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Some Aspects of Fish Biology and Ecology of River Perkerra in Lake Baringo Basin, Kenya

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Abstract

Human activities including construction of dams along the river ecosystems may result in ecological changes in the fish and fisheries. This study assessed some aspects of fish biology and ecology of River Perkerra in Lake Baringo basin, Kenya. Fish species, abundance and distribution, food and feeding habits, maturity stages, growth, length-weight relationships, and sex ratio were the main parameters determined along the river profile earmarked as Chemasus (upstream), Ravine Kabarnet (Mid-stream) and Marigat Embarkment (Downstream) stations. The physico-chemical parameters showed significant spatial variation in relation to the prevailing human activities within the catchment. Chemusus station had the highest DO, TDS and pH, whereas lower reaches in Marigat embarkment had the highest phosphates values than other sites. Two species (*Labeobarbus altenialis* and *Labeo cylindricus*) were identified hence poor fish diversity in River Perkerra. The mean length of *L. altenialis* was higher at Ravine Kabarnet than at Marigat embarkment but the weights showed inverse relationships. Many species' diet consisted of insect remains, plant materials, detritus, plant remains, algae where the stomach fullness for most fish was 0.5 and 0.75. The two species were classified as omnivorous but to a larger extent, very opportunistic. Sampled fish exhibited negative allometric growth (b<3) which is reminiscent of poor growth conditions. Variations in fish community attributes were associated with longitudinal anthropogenic, physiological, biological and environmental factors. Sex ratios of fish in the river indicated that more females occurred than males. The vast majority of *fish species* were in stage III and IV. Management of River Perkerra fisheries requires to set aside a single economic vision of the resource use moving to an ecosystem-oriented approach that incorporate, among other components, the hydrological regime, species life history traits, fishing impacts on other species, and main stakeholders' socioeconomic requirements as key elements for the preservation of fishery sustainability.

Keywords: Riverine fisheries, Water quality, River Perkerra, management initiatives, anthropogenic influences

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Introduction

Rivers are important sources of water, food and other suites of ecosystem services to the society and therefore activities that may affect their integrity should be largely controlled. There are, however, a number of human activities that are widely practiced in watersheds, especially at the river basins scale which are regarded currently as a threat to riverine environments (Liu et al. 2020; Nyakeya et al., 2020a; Macklin & Lewin 2019; Nyakeya et al., 2018a, b, c, d; Gichana et al., 2015). Activities in the riverine ecotones including agriculture, industrial development, dam construction, urban development, mining and quarrying, waste discharge, overfishing and illegal fishing have greatly modified cycles (Bonacci and Oskoruš 2019; Nyakeya et al., 2018a, b, c, d; Ferreira et al. 2017; Nyakeya et al., 2016). When these activities occur at large spatial scale, they may result in modified structures and processes in the aquatic ecosystems (Bu et al. 2014; Fana & Shibata, 2015), whole-stream productivity, and affect the trophic processes from local to ecosystem and catchment scale (Kumar & Jayakumar, 2020; Changwony et al. 2015; Villeneuve et al. 2015). By virtue of their strong connections to surrounding landscapes, what transpire in the river ecotones are rapidly conveyed throughout fluvial systems, making streams among the most highly modified ecosystems by humans (Dudgeon et al. 2006). For instance, changes in water quality parameters and population structure of wild migratory fish have been documented to change in several rivers undergoing human activities (Isaak et al., 2018; Lin et al., 2018; Arantes et al., 2019). Changes adjacent to the riverine environment has the potential to modify the structures and processes of aquatic ecosystems from local to ecosystem and catchment scale (Kumar & Jayakumar, 2020; Nyakeya et al., 2018c, d; Gichana et al., 2015). The outcomes of these effects manifest through changes in the productivities and trophic structures of affected riverine ecosystems (De Marco et al., 2020). Therefore, information of the changes of riverine biological indicators remains important.

Despite the significance of riverine fisheries in Kenya, there are very few or no previous studies that have been conducted on population assessments/changes, feeding habits, breeding in several rivers in Kenya (Masese et al., 2013). Few previous reports presented a broad picture of catch trends, and how they are affected by human activities, albeit they are decadal old literature (e.g Whitehead, 1959; Cadwalladr, 1965; Ochumba & Ala, 1992). Lack of a comprehensive analysis, however, is not surprising since only rough landing records are available, and additional relevant fishing parameters such as effort, catch per unit effort and length structure data are rarely collected on a temporal basis (Nyakeya et al., 2020b; Nyakeya et al., 2018a). In absence of suitable information, several indicators could be applied to assess fishery status and trends. The development of valid indicators and their respective reference values still represent a major challenge for rivers in Kenya, due to the current lack of reliable fishery information and the expected dependence of species abundance on the hydrological regime. Fishery management in most rivers is becoming a relevant and demanding issue (Nyakeya et al., 2018b). In recent years, however, a decrease in the fish catch in several rivers in Kenya, have been noted as a result of overexploitation of several migratory stocks. Simple indicators based on length structure monitoring, common fish biological characteristics - such as growth parameters, natural mortality, and reproductive patterns - and basic fishery information, coupled with hydrological information and human activities can be integrated and used to follow fishery trends and to predict how management directions could affect stock sustainability (Riziki et al., 2021).

Flowing down from the north-eastern part of the Mau Complex, the Perkerra River has served citizens of the Rift Valley for several years. Over the approximately 100 km length that the river covers from the Mau Forest to Lake Baringo, this waterway is a primary source of livelihood amongst the communities it flows through. Up to 1985, the water in Perkerra River remained clean, safe, and sufficient for communities in the region and for fisheries. However, in the recent past the water has become polluted and decreased substantially in volume, and the fishery in the river appear to decline. These problems have been exacerbated in recent years, as community settlement and extreme drought conditions worsen, as well as threatening the continued existence of the Perkerra River itself (K. Kipkorir, Personal observation). Human activities in the upper catchment have had severe impacts on the flow of the river. This has affected the Perkerra River throughout its course, as muddy water with a decreased flow have become common in many areas. Another key component of the degradation has been the community re-settlement that has occurred in the past few years. Due to poor land allocation systems, and the lack of implementation when dealing with land policies and laws, individuals have encroached into forestland, clearing the trees and destroying the local environment. Additionally, poor farming methods, and a lack of conservation among community individuals in the region, have had dramatic effects on the river. These methods include farming on sloped lands, farming into riverbanks, planting of inappropriate species of trees such as Eucalyptus, and lack of soil conservation measures. However, knowledge on the status of fisheries in this important riverine environment continues to languish behind other riverine environments and thus posing great challenge to prescribing the management strategies for restoration of the river. This study, therefore, assessed some aspects of fish biology and ecology of River Perkerra in Lake Baringo basin, Kenya in order to inform its management.

Materials and methods

Study area

River Perkerra catchment with an area of 1207 km^2 is part of the larger Lake Baringo drainage basin of 6820 km^2. The basin is drained by six seasonal rivers and one perennial river (Riziki et al., 2021; Nyakeya et al., 2020b; Nyakeya et al., 2018a, b). The lake is located in the eastern Great Rift Valley in Kenya in a semi-arid environment. It has one subsurface outlet, which drains out at Kapedo, 50 km North of the lake. Through subsurface flow, the sediments are filtered thus ensuring total retention of trapped sediments in the lake. The mean annual rainfall in this area is about 700 mm, while evaporation rates are about 1800 mm annually. The hill slopes around the divide of the basin are semi-humid with a mean annual rainfall of 2000 mm, while the mean annual evaporation is about 1600 mm. River Perkerra (Figure 1) is a heterogeneous catchment with a fragile ecosystem. Its soils are mainly clay, loam and sand in texture. The inhabitants of the semi-arid lower reaches of the catchment are nomadic pastoralists who keep traditional cattle under communal grazing. In the upper reaches of the catchment, agriculture is practised by the local communities, but mainly for subsistence and export (horticulture) purposes. The major land covers in the catchment are forest 26%, evergreen and semi-deciduous bushland 37%, and deciduous and semi-deciduous bushland 37%. Details of the catchment characteristics are shown in Figure 1.

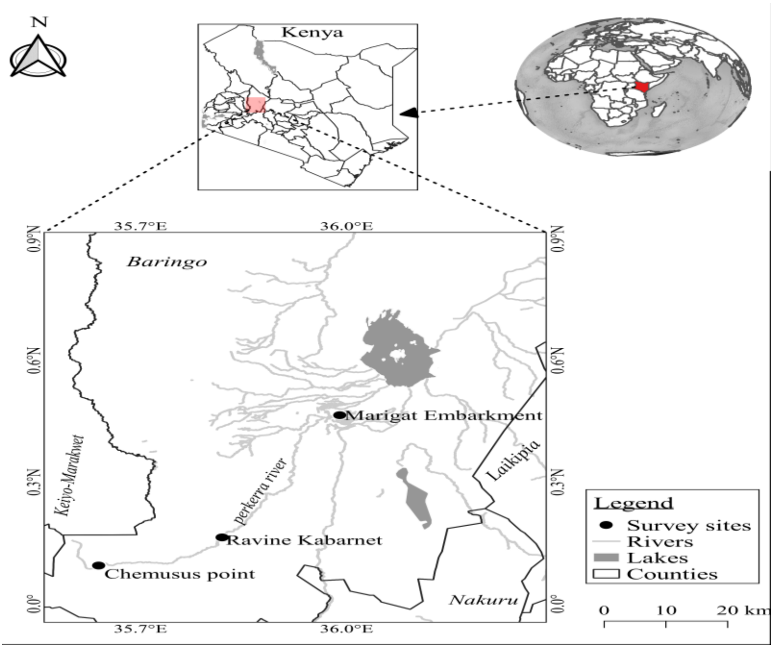

Figure 1: Map showing the location of the study area along River Perkerra

Selection of study sites

Sampling sites were selected randomly based on a number of factors: accessibility, physical proximity, habitat diversity and riparian land uses. The Geographical Position System (GPS) was used to mark the sampling points prior to sampling. Sites differing in human activities were selected for current study, and their characteristics are as described in Table 1. Watershed delineation and classification were conducted in ArcGIS version 3.2. Based on topographic maps at a scale of 1:250,000, the watersheds were first delineated and overlain on aerial photos then divided into polygons of different land use type. The areas of the polygons were calculated to determine the dominant land use type. Only the watershed areas upstream of the sampling locations were considered.

Table 1: Description sampling sites

Sampling sites	Latitude	Longitude	Mean depth (m)	Mean width (m)
Chemusus point	E035°38'21.0''	N00°05'39.5''	1.68 ± 0.34	18.5 ± 5.33
Ravine Kabarnet	E035°49'08.1''	N00°09'49.5''	1.22 ± 0.55	4.5 ± 0.83
Marigat Embarkment	E035°59'24.4''	N00°27'54.3''	1.28 ± 0.55	4.1 ± 0.76

Measurement of the physical and chemical water quality parameters

Water was sampled and analysed using standard methods described in APHA (2005). Triplicate samples of all parameters were collected at the surface (0 m) along River Perkerra during the sampling expedition. Temperature, conductivity, dissolved oxygen (DO), total dissolved solids (TDS), pH, salinity and Sechi depth were measured at each sampling sites. The temperature, conductivity, pH, TDS, DO, and salinity were measured *in situ*, using a Surveyor II model hydrolab, with independent probes for each variable.

Fish sampling

Fish were sampled at each of the sampling sites using an electro-fisher along the river. The sampling period lasted approximately 30 minutes. At each of the sampling site, electro-fishing time was about 15 minutes covering an area of approximately 100 m for each sampling site. Sampling gears were deployed proportionally according to suitable habitats within each bend. After capture, the fork length (FL) and standard length (SL) were measured to the nearest 0.1 cm and the eviscerated body weight (W) to the nearest 0.01 g. The specimens were dissected to expose the viscera where the dominant food items were recorded. The total catch from each gear was weighed in g, using a digital weighing scale (5 kg Vibra Model from Shinko Devshi Co. Ltd, Japan).

Upon data collection, fish specimens were immediately tagged, and gut content extracted and preserved in 5% formalin for laboratory examination. The frequency of occurrence was used to compute the individual food items sorted and identified. The number of stomachs where the food item occurred were recorded and expressed as a percentage of all the stomachs being analysed. The index of occurrence (Io):

$Io = Na/Nt \times 100$ (%), (Windell, 1968; Hyslop, 1980)

Where

Na = the number of stomachs where a food category is recorded, and

NT = total number of stomachs

Data analysis

All statistical analyses were performed using STATISTICA 10.0. Normality and homoscedasticity of data distribution was checked by means of skewness and kurtosis. In case where data was found not to follow normal distribution (heteroscedastic), log transformation was used to normalize all the biological data. For each tested data set, between-site differences in concentrations of abundance of fish species and taxonomic richness were tested using one-way analysis of variance (ANOVA). The assumption of normality prior to ANOVA was verified using the Shapiro–Wilk test. Fish species distribution was analysed using two-way interaction where sampling location and fish species were factors. Abundance data were not normally distributed even after log-transformation, and between-sites differences were tested using the non-parametric Kruskall–Wallis test. All results were declared significant at $P < 0.05$.

Results and Discussion

Water quality parameters

An overview of the physical and chemical water quality parameters along River Perkerra is provided in Table 2. All the physico-chemical water quality parameters demonstrated significant ($P < 0.05$) spatial variations except the Secchi disk measurement. Temperature fluctuated between 15.2 ± 0.33 and 16.8 ± 0.26 ^{o}C, with Marigat Embankment recording the highest level (16.8 ± 0.26 ^{o}C). The lowest DO level (2.44 ± 0.08 mg/L) was recorded at Kabarnet Ravine Bridge while the highest (3.44 ± 0.21 mg/L) was observed at the Chemasus station. TDS ranged from 25.39 ±1.56 to 29.15 ± 1.39 mg/L, with the least value being observed at Margat Embankment station in the lower part of the river. Salinity was within the acceptable limits for freshwater ecosystems and it varied between 0.12 ± 0.06 and 0.14 ± 0.03 ppt. The highest level was recorded at Chemusus station (upstream) whereas the lowest was observed at the downstream station (Marigat Embankment). The pH was neutral in all the stations except at the Marigat embankment where it was somehow acidic (6.45 ± 0.12). The Secchi disk measurement remained constant (about 100 cm) in all the stations. Marigat Embankment station recorded the highest level of phosphates (2.99 ± 0.16 mg/L) followed by Kabarnet Ravine (1.93 ± 0.17 mg/L) and then Chemasus with the lowest value of 1.75 ± 0.11 mg/L. the level of phosphates ranged between. Chemusus station recorded the lowest (3.49 ± 0.14 mg/L) level of phosphates while Kabarnet Ravine Bridge had the highest (4.25 ± 0.18 mg/L).

Table 2: Mean value (±SE) of physicochemical parameters in River Perkerra at the three sampling stations during the study period.

	Sampling stations				
Parameters	**Chemusus point**	**Ravine Kabarnet**	**Marigat Embankment**	**F**	**P - value**
Temperature (°C)	15.2 ± 0.33^{a}	16.3 ± 0.12^{b}	16.8 ± 0.26^{b}	20.91	< 0.001
DO (mg/L)	3.44 ± 0.21^{d}	2.44 ± 0.08^{b}	3.31 ± 0.30^{c}	24.11	< 0.001
TDS (mg/L)	29.15 ± 1.39^{c}	28.21± 1.28^{c}	25.39 ±1.56^{b}	40.46	< 0.001
Salinity (ppt)	0.14 ± 0.03^{c}	0.13 ± 0.04^{b}	0.12 ± 0.06^{a}	7.86	0.003
pH	6.95 ± 0.12^{c}	7.39 ± 0.23^{d}	6.45 ± 0.12^{b}	20.05	< 0.001
Secchi disk (cm)	0.97 ± 0.25^{a}	0.97 ± 0.33^{a}	0.99 ± 0.16^{a}	8.04	0.002
Phosphates (mg/L)	1.93 ± 0.17^{b}	1.75 ± 0.11^{a}	2.99 ± 0.16^{d}	14.52	< 0.001
Nitrates (mg/L)	3.80 ± 0.12^{b}	4.25 ± 0.18^{c}	3.49 ± 0.14^{a}	3.8	0.013

Fish abundance and distribution

Fish composition and catch data along River Perkerra together with statistical analysis of the distribution of the data is shown in Table 3. A total of 2 fish species were caught in River Perkerra; *Labeo cylindricus* and *Labeo altenialis*. There was a significant difference in the fish catch data based on the sampling location and fish species. In addition, the interaction between sampling location and fish species resulted in difference in the catch data ($P < 0.05$). *Labeo cylindricus* sampled at Marigat Embankment was the largest number (n=211) of sampled fish. Comparatively the mean length of *Labeo altenialis* was higher (12.44 ± 3.95 mm) at Ravine Kabarnet than at Marigat Embankment (10.42 ± 2.41 mm) but the weights showed inverse relationships where *L. altenialis* at Marigat Embankment weighed more (52.11 ± 12.13 g) than those at Ravine Kabarnet (20.16 ± 6.17 g). Meanwhile the mean length and weight of *L. cylindricus* were higher at Marigat Embankment compared to Ravine Kabarnet (Table 3). No fish was sampled at Chemusus Point.

Table 3. Description of the biological data of the fish species captured at three stations along River Perkerra. Sample size (n), (mean ± SE [Range]) fork length (FL) and (mean ± SE) weight

Sampling sites	Fish species	n	FL (cm)	Mean weight (g)
Chemusus point	**No fish**	-		
Ravine Kabarnet	*L. altenialis*	72	12.44 ± 3.95 [4.3-22.7]	20.16 ± 6.17
	L. cylindricus	5	16.72 ± 4.43 [3.7-25.7]	42.16 ± 8.10
Marigat Embarkment	*L. altenialis*	42	10.42 ± 2.41 [3.1-25.3]	52.11 ± 12.13
	L. cylindricus	211	18.32 ± 4.41 [5.7-28.3]	52.62 ± 11.37

**Mean values with different superscripts across the same rows show significant difference (p > 0.05).*

Food and feeding habits

The dietary status of fish sampled along different locations of River Perkerra is shown in figure 2. A total of 7 types of food items fed by fish species in River Perkerra were identified: insects, plant remains, green algae, blue green algae, detritus, diatoms and mollusks. Green algae, blue green algae and diatoms constituted food items of plant origin. Green algae were represented in fish stomachs mainly by *Coelastrum* spp. and *Cosmarium* spp. On the other hand, blue green algae were represented by *Anabaena* spp., *Coelospharium* spp. and *Micrcystis* spp. Diatoms constituted of mainly two species: *Navicula* spp., *Cyclotella* spp. Insects and Mollusks are the only groups that constituted food items of animal origin. Insects constituted of Coleopteran, Ephemeroptera and Chironomid remains.

In terms of occurrence, 66.7% of green algae were recorded at both stations Kabarnet Ravine and Marigat Embankment, an indication that it is the most important food for *L. altenialis* (Figure 2).

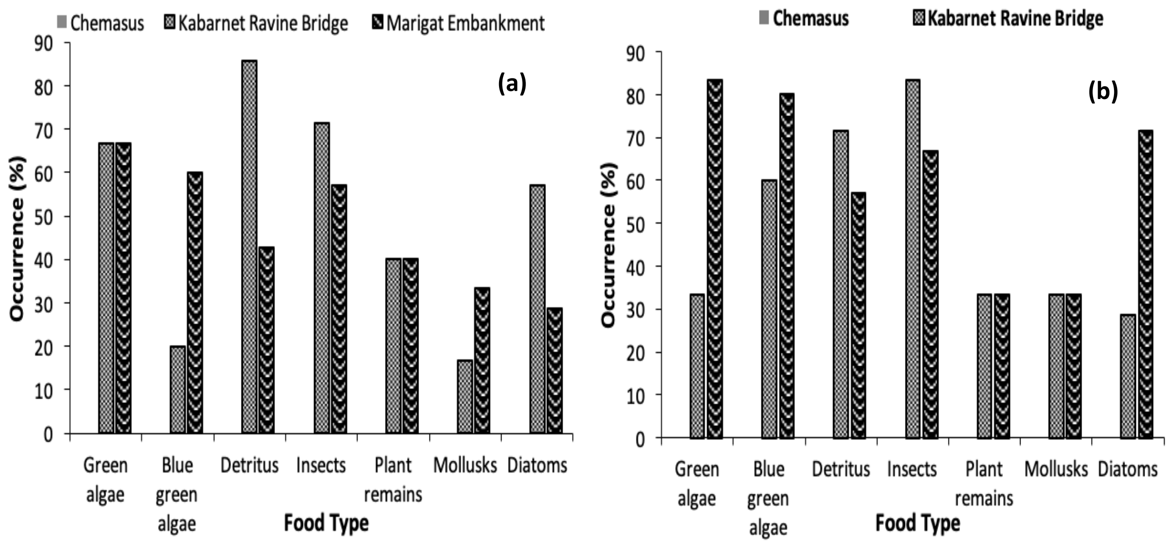

Figure 2. Food type and occurrence in percentage for **(a)** *L. altenialis* and (b) *L. cylidricus* in River Perkerra during the study period

Detritus constituted the highest percentage (85.7%) of food occurring in the gut of *L. altenialis* at the midstream station of Kabarnet Ravine when compared to the rest of the food items in the total number of guts examined. Mollusks were the least preferred food item of *L.*

Green algae, blue green algae, detritus, insects and diatoms with percentage occurrence of 83.3%, 80.0%, 57.1%, 66.7% and 71.4% respectively at Marigat Embankment station formed the most important diet of *L. cylidricus*. Plant remains and mollusks were the least preferred food items for *L. cylidricus* both having recorded 33.3% of the food items at the two stations.

Stomach fullness index

The feeding intensity as an index of the stomach fullness is as shown on Table 4. The maximum number of empty stomachs was

altenialis having recorded the lowest percentage (16.7%) at Kabarnet Ravine station. Another food item that could be of importance to *L. altenialis* are the insects which constituted 71.4% and 57.1% for both Kabarnet Ravine and Marigat Embankment stations respectively.

recorded at the upstream station (Kabarnet Ravine), 9.7% and 20.0% for *L. altenialis* and *L. cylidricus* respectively unlike the lower proportion observed downstream (9.5%, *L. altenialis*; 8.5%, *L. cylidricus*). Conversely, 2.8% and 0.0% full stomach was recorded for *L. altenialis* and *L. cylidricus* respectively at Kabarnet Ravine station. However, downstream at Marigat Embankment 16.7% for *L. altenialis* and 4.7% full stomachs were observed. Of significance is that most of the fish species sampled were either ¾ full, ½ full or ¼ full (Table 4).

Table 4: Stomach fullness index in Perkerra River during the sampling period (n=330)

	Species	¼ Full	½ Full	¾ Full	Empty	Full	Total
Ravine Kabarnet	*L. altenialis*	9.7	11.0	62.5	9.7	2.8	100.0
	L. cylindricus	0.0	20.0	60.0	20.0	0.0	100.0
Marigat Embankment	*L. altenialis*	9.5	26.2	38.1	9.5	16.7	100.0
	L. cylindricus	12.3	22.3	51.7	8.5	4.7	100.0

Length/Weight relationships

The length/weight relationships of the fish species sampled during the study is provided in Figure 3. The regression coefficient b for *L. altenailis* and *L. cylindricus* sampled at Ravine Marigat station were 2.8 and 1.0 respectively. At Marigat Embankment, the b values were 1.1 for *L. altenailis* and 1.4 for *L. cylindricus*. There was a significant difference ($p < 0.05$) in the length-weight relationship of both the fish species occurring at Ravine Kabarnet and Marigat Embankment stations.

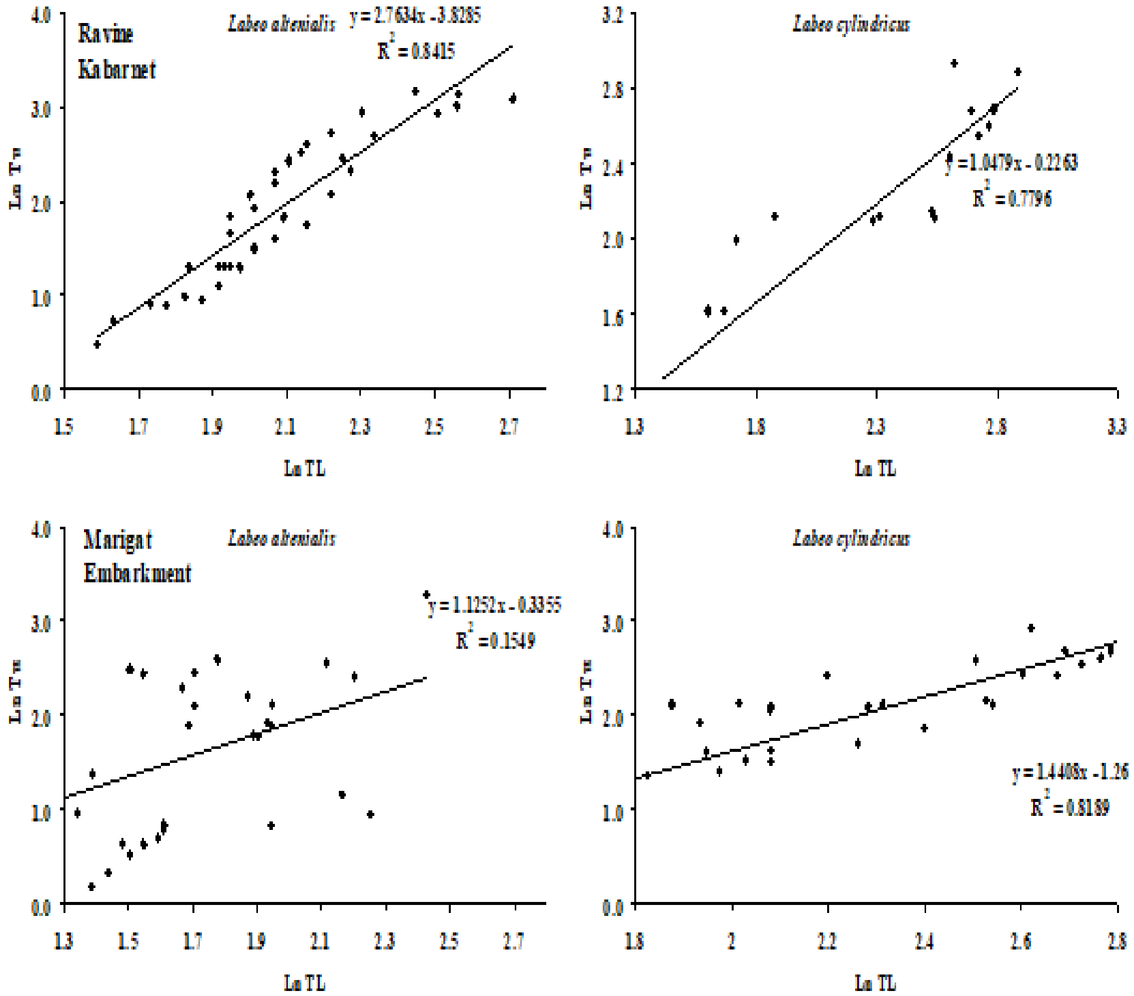

Figure 3: Length-weight relationships of fish species sampled from River Perkerra

Sex ratio

Sex ratios of fish sampled along different locations of River Perkerra is provided in Table 5. The results indicate that for all the sampled fish at all sampling points, more females occurred than males.

Table 5: Sex ratios of fish sampled along different locations of River Perkerra

Sampling sites	Fish species	Sex ratio (male: female)
Chemusus	-	-
Ravine Kabarnet	*Labeo altenialis*	5:7
	Labeo cylindricus	3:5
Marigat Embarkment	*Labeo altenialis*	4:32
	Labeo cylindricus	14:23

Maturity stages

Maturity stages of the two fish species in percentage form at River Perkerra are shown in Table 6. The vast majority of *L. altianalis* were in stage I and III followed by stage IV while most of the *L. cylindricus* were in stage III and IV followed by I. A total of 7.0% and 9.4% species of *L. altianalis* and *L. cylindricus* respectively were already spent. When the two species are combined, stages III and IV had the largest number of fish, 49.0% and 48.3% respectively.

Table 6: Percent maturity stages of fish species at Perkerra river (n=330) during the sampling period

Species	I	II	III	IV	V	Spent
L. altianalis	26.3	17.5	26.3	18.1	7.0	4.7
L. cylindricus	14.5	13.2	22.6	30.2	9.4	10.1
Total	40.8	30.8	49.0	48.3	16.5	14.7

Sizes and ages at maturity

The minimum sizes at which the species mature were 13 cm for *L. altenialis* and 17 cm for *L. cylindricus*. The majority of the species studied matured for the first time at the end of their second year. A decrease in mean length is often accounted for by an observed increase in catch and particularly as the result of uncontrolled fishing activities. Alternatively, however, this diminution could also be explained by an increase in recruitment success. A common observation was that fish of 25 cm length were being harvested, implying the removal of a significant number of immature fish that were accordingly smaller than size at first maturation

Discussion

Physico-chemical environment along River Perkerra showed significant spatial variation in relation to the prevailing human activities within the catchment. Temperature remained almost constant in all the stations probably due to the constantly flowing waters in the river except at Chemusus point where it was a little bit lower owing to the fact that this is where the dam is situated. The lowest temperature at Chemusus dam could also be explained by the fact of its location at high altitude area compared to Ravine Kabarnet and Marigat Embarkment. The DO was highest at Chemusus Point which was situated at high altitude area along River Perkerra. Meanwhile the TDS was highest at Chemusus Point and Ravine Kabarnet which are situated in the upstream and midstream of the river. This could be attributed to the on-going construction of the second Chemusus water distribution centre to low lying altitude towns resulting to high deposition of sediments into the river at Chemusus sampling station. These points (Chemusus and Ravine Kabarnet) receive a lot of leaves shed from the thick natural forest of Olembusi that forms part of the larger Mau Forest ecosystem. Rotting tree debris in the water could also be the reason for high TDS levels. Vast agricultural activities at Ravine Kabarnet is another possible reason for increased TDS. High TDS along the riverine environment correspond to uptake of dissolved materials and deposits from the geological basin. Salinity was highest in the dam compared to other sites probably due to periodic accumulation of dissolved salts over a period of time. The pH was relatively high at the midstream of the Perkerra River, which may be due to the nature of the soils and the geological set up which is mainly volcanic in the area as the river approaches the Great Rift Valley. Possible irrigation activities at the river ecotones at this station could as well be responsible. The pH at the lower parts of River Perkerra is somewhat lower in comparison to the other sites, which can be attributed to the high influx of freshwater from the surface run-off and the incoming tributaries.

The Kimau Dam had the highest turbidity compared to the sites along the river, which signify high deposition of sediment loads in the dam from the inlet Rivers. The concentration of phosphates was significantly highest in Marigat Embarkment and lowest at Ravine Kabarnet. These patterns appear related to human activities where more phosphates at the lower reaches of River Perkerra could be due to input from tributaries and other sources surrounding the sampling locations where irrigation is done for the growth of horticulture crops such as tomatoes where a lot of fertilizers are applied. The application of fertilizers in farmlands and animal watering points along rivers and influent streams is known to increase phosphate and nitrate concentrations in riverine ecosystems. Finally, the lowest concentration of nitrate occurred at Marigat Embarkment probably associated with low aquatic production in streams due to low water residence time.

The stomach fullness index showed high variation in the fish species with a high percentage being ¾ full. Very few had their stomachs full whereas a number were totally empty. The variations in the levels of food consumption by the various fish species may correspond closely with the season. This is because the temporal changes of biotic and abiotic factors can change or alter community structure in the aquatic ecosystem thus affecting the food web. There could be high chances that food availability was somehow low during our sampling period. Low feeding rate can also be contributed to the sex of fish where females allocate much of its energy in reproduction other than feeding. The proportion of empty stomachs could be as a result of post sampling where digestion may have occurred due to shocks from the electro fisher. Similar observations have been made by other authors who reported many empty stomachs of riverine fishes caught using different methods such as netting due to food digestion in the process of being caught (Dadebo et al., 2005; Shinkafi et al., 2011). The low feeding rate as portrayed by the stomach fullness index corresponds well with the food occurrence, an indication of poor food distribution in the sampling stations. However, green algae occurred in equal proportion for L. altenialis at Ravine Kabarnet station probably due to light attenuation which favoured primary productivity. The same observation and explanation could be true for the diatoms. Blue green algae were low in Ravine Kabarnet due to low nutrients but going downstream it was elevated because of the many sources of organic enrichments from the nearby irrigated farms. Detritus is in plenty in the stomach of both fishes due to a lot of organic particles generated from the nearby forest and because of the opportunistic nature of these fishes. Generally, the two species could be classified as omnivores but to a larger extent they are opportunistic – feeding on anything they come across.

Length-weight relationship is important in understanding the structure and function of fish populations (Ighwela et al., 2011). Plotting log 'a' against log 'b' in length-weigh relationship, a straight line is given and this helps in detecting the outliers. In the present study, the r coefficient for *L. altenialis* and *L. cylindricus* at Ravine Kabarnet station were high (r = 0.8415 and r = 0.7796 respectively). This showed that the linear regression model used in this study was reliable and fitted the data well. The same case occurred for *L. cyndlicus* sampled at Marigat Embarkment station. The results also demonstrated that the body weight of the fish species increased as the total length increased. However, the calculated correlation coefficient for *L. altenialis* sampled at Marigat Embarkment was too low (r = 0.1549) which is an indication of poor growth rate. Generally, the value of the regression coefficient 'b' in this study ranged between 1.05 and 2.76, implying that both the fish species in the two sampling locations exhibited allometric growth which is reminiscent of poor growth conditions. According to Kleanthidis et al. (999) the value of 'b' for an ideal fish is 3.0, indicating an isometric growth that is reminiscent of a favourable environment. Both fish species therefore, demonstrated a negative allometric growth since their 'b' value was less than 3. This means that they grew with a thin body unlike fish displaying a positive allometric growth (b is equal or greater than 3) whose body is stout with an increase in length. The poor well-being of these fishes could be due spawning. Some of this fish species move upstream to spawn and thus they infest a lot of energy resources in reproduction ending up losing their weight gain. According Competition for food and poor environmental conditions could also be the reason for the negative allometric growth. River Perkerra is influenced by anthropogenic activities ranging from dam construction, unregulated water abstraction both for domestic and agricultural use, which cause pollution thus affecting the fishes either directly or indirectly. Nonetheless, this is a river traversing a vast arid and semi-arid area with unpredictable water flooding during spates and highly reduced water volumes during the dry spell. This kind of erratic water level fluctuations is likely to influence river productively hence affecting the food availability and feeding characteristics. Growth performance is likely to change from one point to another and depending on the time of the year (Fulton, 1904). According to Suquet et al. (2005) changes such as availability of food, quality and quantity of food, feeding rate, spawning period of fish could affect the b. this is because the b value in fish growth is an indicator of food availability and growth pattern, which is influenced by the season of the year (Wotton, 1995). Physiological and biological factors such as gonadal development can affect the weight gain and therefore the b value in the length-weight relationship (Zdanowski et al., 2001).

Many of the sampled fish species were not mature (stages I to III) most probably due to young fish moving downstream to locate foraging sites until maturity when they move upstream to spawn. The spent fish is an indication of mature fish that have spawned upstream and probably moving downstream to forage. Similarly, the fish species in stages IV and V show a likelihood of fish ready to spawn hence moving upstream.

Conclusions and recommendations for management

The water quality, fisheries ecology of River Perkerra showed patterns reminiscent of changes in human activities. The length-weight relationship showed that fish with poor growth rate (b<3) an indication of poor river environment. Although, seven food items were found in the stomach of the two fish species studied, there is a clear indication of poor occurrence as insinuated by the stomach fullness index which showed few fish feeding to fullness. The two fish species were found to be mainly opportunistic – feeding on any food they encounter. To ensure maximum benefits to the riparian community in terms of meeting their economic livelihood and secured nutrition, there is need for sound management strategies of River Perkerra and its entire catchment for sustainable fisheries exploitation. The first step from the government in terms of management is a basic need for the implementation of laws and policies that regulate human activities. This means that everything from slopes to individual farms must be examined to make sure they meet regulatory standards. Some of the government standards that should be on the top of the priority list are buffer zones along riverbanks, terraces for soil conservation along steep slopes and adherence with government minimum water quality standards.

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