academicJournals

Vol. 9(4), pp. 53-61, April 2017
DOI: 10.5897/JENE2016.0608
Article Number: 6B3ABFC63783
ISSN 2006-9847

http://www.academicjournals.org/JENE

Journal of Ecology and the Natural Environment

Full Length Research Paper

"Diet analysis of the African clawless otter (*Aonyx capensis*) in and around Lake Tana"

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Received 11 September, 2016; Accepted 7 February, 2017

The diet composition of the *African clawless otter* (*Aonyx capensis*) was studied by analyzing of 440 spraint samples collected during January, 2014 and December, 2015 in both dry and wet seasons from eight sites in and around Lake Tana, North West Ethiopia. Percentage frequency of occurrence and relative percentage frequency of diet items in the spraint samples were calculated.The statistical analysis was conducted using chi-square and one-way ANOVA tests.The number of diet categories per spraint ranged from 1 to 4 with a mean of 1.42 ± 0.591. Fish was the dominant prey item in all sites with an overall frequency of occurrence of 84.77% and a relative percentage frequency of 59.68%. *Labeobarbus* spp. was the most frequent fish prey (35.45%). Crabs were the second most frequent prey items with percentage frequency of 33.41% and a relative percentage frequency of 23.52%, while small mammals and birds were the least frequent dietary items with percentage frequency of 0.45 and 0.23%, respectively. Other identified diet items and the respective percentage frequency were plant matter (6.17%), insects (5.68%), amphibians (5%), mollusks (2.5%) and unidentified items (3.86%). Variation on fish and crab prey items were observed between seasons and sites, while no variation was observed for other prey items. The results suggested a dietary flexibility and shift in the *African clawless otter* from crabs to fish that can be explained by availability and accessibility.

Key words: African clawless otter, *Aonyx capensis*, food items, Lake Tana.

INTRODUCTION

Otters belong to Order Carnivora,Family Mustelidae, Sub-family Lutrinae characterized by long streamlined bodies, fine dense hair and scent glands at the base of the tail (Kruuk, 2006). They are a unique group among carnivores due to their adaptation to semi-aquatic mode of life (Foster-Turley, 1990). Otters obtain most of their

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food from water, whereas reproduction and resting take place on land (Mason and Macdonald, 1986). They are one of the top predators of aquatic ecosystems and key-stone species of wetland environments (Mason and Macdonald, 1986; Ottino and Giller, 2004).

There are 13 extant species of otters of which three are limited to Sub-Saharan Africa (Nel and Somers, 2007). These are the Congo clawless otter (*Aonyx congicus*) limited to the Congo basin; the *African clawless otter* (*A. capensis*) occurring in most parts of western, eastern and southern Africa and the Spotted-necked otter (*Lutra maculicollis*) occurring in most parts of western, central and south-eastern Africa (Nel and Somers, 2007). The latter two species are found in Ethiopia (Yalden et al., 1996).

The *African clawless otter* is listed as 'Near Threatened' in the IUCN Red List for habitat loss (Jacques et al., 2015). It is the most widely distributed otter species in Sub-Saharan Africa ranging from Senegal in the west and Ethiopia in the east; also extending to southern Africa, but not in the central African rainforest region of the Congo Basin and arid areas (Rowe-Rowe and Somers, 1998; Kruuk, 2006; Nel and Somers, 2007; Jacques et al., 2015).

The African clawless otter is adapted to feed on crustaceans using its large molars and premolars for crushing the exoskeleton of its prey (Hussein et al., 2011). In freshwater habitats, the African clawless otter is generally regarded as crab eater, but it also consumes a variety of items including fish, amphibians, reptiles, aquatic insects, worms, crustaceans, birds and small mammals (Row-Rowe, 1977; Rowe-Rowe and Somers, 1998). According to Kingdon (1977), freshwater crab is an important prey of African clawless otters in most areas, but in some marshes, mussels and large aquatic snails may be more common prey item, while in swamps and rivers fish are also important prey items. Other food items, such as amphibians, water fowl and their eggs, monitor lizards, crocodile eggs, cane rats and other rodents are also consumed (Kingdon, 1977). Generally, African clawless otters are regarded as crab eaters, but in some areas, where crustaceans are absent or rare, fish was the dominant food item (Watson and Lang, 2003).

The diet of African clawless otter has been studied by Kruuk and Goundswaard (1990) in Lake Victoria, Butler and du Toit (1994) in Zimbabwe, Rowe-Rowe (1977), van der Zee (1981), Verwoerd (1987), Perrin and Carugati (2000), Somers (2000), Somers and Nel (2003), Watson and Lang (2003), Jordaan et al. (2015) in South Africa and Ogada (2006) in Kenya. However, scientific data on the ecology of the species in Lake Tana is not available and elsewhere in Ethiopia is not available. A recent study conducted by the authors in Lake Tana suggested the presence of fishermen-otter conflict.

According to this study, all 204 fishermen interviewed felt that otters cause conflict by depredating netted fish and damage of fish nets. As a result, the fishermen expressed negative attitude towards otters (Ergete et al., 2016, unpublished data). Due to the complete lack of research and conservation attention on these populations, the potential conflict with fishermen could go unnoticed and result in adverse effect. Thus, the objective of this study was first; to add on the available data on the feeding diet of *African clawless otter* in African. Our current knowledge is inconclusive and mainly based on research conducted on South Africa populations (van der Zee, 1981; Verwoerd, 1987; Perrin and Carugati, 2000; Somers, 2000; Somers and Nel, 2003; Watson and Lang, 2003; Jordaan et al., 2015). We attempted to test if crabs are the preferred prey as observed in previous studies (Rowe-Rowe, 1977; Nowak, 1991; Butler and du Toit, 1994; Lavriviere, 2001; Carugati and Perrin, 2003; Somers and Nel, 2003) or there is a potential to shift to other prey such as fish as reported in others (Verwoerd, 1987; Somers, 2000). Second, the otter is one of the neglected species research and conservation wise in Ethiopia. This study attempted to generate data on the diet of the *African clawless otter* and explored if fish are the dominant diet in Lake Tana. By highlighting the importance of fishermen-otter conflict, we attempted to attract research and conservation attention towards this population.

MATERIALS AND METHODS

The study area

Lake Tana is located in the North-western part of the Ethiopian Highlands about 565 km from the capital Addis Ababa, at coordinates 11°36'02.5'' and 12°14'25.5''N and 37°01'33.6" to 37°24'03"E (Figure 1) at an altitude of 1785 m asl (Poppe et al., 2013). It is Ethiopia's largest lake and a source of the Blue Nile, which contributes for around 85% of the river's water (Dejen et al., 2009; Getahun and Dejen, 2012). The total surface area of Lake Tana is around 3150 km² with a catchment area of 16,500 km^2 (Dejen et al., 2009) stretching approximately 84 km long and 66 km wide. It is a shallow non-rift valley lake with an average depth of 8 m and maximum of 14 m. Lake Tana is also a reservoir of half of the country's freshwater resources (Dejen et al., 2009). There are seven permanent rivers; Gilgel Abay (Little Abay), Megech, Gumara, Rib, Geleda, Arno-Garno and Dirma Rivers that feed the lake (Lamb et al., 2007; Heide, 2012). The Blue Nile (locally called '*Abbay*') River is the only outflow at the southern tip of Lake Tana. The climate around Lake Tana and its associated wetlands is of warm-temperate tropical highland monsoon with little mean annual temperature variation throughout the year (19°C in December to 23°C in May with an average of 21.7°C) (Heide, 2012). The rainfall pattern is unimodal and the mean annual precipitation ranges between 800 and 2000 mm with peaks between July and September (Dejen et al., 2004).

Methods

The universal method for obtaining information on the diet

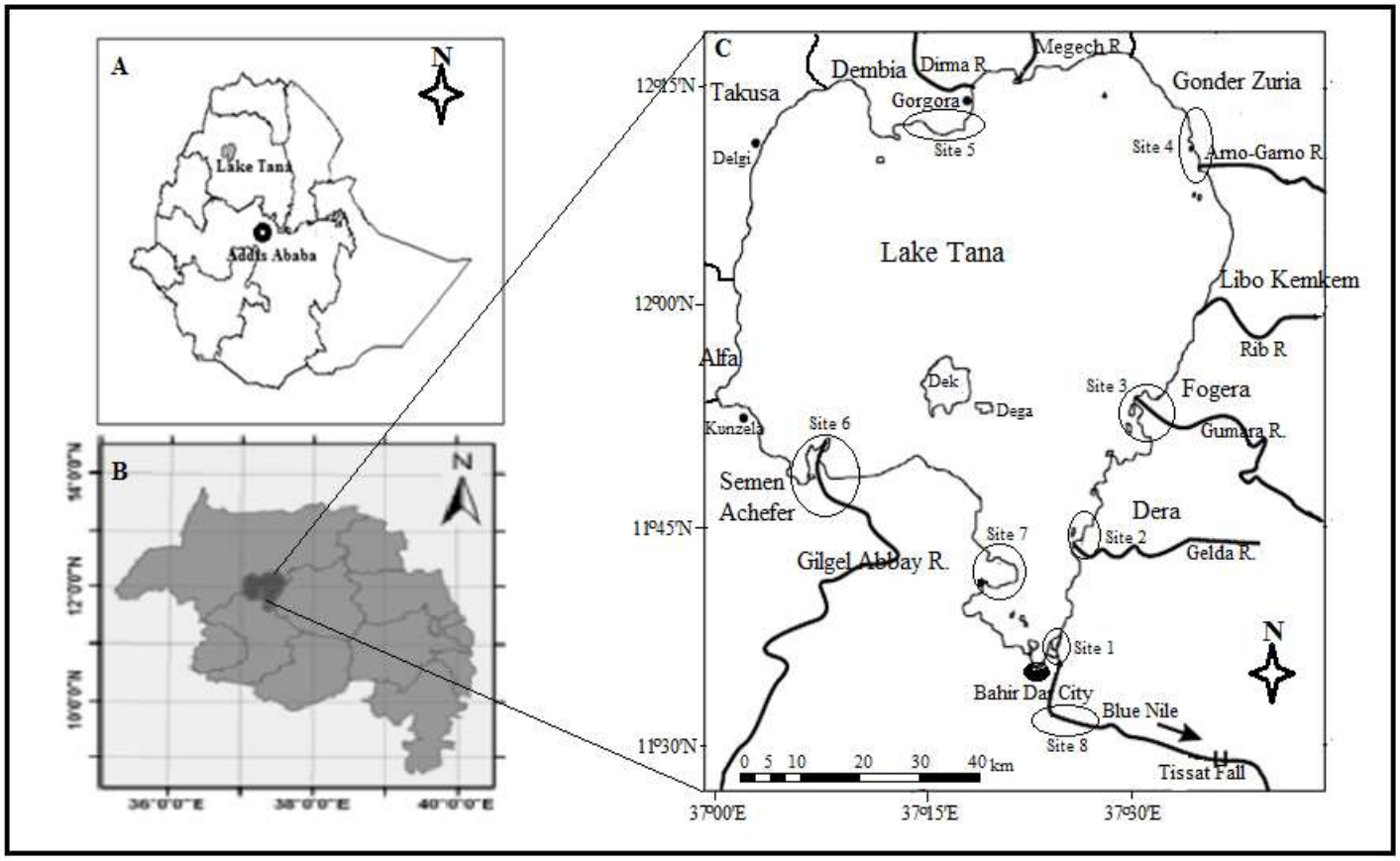

Figure 1. Map of (A) Ethiopia showing the location of Lake Tana, (B) Amhara Regional State and (C) Lake Tana showing the major tributaries and the out flowing river Blue Nile and the eight spraint sample collection sites.

composition of otters is based on the identification of prey remains in the spraints, because most parts of the skeleton of prey are left undigested (Kruuk, 2006).Aiso the *African* clawless otter is shy and nocturnal, thus spraint analysis is the most feasible option of studying its diet. A total of 440 spraints from eight sites were collected for two years between January, 2014 to December, 2015 for both wet (June - September) and dry (November - May) seasons. The sampling sites were described and distributed along the shore of Lake, on the Lake Islands and the main river systems of the Lake (Figure 1 and Table 1). Spraints of the *African clawless otter* were identified from related species in the area such as the spotted-necked otter (*Lutra maculicollis)* and the marsh mangoose (*Atilax paludinosus)* based on their large size, strong odor deposition shape and substrate (Rowe-Rowe, 1977). Spraints were collected from common latrines, den entrance and wallowing sites. Time and date, location, season, habitat feature and substrates were recorded for each spraint. Spraints were air dried and stored in polyethylene plastic bags until analysis.

Spraints were analyzed at the Zoology Research Laboratory of the Department of Zoological Sciences, Addis Ababa University following Somers and Nel (2003). They were soaked in liquid detergent overnight in 250 ml of beaker to remove sand, debris and other binding mucilages. Then, the samples were washed under running water by using an iron sieve of mesh size 500 µm and carefully transferred to a sheet of paper and left for 24 h to dry at room temperature. Prey remains from the cleaned spraint were examined by using a hand lens and stereo microscope.

The prey items were categorized as fish, crab, amphibian, mollusc, bird, small mammal, insect, plant matter and unidentified item. Crabs, mollusks and insects were identified based on their characteristic exoskeletons. Fish remains were identified mainly by the shape of vertebrae, scales, otoliths, operculae, jawbones, teeth and pharyngeal bones. Amphibians were identified from sacral vertebra and ilium bones; birds by their feathers; and small mammals from fur, and heterodont dentition. Obliterated items which were difficult to put under any of the above prey groups were categorized as unidentified. A reference collection including photos was made of the bone of the fish items for further identification. Fish species were identified based on presence/absence of scale and dentition. Members of the Family Clariidae have no scales. Cichilidae have small scales. Cyprinidae lack teeth on their jaws but possess pharyngeal teeth. Also, they have large scales. The two genera in Cyprinidae were identified based on scale patterns. A Guide book on the fishes of Lake Tana (Getahun and Dejen, 2012) was used as a reference in the taxonomic identification of the fish items.

Data analysis

The diet composition was analyzed using frequency of occurrence which is the total number of occurrence of a food item, percentage

Table 1. Location and discription of sampling sites in and around Lake Tana.

Sampling site	Location	Lake shore and river bank habitat type description
Site 1	Debremariam island, Shum Abo and Cherechera	Dominated by forest vegetation, reed beds and rocky habitats densely covered by shrubs, trees and reed beds
Site 2	Bet-Menzo islets, Korata area and including Geleda River	Sites characterized by short grass, pasture as well as cultivated land and Rocky areas covered by vegetation
Site 3	Tana Kirkos peninsula, Wagetera and Gumara River	Site densely covered by vegetations, grass, farm lands, rocky areas, wetland and reed beds
Site 4	Mitreha Abaworka and Arno-Garno River	Farm land and wetlands are common and covered by grass and cultivated land
Site 5	Gorgora	Rocky shore with vegetation, farmland, wetlands as well as reed beds
Site 6	Gilgel Abbay and its Delta	River banks covered by farmland, pastureland, wetlands, and densely covered by shrubs, trees, reed beds and rocky areas
Site 7	Zegie Peninsula including Yeganda and Ambo Bahir wetlands	Sites covered by farm lands, forest vegetation with rocky as substrate, grasslands, wetlands, as well as reed beds
Site 8	Blue Nile River	Riverine forest vegetations, rocky, reed beds are common

frequency of occurrence and relative percentage frequency of occurrence of each food item. The percentage frequency of occurrence of the prey item was calculated as:

$PF = [(n_i/N)*100]$

Where: n_i = the number of spraints in which the i^{th} item occurred;

N = the total number of spraints.

The relative percentage of frequency, of occurrence was given as

: $RPF= [n_i/\sum (n_i+n_{ii}+...n_x)*100]$

Where: RPF = Relative percentage of frequency;

n_i = frequency of occurrence of the i^{th} item;

$\sum (n_1+n_2+...n_x)$ = the sum of the frequency of occurrence of all item.

The difference in the number of diet items per spraints were compared using the Chi-square nonparametric test. The seasonal variation in occurrence of diet categories and the spatial variation of occurrence of the two dominant diet items, fish and crab, between the eight sampling sites, were compared using one way ANOVA. Post hoc Tukey test was used to determmine the level of significance in seasonal and spatial variation. For all tests, the significance level was determined at the 95% confidence interval.Data were analyzed on SPSS statistical software ver. 20.

RESULTS

Diet composition

A total of 440 spraints of the *African clawless otter* were collected from the eight sampling sites. More samples were collected during the dry season (242) than the wet season (198) and the difference was significant (χ^2 = 4.40, df = 1, P < 0.05) (Table 2). Nine prey categories (fish, crab, amphibian, mollusk, bird, small mammal, insect, plant matter, and unidentified) were identified from the spraints with a mean number of 1.42 ± 0.591 prey types per spraint. Most of the spraint samples (>63%) contained a single prey item while less than 1% of the samples contained four items and none of the spraints contained more than four items. The difference in number of diet items per spraint was significantly different in both seasons (χ^2 = 444.49, df = 3, P < 0.05) (Figure 2). Fish was the dominant diet with overall percentage frequency of 84.77%. Cyprinidae was the most frequent fish family (46.36%) *Labeobarbus* spp. was the most common fish species in the diet (35.45%). Other fish species in the diet were *Clarias gariepinus* (Family Clarridae, 17.04%) and *Oreochromis niloticus* (Family Cichlidae, 21.36%) (Table 3). Crabs were the second important prey items with percentage frequency of 33.41%. The remaining prey groups had an overall contribution of less 10% with small mammals and birds being the least frequent dietary items (0.45 and 0.23% respectively) (Table 3).

Seasonal variation

The percentage frequency of fish was significantly higher during the wet season (96.97%) than the dry season (74.80%) ($F_{1\ 438}$ = 45.600, P < 0.05), while crabs showed

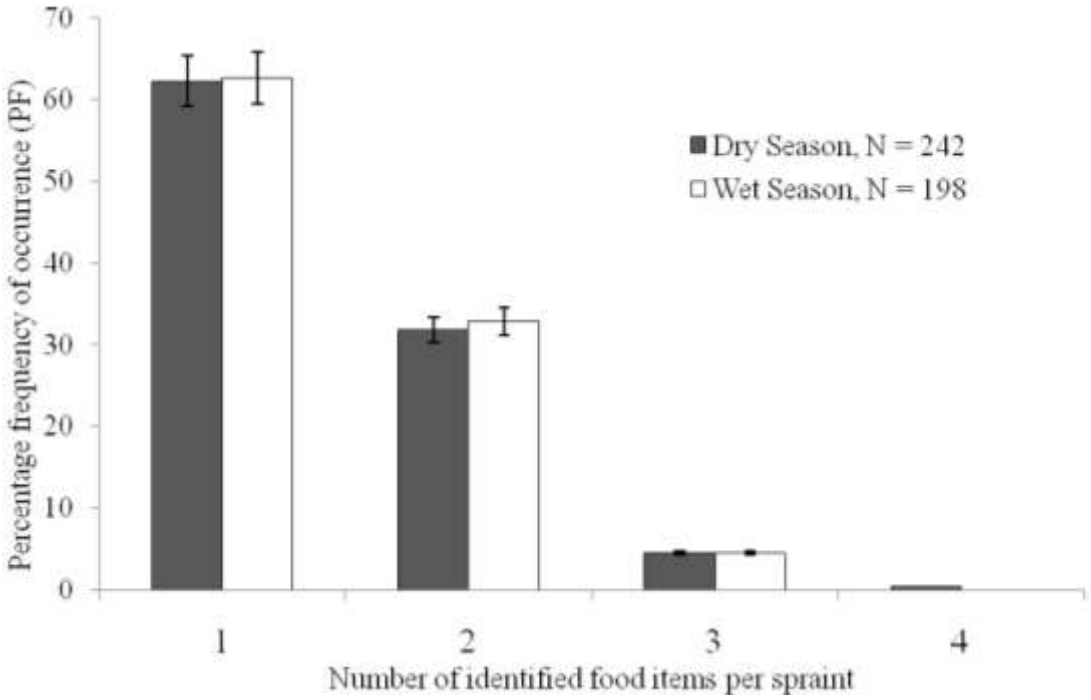

Figure 2. Number of diet items per spraint during dry and wet season.

Table 2. The number of spraints of *Aonyx capensis* collected from eight sampling sites during the wet and dry seasons.

Seasons	Sampling sites								Total
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	
Wet	21	15	22	20	17	57	23	23	198
Dry	46	31	18	23	19	51	27	29	242
Total	67	44	40	43	36	108	50	52	440

significantly higher percentage occurrence during the dry season (40.50%) than the wet season (24.75%) ($F_{1\ 438}$ = 12.428, $P < 0.05$). Amphibians showed the reverse trend decreasing from 8.08% in the wet season to 2.48% in the dry season ($F_{1\ 438}$ = 7.280, $P < 0.05$), (Table 3). Birds and mammals were missing from the dry season samples while the remaining (mollusks, insects, plant matters and unidentified) items occurred in both seasons with no significant seasonal variation ($P > 0.05$) (Table 3).

Spatial variation in diet composition

Birds and small mammals diets were restricted to one and two sampling sites respectively while the remaining items were common for all the sampling sites (except molluscs which were not recorded from three sites) (Figure 3). Fish showed a significantly highest frequency of occurrence in site 6 (93.52%) and lowest in site 1 (73.13%) ($F_{7\ 432}$ = 2.765, $P < 0.05$). Tukey test showed significance difference between Site 6 and 1 while there was no difference with the rest. The difference in percentage frequency of occurrence of crabs was also showed significantly spatial variation with highest value from site 1 (52.24%) and lowest from site 6 (14.81%) ($F_{7\ 432}$ = 5.777, $P < 0.05$). Tukey test showed significant difference between site 1, 4 and 6 (Figure 3). The other diet items did not show significant variation in their percentage frequency of occurrence among the sampling sites ($P > 0.05$) (Figure 3).

DISCUSSION

The results showed that the diet of the *African clawless otter* is composed of a broad trophic niche. Similar

Table 3. Occurrence (O), percentage frequency of occurrence (FO) and relative frequency of occurrence (RFO) of food items in the spraints of the African clawless otter during dry and wet seasons in and around Lake Tana.

Prey type	Wet (N = 198)	Dry (N = 242)	Overall O (PF)	RFO
	O (PF)	O (PF)		
Fish	192 (96.97)	181 (74.80)	373 (84.77)	59.68
Clarridae (*Clarias gariepinus*)	40 (20.20)	35 (14.46)	75 (17.04)	(12.00)
Cichilidae (*Oreochromis niloticus*)	52 (26.26)	42 (17.36)	94 (21.36)	(15.04)
Cyprinidae	100 (50.51)	104 (42.96)	204 (46.36)	(32.64)
Barbus spp.	25 (12.63)	23 (9.50)	48 (10.91)	(7.68)
Labeobarbus spp.	75 (37.88)	81 (33.47)	156 (35.45)	(24.96)
Crabs	49 (24.75)	98 (40.50)	147 (33.41)	23.52
Amphibians	16 (8.08)	6 (2.48)	22 (5.00)	3.52
Mollusks	3 (1.52)	8 (3.31)	11 (2.50)	1.76
Birds	1 (0.50)	0	1 (0.23)	0.16
Small mammals	2 (1.01)	0	2 (0.45)	0.32
Insects	16 (8.08)	9 (3.72)	25 (5.68)	4.00
Plant matters	16 (8.08)	11 (5.55)	27 (6.17)	4.32
Unidentified	6 (3.03)	11 (5.55)	17 (3.86)	2.72

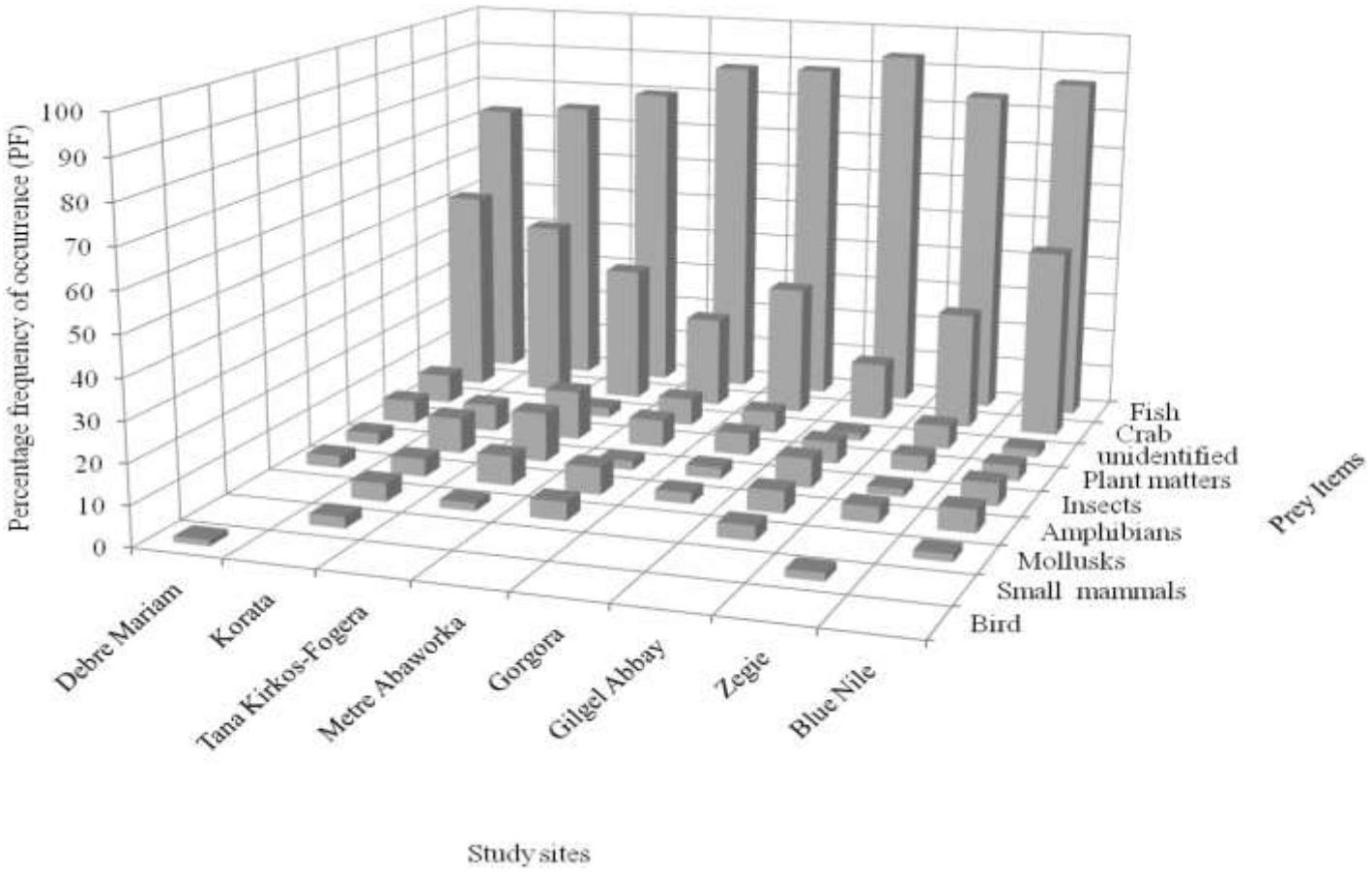

Figure 3. Study site variation in prey composition (Percentage of occurrence) of African clawless otter in the study area.

observations were reported previously where the diet included fish, crabs, birds, dragonfly larva, insects, mollusks, reptiles, rodents, shrews, and seaweeds (Nowak, 1991; Rowe-Rowe and Somers, 1998; Lariviere, 2001;Watson and Lang, 2003).This was in contrast with that of the Eurasian otter (*Lutra lutra*) which had only five diet items; fish, amphibians, birds, mammals and insects in different freshwater habitats (Krawcrzyk et al., 2016). Although mollusks, insects, amphibians and other items were abundant in and around Lake Tana (Pers. Obs.), they were not largely taken by *African clawless otter* and also predation on bird and small mammals was very rare. The same result was reported by Rowe-Rowe (1977, 1978) and Butler and du Toit (1994) indicating that mammals and birds formed a very small amount of the diet of otters in South Africa and Zimbabwe, respectively. Insects had a very low percentage frequency of occurrence (5.68%) in the present study which contrasts the 19% occurrence reported from the Eastern Cape Province, South Africa (Somers and Purves, 1996).

The present study sheds new insight on our knowledge of the diet composition of the African clawless otters. Previously, crabs and other crustaceans were regarded as the preferred and primary prey while fish, mollusks, and frogs were secondarily important (Rowe-Rowe, 1977; van der Zee, 1981; Arden-Clarke, 1986; Kruuk and Goudswaard, 1990; Nowak, 1991; Butler and du Toit, 1994; Ligthart et al., 1994; Kingdon, 1997; Somers, 2000; Lariviere, 2001; Somers and Nel, 2003; Emmerson and Philip, 2004; Ogada, 2006; Jordaan et al., 2015). Our study showed that fish was the dominant prey item in and around Lake Tana during both wet and dry seasons. A study conducted on fishermen attitude and conflict with otters in and around Lake Tana also suggested that fish was the dominant diet item (Ergete et al., 2016, unpublished data). In light of these results, the diet selection and foraging behavior of the *African clawless otter* showed flexibility. Local flexibility and variation of the diet was also reported in the following previous studies. In Batty's Bay area of the Western Cape Province of South Africa, fish was the most important prey category (59% of biomass) followed by octopus (15%), crab (13%) and lobster (10%) (Verwoerd, 1987). Watson and Lang (2003) reported 69% relative frequency of fish in the diet of *African clawless otter* in Groenvlei Lake, South Africa. In coastal waters of the Cape Province of South Africa, the most important prey categories of African clawless otter were 50% fish, 28% crabs, 11% lobster and 6% abalone (Somers, 2000). Dietary shift was also recorded in the Eurasian otter. A diet analysis study conducted in Shapwick Heath, UK, showed that the proportion of birds (41%) showed a significant increase compared to previous studies in Slapton Ley in 1981 (4.6%) and Somerset Levels in 1975 (4.71%) (de la Hey, 2008).

We suggest that the dietary flexibility of the African clawless otter might be governed by opportunism. Currently, there are commercial fishing practices in all of the eight sampling sites of the present study area *The African clawless otter* might adapt to foraging on netted fish which is more profitable than actively searching and capturing crabs or other prey. This will apparently incur energetic costs with uncertain probability of success compared to depredation of netted fish.This was also supported by the presence of fishnet remains which were observed in some of the spraints of *African clawless otter* in the present study. In addition the study on fishermen attitude and conflict with otters (Ergete et al*.,* 2016, unpubl. data) indicated that *African clawless otter* caused loss of captured fish and damage of fishing equipment in the present study area. Similarly, the *African clawless otter* is reported to shift its diet from crabs to fish in areas where crustaceans are rare (Watson and Lang, 2003).

The dietary contribution of the different fish species may show correlation with their abundance. There are 17 species that belong to the genus *Labeobarbus* in Lake Tana compared to only three species of *Barbus* (Getahun and Degen, 2012). The former is apparently a more diverse group and contributed the highest proportion of the diet. Two other genera (*Gara* and *Varicorhinus)* within Family Cyprinidae were not represented in the spraints. This might be due to their small population size in the study area (Getahun, Pers. Com.). In the Eurasian otter, the dietary contribution of fish was influenced by seasonal changes and preference while there was no correlation with population size. In this species, *Leuciscus cephalus* was the preferred fish diet which was also most commonly consumed in the cold season while *Capoeta* spp. was dominant during the warm season (Mirzaei et al., 2014).

The diet of the *African clawless otter* like other species of small-clawed otters (Kanchanasaka and Duplaix, 2011), spotted-necked otter (Perrin and Carugati, 2000), European otter (Sales-Luis et al., 2007) and the American river otter (Melissa, 2006) showed a seasonal variation in its diet. The high percentage occurrence of fish in the wet season diet of the *African clawless otter* may be explained by the spawning migration behaviour for reproduction in their breeding sites to the rivers and shores. Anteneh et al. (2012) reported that the spawning migration of fish from Lake Tana through rivers and wetlands has a wet season peak (July to October) while their spawning was also slowed by low water temperatures. This behavior might rendered the fish more vulnerable to predation in the wet season. Additionally, some species such as *Oreochromis niloticus* breads, grow and feed among the macrophytes at shallow areas of the shore and associated wetlands (Getahun and Dejen, 2012). Rowe-Rowe (1977) reported that the seasonal patterns of prey in the diet might be related to ease of capture of the prey which was affected by water temperature and level.In contrast to fish,more crabs were

consumed by *African clawless otter* during the dry season. This might be due to the decrease in the water level during the dry season that allowed the *African clawless otter* to find and capture crabs easily to locate and capture under and/or between the rocks near shore. Similar results were reported by Somers and Nel (2003) in the Olifants and Eerste Rivers in the Western Cape Province. Plant matters in the diet were higher in the wet and lower in the dry. In the dry season plant matters was rare on the river banks and on most parts of the shore of the Lake (Pers.Observ.). Most probably, the plant matter observed in the diet was ingested accidentally. Lariviere (2001) indicated that seaweeds are among the food items taken occasionally by African clawless otter. The consumption of vegetation may depend on the species and the season (Reyes, 2007). The difference in the diet of prey items between seasons in the study area may be affected by factors such as climate, human disturbance, water temperature, presence and absence of reed beds, prey availability and abundance (Verwoerd, 1987; Somers, 2000).

The spatial differences in diet composition in the study area may be due to the occurrence of prey, behavioral adaptation of the African *clawless* otter and preference of Rivers than Lakes. Studies by Rowe-Rowe (1977) in Natal the African clawless otters spent more time hunting in the tributaries and the distribution of scats indicated a similar pattern. The *African clawless otter* showed different diet profile in different areas (Kruuk, 2006) Across most of its ranges,crustaceans were the main prey, while in this study fish was the most preferable prey item. This variation in the diet of *African clawless otter* in different sites may be due to different topographic features and prey availability rather than a result of prey selection. Emmerson and Philip (2004) reported that the diet of *African clawless otter* varies with site due to the wide distribution throughout Sub-Saharan Africa. Studies by Baltrunaite (2009) in Lithuania also noted that changes in the diet of otters are related to different habitat. Rowe-Rowe (1977) and Rowe-Rowe and Somers (1998) also reported that diet of the African clawless otter varies depending on locality, season and prey availability.

In conclusion, the present study suggested that the *African clawless otter* can adapt to a fish dominated diet based on availability and ease of access as opposed to the previous knowledge that crabs are universally dominant. The study also strengthens previous knowledge that crabs and fish constitute the core diet of *African clawless otter* which is supplemented by amphibians, insects, mollusks, plant matter and occasionally birds and mammals.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors acknowledge Department of Zoological Sciences, Addis Ababa University, for funding the study, Amhara National Regional State Culture, Tourism and Parks Development Bureau for granting permission to conduct the survey in and around Lake Tana and Bahir Dar Fishery and Other Aquatic Life Research Center for their logistic support, and Abebe Getahun for his assistance in identification of fish species. We are also thankful to the Associate Editor and the anonymous reviewers for their valuable comments.

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