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RESEARCH ARTICLE

FEEDING HABITS AND SOME BIOLOGICAL ASPECTS OF FISH SPECIES IN GILGEL GIBE RESERVOIR, OMO-TURKANA BASIN, ETHIOPIA

***Mulugeta Wakjira**

Department of Biology, College of Natural Sciences, Jimma University, P. O. Box 1527, Jimma, Ethiopia

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ABSTRACT

Relative abundance, feeding habits, length-weight relationships and conditions factors of two fish species from Gilgel Gibe reservoir, Ethiopia, were investigated. Percentage index of relative importance (%IRI) was used to investigate relative abundance of the fish species. Frequency of occurrence and volumetric methods were used in analyzing feeding habits of the fishes. However, an index of preponderance was used to assess relative contribution of prey items to the fish diets. The diet breadth index (B_A) values (*O. niloticus* = 0.40 & *L. intermedius* = 0.63) suggested an omnivorous feeding habit for both fishes. The Horn's overlap index (44 %) indicated considerable prey overlap between the two species. The feeding habit of *O. niloticus* did not vary between seasons. The lines of best fit to the regressions of log transformed Weight-Total length had the equations of a form log W = 2.76 log TL-1.40 (R^2 = 0.89) for *O. niloticus* and log W = 2.24 log TL-0.79 (R^2 = 0.59) for *L.intermedius*. Seasonal variations in 'b' and condition factors as well as dependence of the latter on fish size were also investigated. The findings of the present study are of functional value in the proper management and exploitation of the reservoir's fishery resource.

INTRODUCTION

At present reservoir fisheries have become important components of capture fisheries in Ethiopia primarily owing to the construction of considerable number of dams. A fishery activity in Gilgel Gibe reservoir, Ethiopia, is an important source of income and livelihood to the local people. At present, the reservoir is characterized by high fish yield suggesting that the reservoir is probably in its trophic surge phase which could last a few years (Wetzel, 2001). The change from a riverine into a lacustrine environment might affect its fish composition, abundance and other dynamics. Moreover, the feeding habits of fishes could vary in relation to various factors including habitat type, season of a year, fish ontogenetic stage, etc (Gerking 1994). Thus, practical information on the relative abundance and feeding habits of fish species becomes essential for the proper management and exploitation of the reservoir fishery resources. Furthermore, establishing specific length-weight relationship (LWRs) for a particular fish species of a particular water body has a number of important applications (Morey *et al*., 2003). For instance, it is important in estimating standing crop biomass of a species (Isa *et al*., 2010), assessing seasonal variations in fish growth (Pervin and Mortuza, 2008), providing information on fish habitat (Oni *et al*., 1983), modeling aquatic ecosystems (Kulbicki *et al*., 2005) and fish stock assessment. The parameter 'b' of LWR can be used for length-weight conversion in fish growth equations and estimation of mean weight of a particular fish length class (Froese, 2006). The length-weight parameters of the same species could vary depending on ecological, seasonal and fishing factors. Therefore, when LWRs are required for use elsewhere, the choice to use a published LWR should be according to where the samples were obtained in the same season and in the same or adjacent areas (Froese, 2006). The LWRs also help to estimate condition factor, an index which often is used to compare the wellbeing or welfare of a fish. It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition (Bagenal and Tesch, 1978). Condition factor is a useful index for monitoring of feeding intensity, age, and growth rates in fish (Oni *et al*., 1983). If parameter 'b' of the LWR of fish samples is equal to 3, then small specimens in the sample under consideration have the same form and condition as large specimens. If b > 3, then large specimens have increased in height or width more than in length, either as the result of a notable ontogenetic change in body shape with size, which is rare, or because most large specimens in the sample were thicker than small specimens, which is common. Conversely, if b < 3, then large specimens have changed their body shape to become more elongated or small specimens were in better nutritional condition at the time of sampling (Froese, 2006). Additionally, because fish condition factor can be influenced by both biotic and abiotic environmental conditions, it becomes an important index to assess the status of the aquatic ecosystem in which fishes live (Bagenal and Tesch, 1978).

Corresponding author: Mulugeta Wakjira,
Department of Biology, College of Natural Sciences, Jimma University, P. O. Box 1527, Jimma, Ethiopia.

Despite the usefulness of data on species composition, relative abundance, feeding habit, LWRs and condition factor in fisheries management, and the importance of Gilgel Gibe reservoir fisheries to the local people, information about these important parameters of fish species in the reservoir do not exist except for a preliminary limnological survey conducted from 2004 to 2006 (Tariku *et al*., 2006). The present study was conducted with the objective of bridging this gap and thus to provide useful information for the proper management of Gilgel Gibe reservoir fisheries.

METHODS

Study area and sampling locations

The study was conducted in Gilgel Gibe reservoir, constructed on Gilgel Gibe River, a tributary of a major Gibe River, located within the Omo-Turkana drainage basin in the southwestern part of the country. It was commissioned in 2004 as a hydropower dam and located at an altitude of 1640 m above sea level (asl) at geographic coordinates of $07.4253\text{-}07.5558^0$N and $37.1153\text{-}37.2033^0$E. Its maximum and minimum water levels during wet and dry seasons respectively are 1671 m and 1653 m asl. It has a total surface area of 51 km^2 and max volume of 900 million m^3 (Ethiopian Electric Power Corporation, 1997). Its depth ranges between 2 m and 35 m with a mean depth of about 17.6 m. It drains a total catchment area of 4225 km^2. The mean annual atmospheric temperature is 19.2 ^{0}C. The mean annual rainfall ranges between 1300 mm and 1800 mm in the catchment areas. Sampling was undertaken at two major localities known for most of the fisheries landings namely Dimtu and Deneba located on the northwest and northeast coast of the reservoir respectively (Fig 1). Each locality was sampled at three subsites. The Dimtu sampling locality represented the transition zone while Deneba located near the dam represented the lacustrine zone of the reservoir.

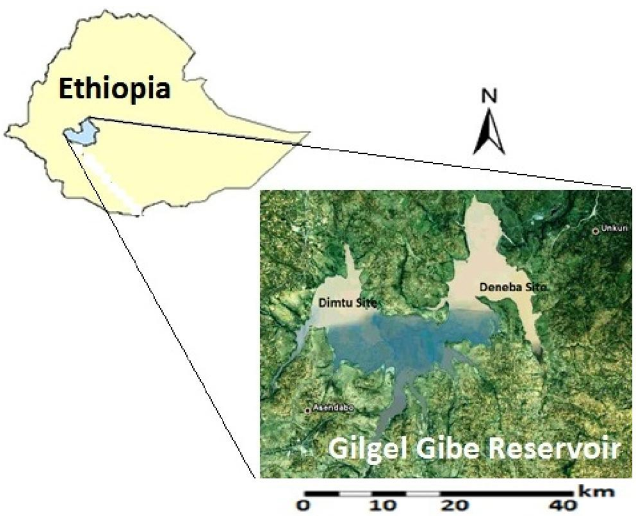

Fig. 1. Gilgel Gibe reservoir

Fish sampling and identification

Fish sampling was conducted in July - October, 2008 (wet season) and November, 2008-February, 2009 (dry season). Fish specimens were sampled using gillnets of mesh sizes 60 mm, 80 mm, 100 mm and 120 mm to allow the catch of various size classes. The sampling gears were set always in the evening at 18:00 local time and fish specimens were collected in the morning before 7:00 local time. The same type and number of gillnets were employed throughout the sampling period to maintain uniform sampling effort to allow seasonal comparisons. The fish specimens were identified according to standard identification keys (Golubtsov *et al*., 1995; Skelton, 2001; Paugy *et al*., 2003). Contents of all non-empty guts were collected and preserved in 5% formalin solution for diet analysis in the laboratory (Bowen, 1996). Gut contents were collected from stomach for *O. niloticus* and anterior portion of intestine for the stomachless *L. intermedius.* Food items were identified under dissecting and compound microscopes. Total length (TL) and Weight (W) measurements were taken onsite for all the specimens collected (n = 1727 for *O. niloticus* and n = 243 for *L. intermedius*). TL was taken from tip of the snout to the extended tip of the caudal fin to the nearest 0.1 cm and W was taken to the nearest 0.1 g. Finally, some voucher specimens were preserved in 70 % ethanol and stored in Zoological Sciences Laboratory, Department of Biology, Jimma University.

Data Analysis

As an estimate of the reservoir's species diversity, Shannon diversity index (H') was computed as:

$$H' = -\sum_{i=1}^{n}(\text{Pi})(\text{lnPi})$$

Where,
P_i = proportion by number of i^{th} species
S = total number of species sampled

Relative abundance of each fish species was computed as an index of relative importance (IRI) according to Kolding (1989). Computation of IRI as a measure of relative abundance helps to overcome the deficiencies of percentage by number, percentage by weight and percentage frequency of occurrence, to adequately represent the ecological importance of a particular fish species. IRI of i^{th} fish species was computed as:

$IRI_i = (\%W_i + \%N_i)\ \%O_i$, where, %Wi = percentage weight of the i^{th} species in total sample, $\%N_i$ = percentage number of i^{th} species in total sample, $\%O_i$ = percentage frequency of occurrence of i^{th} species in the settings of the samples. An index of preponderance (IP) was used to assess the important diets in the feeding habits of the fish species according to Natarajan and Jhingran (1961) as:

$IP_i = (\%V_i)\ (\%O_i)$, where, $\%V_i$ = percentage volume of a particular diet in the total volume of food items, $\%O_i$ = percentage frequency of occurrence of a particular diet in the total number of guts examined.

The diversity of prey items taken by each fish species was assessed using a diet breadth index (B) as:

$$B = \frac{1}{\sum_{i=1}^{n} Pi^2}$$

Where,
P_i is the proportion of each prey category, n = the number of different prey Categories

B was standardized according to Gelwick and Mathews (2007) to scale from 0 to 1 as: $B_A = (B-1) / (n-1)$. The extent of diet overlap between the two fish species was assessed using Horn's index (H) as:

$$H = \frac{2\sum_{i=1}^{n} PijPik}{\left(\frac{\sum_{i=1}^{n} Pij^2}{J^2} + \frac{\sum_{i=1}^{n} Pik^2}{K^2}\right)JK}$$

Where,
P_{ij} = volume proportion of prey i in the total preys consumed by fish species j
P_{ik} = volume proportion of prey i in the total preys consumed by fish species k
n = the total number of prey categories
J, K = total amount (ml) of all the preys consumed by fish species j and k respectively (Gelwick and Mathews, 2007).

Total length was related to weight for each fish species using the power equation according to Bagenal and Tesch (1978) as: $W = aTL^b$, where, W = observed weight of fish (g), TL = total length of fish (cm), a and b = parameters whose values are determined after logarithmic transformation of TL and W using the least square linear regression as: logW = log a + b logTL, where, log a = y-intercept of the regression line, b = slope of the regression line (= the growth coefficient). The log-log plots of TL and W values were visually inspected for any extreme outliers prior to the linear regression analysis (Froese, 2006). The 95% confidence interval (CI) of b was computed using the equation: CI = b ± 1.96 SE (b), where, SE (b) = standard error of b. The mean b value for each species was tested using the one sample t-test to verify whether it significantly varied from the isometric value of 3 at 5 % level of significance. Fulton condition factor (k) was computed using the equation: $k = 100W/TL^3$ (Bagenal and Tesch, 1978), where, W = measured weight of fish (g), TL = total length of fish (cm). The condition of each fish species was interpreted by comparing the mean Fulton condition value against the mean condition factor (k_{mean}) computed according to Clark (1928) as $k_{mean} = 100aTL^{b-3}$. Fish condition across the species was compared based on relative weight according to Froese (2006) as:

$$W_{rel} = \frac{100W}{(a_m)(TL^{b_m})}$$

Where,
W_{rel} = relative weight (g), W = measured weight (g), a_m and b_m = geometric means of mean a and mean b for the fish species under consideration.

One-way ANOVA in SPSS (version 16.0) was used to test for the significant variations in the mean values of relative number, weight, b and condition factors across seasons and size ranges for each fish species at 5 % level of significance. In the analysis of condition factors across the various fish size classes, a Tukey test was used for Post Hoc Multiple comparison to identify groups with significant mean differences. For the purpose of ANOVA, normality of data was tested using a Shapiro-Wilk test, and homogeneity of variance was assessed using Levene's test for equality of error variances.

RESULTS

Composition and relative abundance

Two fish species, *Oreochromis niloticus* (Linnaeus, 1758) and *Labeobarbus intermedius* (Rüppell, 1835), belonging to families Cichlidae and Cyprinidae, respectively, were identified from the entire sample. Shannon diversity index (H') for the reservoir based on the two species was 0.37. The relative abundance by number, weight (g) and the percentage index of relative importance (%IRI) values for each fish species identified from the reservoir are summarized in Table 1. *O. niloticus* was the most frequent and important species with the highest value of percentage index of relative importance (91.88%). The dominance of *O. niloticus* both in number and weight was statistically significant (One-way ANOVA, $p < 0.000$). Seasonal comparison (Table 1) demonstrated that *O. niloticus* had the highest relative abundance during the dry season (62.52 %) in contrast to *L. intermedius* which had the highest value during the wet season (80.57 %). However, the seasonal difference was statistically not significant for *O. niloticus* ($p > 0.05$) while it was significant for *L. intermedius* ($p < 0.05$).

Feeding habits

A total of 1050 (60.80 %) and 205 (84.36 %) *O. niloticus* and *L. intermedius* gut samples were non-empty and analyzed for feeding habits as summarized in Table 2 & Table 3 respectively. Prey items identified in the stomach of *O. niloticus* included aquatic insects, zooplankton, phytoplankton and detritus (Table 2). Aquatic insects and phytoplankton constituted bulk of the diet of *O. niloticus* accounting for 78.92 % by volume of its diet. All the prey items identified in the stomach of *O. niloticus* were nearly equally frequent occurring in more than 50 % of the fish specimens examined. Nonetheless, phytoplankton and detritus were the most frequent food items of *O. niloticus* occurring respectively in 75.1 % and 70 % of the fish specimens examined.

Table 1. Summary of the %W, %N, %O and %IRI values for the two fish species sampled from Gilgel Gibe reservoir. %IRI for seasonal comparison was computed separately for each species whereas for comparison between the two species (shown in asterisks) it was computed as a fraction of the values for the entire sample

Species	Season	W	%W	N	%N	O	%O	IRI	%IRI
O. niloticus	Wet	236400	33.28	576	33.35	6	100	6663	37.48
	Dry	474000	66.72	1151	66.65	5	83.33	11113.72	62.52
	Total	710400	88.94	1727	87.67	6	100	17661	91.89*
L. intermedius	Wet	65000	73.61	178	73.25	3	50	7343	80.57
	Dry	23300	26.39	65	26.75	2	33.33	1771.16	19.43
	Total	88300	11.06	243	12.33	4	66.67	1559.41	8.11*

Table 2. Feeding habits of *O. niloticus* in Gilgel Gibe reservoir. Percentage volume (% V), percentage frequency of occurrence (% O) and percentage index of preponderance (% IP) of the different prey items in the diet of 1050 *O. niloticus* are shown. The bold fonts represent values for the major prey categories

Food item	%V	%O	IP	%IP
Phytoplankton	**36.65**	**75.10**	**2752.42**	**39.50**
Zooplankton	**6.50**	**55.20**	**358.80**	**5.15**
Cladocera	4.90	40.20	196.98	2.83
Copepods	1.60	37.40	59.84	0.86
Aquatic insects	**41.00**	**67.00**	**2747.00**	**39.42**
Diptera	12.10	47.20	571.12	8.19
Hemiptera	11.30	36.30	410.19	5.89
Coleoptera	12.80	55.90	715.52	10.27
Odonata	4.80	23.70	113.76	1.63
Detritus	**15.85**	**70.00**	**1109.50**	**15.92**

Table 3. The feeding habit of *L. intermedius* in Gilgel Gibe reservoir. Percentage volume (%V), percentage frequency of occurrence (%O) and percentage index of preponderance (%IP) of the different prey items in the diet of 205 *L. intermedius* are shown. The bold fonts represent values for the major prey categories

Food item	%V	%O	IP	%IP
Phytoplankton	**5.00**	**20.67**	**103.35**	**1.63**
Zooplankton	**29.50**	**40.15**	**1184.43**	**18.65**
Cladocera	11.65	65.80	766.57	12.07
Copepods	8.51	43.90	373.59	5.88
Rotifers	9.34	49.20	459.53	7.23
Aquatic insects	**21.50**	**83.65**	**1798.48**	**28.31**
Diptera	14.13	78.70	1112.03	17.51
Coleoptera	7.37	67.90	500.42	7.88
Macrophytes	**30.50**	**80.45**	**2453.73**	**38.63**
Detritus	**10.50**	**72.23**	**758.42**	**11.94**
Fish otoliths	**3.00**	**17.87**	**53.61**	**0.84**

The percentage of index of preponderance (%IP), which takes into account of both the volume composition and frequency of occurrence of the prey items, showed aquatic insects and phytoplankton were the most dominant in the diet of *O. niloticus* followed by detritus. Coleoptera and Diptera were the most dominant aquatic insects important in the diet of *O. niloticus* with 10.27 % and 8.19 % of %IP. Only crustacean zooplankton (cladocera and copepods) were identified in the diets of the *O. niloticus* specimens with 2.83 % and 0.86 % of %IP respectively. Macrophytes, zooplankton and aquatic insects constituted 81.50 % by volume of the prey items consumed by *L. intermedius* (Table 3). Detritus, despite its lower contribution (10.50 %) to the volume of *L. intermedius* diet, was one of the most frequent prey items that occurred in 72.23 % of the fish specimens examined. Virtually all the food items identified in the diet of *O. niloticus* were also observed for *L. intermedius* except for some variations. Macrophytes, fish otoliths and rotifers were observed only in the gut of the *L. intermedius*. In contrast, hemiptera and odonata were retrieved only from the diet of *L. intermedius*. Analysis of the %IP showed macrophytes and aquatic insects were the most dominant diets of *L. intermedius* followed by zooplankton.

Seasonal variations in feeding habits

Seasonal comparison in the feeding habits of *O. niloticus* (Fig 2) showed that the fish had more or less uniform feeding habit both during the wet and dry seasons. Aquatic insects and phytoplankton were the most dominant prey items for *O. niloticus* accounting for more than 80 % of %IP during each season. Detritus (28.85 %IP) and macrophytes (38.21 %IP) were the most important elements in the diet of *L. intermedius* during the wet season. *L. intermedius* consumed substantial

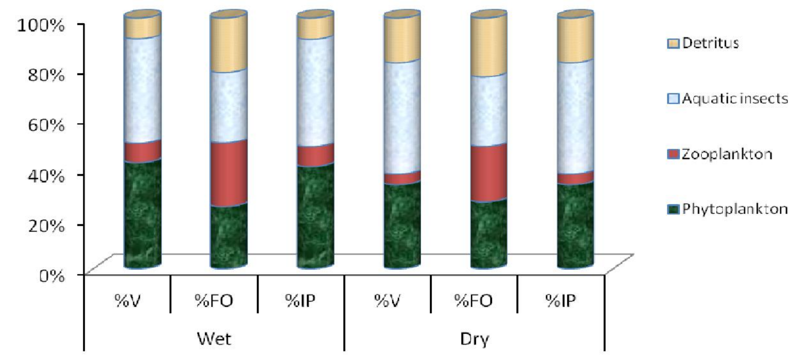

Fig. 2. Seasonal comparison of *O. niloticus* feeding habits in Gilgel Gibe reservoir

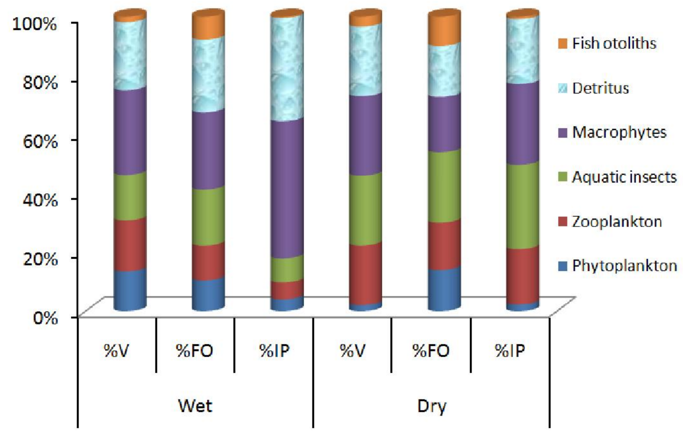

Fig. 3. Seasonal comparison of *L. intermedius* feeding habits in Gilgel Gibe reservoir

amount of aquatic insects (28.31 %IP) and macrophytes (27.18 %IP) during the dry season (Fig 3).

Diet breadth and Overlaps

The diet breadth index (B_A), a measure of the diversity of prey items taken by each fish species, was 0.40 and 0.63 for *O. niloticus* and *L. intermedius* respectively. The Horn's (H) diet overlap index for *O. niloticus* and *L. intermedius* was 0.44.

Length-Weight Relationships (LWR)

Five specimens of *O. niloticus* were omitted from the LWR as well as condition factor analyses because they were found extreme outliers from the visual inspection of the log-log plot of TL and W. Thus, a total of 1722 *O. niloticus* and 243 *L. intermedius* specimens were included in the analysis of LWR. Linear regression analysis showed that the relationship between Total Length (TL) and Weight (W) was statistically significant for both *O. niloticus* and *L. intermedius* collected during the entire study period ($p < 0.000$). The lines of best fit to the regressions of log transformed TL and W and the corresponding R^2 are given by Fig 4 and Fig 5 for *O. niloticus* and *L. intermedius* respectively.

The values of the parameters a and b and the 95 % confidence interval for b estimated from the linear regression of log transformed data are summarized in Table 4. The total mean b values were significantly smaller than the isometric value of 3 for both species (one sample t-test, $p < 0.000$). Seasonal analysis showed that the difference in the mean b value was not significant between the wet and dry seasons (one way ANOVA, $p > 0.05$) for *O. niloticus*. However, *L. intermedius* had higher mean b value (3.49 ± 0.15[SE], Table 4) during the dry season which was statistically significant ($p < 0.05$).

Condition factor

The mean values of the relative weight index (Froese, 2006) for *O. niloticus* and *L. intermedius* were 124.97 ± 24.94 % (SD) and 88.06 ± 28.71% (SD) respectively and the difference was statistically significant between the two species (one-way ANOVA, $p < 0.000$). The mean Fulton condition values (k) for *O. niloticus* and *L. intermedius*, along with the minimum and maximum values of total length and weight, are summarized in Table 5. The differences in the mean Fulton condition values of *O. niloticus* were statistically not significant between the wet and dry seasons (one-way ANOVA, $p > 0.05$) whereas, it was significant for

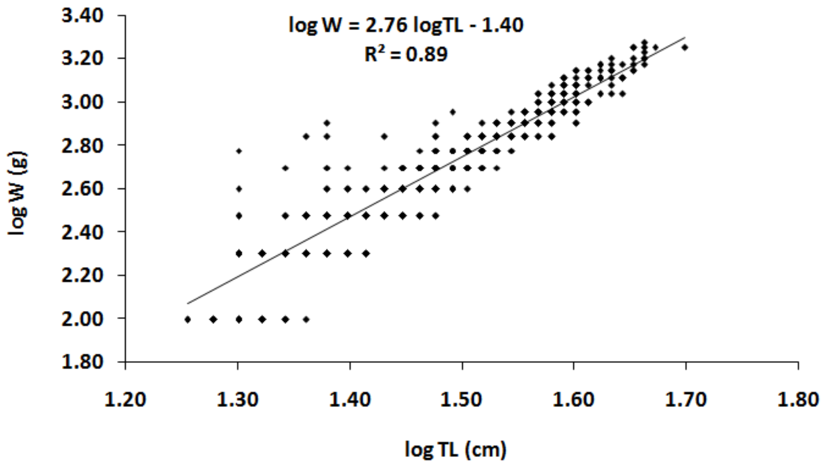

Fig 4. The logW-logTL regression plot of *O. niloticus* collected during the entire study period (n = 1722)

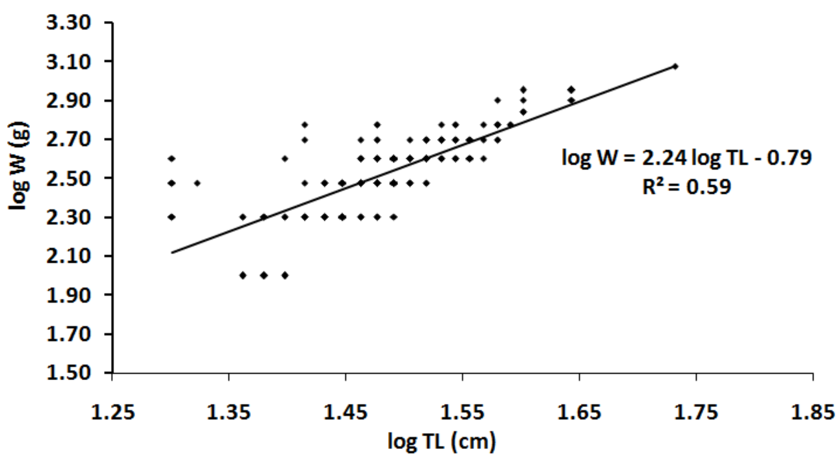

Fig 5. The logW-logTL regression plot of *L. intermedius* collected during the entire study period (n = 243)

Table 4. The estimated a and b values from the linear regression of LWR of the fish species identified from Gilgel Gibe reservoir a = intercept of the regression line; b = slope of the regression line; SE = standard error; CI = confidence interval; R^2 = regression coefficient

Species	Season	Locality	Log a	b	SE (b)	95% CI (b)	R2
O. niloticus	Wet	Deneba	-1.44	2.79	0.05	2.70-2.89	0.91
		Dimtu	-1.36	2.74	0.06	2.61-2.86	0.88
		Wet total	-1.40	2.76	0.03	2.70-2.82	0.90
	Dry	Deneba	-1.44	2.79	0.04	2.72-2.86	0.90
		Dimtu	-1.33	2.71	0.05	2.62-2.81	0.87
		Dry total	-1.40	2.76	0.39	2.69-2.85	0.89
		Total	-1.40	2.76	0.02	2.72-2.81	0.89
L. intermedius	Wet	Deneba	-0.20	1.85	0.18	1.49-2.21	0.51
		Dimtu	-0.24	1.88	0.21	1.47-2.29	0.52
		Wet total	-0.23	1.87	0.14	1.61-2.14	0.52
	Dry	Deneba	-2.65	3.43	0.21	3.01-3.86	0.89
		Dimtu	-2.85	3.57	0.23	3.11-4.04	0.90
		Dry total	-2.72	3.49	0.15	3.18-3.79	0.89
		Total	-0.79	2.24	0.12	2.00-2.47	0.59

Table 5. Some descriptive statistics of total length (TL), Weight (W) and mean Fulton condition factors (k ± SD) for the fish species collected from Gilgel Gibe reservoir. N = number of fish samples; SD = standard deviation; min = minimum; max = maximum

Species	Season	N	TL (cm)			W (g)			k ± SD
			min	max	mean± SD	min	max	mean± SD	
O. niloticus	Dry	1151	18	50		100	1900		1.87±0.41
	Wet	576	18	47		100	1800		1.87±0.34
	Total	1727	18	50	27.19±5.49	100	1900	413.24±279.78	1.87±0.40
L. intermedius	Dry	65	23	44		100	900		1.02±0.18
	Wet	178	20	54		100	1200		1.33±0.54
	Total	243	20	54	30.75±4.35	100	1200	363.37±152.98	1.25±0.49

L. intermedius ($p < 0.000$). Condition factors were compared across the size classes of 16 - 21 cm, 22 - 26 cm and 27 - 50 cm for *O. niloticus* and across 20 - 28 cm, 29 - 31 cm and 32 -54 cm for *L. intermedius*. The grouping of each species into the respective size classes was based on the pattern of length frequency distribution. The differences in the mean Fulton condition values among all the three pairs of size classes were statistically significant for *O. niloticus* (One-way ANOVA, $p < 0.000$) while it was not significant between the size classes of 29 cm - 31 cm and 32 cm - 54 cm for *L. intermedius* ($p > 0.05$).

DISCUSSION

The Shannon diversity index value for the reservoir was much lower than the typical value range of 1.5 to 3.5 which is an apparent a consequence of both its poor species richness and a highly uneven relative abundance between the two species (Table 1). The significantly higher relative abundance of *O. niloticus* than *L. intermedius* might relate to the damming effect that impoverished the latter which normally has better adaptation to lotic ecosystems (Bone and Moore, 2008). Yet, both of these fish species are important sources of fishery to the local people. Specific reports on fish diversity of Gilgel Gibe River and its associated streams prior to the creation of Gilgel Gibe reservoir are virtually non-existent. *L. intermedius* was reported as occurring in Gilgel Gibe River in 1954 (Anonymous, 2002). Others (e.g. Roberts, 1975; Leveque *et al.,* 1991) just indicated its occurrence in the Omo-Turkana drainage basin, where the river and the reservoir are located. Similarly, the occurrence of *O. niloticus* in Omo-Turkana basin has been indicated by recent studies (Golutsov and Darkov, 2008). Thus, it is likely that these fish species had existed in the basin and might have established themselves in the reservoir after the damming. Feeding habit analysis and the values for the diet breadth indices of *O. niloticus* (B_A= 0.40) and *L. intermedius* (B_A = 0.63) showed that both species were apparently omnivorous utilizing various types of food resources in the reservoir. The relatively higher value of diet breadth index for *L. intermedius* suggests the more generalist nature of the fish than *O. niloticus*. More diverse types of prey items were retrieved from the diet of *L. intermedius* (cf. Table 2 and Table 3). However, the importance and contribution of the various prey items to the diets of both fishes varied between the two species. *O. niloticus* predominantly fed on aquatic insects and phytoplankton which remained major components in its diet both during the wet and dry seasons (Table 2; Fig 2). Detritus and zooplankton generally remained less abundant in the diet of *O. niloticus*; however, detritus was the most frequent item next to phytoplankton occurring in 70 % of the *O. niloticus* specimens examined. The feeding habit of *O. niloticus* in Gilgel Gibe reservoir observed in the preset study is in agreement with the omnivorous nature of the Cichlid family investigated elsewhere (Gerking, 1994; Bone and Moore, 2008). Macrophytes, aquatic insects and zooplankton, respectively, were the most dominant food items for *L. intermedius* although their relative contribution varied according to season. *L. intermedius* fed mainly on macrophytes and detritus during the wet season whereas it largely consumed aquatic insects, macrophytes, detritus and zooplankton during the dry season. This seasonal variability in the feeding habit of *L. intermedius* in Gilgel Gibe reservoir agrees with the study of Sibbing and Nagelkerke (2001) who found large barbs of Lake Tana, upper Blue Nile basin, omnivorous which can shift its diet depending on availability of prey, seasonal and spatial differences. Moreover, the consumption of more detritus (28.85

%IP) and less benthic insects (6.75 %IP) by *L. intermedius* during the wet season is comparable with the finding of Balcombe *et al*. (2004) who found similar consumption pattern for *Barbus* sp when the water level is high in a Sri Lankan reservoir. Phytoplankton, zooplankton, aquatic insects and detritus common to the diets of both fish species. Macrophytes and fish otoliths were found only in the diet of *L. intermedius*. The contribution of phytoplankton to the diet of *L. intermedius* (1.63 %IP) was virtually negligible while it was the most dominant and common component in the diet of *O. niloticus* (39.50 %IP). Fish prey, as perceived from the identification of otolith, was also poorly represented in the diet of *L. intermedius* (1.05 % IP). This observation stands in contrast to the previous reports from other water bodies in Ethiopia (e.g. Desta *et al*., 2006) and might have been the consequence of sufficient availability of other prey items in the reservoir. Diptera and coleoptera were consumed by both fish species while relatively more diverse aquatic insect groups were consumed by *O. niloticus*. Cladocera and copepods were consumed by *O. niloticus* while *L. intermedius* also consumed rotifers in addition to the crustacean zooplankton. Despite some of these differences in prey items, the two fish species occurring in the reservoir still had high value of diet similarity index (H' = 0.44). This high diet similarity between the two species should be indicative of the availability of various food resources in the reservoir rather than competition bottlenecks. Rich occurrence of the various food items should be ascribed to high trophic surge resulting from the process of decomposition of the natural vegetation inundated by water filling up the reservoir (Wetzel, 2001; Chipps and Garvey, 2007). Furthermore, the presence of both benthic prey items (e.g. aquatic insects) and pelagic prey items (e.g. phytoplankton and zooplankton) in the diets of these fish is also a clear indication of their ability to utilize resources from different habitats.

Analysis of the LWRs showed that the relationship between the TL and W was strong for both species. However, from the log-log regression plots (Fig 4 and Fig 5) we observe that *O. niloticus* had larger R squared value ($R^2 = 0.89$) and thus much stronger LWRs. The mean growth coefficients (b) were significantly lower than the isometric value of 3.0 signifying negative allometric growth pattern for both species (Bagenal and Tesch, 1978; Froese, 2006). However, analysis of fish conditions across various size classes (discussed below under fish condition) implies that the lower b values observed for both species should rather be suggestive of a better condition for the smaller size fish specimens (Pauly *et al*., 2008). No seasonal variation was observed in the LWRs of *O. niloticus* whereas *L. intermedius* had different LWRs during the wet and dry seasons whose mean b values varied significantly. Therefore, it is recommended that any attempt to make use of the LWRs obtained in the present study for the management purpose should consider seasonal effect for *L. intermedius* (Froese, 2006). Moreover, the mean b values of 2.76 and 2.24 observed, respectively, for *O. niloticus* and *L. intermedius* in Gilgel Gibe reservoir in the present study varied from the values reported from other water bodies of Ethiopia for the same species as summarized in Table 6.

To interpret the conditions of each fish species, their Fulton condition values (k) were compared against the values of mean condition factor (k_{mean}) computed according to Clark (1928). The Clark mean condition values for *O. niloticus* was 1.81 against the Fulton condition value of 1.87, and it was 1.18 for *L. intermedius* against the Fulton's condition value of 1.25. Comparison of the two indices showed that the measured weight of *O. niloticus* was 13.55 % above and that of *L. intermedius* was 5.64 % above the mean weight computed from their LWRs. Therefore, the analysis showed that both *O. niloticus* and *L. intermedius* relatively had good condition. The relative weight index according to Froese (2006) was used, instead of the Fulton condition factor, to compare the conditions between the two species because (1) variation in mean length between the two species was significant, (2) their mean b values were significantly lower than 3.0. *O. niloticus* had the highest relative weight index value of 124.97 ± 24.94 % (SD) as compared to *L. intermedius* which had a value of 88.06 ± 28.71 % (SD). Thus, while both species were generally in good condition, the relative weight index suggests that *O. niloticus* was in a much better condition than *L. intermedius*. Comparison of Fulton condition across the three major size classes for each species showed that the mean condition values (k) were inversely related to fish size. O. *niloticus* specimens in the lowest size class (16 - 21 cm) had a mean condition of 2.1 ± 0.74 (SD) and the larger specimens (27 - 50 cm) had a value of 1.78 ± 0.25 (SD). Similarly, specimens of *L. intermedius* in the lowest size range (20 - 28 cm) had a mean condition of 1.44 ± 0.87 (SD) and the larger specimens (32 - 54 cm) had a value of 1.13 ± 0.17 (SD). Earlier reports on the conditions of these fish species from other water bodies of Ethiopia are as summarized in Table 6 for comparison. Comparatively the values of Fulton condition factor recorded in the present study are lower for *O. niloticus,* whereas they are comparable for *L. intermedius*. In conclusion, though Gilgel Gibe reservoir was found to be poor in its fish species composition, the relative abundance assessment showed that the reservoir can support considerable amount of fishery as also observed from its current fishery activity. Both *O. niloticus* and *L. intermedius* had omnivorous feeding habit exploiting variety of rich food resources available in the reservoir as could be inferred from their diet breadth and overlap indices. Thus, the study among

Table 6. Summary of the earlier reports on the mean 'b' values of the LWRs and Fulton conditions (k) for *O. niloticus* and *L. intermedius* from various Ethiopian waters

Species	b	k	Locality in Ethiopia	Reference
O. niloticus	3.03	-	Lake Zeway, Rift Valley basin	Tadesse (1988)
	2.90	-	Lake Awassa, Rift Valley basin	Admassu (1990)
	-	1.67	Lake Langano, Rift Valley basin	Tadesse (1998)
	2.95	2.35	Lake Chmao, Rift Valley basin	Teferi and Admassu (2002)
	3.07	2.05	Baro River, White Nile basin	Melak (2009)
L. intermedius	2.96	1.14	Angereb River, Tekeze-Atbara basin	Tesfaye (2006)
	3.18	1.05	Sanja River, Tekeze-Atbara basin	Tesfaye (2006)
	2.98	1.30	Arno-Garno River, Blue Nile basin	Gebremedhin (2011)

others affirmed the importance of establishing functional data on feeding habit as well as LWR and condition factors for Gilgel Gibe reservoir for effective management of its fisheries.

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