

Diversity, Relative Abundance and Biology of Fishes in Borkena and Mille Rivers, Awash Basin, Ethiopia

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Abstract: Diversity, relative abundance and biology of fishes in Borkena and Mille Rivers were studied in April and October, 2009 using gillnets of stretched mesh size from 6-14 cm, monofilaments of different mesh size hook and line and beach seines. Abiotic parameters, temperature, dissolved oxygen, transparency, conductivity and pH of the rivers were taken. A total of 2021 fish specimens were collected from both rivers. Here, 6 species, 5 genera and 2 families were recorded from both rivers. Family Cyprinidae was best represented in the two rivers. *Garra dembecha*, *Labeobarbus intermedius* and *Clarias gariepinus* were the most dominant fish species in both rivers. Mille River had higher fish species diversity ($H' = 2.85$) than Borkena River ($H' = 2.53$) in dry season ($H' = 3.8$) than in wet season ($H' = 2.54$). In dry season, *C. gariepinus*, *G. dembecha* and *L. intermedius* were the most abundant species in Borkena River with percentage Index of Relative Importance (IRI) of 40, 31.4 and 22.3, respectively. Whereas in Mille River during dry season *G. dembecha*, *L. intermedius* and *V. beso* were the most abundant fish species with percentage IRI of 54.5, 18.3 and 7.4, respectively. There was significant difference in Fulton's condition factor of *G. dembecha* and *L. intermedius* between Borkena and Mille Rivers. Fish diversity of Borkena and Mille Rivers is less as compared to most studied rivers in Ethiopia but the abundance was highest. The watershed of both rivers is highly degraded and that might have resulted in low diversity. Therefore, afforestation program should be practiced around these rivers to prevent further loss of the aquatic biodiversity.

Key words: Condition factor, cyprinids, length-weight relationship, fecundity, sex ratio

INTRODUCTION

Ethiopia is a land locked country that depends on the inland waters for the supply of fish as a cheap source of animal protein. It has a number of lakes and rivers with substantial quantity of fish stocks. The total area of the lakes and reservoirs stands at about 7000-8000 km² and the important rivers stretch over 7000 km in the country (Tesfaye, 1998).

Although, Ethiopia has high production potential and diversity of fish fauna, notable fishery investigation has been carried out only in a few of the numerous freshwater bodies. The territory of Ethiopia seems to be among the regions of African continent which are least explored for their ichthyofauna (Golubstov *et al.*, 1995). Knowledge on diversity, population structure, distribution and population of the Ethiopia ichthyofauna and biology of fish species has been poorly known relatively a large number of small, medium and even some large rivers have not been well studied and explored (Abebe, 2005). Therefore, further study on the rivers is vital and a time demanding task. Amhara region has high

fish production potential from major lakes; Lake Tana, Lake Lugo, Lake Ardibo and other small water bodies. Moreover, the region has also a considerable fish potential from rivers like; River Shinfa, River Sanja and others (Dereje, 2008). Relatively major rivers in Amhara region were investigated for their fish diversity. However, Borkena and Mille are two tributary rivers of Awash River in Awash basin originated from the highlands of Wollo where little attention has been given for diversity, abundance and economic importance of fish fauna. The purpose of the study was, therefore, to identify fish diversity in Borkena and Mille Rivers, quantify the relative abundance of fish species and to examine some aspects of the biology of the dominant fishes.

MATERIALS AND METHODS

Study area: Awash basin has three main catchments; upper, middle and lower Awash. Borkena and Mille Rivers are found in lower Awash with catchment area of 3,212 and 5,803 km², respectively. Borkena and Jara are main tributaries of Borkena River. Mille, Genale, Wekele and

Tekre are major tributaries of Mille River (Wehner, 2001). Borkena River is located at latitude of 11.65°N and longitude of 39.65°E; whereas, Mille River lies at latitude of 11.63°N and longitude of 39.8°E. Borkena River has three sub-basins: Dessie, Kombelcha and Chefa (Tadesse, 1980). Mille River has two sub-basins; upper and lower Mille. Both Borkena and Mille originate from South Wollo, Borkena from Kutaber and Mille from Ambasel and Tehulederie Woredas SWA.

Site selection and sampling: In this study, six sampling sites were selected; three from each river. Site selection was done by considering nature and velocity of the flowing river, interference by human beings and other farm animals and substrate type of the sediments and accessibility (Table 1). Each sampling site was sampled twice at dry and twice in wet seasons in both rivers. Gillnet of stretched mesh size of 6-14 cm and hook and lines were used to sample fish by setting the net and the hook for 14 h overnight at deeper part of the river. Monofilament gillnets with meshes size of 5-55 mm

were set on the rivers for 1 h to sample small-sized fish species. In addition to this, beach seines (mention the mesh size) were used in suitable areas of the rivers. Immediately after capture, a gentle pressure was applied on the abdomen to check whether ovulation/spermatation has occurred or not. Then, total length and weight of all specimens of fish were measured.

Pictures were taken for each species. After taking the entire necessary information individual specimen was preserved with 4% formalin in plastic jar and transported to the laboratory for further identification and measurement.

Gulo site is found in Gulo village where the bank of Borkena River is exposed to agricultural activity. Hot spring site is located near the hot springs in Chefa. Nursery site is found near Artumafursie nursery where the bank of the river is highly vegetated. Bridge and near bridge sites in the Mille River are exposed to human and cattle interference. Seitanbahir site is relatively less exposed to interference and is vegetated (Fig. 1).

Table 1: Characteristics of sampling sites

Rivers	Fishing site	-----Location-----	-----Distance from nearby town-----
Borkena	Gulo	1417 m 10°42'09"N 39°49'08"E	4 km Kemisse
	Hot spring	1401 m 10°37'55.4"N 39°55'42.2"E	10 km Cherete
	Nursery	1394 m 10°38'09"N 39°55'58.2"E	15 km Kemisse
Mille	Bridge	1652 m 11°22'51"N 39°38'27.7"E	8 km Hayq
	Near bridge	1645 m 11°22'58"N 39°38'27.7"E	7 km Basomille
	Seitanbahir	1610 m 11°24'13.6"N 39°38'26.6"E	10 km Chefe

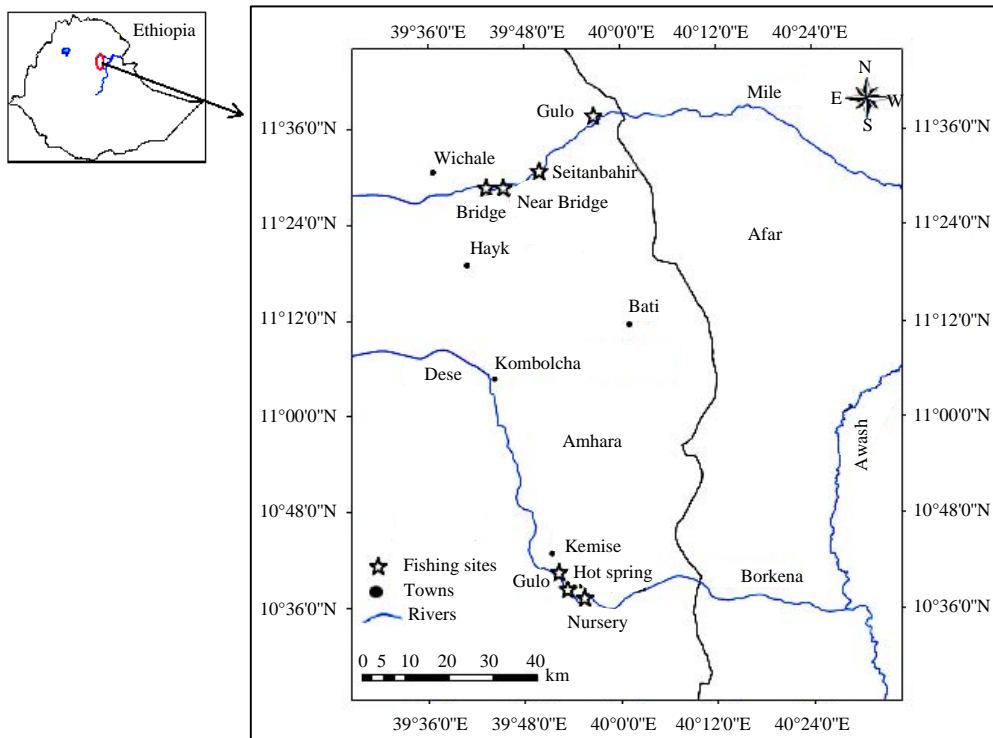


Fig. 1: Map of study sites in Borkena (Gulo, hot spring and nursery) and Mille River (Bridge, near bridge and Seitanbahir)

Laboratory studies: Specimen of fish were soaked in tap water for 1 day to wash the formalin and were identified to species level using specimen deposited at Bahir Dar Fish and Other Aquatic Life Research Center and by using identification key (Golubstov *et al.*, 1995).

Species diversity and relative abundance: Estimation of relative abundance of fish was made by the contribution of the catch in each sampling effort. An Index of Relative Importance (IRI) and Shannon diversity index (H') was used to evaluate relative abundance and diversity of fish, respectively. An index of relative importance is a measure of 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). The IRI gives a better replacement of the ecologically important species rather than the weight, number or frequency alone. Index of relative importance:

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

Where:

- $W_i(\%)$ = Percentage weight of total catch
- $N_i(\%)$ = No. of each species of total catch
- $F_j(\%)$ = Percentage frequency occurrence of each species in total number of settings
- $W_j(\%)$ = Percentages weight in total catch
- $N_j(\%)$ = No. of total species in total catch

Shannon index of diversity (H'): The Shannon index of diversity (H') is a measure of species weighed by the relative abundance (Begon *et al.*, 1990). Shannon index of diversity (H') was calculated using the equation as:

$$H' = -\sum P_i \ln P_i$$

Where, p_i is the proportion of individuals in the i th species. Shannon index was used to indicate diversity of fishes at different sampling sites or rivers.

Length-weight relationship: The relationship between total length and total weight of most dominant fish was calculated using power function as in Bagenal and Tesch (1978):

$$TW = aTL^b$$

Where:

- TW = Total Weight (g)
- TL = Total Length (cm)
- a = Intercept of regression line
- b = Slope of regression line

Condition factor (Fulton factor): The wellbeing of each dominant species was studied by using Fulton condition factor (Bagnal and Tesch, 1978). Fulton condition factor (%) was calculated as:

$$FCF = \frac{TW}{TL^3} \times 100$$

Where:

- TW = Total Weight (g)
- TL = Total Length (cm)

Fecundity: Fecundity was determined gravimetrically, from stage IV maturity stage. Three sub-samples of 1 g of 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. The relative fecundity was calculated by dividing the total number of eggs per fish weight. The relationship of fecundity with total length, total weight and ovary weight were calculated according Bagenal and Tesch (1978) using the following equation:

$$F = aTL^b = aTW^b = aGwt^b$$

Where:

- F = Fecundity
- TL = Total Length (cm)
- TW = Total Weight (g)
- Gwt = Gonad weight
- a = Constant
- b = Exponent

Sex ratio: Sex ratio was determined using the equation:

$$\text{Sex ratio} = \frac{\text{No. of females}}{\text{No. of males}}$$

Statistical analysis: Descriptive statistics, ANOVA and regression were used to analyze the collected data using SPSS software.

RESULTS AND DISCUSSION

Abiotic parameters: Physical and chemical parameters (Temperature, transparency, conductivity, oxygen and pH) that were taken from all sites in Borkena and Mille river were analyzed using independent t-test and the result of the analysis showed significant difference in pH and transparency between the two rivers (Table 2).

The mean temperature values of Borkena River was (28.65°C) that is higher than Mille River (25.30°C). But, the value of temperature in these rivers was <32.5°C which is the limit for aquatic life (Hauer and Hill, 1996). Aquatic animals need Dissolved Oxygen (DO) to live. Fish,

Table 2: Mean and standard deviation of physico-chemical parameters in Borkena and Mille (DO (mg L⁻¹), temperature (°C), transparency (cm), conductivity (μ sec cm⁻¹))

Rivers	pH	DO	Temperature	Transparency	Conductivity
Borkena	5.85±1.280	5.97±2.029	28.65±4.912	34.17±21.3	1002.33±283.50
Mille	7.72±0.894	5.09±1.830	25.30±3.510	93.33±38.8	719.80±300.92

± values are shown as Mean±SE

Table 3: Fish species presence in sampling sites (Present (+), Absent(-))

Rivers	Site	Fish species					
		<i>C. gariepinus</i>	<i>G. dembecha</i>	<i>V. beso</i>	<i>L. horie</i>	<i>L. nedgia</i>	<i>L. intermedius</i>
Borkena	Gulo	+	+	-	-	+	+
	Hot spring	+	+	-	-	+	+
	Nursery	+	+	-	-	+	+
Mille	Bridge	+	+	+	+	+	+
	B. bridge	+	+	+	+	+	+
	Seitanbahir	+	+	+	+	+	+

invertebrates, plants and aerobic bacteria all require oxygen for respiration. The amount of oxygen required varies according to species and stage of life. For example, DO levels <2 or 1 mg L⁻¹ will not support fish and levels 5-6 mg L⁻¹ are usually required for growth and activity (Campbell and Wildberger, 1992). In Borkena River, the mean DO level was higher (5.97 mg L⁻¹) than Mille River (5.09 mg L⁻¹). In both rivers, the values of mean DO were >5 mg L⁻¹ that can support growth and activities (Hauer and Hill, 1996).

A pH range of 6.5-8.2 is optimal for most organisms (Campbell and Wildberger, 1992). The pH of Borkena River (5.85±1.28) was lower than Mille River (7.72±0.894) and this might be due to higher pollutant load released to Borkena from industries than Mille.

The specific conductance of seawater is usually expressed in terms of salinity APHA (1992). The conductivity of Borkena River (1002.33 μS cm⁻¹) was higher than Mille River (719.83 μS cm⁻¹). In both cases, the conductivity values were higher that might be due to the total dissolved solids from ground water in Mille River and the presence of hot springs near Chefa and volcanic activity near Afar region in case of Borkena River.

Fish species composition: In both Mille and Borkena Rivers, the fish species which were dominant were member of the family Cyprinidae, *Labeobarbus intermedius*, *Garra dembecha* and *L. nedgia*. *Clarias gariepinus* which is in the family Clariidae was also found in these rivers. *Labeo horie* and *Varicorhinus beso* (Cyprinidae) were exclusively found in Mille River in both seasons. *Gara dembecha* and *L. intermedius* were dominant fish species in both rivers in dry and wet seasons. Borkena River has 4 fish species which was less than Mille River which has six species that belong to Cyprinidae and Clariidae. Fish species in Borkena were *L. intermedius*, *L. nedgia*, *G. dembecha* and *C. gariepinus*. Mille River has additionally *Labeo horie*

and *V. beso*. The fish species composition of the two rivers was very low as compared to the result obtained by Genanaw (2006) that was 10 species in Sanja and Angereb Rivers (Beletew, 2007), 17 species in Beshilo, Dura and Ardi Rivers (Zelege, 2007), 23 species in Beles, Gelgel Beles (Dereje, 2008) and 27 species in Guang, Ayma, Gendwuha and Shinka Rivers (Table 3).

Flow variability has an effect on fish assemblage, sometimes high flows, for instance, can destroy fish habitat and can also wash the eggs of the fish that have been already laid. On the other hand, during the dry season when the flow is low and when the water is reduced, the fishes are trapped in very small shallow pools that cause stress on fish and make very visible to predators and hence, only very tolerant species such as Cyprinids and Clariidae families survive in seasonal and swiftly flowing rivers Genanaw (2006). In agreement with Genanaw (2006), Borkena and Mille Rivers flow swiftly and have the potential to destroy fish habitat and wash out the eggs of fish that have been laid and could be the possible reason for very low species diversity in these rivers. Mille River has very clear water except during main rainy season (June to September) and Borkena River is seasonal in its Dessie and Kombolcha sub-basins in dry season (October to February). This might expose the fish species and their larvae for predators. Mille River is perennial in its entire basin unlike Borkena River and this could be one possible reason for higher fish species diversity (Table 3).

Species diversity and abundance: Borkena and Mille Rivers were dominated by family Cyprinidae mainly by genera *Barbus* and *Garra*. The result of the present study agrees with Roberts (1975) and Getahun and Stiassny (1998) in that fish species in Awash basin are dominated by family Cyprinidae (Genera, *Barbus*) and *Garra*. Percentage IRI of *G. dembecha* was higher at Seitanbahir and lower at hot spring in dry season and it was higher in

near bridge and lower at nursery site in wet season. Percentage IRI of *L. intermedius* was higher at nursery and lower at hot spring in dry season whereas it was higher at nursery and lower at Gulo, near bridge and seitanbahir (Table 4 and 5).

Shannon diversity index: Shannon diversity index was used to evaluate species diversity of sampling sites and rivers. Shannon diversity index explains both variety and the relative abundance of fish species (Naesje *et al.*, 2004). Mille River has more species diversity than Borkena River in both seasons. The univariate analysis showed that there was significant difference in Shannon index (H') and Number of species (N) between Borkena and Mille Rivers (p<0.05).

The number of fish species was higher in dry season than wet season in all sites as a result the Shannon

diversity index (H') was higher in dry season in all sites except Gulo. Seitanbahir site of Mille River had the highest fish species and Shannon index (H') in both seasons (Table 6).

Length-weight relationship: The relationship between total length and total weight for dominant fish species, *L. intermedius* and *G. dembecha* was curvilinear and as a result the line fitted to the data was described by the regression equation (Table 7). In fishes, the regression coefficient $b = 3$ describes isometric growth, when the value becomes exactly 3 if the fishes retain the same shape and their specific gravity remains unchanged during their life time (Ricker, 1975). If the weight increases as the fish length increases, it is said to be isometric growth. However, fishes may have b value greater or less than 3, a condition of allometric growth (Bagenal and Tesch, 1978). In agreement with Genanaw (2006) in Angereb and Sanjar rivers, Wassie (2005) in Dirma and Megech Rivers and Abebe *et al.* (2008) in Rib River, *L. intermedius* showed nearly isometric growth in Borkena and Mille Rivers (Table 5). *Garra dembecha* in Borkena River showed positive allometric growth unlike that reported by Akewack (2007) but it showed nearly isometric growth in Mille similar to Akewack (2007) in Lake Tana (Table 7).

Fulton's Condition Factor (FCF): The measure of fish condition can be linked to the general fish health, fat and

Table 4: Fish distribution in the two rivers during dry and wet seasons

Fish species	Family	Rivers			
		Borkena		Mille	
		Dry	Wet	Dry	Wet
<i>Clarias gariepinus</i>	Clariidae	+	+	+	+
<i>Garra dembecha</i>	Cyprinidae	+	+	+	+
<i>Labeo horie</i>	Cyprinidae	-	-	+	+
<i>Labeobarbus intermedius</i>	Cyprinidae	+	+	+	+
<i>Labeobarbus nedgia</i>	Cyprinidae	+	+	+	+
<i>Varicorhinus beso</i>	Cyprinidae	-	-	+	+

Table 5: Percentage IRI of dominant fish species in Borkena and Mille Rivers by season

Fish species	Sites											
	Gulo		Hot spring		Nursery		Bridge		Near bridge		Seitanbahir	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
<i>G. dembecha</i>	30.8	2.48	27.5	1.9	35.20	0.8	54.5	6.9	49.9	12.2	60.7	3.47
<i>L. intermedius</i>	16.5	0.48	0.0	70.6	46.90	71.2	25.9	20.8	7.9	0.0	24.4	0.04

Table 6: Shannon index and number of fish species in Borkena and Mille Rivers

H'/N	Sites											
	Gulo		Hot spring		Nursery		Bridge		Near bridge		Seitanbahir	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
H'	0.94	0.43	0.69	1.04	0.9	1.07	1	1.3	0.73	1.15	1.1	1.3
N	3.00	3.00	2.00	4.00	3.0	4.00	5	6.0	3.00	5.00	5.0	6.0

Table 7: Length-weight relationship of dominant fish species in Borkena and Mille Rivers

Fish species	Family	Rivers			
		Borkena		Mille	
		Dry	Wet	Dry	Wet
<i>Clarias gariepinus</i>	Clariidae	+	+	+	+
<i>Garra dembecha</i>	Cyprinidae	+	+	+	+
<i>Labeo horie</i>	Cyprinidae	-	-	+	+
<i>Labeobarbus intermedius</i>	Cyprinidae	+	+	+	+
<i>Labeobarbus nedgia</i>	Cyprinidae	+	+	+	+
<i>Varicorhinus beso</i>	Cyprinidae	-	-	+	+

Table 8: Mean and standard deviation of Fulton condition factor for the dominant fish species

Rivers	Species	Regression equation	Mean±SD of TL	Mean±SD of TW	R ²	n	Sig.
Borkena	<i>G. dembecha</i>	TW = 0.0152TL ^{2.73}	9.35±0.3	19.10±22.20	0.98	664	0.001
	<i>L. intermedius</i>	TW = 0.0056TL ^{3.12}	22.30±7.6	160.20±163.0	0.99	186	0.001
Mille	<i>G. dembecha</i>	TW = 0.0074TL ^{3.004}	9.90±2.8	20.64±19.23	0.98	482	0.001
	<i>L. intermedius</i>	TW = 0.005TL ^{3.20}	14.23±5.9	56.21±39.50	0.97	256	0.050

Table 9: Sex ratio of fishes in Borkena and Mille Rivers

Fish	River	Sex	Mean±SD
<i>G. dembecha</i>	Borkena	F	1.42±1.23
		M	1.36±1.75
		Total	1.37±1.62
	Mille	F	1.22±1.25
		M	1.23±1.24
		Total	1.25±1.69
<i>L. intermedius</i>	Borkena	F	1.13±0.34
		M	1.32±1.16
		Total	1.23±0.85
	Mille	F	1.29±1.35
		M	1.36±1.74
		Total	1.31±1.60

lipid content, prey or food availability, reproductive potential, environmental condition and water level fluctuation. In general, higher condition is associated with higher energy (fat) content, increasing food base, reproductive potential or more favorable environmental conditions (Pauker and Rogers, 2004). The mean Fulton condition factor value obtained in Dereje (2008) for *L. intermedius* was 1.12, greater than reported by Genanaw (2006) from Angereb and Sanja Rivers with a value of 1.06 and (Zelege, 2007) in Beles and Gelgel Beles with value of 1.0. However, Fulton condition factor of *L. intermedius* obtained in Borkena and Mille Rivers were 1.23 and 1.31 which were greater than even the one mentioned in Dereje (2008) in Guang, Ayima, Gendwuha and Shinfa. There was significant difference in Fulton's condition factor of *L. intermedius* between Borkena and Mille Rivers ($p < 0.001$). The Fulton condition factor of *L. intermedius* in Mille River (1.31±1.60) was higher than Borkena River (1.23±0.85). Therefore, *L. intermedius* was in better condition in Mille River than Borkena River. The Fulton's condition factor of *G. dembecha* in Borkena and Mille Rivers were 1.37±1.61 and 1.25±1.69, respectively. Therefore, *G. dembecha* were in better condition in Borkena River than Mille River. The Fulton's condition factor of *G. dembecha* obtained by Akewack (2007) was 1.421±0.012 which was higher than in either of the two rivers. The univariate analysis test showed that there was no significant difference in Fulton's condition factor between female and male *G. dembecha* and *L. intermedius* ($p > 0.05$) (Table 8).

Sex ratio: A total of 2021 fish were collected in Borkena and Mille Rivers during this study period. From this catch, 48 (2.3%) specimens were unsexed and 1973 fish (97.7%) were sexed and of which 1199 were females and 774 were

males. Females were numerous than males. The Chi-square test showed that there was no significant difference between number of male and female in all fish species except *G. dembecha* and *L. nedgia* in Borkena and Mille Rivers (Table 9).

Fecundity: Fecundity of the most dominant fish species (*G. dembecha* and *L. intermedius*) was done from sample taken both from Borkena and Mille Rivers. *Garra dembecha* with total length of 48-124 mm had absolute fecundity from 320-1130 eggs. *Labeobarbus intermedius* with total length of 266-467 mm had absolute fecundity of 2736-12124 eggs. The relation between Absolute Fecundity (AF) with Total Length (TL), Total Weight (TW) and Gonad Weight (GW) for the 2 species was linear. There was significant relation in absolute fecundity with gonad weight, total length and total weight in both *L. intermedius* and *G. dembecha* ($p < 0.05$). The absolute fecundity of *G. dembecha* ranged from 1215-1229 in Lake Tana (Akewack, 2007) higher than the result obtained from Borkena and Mille Rivers, 320-1130.

Fishery status in Borkena and Mille Rivers: There were 50 fishermen in Borkena River higher than Mille River (30) during the study period. The fishermen around Borkena River were totally dependent on fishing unlike the case in Mille River that was seasonal, fishing only during non-farming season. *Clarias gariepinus* was the preferred fish species by fishermen and the people around Borkena River. *Gara dembecha* species was highly preferred around Mille River and used to make wot (Ethiopian national hot stew) during wedding ceremony. Since, both Borkena and Mille Rivers are found in highly populated areas where high agricultural activities are practiced, the rivers were are highly degraded.

CONCLUSION

Fish diversity of Borkena and Mille Rivers is less as compared to most studied rivers in Ethiopia, but the abundance is highest. *Clarias gariepinus* and *G. dembecha* are consumed by the people around these rivers unlike most people living in Amhara region. The watershed of both Millie and Borkena Rivers is highly degraded. Therefore, afforestation program should be practiced around these rivers. Socio-economic aspect of fishing in both Borkena and Mille Rivers should be studied in detail. Training on post-harvest loss prevention and preservation should be given for fishermen.

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