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SHORT COMMUNICATION

SOME REPRODUCTIVE ASPECTS OF SPECIES OF *LABEOBARBUS* (CYPRINIDAE: TELEOSTEI) IN GILGEL ABAY RIVER AND ITS TRIBUTARIES, ETHIOPIA

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ABSTRACT: Six sampling sites of Gilgel Abay River and its tributaries, were sampled by using monofilaments (5-55 mm) and gillnets having mesh sizes of 6, 8, 10, 12 and 14 cm stretched bar mesh with a length of 25 m and depth of 1.5 m, twice each month from August to October, and once in November, 2011. Fishes were identified to the species level. Fork length (FL), total weight (TW) and gonad weight (GW) of each specimen were measured. The relationship between FL and TW for the dominant species of *Labeobarbus* showed curvilinear relationship. Condition factor of *L. intermedius*, *L. brevicephalus* and *L. nedgia* showed that there was significant difference ($p<0.001$) between sexes in all three species. In all catch, females were more numerous than males. The highest GSI (15.54%) was recorded for *L. brevicephalus* but the maximum mean monthly GSI (7.01%) was recorded for *L. longissimus* in September and minimum GSI (0.45%) for *L. macrophtalmus* in August. Absolute fecundity, mean fecundity and mean FL for *L. intermedius* was the highest than the rest. The relationship between absolute fecundity (AF) and FL, TW, and GW of *L. intermedius*, *L. brevicephalus*, and *L. nedgia* were linear (AF=596.4FL-8990, R^2=0.79; AF=19.78TW+978.1, R^2=0.79 and AF=371.5 GW+573.5, R^2=0.93). There was also strong relationship between AF and FL, TW, and GW ($p<0.001$) in the three species.

Key words/phrases: Abay basin, Condition factor, Conservation, Fecundity, Lake Tana.

INTRODUCTION

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 fresh water (Reyntjens *et al*., 1998; de Graaf *et al*., 2004). Three of the fish families of Lake Tana, each

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represented by single species are Cichlidae, Clariidae (*Oreochromis niloticus* and *Clarias gariepinus*) (Vijverberg *et al*., 2009) and Balitoridae (*Afronemacheilus abyssinicus*) (Abebe Getahun and Eshete Dejen, 2012).

Cyprinidae is the largest family of fish in Lake Tana, and is represented by four genera: *Barbus*, *Varicorhinus*, *Garra* and *Labeobarbus*. *Barbus* is represented by three species: *B. humilis*, *B. pleurogramma* and *B. tanapelagius* (Eshete 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) (Akewake 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. dainellii*, *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).

Different studies have been conducted on the spawning behaviour of *Labeobarbus* spp. in some inflowing rivers of Lake Tana, such as Gelda and Gumara (Nagelkerke and Sibbing, 1996; Abebe Ameha and Alemu Assefa, 2002; Palstra *et al*., 2004; de Graaf *et al*., 2005), Ribb (Abebe Getahun *et al*., 2008), Dirma and Megech (Wassie Anteneh, 2005) and Arno-Garno (Shewit Gebremedhin, 2011). These studies indicated the upstream spawning migration of some lacustrine *Labeobarbus* species and their biological characteristics. However, similar studies were not conducted on one of the major inflowing rivers of Lake Tana, Gilgel Abay River and its tributaries. Therefore, this study was designed to investigate some reproductive aspects of species of *Labeobarbus* that spawn in Gilgel Abay River and its tributaries.

MATERIALS AND METHODS

The study area

Gilgel Abay River is one of the major inflowing rivers of Lake Tana, situated on the southwestern side of the lake (Fig. 1). Gilgel Abay originates from Sekela Woreda, Gish Abay, and its main tributaries are the rivers Koga, Jema, Ashar, Kilty and Zabzi. The upstream vegetation of these rivers is characterized by scattered trees and bushes, while *Cyperus papyrus* and species of grasses dominate at the river mouth. All of these rivers, especially Koga, 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 decreases during the dry season, especially in Zabzi, which is a small river, as compared to the rest.

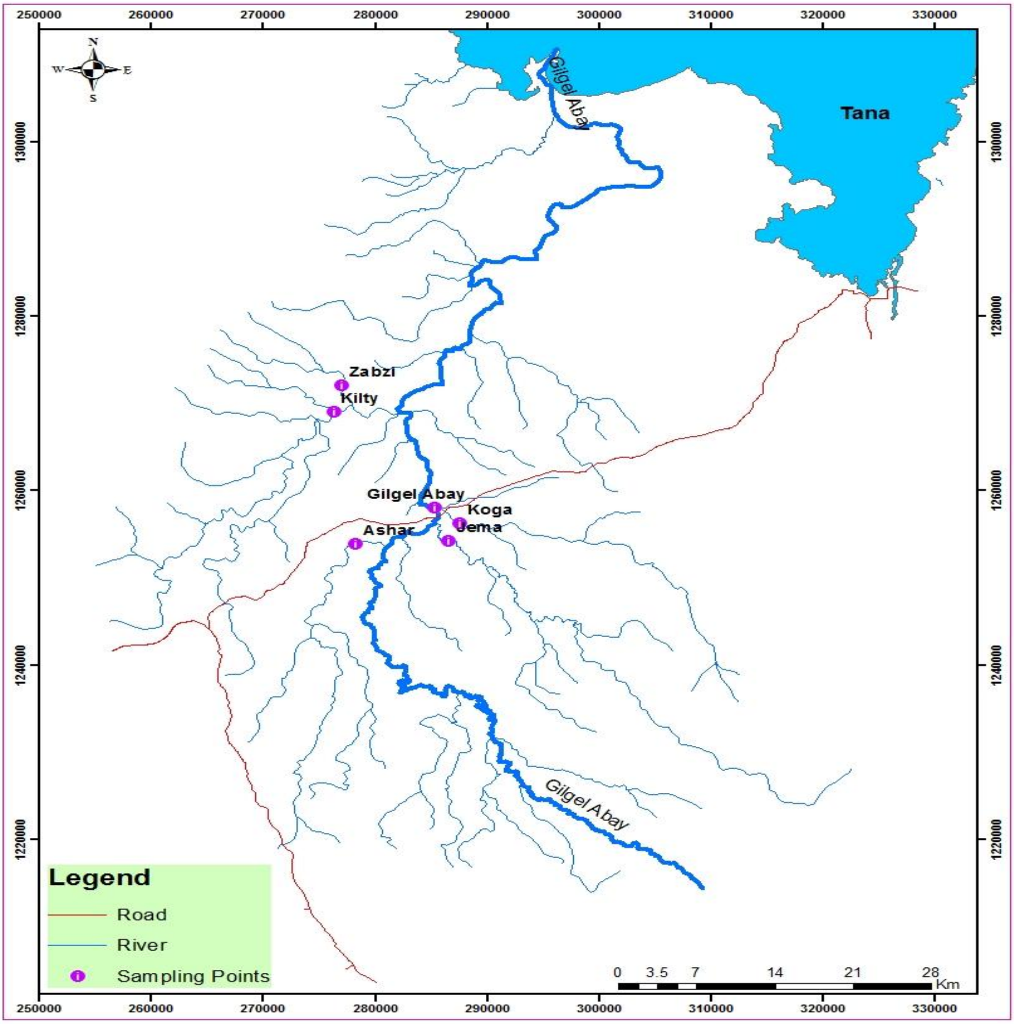

Fig. 1. Map of the study area indicating the southern gulf of Lake Tana, and the lower parts of Gilgel Abay River and its tributaries.

In addition to the fish, the major vertebrate fauna around Gilgel 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 blue hippopotamus at the mouth of Gilgel Abay

River and other lizards snakes and amphibians belonging to the genera *Ptychadena*, *Phrynobatrachus*, etc.

Field sampling

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

Table 1. Sampling sites and their distance and characteristics.

Sites	Air distance from the mouth of Gilgel Abay (km)	Characteristics of the site	Coordinates
Gilgel Abay River	50	Sandy, about 7.5 m wide during the rainy season	11° 21' 52.8″N 37° 02' 09.3″E
Jema River	52	Sandy, about 4.5 m wide in the rainy season	11° 21' 22.8″N 37° 02' 13.8″E
Koga River	50	Somewhat sandy, about 3.5 m wide in the rainy season	10° 21' 58″N 37° 02' 33.6″E
Kilty River	43	Highly sandy, covered with trees and bushes and it is about 4.7 m wide during the rainy season	11° 28' 21.6″N 36° 58' 10.8″E
Zabzi River	41	More sandy than the rest about 3.5 m wide during the rainy season	11° 29' 02.4″N 36° 57' 43.8″E
Ashar River	55	A little bit sandy and it is about 5 m wide during the rainy season	11°20'38.5 ″N 36°58'13.3″E

Fish samples were collected twice every month from August to October and once in November in 2011 at all sites. Gillnets of mesh size of 6, 8, 10, 12 and 14 cm stretched bar mesh, having a length of 25 m and depth of 1.5 m, and monofilaments having mesh size of 6 cm were used to sample fish by setting at least for six hours during the day time. Fishes were identified to species level using the keys developed by Nagelkerke (1997). Then, fork length, total weight and gonad weight of each *Labeobarbus* specimen were measured using meter and sensitive balance, respectively. Specimens were dissected and gonad maturity of each fish specimen was identified by using a seven-point maturity scale (Nagelkerke, 1997).

Gonad weight of each *Labeobarbus* specimen was measured to the nearest 0.01 g using sensitive balance. Samples of eggs from some ripe females of *Labeobarbus* species (gonad stage VI) of different fork lengths, were preserved with 4% formalin to determine estimated fecundity.

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).

Length-weight relationship

The relationship between fork length and total weight of the dominant (in number) species was calculated using power function as in Bagenal and Tesch (1978).

$$TW = aFL^b$$

Where, TW-total weight (g), FL-fork length (cm), a and b are intercept and slope of regression line, respectively.

Fulton's condition factor

Using the formula developed by Lecren (1951) and Bagenal and Tesch (1978), Fulton's condition factor (%) was calculated as:

$$\mathrm{FCF} = \frac{\mathrm{TW}}{\mathrm{FL}^b} \times 100$$

Sex ratio

Sex ratio is the ratio of females to males. It was determined using the formula:

$$\text{Sex ratio} = \frac{\text{Number of males}}{\text{Number of females}}$$

Chi-square (χ^2) was used to test whether significant difference exist in sex ratios seasonally and spatially for each 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 as:

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

Fecundity

Fecundity was estimated using gravimetric method (MacGregory, 1957). Eggs from the ripe female fish were preserved in labeled plastic vials, containing 4% formalin for fecundity estimation (Bagenal, 1978). Three sub-samples of 1 g eggs were taken from different parts of ovary and counted and then, the average was calculated. The total number of eggs per ovary was calculated by extrapolation from the mean calculated. The correlation of fecundity with total length, total weight and ovary weight was done according to the following formula (Bagenal and Tesch, 1978):

$F=aFL^b$; $F=aTW^b$ and $F=a\ GW^b$, where, F-Fecundity; FL-Fork length (cm); TW-Total weight (g); GW-Gonad weight (g); a-constant and b-exponent.

Data analysis

After testing for normality of raw data, length-weight relationship and spatial and temporal segregation data were analyzed by using one-way ANOVA; and Mann-Whitney U test was used to analyze condition factor. SAS version 9 was used to compute regression and correlation analyses.

RESULTS AND DISCUSSION

Length-weight relationship

The relationship between fork length and total weight for the four most abundant species, *L. intermedius*, *L. brevicephalus*, *L. nedgia* and *L. surkis* showed curvilinear relationship and was statistically significant ($P<0.001$) (Table 2). The value of the regression coefficient “b” is close to cube which describes isometric growth, that is, weight increases according to fish length. Similar isometric growth of *L. intermedius* was recorded from Arno-Garno River (Shewit Gebremedhin, 2011), Megech and Dirma rivers (Wassie Anteneh, 2005) and Ribb River (Abebe Getahun *et al*., 2008). Nagelkerke *et al*. (1994) and Demeke Admassu and Elias Dadebo (1997) also obtained similar results from Lake Tana, and Lake Hawassa, respectively. Similar results have also been reported from Sanja River (Genanaw Tesfaye, 2006), Gendewuha, Guang, Shinfa and Ayima rivers (Dereje Tewabe, 2008), Borkena and Mille rivers (Assefa Tessema, 2010) and at the headwater of the Blue Nile River (Mohammed Omer, 2010).

Table 2. The length-weight regression equations and the correlation coefficient (R^2) of *Labeobarbus* species pooled from all sampling sites.

Species	**N**	**Regression**	**R^2**	**P-values**
L. intermedius	502	$TW=0.033FL^{2.7}$	0.87	0.000***
L. brevicephalus	172	$TW=0.023FL^{2.8}$	0.83	0.000***
L. nedgia	86	$TW=0.013FL^{3.0}$	0.94	0.000***
L. surkis	71	$TW=0.011FL^{3.1}$	0.91	0.000***

Note: *** (P<0.001)

Fulton's condition factor

Condition factor of the dominant *L. intermedius*, *L. brevicephalus* and *L. nedgia* species showed that there was significant difference (p<0.001) between sexes (Table 3).

Table 3. Mean Fulton's condition factor (FCF) of dominant species (Mann-Whitney U test) between sexes.

Species	**Sex**	**N**	**FCF (%) (Mean±S.E.)**	**P-value**
L. intermedius	M	193	1.43±0.02	0.000***
	F	309	1.46± 0.03	
L. brevicephalus	M	82	1.48±0.02	0.000***
	F	90	1.48±0.03	
L. nedgia	M	30	1.43±0.04	0.000***
	F	55	1.44±0.04	

Note: *** (P<0.001)

Sex-ratio

There was significant difference (χ^2, p<0.05) between females and males from the theoretical 1:1 ratio, except for *L. brevicephalus*, *L. tsanensis*, *L. gorgorensis*, *L. truttiformis* and *L. platydorsus* (Table 4). Similar results were obtained for other cyprinid fishes such as, *Labeobarbus* species from Arno-Garno River (Shewit Gebremedhin, 2011) and the same *Labeobarbus* species from Megech and Dirma rivers (Wassie Anteneh, 2005) and *Labeo horie* from Lake Chamo (Elias Dadebo *et al*., 2003).

This difference was most probably related to increased vulnerability of females to some gears due to increased ovarian development as suggested by Taylor and Villoso (1994), or different biological mechanisms such as differential maturity rate or due to the differential mortality rates and migratory rates between the females and males (Sandovy and Shapiro, 1987; Matsuyama *et al*., 1988). Also, conditions in the study area or the behaviour of these fish, or sampling could be other reasons. One or a combination of the above factors might be the cause for the deviation of fish sexes from 1:1 sex ratio in these sites.

Table 4. Number of females, males and the corresponding sex ratios for *Labeobarbus* species in Gilgel Abay River and its tributaries (pooled data from all sites).

Species	Number of females (F)	Number of males (M)	Sex ratio (F: M)	χ^2	P-value
L. intermedius	309	193	1.6:1	27.32	0.000***
L. brevicephalus	90	82	1.1:1	0.37	0.542 (ns)
L. nedgia	55	30	1.8:1	7.35	0.007**
L. surkis	45	26	1.7:1	5.095	0.024*
L. tsanensis	28	26	1.1:1	0.07	0.785 (ns)
L. crassibarbis	33	12	2.8:1	1	0.002**
L. gorgorensis	23	14	1.6:1	2.19	0.139 (ns)
L. truttiformis	10	5	1.2:1	1.67	0.197 (ns)
L. longissimus	9	0	--	--	
L. platydorsus	5	2	2.5:1	1.29	0.257 (ns)
L. macrophtalmus	4	0	--	--	

Note: *** (P<0.001), ** (P<0.01), * (P<0.05) and (ns) not significant (P>0.05)

Gonado-somatic index (GSI)

L. 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 and minimum GSI of 0.45 for *L. macrophtalmus* in August (Table 5). The highest individual GSI of most *Labeobarbus* species was observed in September. This result also agreed with de Graaf *et al*. (2005), where highest GSI for the *Labeobarbus* species in Lake Tana was reported in August to October.

Table 5. *Labeobarbus* species with maximum mean monthly GSI (%) and individual fish with maximum GSI (%) in Gilgel Abay River and its tributaries.

Species	Mean monthly GSI		Individual with max. GSI			
	GSI (%)	Month	GSI (%)	Month	FL (cm)	Site
L. intermedius	3.73	September	11.04	September	22.0	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	3.70	August	9.30	August	20.7	Gilgel Abay
L. surkis	2.56	September	7.90	October	20.4	Kilty
L. gorgorensis	3.80	September	9.69	October	26.4	Gilgel Abay
L. crassibarbis	4.50	August	12.73	September	39.2	Zabzi
L. nedgia	3.17	September	8.90	September	19.3	Kilty
L. longissimus	7.01	September	10.39	September	28.6	Zabzi

Fecundity

Absolute fecundity, mean fecundity and mean FL for *L. intermedius* were 1257-15579 eggs, 4463 eggs and 22.49±0.49 cm, for *L. brevicephalus* 1850-3672 eggs, 2580 eggs and 19.40±0.66 cm and for *L. nedgia* 2025-5688 eggs, 4057.29 eggs and 22.57±1.52 cm, respectively. Fecundity of *L. intermedius* and *L. brevicephalus* in Arno-Garno River ranged from 1935 to 11224 and from 2305 to 4085 eggs, and had an average fecundity of 4607 and 3414 eggs, respectively (Shewit Gebremedhin, 2011).

Fecundity of *L. brevicephalus* was almost similar to what has been reported for the same species from Megech and Dirma rivers (Wassie Anteneh, 2005). The main cause for such variation may be due to the environmental variability of the rivers and watershed, and fish may change their fecundity size from previous times and also there may be change of season. Fecundity of *Labeobarbus* species in other African lakes is moderately higher (Skelton *et al*., 1991). The relationship of absolute fecundity (AF) and FL, TW and GW of the three species was linear and there was strong positive relationship between AF and FL, TW and GW ($p<0.0001$). Similarly, fecundity of *L. intermedius* was strongly and positively correlated with its gonad weight, fork length and body weight in Arno-Garno River (Shewit Gebremedhin, 2011), Beles and Gilgel Beles rivers (Zeleke Berie, 2007), in Gelda and Gumara rivers (Alekseyev *et al*., 1996), in Borkena and Mille rivers (Assefa Tessema, 2010) and at the headwater of Blue Nile River (Mohammed Omer, 2010).

CONCLUSION

From these results, the following conclusions were reached: Length-weight relationship for most abundant *Labeobarbus* fish species showed isometric growth. For all species in the catch, females were large in number. The Fulton's condition factor was different for the most abundant species. *Labeobarbus* fish species had the highest individual GSI and the maximum mean monthly GSI measured in September. *Labeobarbus intermedius* had both the highest number of eggs from dominant species and the largest in number from the total catch. Therefore, *L. intermedius* is best adaptive to this environment and may serve as potential species for fisheries production.

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