

Spawning migration of *Labeobarbus* species to some tributary rivers of Lake Tana, Ethiopia

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ABSTRACT

Spawning migration of *Labeobarbus* species was studied from August to December 2013 in some tributary rivers (Qimon, Guanta, Shini, and Chibirna) of Lake Tana. Fish specimens and physico-chemical parameters were measured bimonthly in August and September but monthly from October to December. Adult fish specimens were caught using 6 and 8 cm stretched mesh size monofilament gillnets and 6, 8, 10 and 12 cm mesh size multifilament gillnets. A total of 933 adult *Labeobarbus* specimens were collected during the study period. *Labeobarbus intermedius* was the most abundant species followed by *L. brevicephalus*. The peak spawning season of *L. intermedius* was from fourth week of August to end of September and for *L. brevicephalus* it was from fourth week of August to beginning of October. Both species were found to spawn in all sampling rivers. However *L. truttiformis* spawned only at Guanta and Qimon Rivers during August while *L. nedgia* in Shini and Chibirna Rivers at the end of September. This implies the presence of micro-spatial segregation among species. Pair-wise comparison of *Labeobarbus* species showed temporal segregation in all sampling months, except *L. brevicephalus* and *L. nedgia*. The present findings showed that small tributary rivers and streams are the main spawning grounds for *Labeobarbus* species of Lake Tana. Therefore, main spawning grounds or routes should be protected from the deleterious effects of anthropogenic activities like illegal fishing, irrigation and sand mining for wise use of the fish resources.

Key words: Fecundity, Fish, Migration, River, Spawning

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INTRODUCTION

Ethiopia is rich in its fish fauna, having a diversified species in the inland water bodies (Abebe Getahun, 2002). The three major fish families (Cichlidae, Clariidae and Cyprinidae) are widely distributed throughout the country. In Lake Tana, Cyprinidae is the largest family and is represented by four genera. These are the genera *Barbus* represented by three species: *B. humilis*, *B. pleurograma*, and *B. tanapelagious* (Eshete Dejen *et al.*, 2003), *Varicorhinus* represented by one specie: *V. beso*, *Garra* represented by four species: *G. dembecha*, *G. tana*, *G. regressus* and *G. small mouth* (Akewake Geremew, 2007) and *Labeobarbus*, which is the most abundant genus of the family and consists of 17 species forming a unique species flock in Lake Tana (Nagelkerke, 1997).

The reproductive biology *Labeobarbus* species of Lake Tana is more or less similar to *Barbus holubi*, *B. kimberleyensis*, *Labeo capensis* and *L. umbratus* which are found in a large reservoir on the Orange River, South Africa (Tomasson *et al.*, 1984). In continuously flowing regulated rivers, time of spawning is governed by water temperatures and fish have moderate fecundity; large eggs, incubation time of several days and the larvae are initially immobile with large yolk sacs (Tomasson *et al.*, 1984).

The single annual upstream migration reproductive strategy of Lake Tana *Labeobarbus* species make them highly vulnerable as fishers target the spawning aggregations (Skelton *et al.*, 1991). The most plausible explanation for the decline of the *Labeobar-*

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bus stock in Lake Tana is thought to be recruitment overfishing by the commercial gillnet fishery that targets the riverine spawners (de Graaf *et al.*, 2004) and poisoning of the spawning stock in rivers using the crushed seeds of Birbira (*Milletia ferruginea*) (Nagelkerke and Sibbing, 1996).

Many recent studies have shown that Lake Tana tributary rivers are severely degraded by different developmental activities like irrigation and sand mining. In so far as we know, there is no any study dealing with the importance of the present small tributary rivers and streams of Lake Tana as the main spawning grounds for some endemic *Labeobarbus* species. Thus, this study aims at investigating the spawning migration fish species to these unexplored tributary rivers of Lake Tana.

MATERIALS AND METHODS

Description of the study area

Lake Tana is the largest lake and situated in the northwest of Ethiopia, at an altitude of 1830 m with a surface area of 3200 km² and a watershed of 16500 km² (Rzóska, 1976). More than 60 small seasonal tributaries and seven permanent rivers (Gumara, Ribb, Megech, Gilgel Abbay, Gelda, Arno-Garno and Dirma) feed the lake. Gumara is one of the largest perennial rivers flowing into Lake Tana and arises from the western side of Gunna Mountain peaks. It has a number of tributary rivers and streams namely: Dukalit, Kizin, Wonzema, Bawaza and Guanta.

A number of tributary rivers join the main Ribb River such as Chibirna, Shini, Kirarign, Keha, Barya, Hamus and Melo Rivers. Shini River is located at 12°05.906'N and 37°45.702'E, and Chibirna River is also located at 12°04.402'N and 37°44.075'E. In Shini River, sand mining is common activity and there is also small scale irrigation. Shini and Chibirna Rivers confluence at Bura Egziabher Kebele before entering

to Ribb River. Both Rivers dry out during the dry season due to excessive withdrawal of water for small irrigation.

Qimon River is located in northeastern part of Lake Tana at 12°11.000'N and 37°34.587'E. This river is starting from Kulkual Ber watershed in Gondar Zuria district and the upstream part of the river watershed is covered by dense forest, gravel beds. Qimon River is characterized by dense forest in the upper part of the river and the mouth of this river is also densely covered by shrubs, grass, and water hyacinth. Guanta River is characterized by dense vegetation. Figure 1 shows the specific sampling sites at the tributary rivers of Lake Tana.

Field sampling and type of data

Abiotic parameters

Physico-chemical parameters were measured in all sampling sites of spawning rivers. Water quality parameters like conductivity, pH, temperature and total dissolved solids (TDS) were measured using Cond/TDS meter (Wagtech Int., Model CE 470 Cond Meter 01189) and dissolved oxygen using oxygen meter (Wagtech Int., Model CO-411). Water transparency (secchi depth) of the rivers was estimated with a standard Secchi Disc of 25 cm diameter.

Gillnet setting and species identification

Sampling sites were selected based on the suitability for gillnet setting and human interference. In all sampling sites of the tributary rivers of Lake Tana, gillnet was set during the day time and sampling of fish was conducted usually from 10:00 am to 3:00 pm. Multifilament gillnets with 6, 8, 10 and 12 cm stretched mesh size and monofilament gillnets with 4 and 6 cm mesh size were used for collecting fish specimens. After capture, the collected specimens of *Labeobar-*

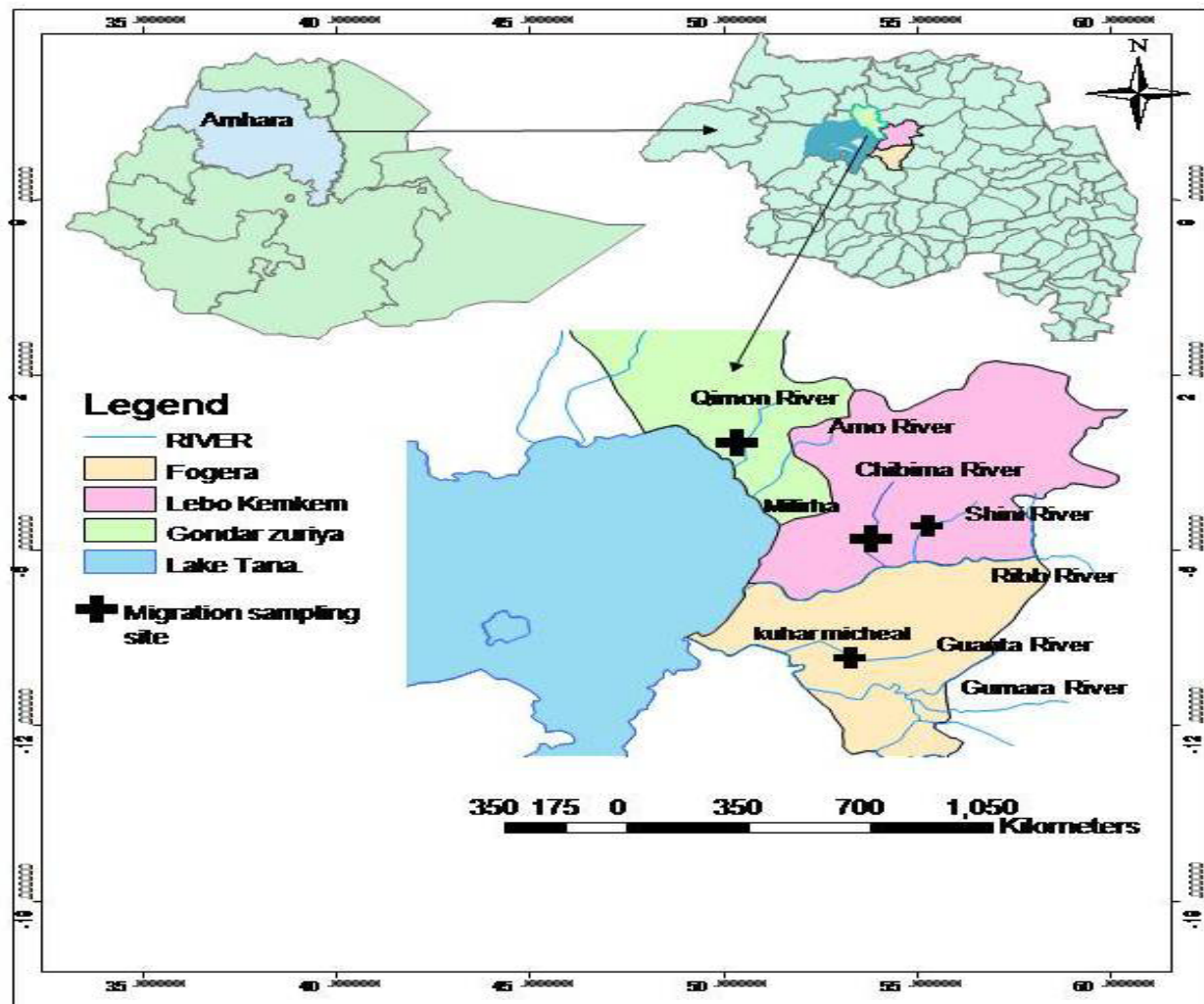


Figure 1. Map of Ethiopia, Amhara, Lake Tana and sampling sites at some inflowing rivers (own map).

bus species were identified to species level using keys developed by Nagelkerke (1997), and Nagelkerke and Sibbing (2000). Then, the specimens' total length, fork length, standard length and total weight were measured to the nearest 0.1 cm and 0.1 g precision for length and weight, respectively. After dissection, gonadal maturities of each fish specimen were identified using seven point maturity scales (Nagelkerke, 1997). Gonad weight was measured to the nearest 0.1 g using sensitive balance.

Relative abundance and fish composition

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 (Kold-

ing, 1999). IRI was used to find the most important species in terms of number, weight and frequency of occurrence in the catches from the different sampling sites. IRI gives a better representation of the ecological importance of species rather than the weight, number frequency of occurrence alone (Sanyanga, 1996).

Percent of IRI was calculated as follows:

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

Where, % W_i and % N_i are percentage 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. %W_j and %N_j are percentage weight and number of total species of total catch, respectively. %F_j is percentage frequency of occurrence of total species in total number of setting.

Gonado-Somatic Index (GSI) and fecundity

GSI is the ratio of fish gonad weight to body weight and used to determine the peak time of reproductive season of spawning migratory species. The GSI was determined using the following formula:

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

Eggs from the ripe female fish were preserved with 8% formalin for fecundity estimation. Three sub-samples of 1 g eggs were taken from different parts of ovary and counted and the average was calculated. The total number of eggs per ovary was calculated by extrapolation from the mean calculated. The correlation of fecundity with fork length, total weight and ovary weight were made to determine the relationship of fecundity with morphometric measurements. Fecundity was determined based on fork length and gonad weight. These two formulas were indicated as follows:

$F = aFL^b$, Where F – fecundity, FL – fork length; a – constant and b- exponent
 $F = aGW^b$, where GW – gonad weight

Data analysis

Data analysis was made using Statistical Package for Social Science Students (SPSS Inc., software version 20.0), SASS version 9.2 and Microsoft Excel. Physico-chemical parameters of water were performed using one way ANOVA. For all ANOVA test, mean comparison was performed using post hoc (LSD) to identify the difference between each parameter among sampling sites. Presence or absence of spatial and temporal segregation patterns of *Labeobarbus* species in all sampling rivers was also analyzed using χ^2 contingency table.

RESULTS

Abiotic parameters

The analysis for temperature, TDS, conductivity and Secchi depth showed significant differences among the different rivers ($p < 0.05$). Mean comparison of all physico-chemical parameters showed significant difference between Guanta River and other sampling rivers (Table 1).

Table 1. Water quality parameters in the sampling sites (Mean \pm S.E).

River	Oxygen (mg l ⁻¹)	Temperature (°C)	Conductivity ($\mu\text{s cm}^{-1}$)	Total dissolved solids (ppm)	pH	Secchi depth (cm)
Chibirna	6.5 \pm 0.44	22.1 \pm 0.63 ^a	313.1 \pm 27.19 ^a	214.3 \pm 19.24 ^a	8.1 \pm 0.13	82.1 \pm 7.78 ^a
Shini	6.5 \pm 0.54	20.8 \pm 1.02 ^{cb}	239.5 \pm 10.12 ^b	162.9 \pm 7.07 ^b	8.2 \pm .14	73.3 \pm 9.52 ^{ba}
Overall mean	6.2 \pm 0.24	20.9 \pm 0.40	235.4 \pm 14.40	159.4 \pm 10.20	8.2 \pm 0.08	65.9 \pm 5.30
P-value	0.52	0.010	0.002	0.003	0.116	0.001

The same subscript letters denotes non-significance at 0.05 using LSD mean comparison.

Species composition and relative abundance

A total of 1178 fish specimens were collected from Qimon, Guanta, Chibirna, and Shini Rivers. From the total specimens collected, 32.24% (382), 17.65% (208), 24.37% (287) and 25.52% (301) were sampled/contributed from Chibirna, Guanta, Qimon, and Shini Rivers, respectively. From the whole catch compositions, the genus *Labeobarbus* contributed 79.2% (933), *V. beso* 14.67% (172), *C. gariepinus* 2.4% (28), and *O. niloticus* 3.5% (41). From the total *Labeobarbus* specimens collected, *L. intermedius* was the most dominant specie (43%) followed by *L. brevicephalus* (23%), whereas the rest were few in number (Table 2).

The relative abundance and distribution of each species varied among sampling rivers across sampling months (Table 3). Most of the species were sampled in good numbers in the month of September. Among the 933 *Labeobarbus* specimens, 97% (905) were from the three dominant species (*L. intermedius*, *L. brevicephalus* and *L. nedgia*). The rest five *Labeobarbus* species were found rarely in all sampling rivers. In all sampling rivers, *L. intermedius* was the most important specie, followed by either *L. brevicephalus* or *L. nedgia* (Table 3).

Table 2. Species composition in all sampling rivers.

Species	Rivers				Total	Percentage
	Chibirna	Guanta	Qimon	Shini		
<i>L. brevicephalus</i>	47	73	126	31	277	23.5
<i>L. crassibarbis</i>	0	0	2	0	2	0.2
<i>L. dejeni</i>	1	0	0	2	3	0.3
<i>L. intermedius</i>	189	81	113	124	507	43
<i>L. megastoma</i>	0	0	5	0	5	0.4
<i>L. nedgia</i>	41	0	1	79	121	10.3
<i>L. truttiformis</i>	0	5	7	0	12	1
<i>L. tsanensis</i>	0	0	6	0	6	0.5
<i>V. beso</i>	90	28	0	54	172	14.6
<i>Barbus humilis</i>	2	0	0	0	2	0.2
<i>C. gariepinus</i>	7	11	1	9	28	2.4
<i>G. dembecha</i>	2	0	0	0	2	0.2
<i>O. niloticus</i>	3	10	26	2	41	3.5
Total	382	208	287	301	1178	100.00

Table 3. Percentage index of relative importance (%IRI) of *Labeobarbus* species from all sampling rivers.

River	Fish species	N	%N	W	%W	F	%F	IRI	%IRI
Qimon	<i>L. intermedius</i>	113	43.46	7133.4	39.54	6	100.00	8300	49.28
	<i>L. brevicephalus</i>	126	48.46	7509.1	41.63	5	83.33	7507.2	44.57
	<i>L. nedgia</i>	1	0.38	129.4	0.72	1	16.67	18.337	1.83
	<i>L. tsanensis</i>	6	2.31	1255.4	6.96	2	33.33	308.96	1.82
	<i>L. truttiformis</i>	7	2.69	1207.3	6.69	3	50.00	469	1.04
	<i>L. megastoma</i>	5	1.92	606.9	3.36	2	33.33	175.98	0.36
	<i>L. crassibarbis</i>	2	0.77	195.7	1.08	2	33.33	61.66	0.36
	Total	260		18037.2			100.00	16958.75	100.00
Chibirna	<i>L. intermedius</i>	189	67.98	1683.1	20.18	6	85.71	7555.83	46.76
	<i>L. nedgia</i>	41	14.75	3631.1	43.53	6	85.71	4994.91	30.91
	<i>L. brevicephalus</i>	47	16.91	2741.5	32.86	5	71.43	3555.29	22.00
	<i>L. dejeni</i>	1	0.36	286.5	3.43	1	14.28	54.18	0.33
		Total	278	100.00	8342.2	100.00		100.00	16160.21
Guanta	<i>L. intermedius</i>	72	48.00	7239.7	47.98	6	85.71	8226.4	59.01
	<i>L. brevicephalus</i>	73	48.67	3536.1	23.43	5	71.43	5150.1	36.94
	<i>L. truttiformis</i>	5	3.33	2474.3	16.40	2	28.57	563.69	4.04
	Total	150	100.00	15090.3	100.00		100.00	13940	100.00
Shini	<i>L. intermedius</i>	124	52.54	11980.20	83.50	6	100.00	13603.86	71.84
	<i>L. nedgia</i>	79	33.47	365.00	2.54	5	83.33	3601.84	19.02
	<i>L. brevicephalus</i>	31	13.14	1746.80	12.17	4	66.67	1687.33	8.91
	<i>L. dejeni</i>	2	0.85	256.20	1.79	1	16.67	43.88	0.23
		Total	236	100	14348.2	100.00	6	266.67	18936.9

Gonado-Somatic Index (GSI) and fecundity

Gonad stage VI (running level) was the highest in levels of percent maturity for all species and at all sampling sites as compared to other stages (Figure 2). From the 933 *Labeobarbus* specimens sampled during peak-seasons, 64.95% were found at maturity stage of IV-VII. The rest 35.5% were immature (I-III) and the peak time of spawning was September (Figure 3).

The mean value of GSI is used to indicate peak time of reproductive season for spawning migratory species. Most of the time, males of the three dominant species had similar peak time which is September while female for *L. brevicephalus* peaked in October which is different from *L. intermedius* and *L. nedgia* that peaked in September and August, respectively.

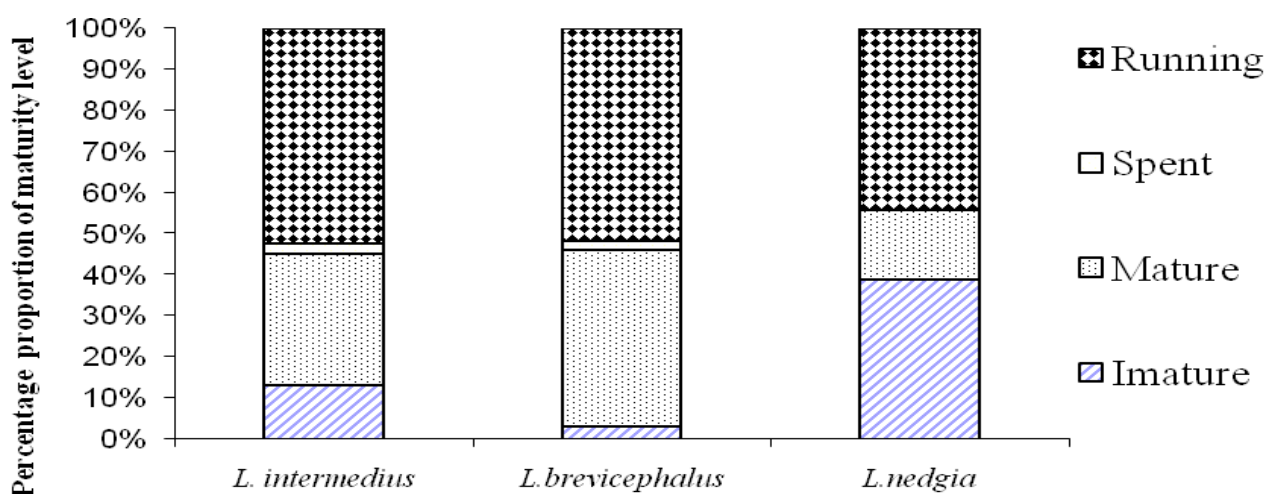


Figure 2. The proportion of maturity stages of the dominant *Labeobarbus* species.

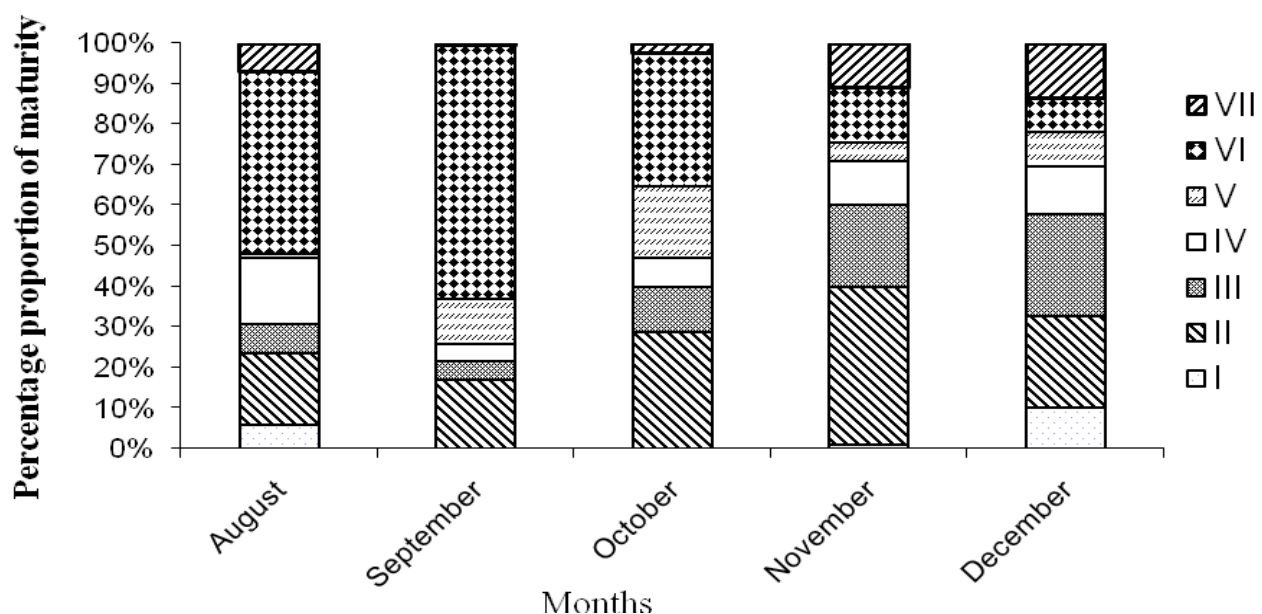


Figure 3. Temporal distribution of maturity levels of *Labeobarbus* species in sampling rivers.

Fecundity rates of the migratory *Labeobarbus* species were determined from a total of 141 specimens which mainly included *L. intermedius* (59), *L. brevicephalus* (67) and *L. nedgia* (15). Absolute (total) fecundity of the most dominant *Labeobarbus* species (*L. intermedius*, *L. brevicephalus* and *L. nedgia*) had linear relationship with their total gonad weight and fork length (Figures 4 and 5). *Labeobarbus intermedius* with fork length of 15 to 28 cm (21.79 ± 0.44 cm, mean \pm SE) had an absolute fecundity of 1265 to 13289 (mean fecundity of 5057), respectively and. *Labeobarbus brevicephalus* with fork length of 15 to

29 cm (19.78 ± 0.29 cm, mean \pm SE) had absolute fecundity ranging from 1225 to 9469 (mean fecundity of 3474), respectively. *Labeobarbus nedgia* with fork length 18 to 37 cm (25.14 ± 1.42 cm, mean \pm SE) had absolute fecundity ranging from 1448 to 14018 (mean fecundity of 5200), respectively.

The highest absolute fecundity (i.e., 18688 eggs) was recorded from *L. truttiformis* in Guanta River which had 58.4 g gonad weight. Absolute fecundity of each dominant migratory fish species had significant difference with their gonad weight ANOVA, ($p < 0.0001$) as shown in Figure 4.

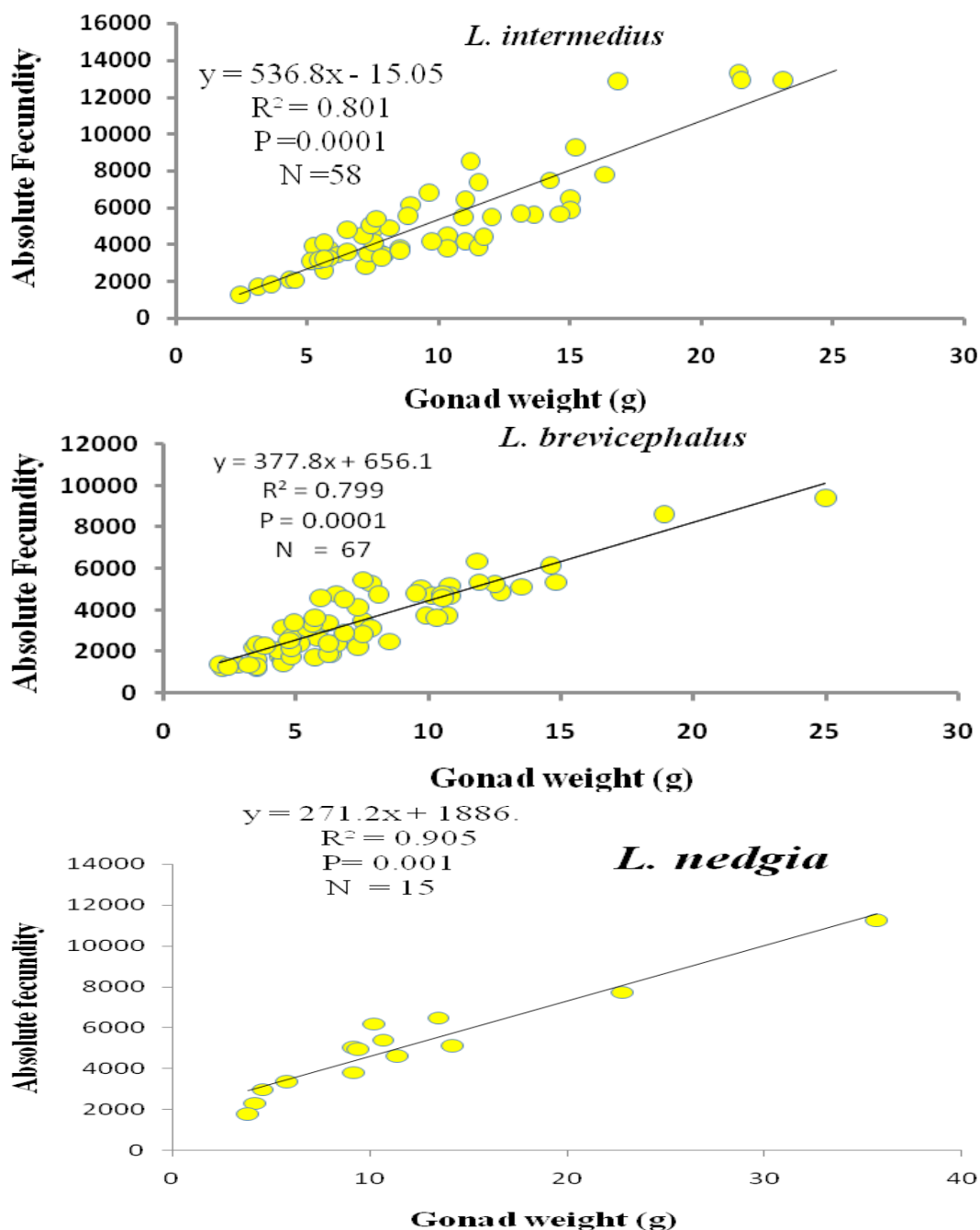


Figure 4. The relationship of absolute fecundity with gonad weight of the dominant *Labeobarbus* species

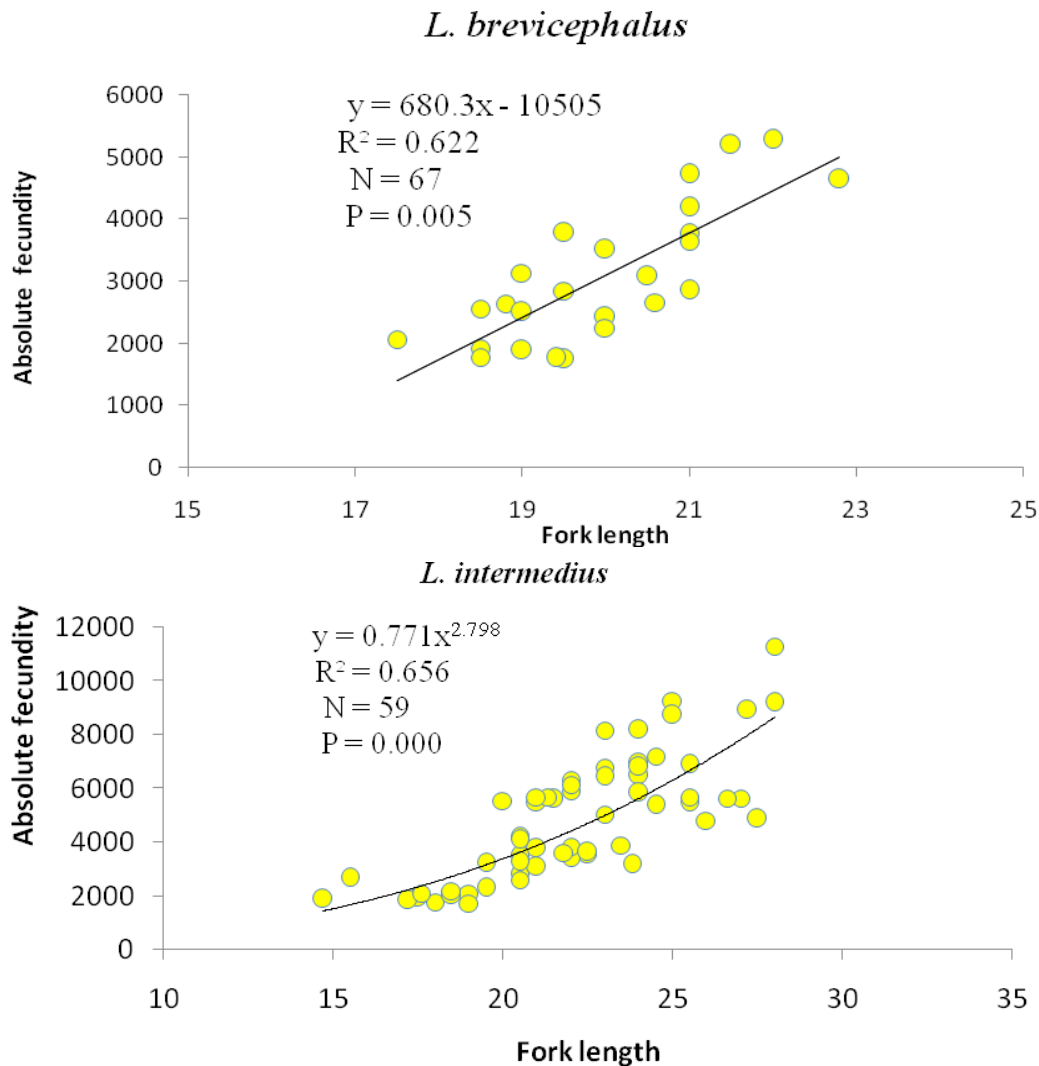


Figure 5. The relationship between absolute fecundity and fork length of *L. brevicephalus* and *L. intermedius*.

Spatial and temporal spawning segregations

Composition and distribution patterns of the three most abundant *Labeobarbus* species did not show significant difference in all sampling rivers except in the case of *L. nedgia* (one way ANOVA, $p > 0.05$) (Table 4).

Table 4. Spatial segregation of the three most dominant *Labeobarbus* species in all sampling rivers (one way ANOVA).

River	<i>L. brevicephalus</i> (N=277) Mean \pm S.E	<i>L. intermedius</i> (N=507) Mean \pm S.E	<i>L. nedgia</i> (N=121) Mean \pm S.E
Chibirna	9.4 \pm 4.43	37.8 \pm 6.02	8.2 \pm 2.20 ^b
Guanta	14.6 \pm 7.15	16.2 \pm 4.59	0.00
Qimon	31.5 \pm 9.89	28.3 \pm 14.50	.3 \pm .25 ^c
Shini	7.8 \pm 4.59	31.0 \pm 7.82	19.8 \pm 8.23 ^a
Total	15.4 \pm 5.07	28.2 \pm 4.28	6.7 \pm 2.55
P value	0.398	0.318	0.01

Spatial and temporal composition of the most abundant *Labeobarbus* species in all sampling rivers (Qimon, Guanta, Shini and Chibirna) is given in Table 5. Main breeding seasons were August, September and October and among these breeding months September was the most peak season for most of male *Labeobarbus* species.

DISCUSSION

Abiotic factors and Spawning grounds

All biological functions of living organisms in aquatic ecosystem such as growth, reproduction,

Table 5. Spatial and temporal segregation of the dominant *Labeobarbus* species (χ^2 Xc contingency table).

Species	Spatial distribution				
	Chibirna	Guanta	Qimon	Shini	Total
<i>L. brevicephalus</i>	47 ^a	73 ^b	126 ^b	31 ^a	277
<i>L. intermedius</i>	189 ^a	81 ^b	113 ^b	124 ^b	507
<i>L. nedgia</i>	41 ^a	0	1	79 ^c	121
Total	277	159	247	234	917
Species	Temporal distribution				
	August	September	October	November	December
<i>L. brevicephalus</i>	25 ^a	166 ^c	33 ^{a,b}	18 ^a	35 ^b
<i>L. intermedius</i>	94 ^a	180 ^b	95 ^a	64 ^a	74 ^a
<i>L. nedgia</i>	14 ^a	60 ^b	21 ^a	16 ^a	10 ^a
Total	140	408	149	101	119

Note: Same superscript letters in a row indicates non-significant difference among each other at 0.05 and Numbers indicate absolute numbers of specimens

Labeobarbus intermedius was the first species to migrate to the upstream sites of Shini River starting from the second week of August and but its catch was higher at the end of September (fourth week). *Labeobarbus brevicephalus* and *L. nedgia* were the last species to migrate to Shini and Chibirna Rivers. *Labeobarbus megastoma* and *L. truttiformis* were caught rarely from Qimon and Guanta Rivers and reach peak during October and August, respectively.

feeding and sexual maturity were determined by abiotic factors (Murdoch and Martha, 1999). The study indicated that all studied tributary rivers had different physico-chemical parameters due to different watershed, anthropogenic activities like sand mining in upstream of the rivers, and natural environmental variability. According to Wassie Anteneh *et al.* (2005) and Shewit Gebremedhin *et al.* (2012), Megech and Arno-Garno Rivers are the

main preferable sites for *Labeobarbus* spawning, the same to that Chibirna, Shini and Qimon Rivers were depicted in current study while Guanta River had less fish diversity as well as least number of spawning migratory species. Highly oxygenated water and gravel beds are general requirements for *Labeobarbus* spawning due to their critical importance in the development of eggs and larvae (Skelton *et al.*, 1991; Rodriguez-Ruiz and Granado Lorencio, 1992; Baras *et al.*, 1996; Baras, 1997; Abebe Getahun *et al.*, 2008). Similar assessment was made by de Graaf (2005) in Gumara, Gilgel Abbay, Ribb and Gelda Rivers that had different physical parameters such as temperature and secchi disk, showing strong seasonal patterns. In contrast with the report of Eshete Dejen (2004), Lake Tana mean value of conductivity was ($132.8 \mu\text{s cm}^{-1}$) which is much lower than conductivity value of the studied tributary rivers. This might be due to the different anthropogenic activities and environmental differences in Lake Tana and its tributary rivers.

In general, the variability of physico-chemical parameters in flowing rivers had strong relations with biological functions of any aquatic organism. Recently, Lake Tana fish production is declining as compared to the last ten years due to environmental and anthropogenic factors (Dereje Tewabe, 2013). This result is in line with Jamu *et al.* (2003) who reported similar results on some physico-chemical parameters that showed significant predictors of the migration dynamics and reproductive status of two *Barbus* species from Lake Chilwa basin (Malawi).

Low abundance and diversity of migratory fish species were recorded in the present study as compared to the previous studies which might indicate the decline of the migratory fish in the lake. Overfishing at Lake Tana and also degradation of spawning grounds and routs were might be main cause of the decline of spawning migratory species.

In agreement with Dereje Tewabe (2013) the main cause for the decline of the migratory fish species is fishing pressure at spawning grounds with illegal monofilament introduction.

Gonado-Somatic Index (GSI %) and Fecundity

Previous studies on reproductive segregation of *Labeobarbus* species of Lake Tana including Palstra *et al.* (2004), de Graaf (2005), Wassie Anteneh *et al.* (2005) and Shewit Gebremedhin *et al.* (2012) have reported the spawning aggregations of ripe and running fishes. According to Wassie Anteneh *et al.* (2005), *L. intermedius* reproduce throughout the year and it is both riverine and lacustrine, whereas in the current study, *L. intermedius* has similar reproductive season (GSI%) with other spawning migratory *Labeobarbus* species. During the end of spawning season high number of spent maturity levels and low abundance of fish specimens were recorded. Similar results were reported by de Graaf *et al.* (2005) that stated the peak-spawning season for *Labeobarbus* species in Lake Tana to be from August to October.

The fecundity rate of most dominant *Labeobarbus* species was in line with the results made by Mohammed Omer (2010) that studied *Labeobarbus* species at the head of Blue Nile River. Lower fecundity value was recorded in this study (*L. brevicephalus*, 1225 eggs) and this absolute fecundity value was lowest as compared to other cyprinids, *Barbus grypus* (16000-235784 eggs), *Labeo senegalensis* (12948-74832 eggs) and *Labeo parvus* (8723-124363 eggs) (Claudine *et al.*, 2013). This difference might be due to difference in genetic variability, food availability and other environmental conditions.

The relationship of fork length and total body weight with absolute fecundity was linear for *L. brevicephalus*. This is in line with the report of

Dagnaw Mequanent (2012). This indicates that absolute fecundity is directly related to the body size of the migratory species. According to Claudine *et al.* (2013) gonad weight is better correlated with reproductive capacity than fish size and fish species with these types of relationship have rapid growth and high fertility. Such characteristics are important for aquaculture development. According to Oliva Paterna *et al.* (2002) fast growth, high fecundity and early maturity are the characteristics of unstable environments.

CONCLUSION

Lake Tana *Labeobarbus* species is a unique species flock that was found highly threatened due to fishing activities and degradation of the environment. Small tributary rivers of Lake Tana (Shini, Qimon, Chibirna, and Guanta Rivers) are main spawning grounds however human interface (unregulated sand mining and irrigation) have influenced these spawning grounds. Numerous table size *Labeobarbus* species were caught from Shini and Chibirna Rivers during sampling seasons, but during the dry season no fish could be seen due to water withdrawal for irrigation. The communities who are living nearby the water bodies are not aware of when and where fish breed. That is why local inhabitants around Qimon and Guanta Rivers have the tradition of capturing fish for consumption and marketing during the peak spawning season and they use traditional fishing methods (using hooks and lines and monofilament gillnets). The time and sites of setting fishing gears are highly correlated with the time of segregation and aggregation of riverine migratory *Labeobarbus* species. Therefore, at least during peak time of spawning season, specific spawning grounds should be closed from fishing activities as well as irrigation canals have to be integrated and harmonized with river biodiversity. The community, governmental and non-governmental organizations, policy makers and fishers should be aware of the reproductive

strategy of the migratory fishes and potential human impacts on them for sustainable utilization of the resources.

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