

Full Length Research Paper

Morphometric relations, diet composition and ontogenetic dietary shift of *Labeobarbus intermedius* (Rüppell, 1836) in Lake Tana gulf of Gorgora, Ethiopia

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Morphometric relations, feeding habits and dietary shifts of *Labeobarbus intermedius* in Lake Tana at gulf of Gorgora were studied during the dry season. A total of 250 fish ranging from 13.2 to 43.8 cm total length (TL) and 73.4 to 742.8 g total weight (TW) were randomly sampled from the lake. The data generated from both morphometric parameters were analyzed using SPSS (Version 20) and expressed using least square regression, and stomach content analysis was based on frequency of occurrence and volumetric contributions. The relation between TL and standard length (SL) was linear ($SL = 0.802 TL - 0.164$) and the relation between TL and TW as well as fork length (FL) and TW was curvilinear and significant ($TW = 0.014 TL^{2.9}$; $TW = 0.029 FL^{2.8}$). The results of gut content analysis revealed that about 4.4% of the sampled fish guts were empty and the remaining non empty. Detritus were the most important food item that dominates the bulk by accounting 43.12% of the total volume of the diet. Other important food items in the diet composition of the fish included insects, phytoplankton and gastropods which constituted 17.89, 14.57 and 12.02% to the bulk, respectively. The remaining groups of food items that included zooplankton, macrophyte and nematode were recorded as foods of minor importance in the diet of the fish. The result revealed that there was no visible dietary shift in the diet of *L. intermedius* in the lake. In conclusion, *L. intermedius* in Lake Tana shows an isometric growth and was found to be omnivorous in its feeding habit.

Key words: Detritus, frequency of occurrence, isometric, *Labeobarbus intermedius*, omnivorous, volumetric composition.

INTRODUCTION

Members of the family Cyprinidae are diverse and the most widely distributed fish species in the world. However, small distribution is observed in Ethiopian water bodies (Nelson, 1994). This large family is represented by four genera of *Barbus*, *Garra*, *Varicorhinus*

and *Labeobarbus* of which the last is the most significant genus of the family that contains 15 species in Lake Tana making a unique species flock in the world (De Graaf et al., 2000). The African big barb, *Labeobarbus intermedius* (Rüppell, 1836) is the third most commercially

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important fish next to *Oreochromis niloticus* and *Clarias gariepinus* with annual production of about 365 tons in the country (LFDP, 1997; Ameha and Assefa, 2002; Ameha, 2004; Dadebo et al., 2013). Nevertheless, its production and consumption has declined recently in the country due to several reasons including recruitment of the young, over fishing by the commercial gill net, presence of fish parasite, bone fullness and the high level of mercury concentration found in the body (Desta et al., 2006; Mengesha, 2009; Dadebo et al., 2013). In line with the above, De Graaf et al. (2004) make known broad damage of fish through the poisoning of the spawning stock using the crushed seeds of birbira (*Milletia ferruginea*).

Knowledge on the morphometric (length-length and length-weight) relationships are critical measures in determinations of growth rates, average weight of given length group, length and age structures (James et al., 2000; Josef and Popoola, 2013). All the aforementioned authors have also elaborated that morphometric relations are vital in verifying the relative well-being of fish and types of habitat they live. Variations on the types of food supply have an impact on the size attained by individual fish. Dadebo et al. (2013) elucidated the definite augmentation in size of fish observed during an ontogeny which might be caused by changes in food quality and quantity in aquatic environment.

In nature, fishes feed on a great diversity of food items such as phytoplankton, zooplankton, benthic and non-benthic invertebrates, benthic deposits, other fish and aquatic macrophytes (Flipos et al., 2013). Studies on the feeding habits of fish is important for pond production management, formulating the dietary needs of species both used in intensive and extensive culture and also in determining whether the population age structure in the fishery is in proper relation to the food resources available to it (Oronsaye and Nakpodia, 2005; Oso et al., 2006; Kariman and Nehad, 2009). The feeding habit of *L. intermedius* from different Ethiopian lakes indicate that the fish is an omnivorous mainly feeding on gastropods, phytoplankton, macrophyte, insect, insect larvae, detritus, nematodes and others (Admassu and Dadebo, 1997; Sibbing, 1998; Desta et al., 2006; Dadebo et al., 2013). The finding of Assaminew (2005) from Lake Koka reveals the piscivorous feeding habit of the fish where the gut contents were composed of fish, fish eggs, fish scales, fish fry and other common insects and nematodes.

Many authors have revealed the impacts of size, maturity, habitat (littoral or profundal) water type and water level on the feeding habits of the fish (Cabana et al., 1994; Persson and Crowder, 1998). In addition to the above, Flipos et al. (2013) explained that the feeding habits of fish shows a significant variation because of seasonal changes.

Numerous studies have been conducted on the biology of the species in many lakes and upstream rivers of the country which are used as site of migration for the fish

during reproduction (Desta et al., 2006; Dadebo et al., 2013; Gebremedhin et al., 2013). However, information on the morphometric relations, feeding habits in relation with ontogenetic dietary shift from Lake Tana which constitutes 15 members of *Labeobarbus* species is diminutive. In addition, area specific information is critical for appropriate management and utilization of the stock, the accessible information on the species from the gulf of Gorgora is not adequate. So, to fill the study gap and bring a baseline data, the present study was conducted with the objectives of determining the morphometric relations, feeding habits and ontogenetic dietary shift in Lake Tana at Gorgora gulf.

MATERIALS AND METHODS

Study area

The presence of rivers, lakes and reservoirs make Ethiopia to be considered as a water tower of East Africa. These water bodies account about 8,800 km² and enclose diverse groups of aquatic organisms. Apart from their economic importance, the water bodies provide great scientific interest and used as area of research to the researchers (Mengesha, 2009; Flipos et al., 2013). Lake Tana is the largest lake of Ethiopia located in the north west part between 12°, 10'N and 37° 23'E with an altitude of 1800 (Figure 1). The total area of the lake reaches about 3,200 km² with maximum and mean depths of 14 and 8 m, respectively (Gebremedhin et al., 2013). The lake is one of most precious natural resource and historical place, which is serving as heritage. The water from the lake is used for hydropower generation, fishery production, irrigation, water supply and waste disposing site. Lake Tana is the main source of Blue Nile River with Oligotrophic character. As compared to other lakes of the country, the lake is rich in its biodiversity of both flora and fauna (Wudneh, 1998; Dejen et al., 2002). Gorgora is a town located in the north shore of Lake Tana with an altitude of 12°14'N and 37°18'E. The town is surrounded by several Churches and Monasteries.

Sampling and measurements

Fish samples were collected from fishermen catch using gill net of 6 to 8 cm stretched mesh size during April and May, 2014. In addition, fingerlings were captured using a beach seine with mesh size of 2 to 4 cm at the shallower parts of the lake. Total length (TL), fork length (FL), standard lengths (SL) and total weight (TW) of all sampled fish were measured to the nearest millimeter and to the nearest gram using measuring board and citizen digital balance (Model CY510).

Morphometric relationships

In order to investigate all morphometric relationships of *L. intermedius*, the least squared regression analysis of Bagenal and Tesch (1978) was adapted or used. The length-length relation was calculated using:

$$TL = aSL^b \text{ or } TL = a FL^b$$

$$TL = a + b SL \text{ or } TL = a + b FL$$

Where, TL = total length, SL= standard length, FL = fork length, 'a'

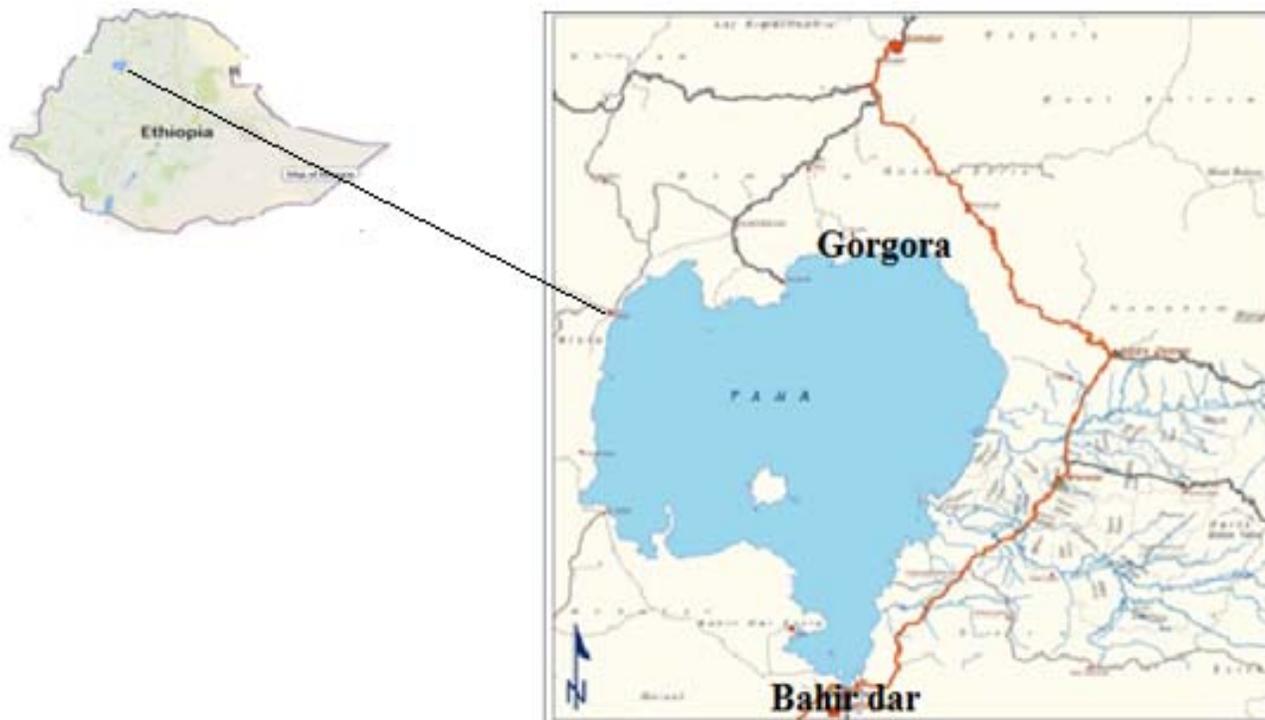


Figure 1. Map of study area (relative position of Lake Tana and Gorgora gulf).

and 'b' = Y intercept and slope of the regression line or equation, respectively. Determination of 'a' and 'b' values were performed using a non-linear regression of which the curves fitting were carried out by chi-square test.

The length and weight relation was also estimated by the following formula:

$$TW = a TL^b$$

Where, TW = total weight, TL = total length, a and b = Y intercept and slope of the equation respectively.

On the other hand, confirmation on length-weight relationship was done using log transformation of the above equation (Josef and Popoola, 2013).

$$\text{Log TW} = \text{log } a + b \text{ log } L$$

Where TW = Total weight, TL = total length, 'a' and 'b' are Y intercept and slope of the equation respectively.

The average condition factor, K was calculated using Fulton's

$$\text{condition factor } K = \frac{1000 \times W}{L^3} \quad \text{Where, } W \text{ is weight and } L \text{ is length.}$$

Food and feeding

After body parameter measurement, guts were collected by dissecting the fish on its ventral side using scissors. The contents were preserved in sampling tubes containing 5% Formalin solution. Thus, all samples were transported to the laboratory for further analysis. In the laboratory, the gut contents were examined using a dissecting microscope (Leica MS5) and Olympus compound microscope using different aquatic flora and fauna books. The relative importances of the different food items found in the gut contents were determined using the method of Windell and Bowen (1978).

Frequency of occurrence

The number of stomach samples containing one or more of a given food item was expressed as a percentage of all non-empty guts examined (Hyslop, 1980; Bowen, 1983).

$$Fi = \frac{100 \times ni}{n}$$

Where: F_i , Frequency of occurrence of the i food item in the sample; n_i , number of guts in which the i item is found; n , total number of guts with food in the sample.

Volumetric analysis

Food items that were found in the guts were sorted into different taxonomic categories and the water displaced by a group of items in each category was measured in a partially filled graduate cylinder. The volume of water displaced by each category of food items was expressed as a percentage of the total volume of the stomach contents (Bowen, 1983).

Data analysis

The data generated from all the parameters measured, morphometric relation, feeding habit and dietary shift were expressed using descriptive statistics. In addition, the results obtained from morphometric relations and dietary shifts were interpreted using correlation and regression.

One way analysis of variance (ANOVA) was used to compare the importance of food items within the species and size class using SPSS Version 20.

RESULTS AND DISCUSSION

Morphometric relations

The morphometric relations between TL and SL of *L. intermedius* from Lake Tana of Gorgora was linear with the equations $SL = 0.802 TL - 0.164$ and highly significant ($p < 0.01$) with R^2 value of 0.969 in which it indicates a strong morphometric relationship (Figure 2). Another significant and curvilinear relation was observed between TL and TW ($TW = 0.014TL^{2.9}$) (Figure 3).

The relation between FL and TW was also curvilinear with $TW = 0.029 FL^{2.8}$, $R^2 = 0.902$ (Figure 4). All morphometric data shows strong and highly significant relation. The linear relation, between TL and SL indicates either of the length measurements can be converted into the other or one can be calculated or estimated from the other; whereas, in the curvilinear relationships of TL and TW the intercept 'a' indicates the average condition factor index of the fish in the lake which is 0.014.

Condition factors show variation that happen seasonally and individually due to sex and gonad development. The average condition factor (K) of *L. intermedius* in the present study is 0.014 which is better than the findings of Gebremedhin et al. (2013), who reported condition factor of the same fish as 0.0137 from Infranz River. This may be due to the difference in availability of food items in the vicinity or due to the period of sampling. The slope of the relation 'b' is 2.9, which is close to 3 and indicates the nearly isometric growth pattern of *L. intermedius* in Lake Tana. Even if there is species dependent variation on the relations of TL and TW because of their inherited body shape and robustness, food availability and the growth pattern has also an impact on it (James et al., 2000).

The isometric growth pattern obtained in the present study may be due to the growth that occurs at same rate for all parts of the organisms so that; its shape is consistent throughout the development. It characterizes fish of unchanging body form and unchanging specific gravity. The result of the present study corroborate with findings of many authors from different inland waters of Ethiopia and abroad (Safran, 1992; Nagelkerke et al., 1993; Nagelkerke, 1997; Anteneh et al., 2008; Gebremedhin et al., 2013).

Food and feeding habits

Out of a total of 250 fish samples, 11(4.4%) of the guts were found as empty and the remaining 239 (95.6%) were observed as non-empty with different food items. The small amount of empty stomach recorded may be

due to the short period of time between capture and the least probability of food loss through digestion or regurgitation. Another reason may also be the resisting ability of detritus for digestion. The sampled fish ranged from 13.2 to 43.8 cm TL and 73.4 to 742.8 g TW with mean values of 27.04 cm and 203.22 g in the same order.

Based on the gut content analysis, detritus was the most important and dominant food item observed in the majority of the guts examined; insect, phytoplankton and gastropods were of intermediate in their dominancy and importance followed by the least abundant zooplankton, ostracods, macrophyte and nematodes whose contribution was small to the total volume of the fish food (Figure 5 and Table 1).

The major food item consumed by *L. intermedius* of Lake Tana was detritus that occurred in 82% of the guts scrutinized and volumetrically it accounts 43.12% to the total compositions of the diet. The result is in consensus with the findings of Assaminew (2005) and Dadebo et al. (2013) which described the detrital feeding habit of the same fish species in Lake Koka. Several authors have reported the digestibility and nutritional importance of detritus in many parts of the world (Dadebo et al., 2013; Filipos et al., 2013).

The mean comparison test of different food items indicates that detritus shows a significantly higher variation both on the frequency of occurrence and volumetric compositions than other food items. The detritivore feeding habit of *L. intermedius* may be due to the bottom dwelling nature of the fish. Another possible justification may be the presence of many emerged, submerged and floating aquatic plants in the surrounding area. The finding of the present study corroborates with findings from local and abroad water bodies (Admassu and Dadebo, 1997; Sibbing, 1998; Sibbing and Nagelkerke, 2001; De Graaf, 2003; Dadebo et al., 2013).

The second most important food item in the diets of the species was insects by occurring in 54% of the guts and volumetrically accounts 17.89%. Among group of insects, *Ephemeroptera* and *Chironomidae larvae* were of important food items with 41.3 and 24.8% occurrence and contribute 6.79 and 5.49% in the diet of the fish, respectively. Other members of insect; *Coleoptera* and *Plecoptera* showed similar occurrence of 20.7%, whereas their contribution (3.13 and 2.49%) to the total volume were small (Figure 5 and Table 1). The finding of the present study is substantiate with De Graaf (2003), who described the diet compositions of *L. intermedius*, as it is composed of detritus, macrophyte and aquatic insects. However, the findings of Dadebo et al. (2013) make known the dominancy of dipterans in the diet. In contrast to the piscivorous nature of *L. intermedius* explained by Desta et al. (2006), the contributions of insects in the present study shows a decline.

Phytoplankton communities were recorded as the third important food item in the diet of *L. intermedius* by

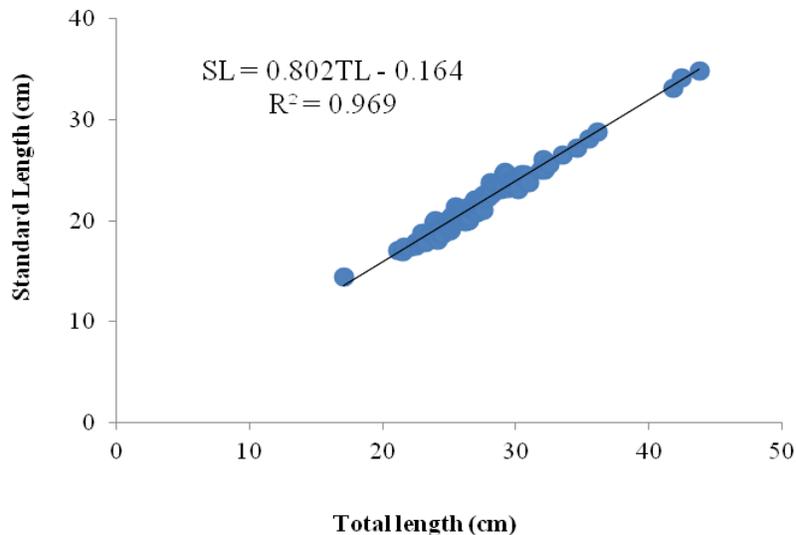


Figure 2. Total length (TL) and standard length (SL) relationship.

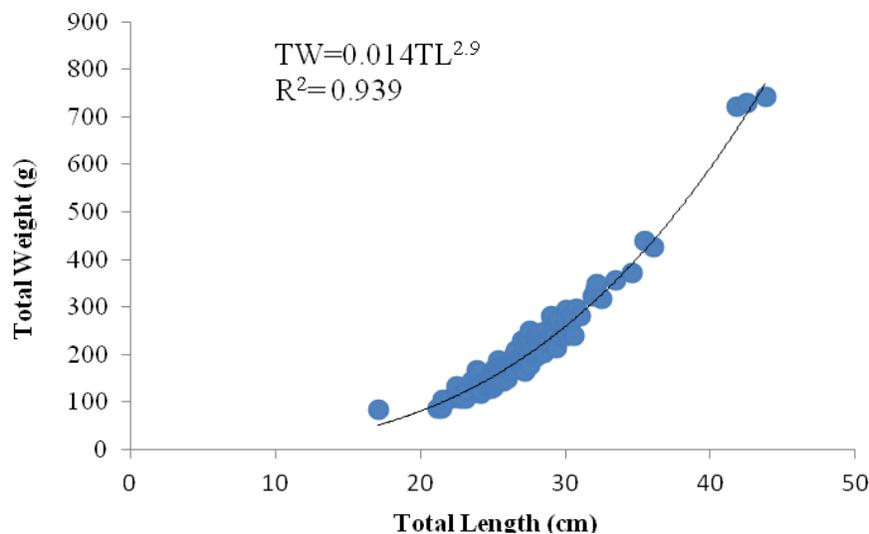


Figure 3. Total length (TL) and total weight (TW) relationships.

accounting 14.57% to the bulk. Intermediate contributions of diatoms and blue greens were comparable by comprising 6.69 and 6.45% to the total volume with the occurrence of 45.5 and 41.3% in the same order. On the other hand, the contribution of green algae was insignificant to the diet of the fish. The contribution of phytoplankton in the diet of the fish is small and rarely reported. This may be due to the accidental intake, while searching other food items. Several authors have disclosed the presence of phytoplankton in the diet of *L. intermedius* (Sibbing and Nagelkerke, 2001; De Graaf, 2003; Desta et al., 2006).

Gastropods occurred in 28.9% of the guts and

volumetrically contributed 12.02% to the total food items. Desta et al. (2006) discloses the dominance of gastropods in the food compositions of *L. intermedius* in Lake Hawassa. The frequency of zooplankton occurrence was 24.8% and their volumetric contributions was 5.17%. Among zooplankton, *Calanoid copepod*, *Cyclopoid copepod*, *Daphnia* and *Moina* were observed in the diet with small contributions. Ostracods show relatively high occurrence of 42.1% but constitute 4.12% to the volume. The remaining groups of food items, macrophyte and nematodes were found to be least in their frequency of occurrence (13.2 and 1.6%) as well as in their volumetric contribution (1.43 and 0.66%)

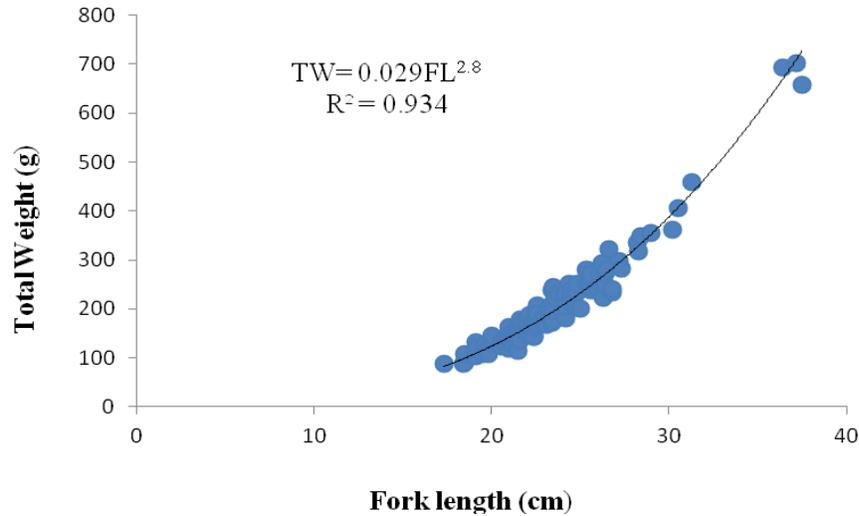


Figure 4. Fork length (FL) and total weight (TW) relation.

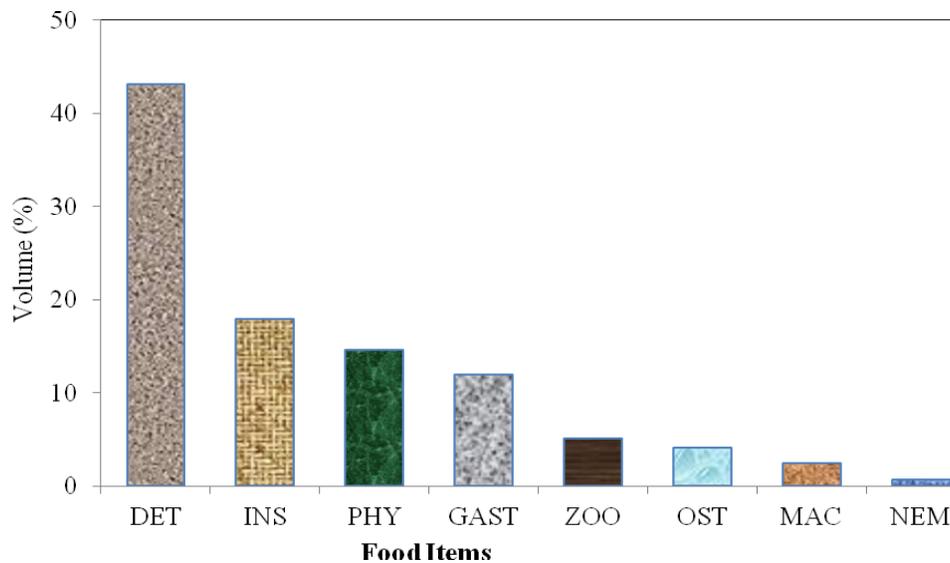


Figure 5. Volumetric contributions of different food items in the diet of *Labeobarbus intermedius* from Lake Tana Gorgora gulf (DET- Detritus, INS- insect, PHY- phytoplankton, GAST- gastropode, ZOO- zooplankton, OST- ostracod, MAC- macrophyte, NEM- nematode).

correspondingly. Unlike to the present finding from the same water body, De Graaf (2003) disclosed the least common occurrence of zooplankton in the diet of the fish.

Ontogenetic dietary shift

In the present study, attempt has been made to show the presence of ontogenetic dietary shift. However, there is no significant shift observed in the diet change as the size of the fish increases. In the first size class (TL < 20

cm), the uncommon phytoplankton constitute almost half (50%) of the gut content, while detritus and insects account 35 and 15% which is relatively small in contribution. Many findings explain the presence of high detritus, zooplanktons and insects which are common in guts of juveniles. The amount of phytoplankton consumed has significantly declines in the second size class (TL < 29.9 cm). Whereas other food items such as, detritus and insect increased in small amount. New food items identified in this size class include zooplankton, macrophyte, ostracode and gastropod which contribute

Table 1. Frequency of occurrence and volumetric contributions of food items in the diet of *Labeobarbus intermedius* from Lake Tana, Gorgora gulf.

Food items	Frequency of occurrence (%)	Volumetric contribution	
		Volume (ml)	%
Detritus	82.6	52.4	43.12
Insect	54.5	21.8	17.89
<i>Ephemeroptera</i>	41.3	8.3	6.7
<i>Chironomidae</i>	24.8	6.7	5.49
<i>Coleoptera</i>	20.7	3.8	3.13
<i>Plecoptera</i>	20.7	3.0	2.49
Gastropod	28.9	14.6	12.02
Diatom	45.5	8.1	6.69
<i>Melosira</i>	38.8	4.4	3.64
<i>Aulacoseira</i>	24.8	1.5	1.25
<i>Cyclotella</i>	17.3	1.0	0.84
<i>Fragilaria</i>	9.1	0.9	0.74
<i>Nitzschia</i>	4.1	0.2	0.19
Blue Green algae	41.3	7.8	6.45
<i>Microcystis</i>	30.6	3.2	2.62
<i>Coelosphaerium</i>	11.6	1.2	0.96
<i>Chroococcus</i>	11.6	0.94	0.77
<i>Planktolyngbya</i>	23.1	2.5	2.05
Zooplankton	19.8	2.9	2.38
<i>Calanoid copepod</i>	19.8	2.6	2.1
<i>Cycloid copepod</i>	2.5	0.4	0.33
<i>Daphnia</i>	2.5	0.34	0.28
<i>Moina</i>	0.8	0.045	0.04
<i>Keratella</i>	0.8	0.045	0.04
<i>Branchionus</i>	19.8	2.9	2.38
Ostracod	42.1	5.0	4.12
Macrophyte	13.2	2.98	2.45
Green algae	16.5	1.7	1.43
<i>Closterium</i>	11.6	1.2	1.0
<i>Botryococcus</i>	5.8	0.4	0.36
<i>Spirogyra</i>	1.7	0.08	0.07
Nematode	1.6	0.8	0.66

24.6% to the total volume of the size class. Among all, gastropods were of good importance.

In the third size class (TL < 39.9 cm), the contribution of detritus (58.5%) becomes significant followed by zooplankton and gastropod which account 12.8 and 9.2% in the same order, while the contribution of other food items become negligible in their contribution.

In the last size class (TL > 40 cm), detritus (59.3%)

continues to be the most common food item consumed by the fish showing significant difference within the size class. Phytoplankton becomes the second dominant food in the size class with 16.5% contribution to the total volume, while other food items show minor importance in the diet of the fish (Figure 6). As compared to the findings of Dadebo et al. (2013), the most common food item eaten by the juvenile fish (< 20 cm) in Lake Koka was

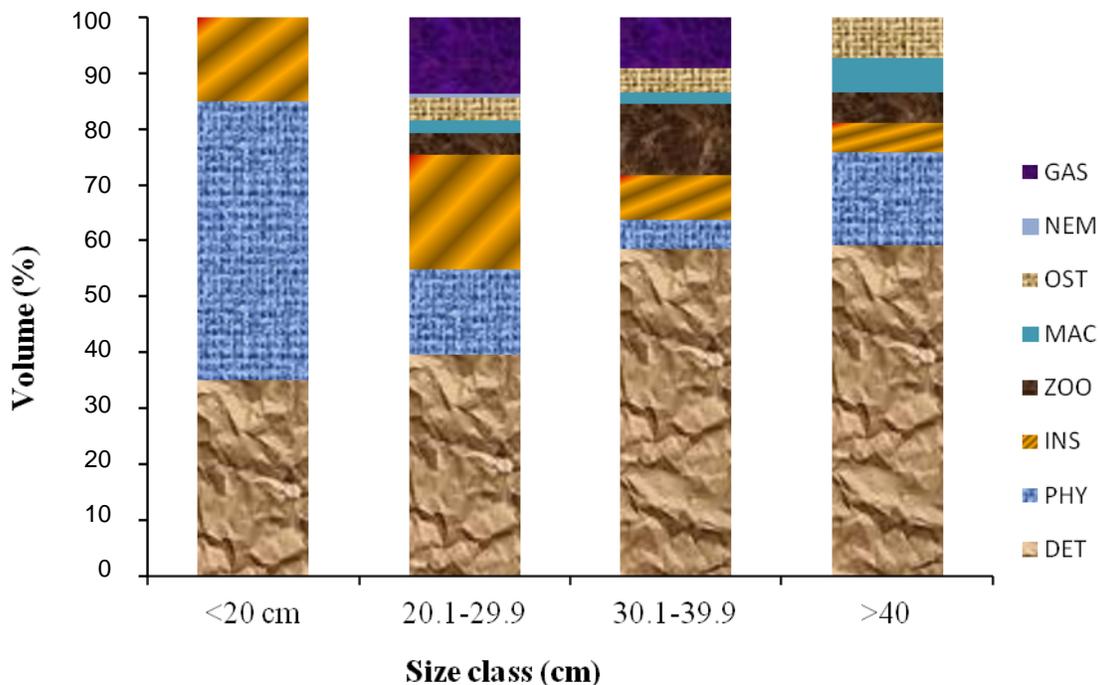


Figure 6. Ontogenetic dietary shift in *Labeobarbus intermedius* of Lake Tana.

detritus and insects. The result adds to explain as the size of the fish increases, macrophyte becomes important food item in the majority of the stomachs examined followed by detritus and insects (De Graaf, 2003).

This observed difference in the dietary shift of *L. intermedius* may be due to the availability and seasonality of food items in the lake. Feeding habits of fish show variation depending on the water type, habitat of the fish, season of study and size (Flipos et al., 2013). Most juvenile fishes prefer to swim in the littoral region and eat small food items such as zooplanktons and insects which are dominated there. As their size increases, they swim in the open water and change their mode of feeding to eat large food items of macrophyte, detritus and others. It might be due to their smaller stomach that cannot support big food items and unavailability of those foods in the bottom. In the present study, there is no visible dietary shift in the diet of *L. intermedius*. This may be due to lack of small sized fish (TL < 10 cm) in the sample. However, the result is in consensus with the finding of Desta et al. (2006), from Lake Hawassa described as the contributions of insects diminished in large size class. Unlike to the above, there is no piscivory observed in the present study.

Conclusions

The result of the present study make known as there is a close relation on the morphometry of *L. intermedius* in

Lake Tana of Gorgora gulf. The fish also inhabits isometric growth pattern. *L. intermedius* feeds on wide varieties of food items and detritus was found to be the major food item in the diet of the fish. Insects and phytoplankton were of intermediate importance however there is no any significant ontogenetic dietary shift in the fish among different size classes. Generally, the fish was found to show an omnivorous feeding habit dominated by detritus.

RECOMMENDATIONS

In order to have full information about the species, further studies should be conducted including its reproductive biology and concentrations of heavy metal analysis. The local government officials should limit the size of the fishing gear and prohibit informal fishermen that recruit the immature. Since the fish is nutritive, it shall be cultivated in aquaculture.

Conflict of Interest

The author(s) have not declared any conflict of interest.

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