their availability in the environment and a higher proportion of mature fish, while at S2 food materials were dominated exclusively by insects and diptera and at S3, plant materials, insects and diptera were more dominant. Gastropods plant seeds and algae were consumed by the fish but at low abundance at all the sampling sites due to lack of preference by the fish. At sampling sites there were strong negative electivity for rotifers and copepods by the fish. At S1, coleoptera and insects were positively selected while at site S2, there was negative electivity for plant materials, invertebrate taxa and gastropods. At S3, strong negative electivity was observed for algae, gastropod shells and cladocera with plant materials, coleopteran and detritus having positive selection.

Keywords: *Labeobarbus altianalis*, feeding habits, spatial variation, electivity index

INTRODUCTION

The Nyando River basin covers an area of 3517 km² of Western Kenya. The river basin drains into the Winam Gulf in Lake Victoria. River Nyando originates near Mount Tinderet and drains the central highlands west of the Rift Valley. The Nyando, which traverses the sugar belt region in Kenya, is apparently polluted by sugar factory effluent (Mugo & Tweddle, 1999). Species abundance and distribution in this river is strongly dependent on habitat type and prevailing conditions (Fayazi, Rahimi, Moradi, Ashtyani, & Galledari, 2006).

The riponbarbel (*Labeobarbus altianalis*) is a ray-finned fish species from East Africa in the family Cyprinidae locally known in Kenya as Fuani or Odhadho depending on the place. It has been found in Lakes and their drainage basins and surrounding areas in the East Africa, including Lakes Kyoga, Edward, Kivu and George (Ondhoru et al., 2017). It has also been reported in Rivers Ruzizi, and Kagera. It is an omnivore and often fished for sport and food while in Rwanda (Kagera River population) it is used for commercial purposes (De Graaf, Megens, Samallo, & Sibbing, 2007).

L. altianalis inhabits inshore waters and rivers and prefers sand and gravel substrate (Eccles, 1992). Juveniles stay in riverine habitats while adults inhabit diverse freshwater habitat which include both riverine and lacustrine habitats (Eccles, 1992). Gastropod molluscs are an important food item in the ecosystem, while insect larvae are of equal importance in hard bottom areas. Plants, fishes, and crustaceans are also eaten by *L. altianalis*. More plant material is consumed by juveniles (Witte & De Winter, 1995).

The fish is slow growing and therefore takes long to mature. Widespread and plentiful for such a large fish is attributed to its ecological tolerance and omnivorous habits. As a result of its widespread status, the Ripon barbel is not considered threatened by IUCN. However local stocks face a serious threat from siltation of aquatic habitats resulting into increased turbidity. According to De Graaf *et al.* (2007) erosion has seriously affected population of this species in Kagera River and must be addressed. Lack of reliable data could have informed IUCN position that does not consider this species threatened. However, recent developments on habitat destruction and fragmentations for example hydroelectric power projects in Sondu Miriu are real threats to this riverine species. *Barbus spp* have not been given the deserved attention despite their socio-economic, socio-cultural and ecological importance therefore it is of importance to re-evaluate existing information on the biology of *L. altianalis* (Chemoiwa *et al.*, 2013; Chemoiwa, Abila, Njenga, & Barasa, 2017; Witte & De Winter, 1995). The diet composition of fish may vary within wide ranges on temporal and spatial conditions and environmental factors (Cabana, Tremblay, Kalff, & Rasmussen, 1994). The major factors that influence fish diet are fish size, maturity, condition, season (water level), bottom, depth, latitude, longitude and habitat types (Persson & Crowder, 1998). In aquatic systems where the water levels in lakes and reservoirs have been known to fluctuate, the quality and abundance of food items for fish vary significantly through time (Cabana *et al.*, 1994). A particular characteristic of fish is that individuals increase in size during their ontogeny and this increment in size is correlated with changes in food quality and quantity in aquatic systems and growth varies according to food availability in the environment (Werner, 1988). Various authors have studied the food of '*Barbus*'. A study done on tributaries of the Luhoho River showed that the species *Labeobarbus altianalis* is a phytoplankton fish feeding mainly on diatoms (Bacillariophyceae), Cyanophytes, Chlorophytes and Euglenophytes in all sites considered and at all ages (Okite, 2017). Balirwa, 1979 studied the food of six cyprinid fishes in Lake Victoria basin and found out that all the species possess tubular stomachs and that the species are omnivorous and their food ranges from debris, diatoms through algae, insect larvae to mollusk. Most fish undergo an ontogenic shift in diet. The ontogenic change in diet may be due to an interaction of changes in external factors (e.g. habitat, food supply, predation risk) and internal conditions (anatomical structures, behaviour, physiological demand) (Luczkovich, Norton, & Gilmore, 1995). Ontogeny diet shift has been shown to occur during the life of many fish species and prey size is generally positively correlated with fish size (Desta, 2007). A fundamental characteristic of fish is that individuals increase considerably in size, which is usually associated with changes in food resource use.

MATERIALS AND METHODS

Study Area

The study was conducted along River Nyando within Lake Victoria basin, Kenya. River Nyando partly originates from Mau Complex and drains a catchment of high agricultural potential dominated with several agro-based industries such as coffee and sugar factories. The River Nyando is one of the rivers flowing into the Lake Victoria in Kenya and is polluted in some stretches by

sugar factory effluent. The various habitats and altitudes along this river is easily accessibility by road.

Three stations were marked along the river to represent up-stream, mid-stream and downstream habitats (Figure 1). Station 1 denoted as S1 was at Fort Tenan Bridge (latitude -0.21208 and longitude 35.30047). This station was picked to represent the upstream habitat of the river. The second station (S2) which was the mid-stream was at Chemelil bridge (latitude -0.1466, longitude 35.12586) while the downstream habitat was represented by S3 (latitude -0.17222, longitude 34.9208) located at Ahero Bridge.

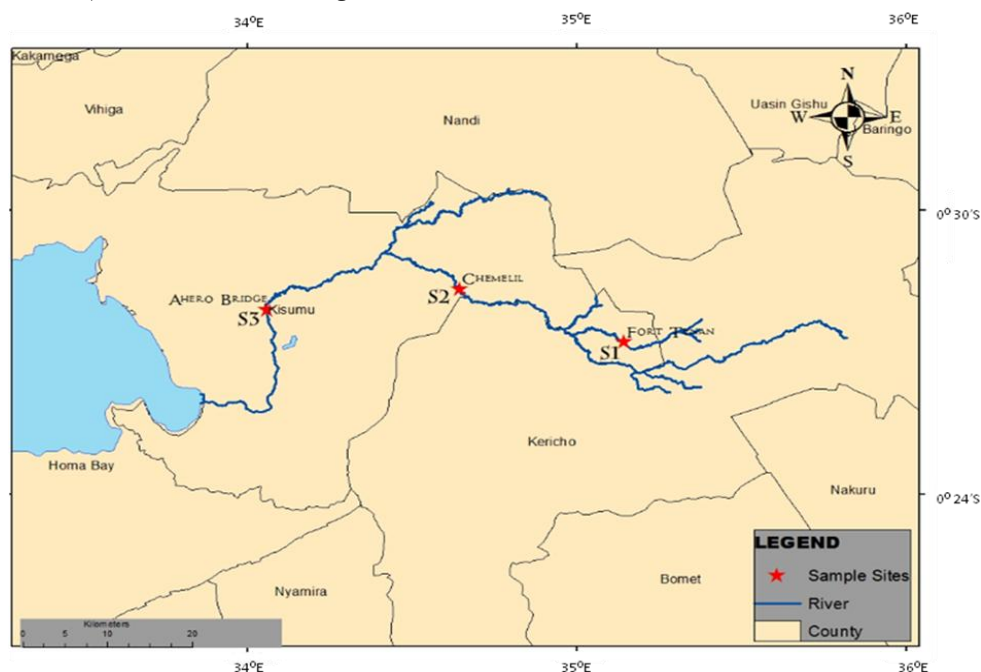


Figure 1: Map showing River Nyando and the sampling stations

Sampling Collection

Sampling was done monthly for six months from Dec 2014 to May 2015. Fish samples were obtained using an electrofisher which quickly immobilized fish and caused minimal habitat disturbance. The generator was a Honda GX 240 8 HP that produced a current at 400 V and 10 A. The electro-fishing exercise was carried out for a timed period, between 15 and 20 minutes per site, depending on water depth, terrain and catches. This allowed enough time for a 50m span of operation upstream and downstream of the generator. At each site location data (GPS readings) and physical characteristics were noted. As soon as the fish were landed, they were counted and identified using morphological characteristics. The non-target species were returned into the river whereas the *L. altianalis* were weighed to the nearest 0.1g using a potable weighing balance. The Total Length (TL) of the fish was measured from the tip of the anterior part of the mouth to the caudal fin and standard length (SL) was measured from the rostral tip of the upper jaw to the origin of the caudal fin. The TL and SL were measured using a meter rule calibrated in centimeters.

Stomach Contents

Sample representatives of *L. altianalis* were gutted and each stomach contents put in a separate vial with labels indicating label, the site collected and collection date. The stomach contents were fixed in 5% formaldehyde. Stomach samples were then taken to the Kenya Marine Fisheries Research Institute (KMFRI) laboratory in Kisumu for analysis. In the laboratory, the peritoneum was removed from the stomachs and examined under a binocular 16 dissecting microscope. Empty or highly digested stomachs were excluded. The relative percentage for each food item in each stomach was recorded. The stomach contents were separated into ten broad categories: sand and/or pebbles (pebbles), terrestrial vegetation or seeds (plant material), Ephemeroptera, Tricoptera, Diptera and Odonata larvae (insect larvae) Isoptera, Odonata and Hymenoptera adults (adult insects), bird feathers (birds), earthworms (annelid), fish, crabs, silt and detritus. Analysis of stomach contents was based on percentage occurrence of dominant food items where more than 50% was considered to be most abundant, 20-50% abundant and less than 20% rare (Ogari & Dadzie, 1988; Okach & Dadzie, 1988).

Data Analysis

All the data generated from the sampling was entered into excel spreadsheet for the purpose of management and storage. All statistical analysis was done using Statistical Package for Social Sciences (SPSS version 17.0) and Minitab version 15 software for windows. Significance was accepted at $P < 0.05$. All the fish sampled were put in categories depending on sizes. The proportions of food items were averaged for every sample and size category per sampling station. The proportions of each food item was represented in tables and compared between stations. The following statistical tests were used:

Numerical abundance (%N) was used to ascertain the diet of the fish and was computed using the formula;

$$\text{Numerical abundance (\%N)} = (N_i / \sum N_i) * 100.$$

(N_i represents the number of food items counted in the stomach, $\sum N_i$ the total number of items counted in all stomachs.

Selectivity of food items by *L. altianalis* was estimated using the Ivlev's index of electivity (E) (Strauss, 1979).

$$E = \frac{r_i - p_i}{r_i + p_i}$$

Where r_i = proportion of a food item in the stomach of the fish.

p_i = proportion of the food item in the water sample

Electivity values determined using this index have a possible range of -1 to +1. Values closer to +1 indicate preference whereas values closer to -1 indicate avoidance of prey. Zero electivity indicates that the prey is being eaten in the same proportion to their availability in the environment.

Chi-square test was applied in determining diet disparities per sampled sites and within the different sampled size classes. The food items that were found in the guts were categorized into different taxonomic groups and the volume of each group was measured (Bowen, 1983). Then the volume of a given category of food items was expressed as a percentage of all the categories of food items present in the samples. The importance of different food items for different size classes was determined by dividing the fish into four size classes (I- < 20.0 cm TL, II-20.0-29.9 cm TL, III-

30.0-39.9 cm TL and IV- > 40.0 cm TL) and determining percentage mean volume of food in each size class.

Water quality parameters were summarized in a table as mean $\pm$ SE for each sampling station and spatial variation tested using one-way ANOVA at 95% confidence level. A correlation analysis was further performed to test the relationship between water quality parameters and condition factor and fish size.

RESULTS

Food of *Labeobarbus altianalis*

Diet composition was analyzed in 170 samples of *L. altianalis* stomachs and their surrounding environment from each sampling station and is shown in Table 1. The most abundant food items at station 1 were detritus (%N = 24.8), Ephemeroptera (13.2), plant materials (12.2) and Rotifers (11.2) for Station 2 the most abundant were (%N=36.7), Insects (35.3) Plant materials (5.80) and Gastropod shells (4.50) and Station 3 most abundant were (%N =39.7), Insects (19.6) Plant materials (13.4) and Detritus (6.2). Coleoptera (≤ 3.2), Gastropod shells (≤ 4.5) and Copepods (≤ 3.5) had low abundance at all the three sampling sites.

Table 1: Food items expressed as percentage contribution by number (%N) in the environment of *Labeobarbus altianalis* at the three sampling sites along River Nyando

Food items	Numerical abundance (%N)		
	S1	S2	S3
Plant materials	12.2	5.8	13.4
Algae	7.2	3.2	2.5
Ephemeroptera	13.2	2.2	2.3
Coleoptera	1.8	1.3	3.2
Cladocera	7.8	3.2	2.5
Plant seeds	8.9	2.4	2.9
Insects	2.2	35.3	19.6
Diptera	5.1	36.7	39.7
Gastropod shells	2.1	4.5	3.2
Detritus	24.8	3.9	6.2
Rotifers	11.2	0.0	2.4
Copepods	3.5	1.5	2.1
Total	100	100	100

Out of the twelve different dietary groups in the environment, ten were in the fish stomach and they included: Algae plant materials, invertebrate, classes mainly ephemeroptera, coleopteran, diptera and insects, gastropods, and detritus as shown in Table 2. There were significant variations in the proportion of the plant materials among the three sampling sites (Chi-square; $\chi^2 = 129.12$, df = 20, $P \leq 0.0001$). At site S1, ephemeroptera (17.1), cladocera (10.7) and detritus (31.1) were the dominant food items, while at S2 the food materials were dominated exclusively by insects (41.3) and diptera (43.1) missing food items were Ephemeroptera, Coleoptera and Cladocera at (0.00) and at S3, plant materials (24.8), insects (15.9) and diptera (32.7) were more dominant. Algae was missing at (0.0). Gastropod shells (≤ 1.7), plant seeds (≤ 7.8), algae (≤ 4.2) and unidentified materials (≤ 3.7) were consumed by the fish but at low numerical abundance at all the sampling sites.

Table 2: Diet composition expressed as percentage contribution by number (%N) in the guts of *Labeobarbus altianalis* at the three sampling locations along River Nyando

Food items	Numerical abundance (%N)		
	S1	S2	S3
Plant materials	7.8	3.4	24.8
Algae	4.2	3.1	0.0
Ephemeroptera	17.1	0.0	2.1
Coleoptera	7.4	0.0	4.4
Cladocera	10.7	0.0	1.6
Plant seeds	7.8	3.2	5.6
Unidentified Insects	5.8	41.3	15.9
Diptera	5.2	43.1	32.7
Gastropod shells	1.7	1.3	1.6
Detritus	31.1	3.1	7.6
Unidentified materials	1.2	1.5	3.7
Total	100	100	100

Ivlev's electivity index for the three sampling sites shows large variations. At all the sampling sites there were strong negative electivity for rotifers and copepods. At site S1, coleoptera and insects were positively selected while at site S2, there was strong negative electivity for invertebrate taxa (EPT) and gastropods. At S3, very strong negative electivity was observed for algae, with plant materials, coleopteran, plant seeds and detritus having a positive selection as shown in Figure 2.

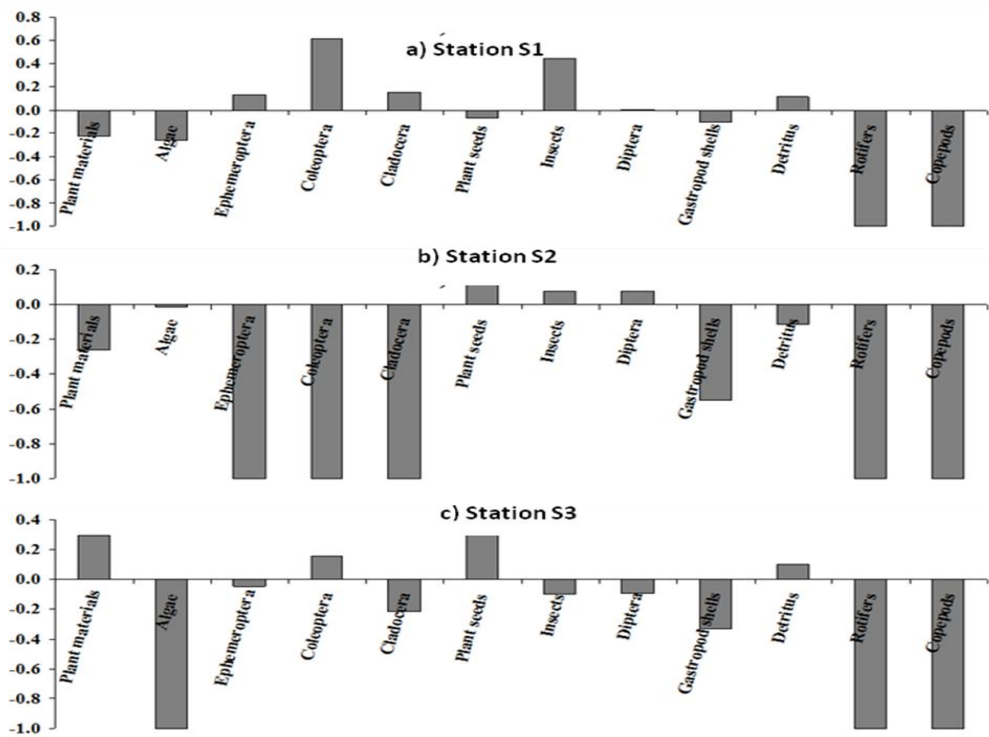


Figure 2: Ivlev's electivity index for pooled data in the three sampling locations

Ontogenetic Shift in Food for *L. altianalis*

The diet of the *L. altianalis* showed significant variation as per the classes and among the sampling locations (Chi-square; $\chi^2 = 89.121$, $df = 18$, $P < 0.0001$). At site S1, plant materials and crustaceans (cladocera) proportions of molluscs increased with respect to size class on the other hand detritus and algae reduced with increase in size class at S2 Diptera and Detritus reduced with increase in size class whereas Insects and plant materials increased with respect to size class at S3 Detritus and Diptera and coleoptera reduced with increase in size class on the other hand insect and plant materials increased with respect to size class. Cannibalism increased with their size class

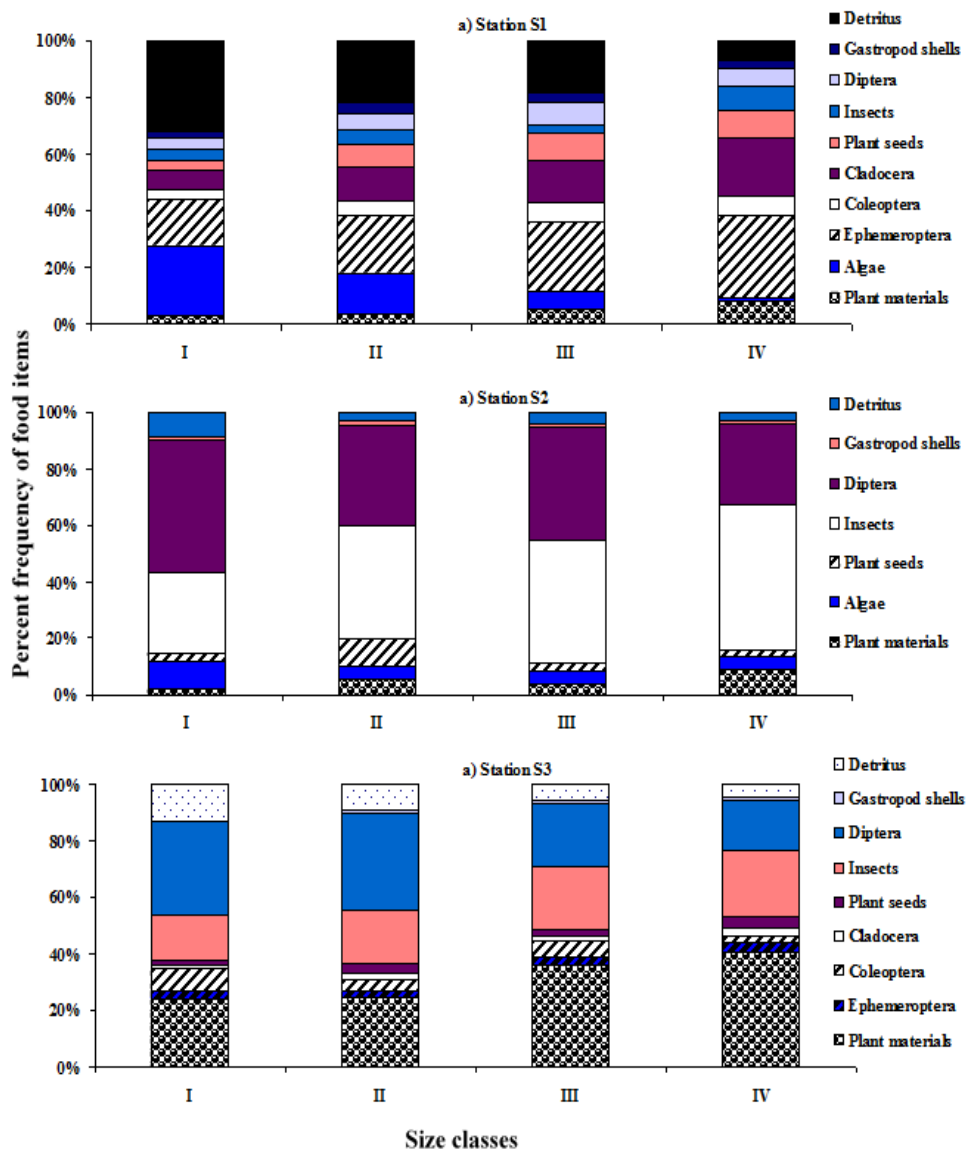


Figure 3: Ontogenetic shift in the diet of *Labeobarbus altianalis* at the three sites in River Nyando

DISCUSSION

Feeding habits of *Labeobarbus altianalis*

From this study ten different dietary groups were recognized. These were: herbaceous plant materials, algae, invertebrate classes mainly ephemeroptera, coleopteran, diptera and insects, gastropods, and detritus. There were significant variations in the proportion of the plant materials among the three sampling sites.

Past research on *L. altianalis*, has shown that it is an omnivorous fish whose diet consists of algae dominated detritus, plant material, mollusks, chironomids and cardis fly larvae (Balirwa, 1979; DeStefano & DeGraaf, 2003; Tómasson, Cambray, & Jackson, 1984). Research in River Nzoia, showed almost the same results that the gut contents of this species show a diet predominated by algae and followed by higher plant material. Insects formed the third most common food. Other items which may be ingested with more or less the same frequency are insects, Ephemeroptera, insect larvae and debris.

From this study the change from one food type in one site to a different type in another is especially necessary for the survival of this species which migrates up affluent rivers for breeding purposes. Diet studies of big barbs from other inland waters of Africa and Asia have been shown to be omnivorous and the fish is able to change its diet depending on availability of prey, seasonal and spatial differences Admasu *et al.*, (2001). Algae and higher plants are likely to be more abundant in riverine than in lacustrine habitats and this was observed by the presence in S3. It is therefore unlikely that algae and higher plants can be limiting. In riverine conditions, rather, animal life might be more restricted.

L. altianalis indicates that the species are versatile feeders, utilizing favoured foods when they are available and changing to others when occasion demands. At site1the predominance of ephemeroptera, cladocera and detritus could be attributed to its availability and abundance in the environment so that fish could not utilize a lot of energy searching for it. The two food items that dominated were insect remains and diptera which is attributed to its availability in the environment. This could be attributed to the effects of pollution by the factories around like chemelil and also erosion as there is a lot of farming along the river banks.

As per electivity index S1 Coleoptera and insect were positively selected, which could be attributed to domination of Mature/ripe and maturing fish that are able to feed on the food and they preferred it. In S2 Plant materials, Invertebrate taxa and gastropods were negatively selected, which could be because the fish did not prefer the food and so could not feed on them. At S3 very strong negative electivity was observed for algae with plant seeds and detritus having positive selection immature fish were more here Demeke Admassu (1997) found out that *Barbus* sp fed on a variety of food and that the composition of the food items varied with the size of fish Some other study on *Barbus* by Corbet (1961) in Lake Victoria demonstrated that there was a shift in diet of the fish with its size increase

Ontogenic shift according to classes and among stations showed that at site S1, plant materials, crustaceans (cladocera) and molluscs increased in proportion with respect to size class while algae and insects showed opposing trends. It is also noted that cannibalism increased with size class at S2 insect remains increased in proportion with class size and was dominant in this station in S3 plant materials increased with class size as AntjeBischoff *et al.*, (1997) research on *Barbus barbus* observed ontogenetic shifts in diet between the fish at different stages of their development

CONCLUSIONS AND RECOMMENDATIONS

Fish diet varied with size of fish and there was selection of specific food among the stations along River Nyando. *L. altianalis* species are versatile feeders, utilizing favoured foods when they are available and changing to others when occasion demands. Rotifers and copepods were avoided by this fish species; the two food items that dominated were insect remains and dipteran. Also, this is attributed to availability in the environment. More studies should be done along other rivers draining to Lake Victoria basin for informed management and conservation issues.

ACKNOWLEDGMENTS

This study was funded through a National Commission for Science, Technology and Innovation (NACOSTI) PhD grant 2011 to E.J.C. Our sincere appreciation to the staff at Kenya Marine and Fisheries Research Institute-Kisumu (KMFRI), especially Deputy Director, Dr. William Ojwang for allowing us to use various research facilities. We also acknowledge the logistical support provided by the technologist at KMFRI, Kisumu Research Centre led by Mr. Z. Awuondo and Patrick Orwa. The authors are also grateful to the anonymous reviewers for their critical comments on the manuscript.

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