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Full Length Research Paper

Spawning migration of *Labeobarbus* species of Lake Tana to Gilgel Abay River and its tributaries, Blue Nile Basin, Ethiopia

Dagnew Mequanent[1], Minwyelet Mingist[2], Abebe Getahun[3] and Wassie Anteneh[4]

[1]Amhara Design and Supervision Works Enterprise, P.O.Box1921,Bahir Dar, Ethiopia.
[2]Department of Fisheries, Wetlands and Wildlife Management, College of Agriculture and Environmental Sciences, Bahir Dar University, P.O. Box 79, Bahir Dar, Ethiopia.
[3]Department of Zoological Sciences, Addis Ababa University, P.O. Box 1176, Addis Ababa, Ethiopia.
[4]Department of Biology, College of Science, Bahir Dar University, P.O. Box 79, Bahir Dar, Ethiopia.

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Fish samples were collected by using monofilaments gillnets (5-55 mm) and multifilament gillnets, having mesh sizes of six, eight, ten, twelve and fourteen centimeter stretched bar mesh, having a length of twenty five meter and depth of one and half meter, on six sampling sites of Gilgel Abay River and its tributaries. Dissolved Oxygen, water temperature, pH, conductivity, total dissolved solids and water transparency were measured. Samples were collected bimonthly from August to October and monthly in November. When all catches are pooled, 89.30% was contributed by the genus *Labeobarbus* and the remaining (5.7%) and (5%) were from the genera *Clarias* and *Varicorhinus*, respectively. *Labeobarbus intermedius* was the most dominant (50.10% by number), followed by *L. brevicephalus* (17.16%) and *L. nedgia* (8.58%). Spatial distribution patterns of the most abundant *Labeobarbus* species did not show significant variation (P >0.05). Temporal segregation among dominant *Labeobarbus* species was not also evident (P >0.05) except, between *L. intermedius* and *L. brevicephalus.* All *Labeobarbus* spp. except *L. dainellii, L. gorguari, L. acutirostris* and *L. megastoma* were found in all sites. Illegal fishing activities were rampant and must be totally prohibited by closing fishing during the spawning months to protect these unique migratory riverine spawning species.

Key words: Conservation, segregation, abundance, temporal, *Labeobarbus*, migration.

INTRODUCTION

Utilization of aquatic resources sustainably, especially the fishery resources as a cheap source of animal protein, is mandatory to alleviate the severe suffering of people due to recurring drought and increasing human population in Ethiopia (Wudneh, 1998). Even though Ethiopia is a land-locked country, there are a number of lakes and rivers with important fish resources. Lake Tana is the largest lake in the country constituting almost half of the freshwater (Reyntjes *et al*., 1998; de Graaf *et al*., 2004). Fish families of Lake Tana include Cichlidae, Clariidae and Balitoridae each represented by single species: *Oreochromis niloticus*, *Clarias gariepinus* and Afronema-*cheilus abyssinicus,* respectively (Vijverberg *et al*., 2009: Getahun and Dejen, 2012). The largest family, however, is Cyprinidae and it is represented by four genera. *Barbus, V aricorhinus, Garra* and *Labeobarbus*. *Barbus* is represented by three species: *B. humilis*, *B. pleurogramma* and *B. tanapelagius* (Dejen, 2003). *Varicorhinus* is represented only by *V. beso*; the genus *Garra* is represented by four species: *G. dembecha*, *G. tana*, *G. regressus* and *Garra* sp. (unidentified species with small mouth) (Geremew, 2007). *Labeobarbus* is the most abundant genus of the family and consists of 15 species (*L. acutirostris*, *L. brevicephalus*, *L. macrophtalmus*, *L. megastoma*, *L. platydorsus*, *L. truttiformis*, *L. tsanensis,L. , L. surkis, L. gorgorensis, L. crassibarbis, L. gorguari, L. nedgia, L. longissimus* and *L. intermedius)* forming a unique species flock in Lake Tana (Nagelkerke, 1997).

Fishes perpetuate themselves in a number of ways.

*Corresponding author. E-mail: dagnewm5@gmail.com
Tel: +251913688949

Success of reproduction depends on when and where the fish reproduces, and what portion of energy is allocated (Stearns, 1992). Genetic and environmental factors are important in determining the reproductive ecology of fishes. The most important environmental factors include the harshness and variability of abiotic factors, the availability of food for the parental fish and their offspring, the presence of predators on the parental fish and their offspring and the level of dissolved oxygen (Lowe-McConnell, 1987; Wootton, 1990). The most favorable areas for fish feeding are not necessarily best for reproduction (Northcote, 1984). Hence, migration enables a fish to utilize different habitats.

Cyprinids are riverine in their origin and they are adapted to live in lakes or lacustrine environments. However, most of these species still migrate upstream to spawn in tributary rivers (Tomasson *et al*., 1984; Skelton *et al*., 1991; Nagelkerke and Sibbing, 1996; Palstra *et al*., 2004; Anteneh, 2005; De Graaf *et al*., 2005; Getahun *et al*., 2008) which indicates that they are not still fully adapted to the lake environment.

Various studies have been conducted on the spawning migration of *Labeobarbus* spp. in some inflowing (perennial) rivers of Lake Tana such as Gelda and Gumara (Nagelkerke and Sibbing, 1996; Palstra *et al*., 2004; de Graaf *et al*., 2005), Ribb (Getahun *et al*., 2008; Anteneh *et al.,* 2013) and Dirma and Megech (Anteneh, 2005) and Arno-Garno River (Gebremedhin, 2011). All these studies clearly showed that some *Labeobarbus* species migrate to upstream for spawning immediately after the rainy season.

Although Gilgel Abay (Figure 1) is the largest tributary of Lake Tana, spawning migration of *Labeobarbus* species has not been studied in this river and in its tributaries (Jema, Koga, Kilty, Zabzi and Ashar Rivers). Therefore, the aim of this study was to investigate whether or not and which type of *Labeobarbus* species of Lake Tana migrate to spawn in Gilgel Abay River and its tributaries as well as to assess spatial and temporal segregations in the actual spawning tributaries of Gilgel Abay. The results of this study are useful for the management of the declining stocks of the unique *Labeobarbus* species because, according to de Graaf *et al*. (2004), these migratory *Labeobarbus* species of Lake Tana are facing problems and showed dramatic reduction, i.e., 75% in abundance (both in number and biomass) of adults and 90% of the juveniles within ten years (1991-2001).

MATERIALS AND METHODS

The Study Area

Lake Tana is situated on the basaltic plateau of the northwestern highlands of Ethiopia at an altitude of about 1830 m and it has an area of about 3200 km^2 (Serruya and Pollingher, 1983; Wood and Talling, 1988). The main tributaries to the lake are Gilgel Abay, Megech, Gumara and Rib Rivers. Together they contribute more than 95% of the total annual inflow (Lamb *et al*., 2007). The Blue Nile is the only out-flowing river.

Gilgel Abay River is originating from Sekela Woreda; its main tributaries are Koga, Jema, Ashar, Kilty and Zabzi (Figure 1). These rivers were covered by scattered trees and bushes and at the mouth of Gilgel Abay River, grasses and *Cyprus papyrus* are dominate. All these rivers, and especially Koga River, are used for irrigation and sand mining purposes. These are serious problems of these rivers in connection to the breeding of *Labeobarbus* spp.The volume of these rivers decrease in dry season especially in Zabzi River, which is a small river, as compared to the rest. However, during spawning time all rivers recover in volume due to the heavy rain in the area.

Flora and Fauna

In the rainy season the mouth of Gilgel Abay River was covered by dense vegetations such as grasses and shrubs, *Cyperus papyrus* is the most common in all seasons. The upper part of these rivers is covered with shrubs, a few big trees and *Eucalyptus spp*.

In addition to the fish, the major vertebrate fauna around Gelgel Abay River include birds such as African fish eagle (*Haliaeetus vocifer*), Egyptian goose (*Alopochen aegytiaca*), African Pied Kingfisher (*Ceryle rudis)*, Grey-headed Kingfisher *(Halcyon leucocephala),* Striped Kingfisher (*Halcyon chelicuti)*, Great white pelican (*Pelecanus onocrotalus),* Nile Monitor (*Varanus niloticus*), the Hippopotamus at the mouth of Gilgel Abay River and other lizards and snakes, amphibians belonging to the genera Ptychadena, Phrynobatrachus, etc.

Field Sampling

Six sampling sites were (Gilgel Abay itself, Jema, Koga, Kilty, Zabzi and Ashar rivers) selected by preliminary assessment based on the nature and velocity of the flowing river, human interference and suitability for fish spawning and availability of fishes; the sites were then fixed using GPS (Figure 1 and Table1).

Fish samples were collected twice per month from August to October and once in November in 2011 at all sites. Gillnets of mesh size of six, eight, ten, twelve and fourteen centimeter stretched bar mesh, having a length of twenty five meter and depth of one and half meter, and monofilaments having mesh size of 5-55 mm were used to sample fish by setting at least for six hours in the day time. Fishes were identified to species level using the keys developed by Nagelkerke (1997). Sex and gonad maturity stages were visually determined using a seven-point maturity scale (Nagelkerke, 1997) and gonad weight of each specimen was measured to the nearest 0.01 g using sensitive balance.

In the laboratory, fish specimens were soaked in tap water for one day to wash the formalin and then were identified to species level using identification key (Nagelkerke, 1997).

Physico-Chemical Characteristics

Physico-chemical characteristics like oxygen content (mgl^{-1})

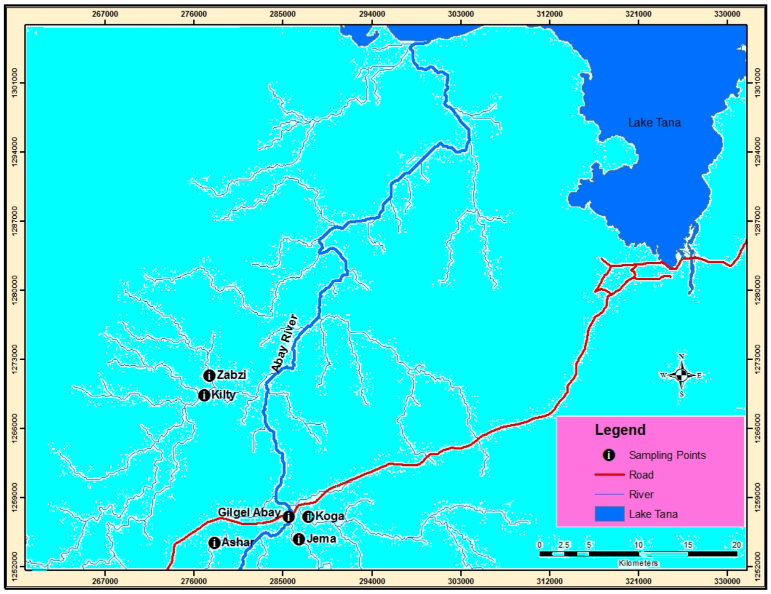

Figure 1. Map of Lake Tana and the sampling sites in Gilgel Abay River and its tributaries

Table 1. Sampling sites and their distance and characteristics mouth Gilgel Abay.

Sites (Rivers)	Air distance from the mouth of Gilgel Abay (km)	Characteristics of the site	Coordinates
Gilgel Abay	50.26	Sandy, about 7.5 m wide during the rainy season	$11^0$21'52.8″N 37^0 02' 09.3″E
Jema	52.02	Sandy, about 4.5 m wide in the rainy season	11^0 21' 22.8″N 37^0 02' 13.8″E
Koga	49.61	Sandy, about 3.5 m wide in the rainy season	10^0 21' 58″N 37^0 02' 33.6″E
Kilty	42.69	Highly sandy, covered with trees and bushes and it is about 4.7 m wide during the rainy season	11^0 28' 21.6″N 36^0 58' 10.8″E
Zabzi	41.01	More sandy than the rest about 3.5 m wide during the rainy season	11^0 29' 02.4″N 36^0 57' 43.8″E
Ashar	54.67	A little bit sandy and it is about 5 m wide during the rainy season	$11^0$20'38.5″N $36^0$58'13.3″E

Table 2. Abiotic parameters in the sampling sites with their means±SE(nonparametric test-Mann-Whitney U test).

Sites (Rivers)	Oxygen (mgl^{-1})	Temperature (^0C)	pH	TDS (ppm)	Conductivity (µs cm^{-1})	Secchi depth (cm)
	Mean ± SE	Mean S±E	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE
Gilgel Abay	6.75±0.53[a]	17.80±0.38[a]	7.58±0.1[a]	35.88 ±6.01[ab]	71.68±12.09[ac]	11.50±4.40[a]
Koga	6.77±0.38[a]	19.33±0.72[a]	7.47±0.15[a]	57.60±4.34[a]	115.30±8.62[a]	12.17±3.48[a]
Jema	6.98±0.52[a]	18.10±0.65[a]	7.64±0.98[a]	42.53±7.96[a]	84.27±15.95[a]	11.33±5.02[a]
Ashar	6.35±0.79[a]	18.95±0.30[a]	7.14±0.23[a]	36.90±8.61[a]	72.53±16.74[a]	11.92±4.01[a]
Kilty	7.65±0.57[a]	19.67±0.82[a]	7.28±0.20[a]	57.78±7.75[a]	114.73±15.46[a]	11.67±4.06[a]
Zabzi	7.52±0.81[a]	20.05±0.68[a]	7.47±0.1[a]	54.20±3.43[ac]	113.70±5.96[ab]	14.67±4.52[a]
Average	**7.00±0.23**	**18.98±0.27**	**7.43±0.07**	**47.48±2.97**	**95.37±5.96**	**12.21±1.63**

Note: Data with same letter represent no significant difference between the sites within a column.

was measured by Oxyguard portable, water temperature (^oC), pH, Total Dissolved Solids (TDS) ($mg1^{-1}$) and conductivity (µs cm^{-1}) were measured using conductivity meter and water transparency (cm) was measured using Secchi-disc at the time of sampling.

Relative Abundance

Index of Relative Importance (IRI) is a measure of the relative abundance or commonness of the species based on number and weight of individuals in catches, as well as their frequency of occurrence (Kolding, 1989, 1999).
Estimation of relative abundance of fishes in these rivers was made by taking the contribution in number and weight of each species in the total catch for each sampling effort and it was used to evaluate relative abundance. Index of relative importance was used to find the most important species in terms of number, weight and frequency of occurrence in the catches from the different sampling localities. Percent of IRI was calculated as follows**:**

$$\%\,\mathrm{IRI} = \frac{(\%\mathrm{W_i} + \%\mathrm{N_i}) \times \%\mathrm{F_i}}{\sum_{j-1}^{s-1}(\%\mathrm{W_j} + \%\mathrm{N_J}) \times \%\mathrm{F_j}} \times 100$$

Where, $\%W_i$ and $\%N_i$ are percentages in weight and number of each species of total catch, respectively; $\%F_i$ is percentage frequency of occurrence of each species in total number of settings. S is total number of species.

Gonado-Somatic Index (GSI)

The graphs of the mean monthly GSI against months was used to determine the period and frequency of spawning of the species during the year (Bagenal, 1978). The percentage of GSI was calculated from the gonad weight (g) and body weight (g), using the following formula:

$$\mathrm{GSI}\ (\%) = \frac{\text{Gonad weight (g)}}{\text{Body weight (g)}} \times 100$$

DATA ANALYSIS

Analysis of variance (ANOVA) was used to analyze spatial and temporal segregation and Mann-Whitney U test was used to analyze biotic parameters (SAS version 9 was used for the analysis).

RESULTS

Physico-Chemical Parameters

There was no significant difference ($p>0.05$) between many of the physico-chemical parameters but there was significant difference ($p< 0.05$) in TDS ($mg1^{-1}$) and conductivity (µs cm^{-1}) between Gilgel Abay and Zabzi Rivers (Table 2).

Species Composition in the Selected Sampling Sites

Thirteen fish species were collected during sampling time. In these catches, 1002 (89.30%) specimens were from the genus of *Labeobarbus* and the remaining was from the genus of *Varicorhinus* and *Clarias*. The highest number of *Labeobarbus* species (30.04%) was found in Gilgel Abay River, and Ashar River was the least (9.18%). There were no records of *L. dainellii*, *L. gorguari*, *L. acutirostris* and *L. megastoma* in all sites.

Labeobarbus intermedius contributed about 50.10% by number *L. brevicephalus* (17.16%) was the second, *L.*

Table 3. Species composition in Gilgel Abay River and its tributaries.

Species	Sites and their corresponding fish numbers						Total
	Gilgel Abay	Koga	Jema	Ashar	Kilty	Zabzi	
L. intermedius	134	90	68	68	65	77	502
L.brevicephalus	68	18	13	19	26	28	172
L. macrophtalmus	4	-	-	-	-	-	4
L. platydorsus		-	7	-	-	-	7
L. truttiformis,	6	-	-	-	-	9	15
L. tsanensis	25	1	5	-	14	9	54
L. surkis	28	17	1	-	25	-	71
L. gorgorensis	19	1	5	-	4	8	37
L. crassibarbis	1	9	11	-	8	16	45
L. nedgia	16	17	13	5	12	23	86
L. longissimus	-	-	-	-	6	3	9
V. beso	13	8	7	8	12	8	56
Clarias gariepinus	17	11	5	11	15	5	64
Total	331	172	135	111	187	186	1122

nedgia the third (8.58%) and *L. surkis* the fourth (7.08%) abundant species in the spawning season. The rest, which were rare in all sampling sites, include *L. tsanensis* (5.39%), *L. crassibarbis* (4.49%), *L. gorgorensis* (3.69%), *L. truttiformis* (1.49%), *L. longissimus* (0.9%), *L. platydorsus* (0.7%), and *L. macrophtalmus* (0.40%) (Table 3).

Gonado-Somatic Index (GSI)

Proportion of mature *Labeobarbus* species (gonad stages IV, V), running (gonad stage VI), and spent (gonad stage VII) was higher (about 72.54%) than the immature gonads (gonad stages I-III) that accounts the remaining percent. *Labeobarbus brevicephalus* had the highest individual GSI (15.54 %) which was observed in September but the maximum mean monthly GSI was 7.01% for *L. longissimus* which was measured in the same month (Table 4).

Segregation of *Labeobarbus* species in Gilgel Abay River and its Tributaries

Spatial segregation

Composition and distribution patterns of the three most abundant *Labeobarbus* species (*L. intermedius*, *L. brevicephalus* and *L. nedgia)* did not show significant variation in all sampling sites (one-way ANOVA, P >0.05) (Table 5).

Temporal segregation

Of the dominant *Labeobarbus* species, the highest proportion was recorded (43.29%) in September and the least was in November. All *Labeobarbus* species showed a declining pattern in catch from October to November (Figure 2). Pair wise comparison of the three dominant *Labeobarbus* species showed that there was no significant variation in temporal segregation (P >0.05) except between *L. intermedius* and *L. brevicephalus* (Table 6).

DISCUSSION

Physico-Chemical Characteristics

Even though dissolved oxygen (DO) varies according to species and life stage, levels below 3 $mgl^{-1}$are stressful to most aquatic organisms and levels 5 to 6 $mgl^{-1}$are usually required to perform their biological functions (Campbell and Wildberger, 1992). The mean DO level of these Rivers was between 5.35 $mgl^{-1}$and 6.98 mgl^{-1}. Therefore, these DO levels may be sufficient enough to perform their biological functions.

Table 4. *Labeobarbus* species with maximum mean monthly GSI (%) and individual fish with maximum GSI (%) in Gilgel Abay River and its tributaries.

Species	Max. mean Monthly GSI (%)	Month mean GSI (%) calculated	Maximum Individual GSI (%)	Monthly max. Individual GSI (%) observed	FL (cm) of individual fish with max. GSI (%)	Site of fish with max GSI (%)
L. intermedius	3.73	September	11.04	September	22	Zabzi
L. brevicephalus	3.47	August	15.54	September	17.1	Kilty
L. macrophtalmus	0.45	August	0.56	August	23.5	Gilgel Abay
L. platydorsus	3.95	September	6.64	September	23.4	Jema
L. truttiformis,	3.45	September	6.12	September	24.9	Gilgel Abay
L. tsanensis	3.7	August	9.3	August	20.7	Gilgel Abay
L. surkis	2.56	September	7.9	October	20.4	Kilty
L. gorgorensis	3.8	September	9.69	October	26.4	Gilgel Abay
L. crassibarbis	4.5	August	12.73	September	39.2	Zabzi
L. nedgia	3.17	September	8.9	September	19.3	Kilty

Table 5. Spatial segregation of the most dominant *Labeobarbus* species in Gilgel Abay River and its tributaries.

Species	(Mean ± SE)						P
	Gilgel Abay	Koga	Jema	Ashar	Kilty	Zabzi	
L. intermedius (N=502)	33.5±12.32	22.5±6.81	17±5.44	17±4.32	16.3±7.26	19.4±10.81	0.68
*L.brevicephal*us (N=172)	17±4.98	4.5±2.1	3.3±1.7	4.8±2.75	6.5±3.93	7±4.14	0.12
L. nedgia (N=86)	4±1.68	4.3±1.44	3.3±1.25	1.3±1.25	3±2.12	5.8±3.01	0.68

Reproduction, growth and breathing rate of fishes directly depend on temperature (^{0}C) variation. Although different fish species have different range of temperature tolerance, tropical fishes cannot survive when water temperature is around 10^{0}C -12^{0}C or less (Shammi and Bhatnagar, 2002). However, all these sites had mean temperatures between 17.80 ^{0}C and 20.05 ^{0}C (Table 2).

According to Shammi and Bhatnagar (2002), pH below 4.5 or above 9 is particularly injurious and unproductive. The pH value of all these sites was between 7.14 and 7.64 (Table 2), which are thought to be ideal breeding grounds for the *Labeobarbus* species of Lake Tana.

The reason for dissimilar result of TDS (mgl^{-1}) and conductivity (µs cm^{-1}) between Gilgel Abay and Zabzi rivers might be due to the fact that these rivers get different organic and inorganic materials due to sediment deposition from various sources. Zabzi appears more turbid than Gilgel Abay River and these might be because Zabzi River gets more organic and inorganic materials deposition from its sources (Table 2). When this study is compared with Arno-Garno River (Gebremedhin, 2011), it had lower average values. This is because the watershed management might be better than that of Arno-Garno River.

Secchi depth didn't show significant variation (P>0.05) between sampling sites (Mann-Whitney U test), which is in contrary to what has been reported by Gebremedhin (2011) in Arno-Garno River. This might indicate that all the sampling sites are receiving almost similar suspended materials from the degraded highlands in that specific period.

Species Composition and Abundance in the Selected Sampling Sites

Labeobarbus intermedius contribute the highest (50.10%) by number and *L. brevicephalus* was the second (17.16%). This is in agreement with the report by Gebremedhin (2011) from Arno-Garno River. Similarly, there was no record of *L. dainellii* and *L. gorguari* in Arno-Garno River (Gebremedhin,

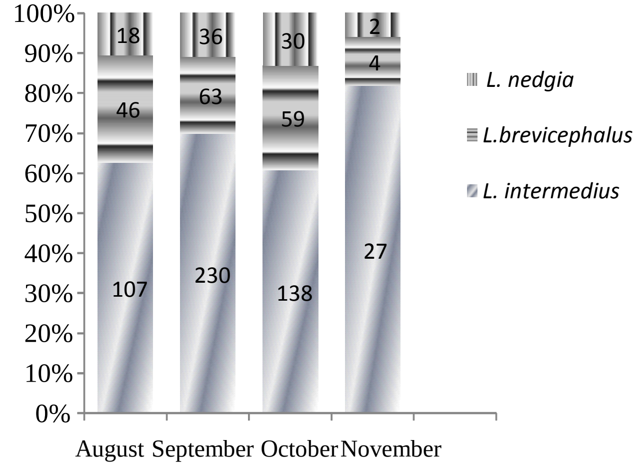

Figure 2. Temporal variation of the three most abundant *Labeobarbus* species in the sampling time (pooled from all sites).

Table 6. Pair wise comparisons of temporal segregation of most abundant *Labeobarbus* species during the peak spawning season in all sampling sites.

	L. intermedius	***L. brevicephalus***	***L. nedgia***
L. intermedius	X		
L. brevicephalus	***	X	
L. nedgia	ns	ns	X

*** (P<0.001), not significant (ns) (P>0.05)

2011) and it was also true for *L. gorguari* in Dirma and Megech rivers (Anteneh, 2005). *Labeobarbus intermedius*, *L. brevicephalus* and *L. nedgia* were found in all sampling sites, indicating that all sites were suitable for these species (Table 2); it was also true for *L. intermedius* and *L. brevicephalus* in Arno-Garno River (Gebremedhin, 2011) and in Dirma and Megech Rivers (Anteneh, 2005).

In Ashar River, only *L. intermedius*, *L. brevicephalus* and *L. nedgia* were collected (Table 3) and they contributed only 9.18% and this might be because of the presence of a water fall in Gilgel Abay River, which is about eleven meter tall and this fall might have blocked spawning migration of *Labeobarbus* species from Lake Tana to Ashar River upstream. Information from fishermen also corroborates this assertion.

Spawning Aggregation and Segregation

The riverine spawners of *Labeobarbus* species in Lake Tana aggregate at river mouths before they migrate upstream to spawn on gravel beds in clear, small and fast-flowing and well-oxygenated tributaries (Nagelkerke and Sibbing, 1996; Dgebuadze *et al*., 1999; de Graaf, 2003; Palstra *et al*., 2004; Anteneh, 2005). Therefore, *Labeobarbus* species which are found in upstream sites of Gilgel Abay River and its tributaries during the sampling periods are believed to aggregate before migrating to upstream sites. A study carried out by Gebremedhin (2011) in Arno-Garno River also shown that those species that were abundant at the river mouth were also abundant in the upstream sites of the river.

Studies conducted by de Graaf *et al*. (2005), confirmed that except, seven species of *Labeobarbus* (*L. crassibarbis, L. dainellii, L. gorguari, L. gorgorensis, L. longissimus, L. nedgia,* and *L. surkis*) the rest fully aggregated at river mouths of Gilgel Abay, Gelda, Gumara and Rib rivers. These seven species (*L. crassibarbis*, *L. dainellii*, *L. gorguari*, *L. gorgorensis, L. longissimus, L. nedgia,* and *L. surkis)* were found rarely at the river mouths for the period of their peak breeding season. As a result, they were left out for further analysis of macro-spatial and temporal segregation at the river mouths (de Graaf *et al*., 2005). But, other study which was conducted by Goshu *et al*. (2010) showed that all *Labeobarbus* species except *L. gorguari* and *L. dainellii* were found at the river mouth of Gilgel Abay River. From one time sampling at the mouth of Gilgel Abay River this study has also confirmed the aggregation of *L. longissimus, L. intermedius, L. nedgia, L. tsanensis, L. crassibarbis, L. and L. truttiformis.*

The presence of all *Labeobarbus* spp. except *L. dainellii, L. gorguari, L. acutirostris* and *L. megastoma* in the upper parts of Gilgel Abay River and its tributaries during the sampling time is partially in conflict with de Graaf *et al*. (2005), and agrees with Goshu *et al*. (2010). The reason for this might be (a) the change of the river mouth of Gilgel Abay to another position (b) fisheries activities are increasing at the river mouths of the feeder rivers at the eastern sides of Lake Tana but, the Gilgel Abay River mouth is far away from Bahir Dar and is not easily accessible to many fishermen or (c) there might be some changes in the physico-chemical characteristics of the river in the past years.

Most *Labeobarbus* species in the upstream areas were caught with gonad maturity stages greater than III. *Labeobarbus acutirostris, L. macrophtalmus*, *L. megastoma*, *L. tsanensis*, and *L. truttiformis* were riverine spawners in Gumara River, but *L. intermedius* was absent from Gumara River (Dgebuadze *et al*., 1999; Palstra *et al*., 2004).

In contrast to this, and in agreement with the findings in Arno-Garno River (Gebremedhin, 2011), and Megech and Dirma rivers (Anteneh, 2005), *L. intermedius* was the dominant species.

Labeobarbus truttiformis which was riverine spawner in Gumara, Megech and Dirma Rivers (Palstra *et al*., 2004; Anteneh, 2005) was also found in Gilgel Abay and Zabzi Rivers. *Labeobarbus macrophtalmus* which is migrating to Gumara River (Palstra *et al*., 2004) but not found in Arno-Garno River (Gebremedhin, 2011), Megech and Dirma rivers (Anteneh, 2005) was rarely found in Gilgel Abay River in this study.

The declining pattern of all *Labeobarbus* species in catch from October to November is an indication of the end of spawning period.

Different studies conducted in other tributaries of Lake Tana also revealed temporal segregation in *Labeobarbus* species.

Gonado-Somatic Index (GSI)

The highest individual GSI of most *Labeobarbus* species was observed in September. This result also agreed with de Graaf *et al*. (2005), peak spawning season for the *Labeobarbus* species in Lake Tana is August to October. *Labeobarbus brevicephalus* has the highest individual GSI (15.54%) measured in September, but *L. megastoma* had the highest (39%) in Arno-Garno River (Gebremedhin, 2011) and *L. tsanensis* (32.52%) in Megech and Dirma Rivers (Anteneh, 2005). The maximum mean monthly GSI was 7.01% for *L. longissimus* which was measured in the same month. However, it was *L. surkis* in Arno-Garno River (Gebremedhin, 2011) and in Megech and Dirma Rivers (Anteneh, 2005).

Missing Species

In up streams of the rivers all the species were found except *L. dainellii, L. gorguari, L. acutirostris* and *L. megastoma*. In contrast to the present study, *L. acutirostris* and *L. megastoma* were found in other tributaries such as Gumara (Palstra *et al*., 2004) and Arno-Garno (Gebremedhin, 2011).

According to Mills (1991), missing *Labeobarbus* species most probably breed in the lake and adjacent floodplains and deposit their eggs on sand or rocks, near roots of plants or on aquatic or flooded terrestrial vegetation as is common in many other cyprinid genera. These missing species may also spawn in other small tributaries of the lake.

Management Practices of Fisheries in Gilgel Abay River and its Tributaries

There are no management practices in these rivers; instead, there are traditional and illegal fishing activities, for example monofilaments, crushed seeds of Birbira and fence as a block are used predominantly in all rivers. During the sampling period, local farmers were using crushed seeds of Birbira with little malathion in Kilty River in the beginning of November. If things continue unabated, migratory *Labeobarbus* species of Lake Tana will be endangered like the large African cyprinids in other lakes. Therefore, full participation of the various stakeholders, including Regional and Federal authorities is very important in order to implement the Fisheries proclamation and conserve these unique species flock.

CONCLUSION AND RECOMMENDATION

Conclusions

From this result, in these rivers the following conclusions were concluded: The highest percentage (89.30%) of the species was from the genus *Labeobarbus;* the remaining few were from the genera *Varicorhinus and Clarias*. *Labeobarbus intermedius* contributed the highest (50.10%),) by number *L. brevicephalus* was the second (17.16%) and *L. nedgia* was the third (8.58%).

Most *Labeobarbus* species in the upstream areas were caught with gonad maturity stages greater than III. Starting from the end of October, catch of *Labeobarbus* spp. was reduced, peak spawning season is between August and October.

There was similar distribution pattern of the three most abundant *Labeobarbus* species in all sites, indicates that these rivers were equally important as spawning grounds of these dominant *Labeobarbus* species.

Individual Gonado-Somatic Index for most *Labeobarbus* species was the highest in September and, the highest proportion of *Labeobarbus* species was recorded in the same month.

If this existing illegal fishing activities or practices are continued in such a way, it will enhance the decrease and finally the extinction of these endemic fish species. As a result of this, livelihood of many fishermen and the ecosystem, not only in these rivers, but also in Tana sub basin will be endangered.

RECOMMENDATIONS

After providing basic information and/or awareness about *Labeobarbus* species for the local people or users, prohibiting (at least from August to October) from any kind of activities in the river, like fishing activities, diversion of the river, dam construction and sand mining (which has a serious impact on the habitat) is the most appropriate measure. Regional (Amhara Region) and Federal fisheries policies should be seriously implemented.

There are water falls in Zabzi, Kilty and Gilgel Abay Rivers, which are approximately nine and half, fifteen and eleven meter tall, respectively.

These falls block further migration of fish as fish never jump these falls. Therefore, for effective management purposes, the final migration distance of the riverine spawners for other rivers and other temporary tributaries of the lake should be studied.

Excessive sand and water extractions must be considered not only to conserve fish breeding grounds but also to monitor other aspects of environmental pollution.

Illegal fishing activities (like use of monofilaments, Seeds of Birbirra tree (*Milletia ferruginea*) with Malathion and fencing) must be totally prohibited both during spawning and non-spawning seasons not only in these rivers but also in any other water bodies. The Kebele fisheries regulatory committee should be functional/ alerted in such situations.

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