E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2018; 6(2): 562-570

www.fisheriesjournal.com
Received: 21-01-2018
Accepted: 22-02-2018

Takele Shitaw
Department of Fisheries Wetland and Wild Life Management, Bahir Dar University College of Agriculture and Environmental Sciences, Ethiopia

Shewit G Medehin
Department of Fisheries Wetland and Wild Life Management, Bahir Dar University College of Agriculture and Environmental Sciences, Ethiopia

Wassie Anteneh
Department of Fisheries Wetland and Wild Life Management, Bahir Dar University College of Agriculture and Environmental Sciences, Ethiopia

Correspondence
Takele Shitaw
Department of Fisheries Wetland and Wild Life Management, Bahir Dar University College of Agriculture and Environmental Sciences, Ethiopia

Spatio-temporal distribution of *Labeobarbus species* in Lake Tana

Takele Shitaw, Shewit G Medehin and Wassie Anteneh

Abstract
This study was conducted from May to December 2016 and the aim was to investigate the spatio-temporal distribution of Labeobarbus species of Lake Tana. Descriptive statistics was used to present the data. Chi-Square Test was used to compare the spatial variations of species between areas, the temporal variations between seasons. *Labeobarbus intermedius* was the most dominant specie, containing 38.8 % of catch followed by *L. tsanensis*, *L. platydorsus*, *L. brevicephalus* within a catch composition of, 18.96%, 13.1%, 10.5%, respectively. *Labeobarbus dainellii* and *L. gorguari* were rarely collected. *Labeobarbus species* of Lake Tana showed significant variation in catches at four sampling sites ($p<0.01$) and also these species showed significant variation in dry and rainy seasons ($p<0.01$). *L. intermedius*, *L. tsanensis*, *L. brevicephalus*, *L. nedgia*, *L. gorgorensis*, *L. truttiformis* were significantly more abundant in rainy season than dry season. The maximum possible diversity of four sampling site. The highest 'J' value was obtained at Gumara site with the value of 0.5. Effort control regulations, limiting the gillnet fishery in spawning seasons and/or areas, will be appropriate to prevent the Labeobarbus fish species of lake Tana.

Keywords: relative abundance, diversity, gillnet selectivity, lake tana, labeobarbus

1. Introduction
Ethiopia is rich in its fish fauna, having a diversified species in the inland water bodies [1]. 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 [2], Varicorhinus represented by one specie: V. beso, Garra represented by four species: G. dembecha, G. tana, G. regressus and G. small mouth [3] and *Labeobarbus*, which is the most abundant genus of the family and consists of 17 species forming a unique species flock in Lake Tana [4]. It is the most abundant genus of the family and consists of 15 species (*L.acutrostris*, *L. brevicephalus*, *L. macrophtalmus*, *L. megastoma*, *L. platydorsus*, *L.truttiformis*, *L. dainellii L. tsanensis*, *L. surkis*, *L. gorgorensis*, *L. Crassibarbis*, *L. gorguari*, *L. nedgia*, *L. longissimus* and *L. intermedius* forming a unique species flock in Lake Tana [4]. *Labeobarbus* species of Lake Tana, belonging to the family of large *Cyprinidae* are the only species flock in the world [4, 5, 6].
Stock reduction of *Labeobarbus* species has been reported by several authors. However, recently nothing is known about spatio-temporal dynamics of *Labeobarbus* species in Lake Tana. At the current situation the distribution and abundance of 15 *Labeobarbus* fish species of lake Tana is not well known (three is no any clear information which is recently documented on the distribution of *Labeobarbus* species of Lake Tana), since there is no any information about which species are threatened or rarely occur and which are more abundant. In addition to this fishing at the spawning ground during spawning season using minimum gillnet mash size in Lake Tana is set long time back. Dramatic reduction of the adult *Labeobarbus* and the even lower proportion of recruits at the end of the 1990s, show the necessity for the development, implementation and control of fisheries legislation in Lake Tana [7]. Their aggregations at the river mouth during spawning migrations makes them vulnerable to recruitment overfishing, because their exploitation can, in extreme cases, lead to a dramatic decrease in the number of recruits. Moreover, at present there is no limitation on the number and type of gillnets used. Information about distribution, abundance of *Labeobarbus* species is required in order to advise on management measures to protect the reproductively

active part of the population. Proper fishery management requires that fishing gear harvest large mature fish while allowing the small juveniles to escape [8]. Such measures could involve the introduction of a minimum mesh size and closed seasons and/or areas. Therefore, this study was intends to generate scientific information about the distribution and composition of these species for the management of Lake Tana fish resource.

2. Materials and Methods

2.1 Description of the Study Area

Lake Tana, is the largest lake in Ethiopia with an area of about 3200 km^2 and it is located in the northwestern highlands of Ethiopia at an altitude of about 1800 m with an average depth of 8 m and maximum depth of 14 m and it is the only source of the Blue Nile River and constitutes almost half of the freshwater bodies of the country [9, 10]. Lake Tana, the third largest Lake in Africa next to Victoria and Tanganyika, originated by the blocking the Blue Nile River with volcanic basalt two million years ago [11, 12]. It is characterized by low nutrient concentrations, relatively high silt concentrations with a loading rate of 8.96-14.84 million tons of soil per year and the trophic status is oligotrophic to mesotrophic [4, 13, 14]. The Lake Tana area has a warm climate with four years mean annual rainfall of about 1564 mm, of which 59 percent fall in the months of July and August, when the mean rainfall can be 444-483 mm per month. The seasonal rains cause the lake level to fluctuate regularly with an average difference between the minimum, in May-June, and maximum in September-October of about 1.5 m. Lake Tana and its adjacent wetlands both directly and indirectly provide a livelihood for more than 500 000 people [15] and about three million people live in the catchment. The population distribution is high in those areas to the northeast and south of Lake Tana [16]. This Ethiopia's largest lake is source of Blue Nile. The only out flowing river is Blue Nile. Ichthyo (fish) fauna is isolated from the lower Blue Nile by a 40m waterfall located 30 km from Lake Tana. Fogera and Dembia Floodplains are the largest wetlands of the country and border Lake Tana in the eastern and northern parts, respectively [17]. The population density ranges from 151-200 persons km^2 in the north and in some parts of Fogera plain to the east, and from 101-150 persons km^2 in the more fertile lowland areas to the east and southwest [17].

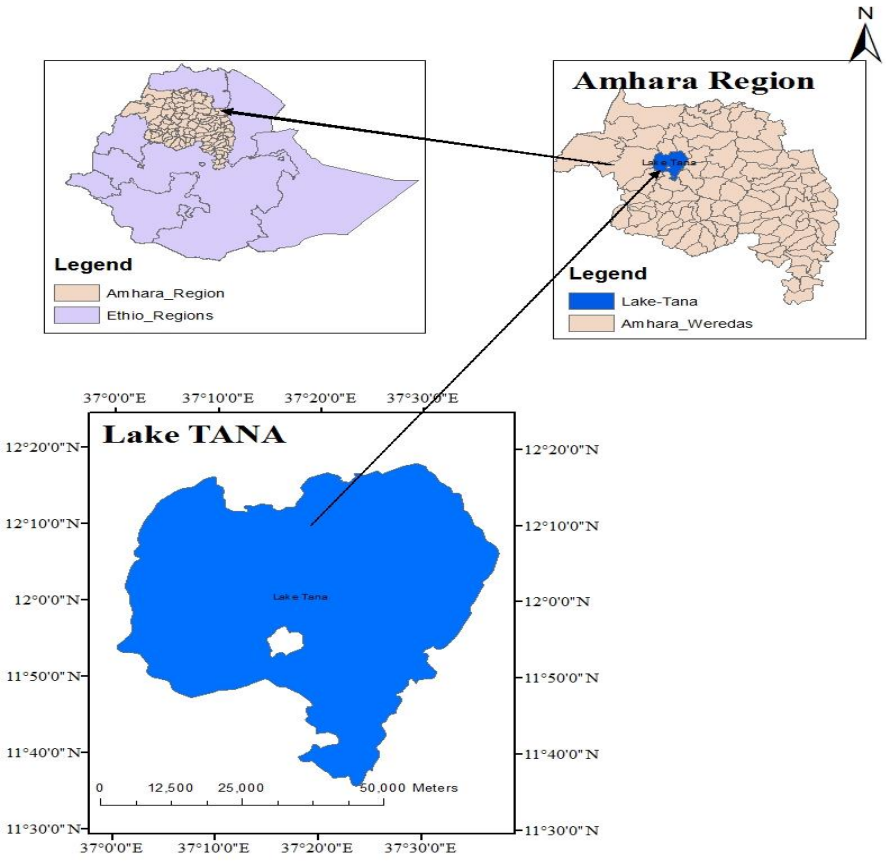

Fig 1: map of Lake Tana and sampling sites

2.2 Sampling and Data Collection

Both fisheries independent and dependent data were used. For fisheries independent data collection four sampling sites (Gorgora from North, Bahir Dar Gulf from South, Nabega from East and Kunzla from West direction of the lake), which are a good representatives of the whole lake in its North-South and East-West direction, were selected (Fig.1). Fish samples were collected monthly at each site for eight months. Gillnets of 6, 8, 10, 12 and 14 cm stretched mesh were used and set overnight in the lake at a depth of about 3m. The five gillnets were connected end to end and the resulting 150 m long panel was set around sunset and retrieved at dawn. Thus, the average gillnet setting time was 12 hrs throughout the sampling period. After the retrieval of the sampling gear, fish caught in the five gillnets were collected separately in five labeled boxes and the variable such as total length, weight, sex and maturity stage were measured on each specimen in the field. The commercial data was collected at the landing site of four selected site (Bahir Dar, Gorgora, Kunzla and Gumara). The commercial catch was recorded monthly from three landing site but samples were collected 3-4 days weekly from Bahir Dar site. *Labeobarbus* species were identified into

species level using keys developed by [4, 18].

2.3 Data Analysis

Chi-Square test was used to compare the spatial variations of species between areas, the temporal variations between seasons. SPSS version 16 and Microsoft Excel sheet 2007 was used to analyze and manage the data. Descriptive statistics was used to present the distribution of the data with respect to the minimum, maximum and mean values as well as the dispersion of the data through standard deviation. An index of relative importance (IRI) and Shannon diversity index (H`) were used to evaluate relative abundance and species diversity of fishes, respectively. IRI gives a better representation of the ecological importance of species rather than the weight, numbers or frequency of concurrence alone. IRI (%) was calculated as:

$$IRI = (\%Wi + \%Ni)\ \%Fi$$ [19].

Where %Wi and %Ni are percentage weight and number of each species of total catch respectively. %F is percentage frequency occurrence of each species in total number of setting.

The H` is a measure of the number of species weighted by their relative abundances. H' was calculated as:

$$H` = \sum Pi \times \ln Pi$$ [20]

Where

H` = the Shannon diversity index

Pi = fraction of entire population made up of the species i

S = number of species encountered

$\sum$ = sum from species 1 to species S

H' was used to indicate diversity at different sampling sites and/or rivers. A high value indicates high species diversity.

Species equitability

Species equitability or evenness Index (J) that refers to the degree of relative dominance of each species in the sampling station was calculated according to [21] as:

$$J = \frac{H'}{\ln S}$$

H'max (the maximum possible diversity of the site) was determined as follows: LN(S) [22].

3. Results

3.1 Fish composition and distribution

A total of 15 *Labeobarbus* species namely*; L. acutirostris L. brevicephalus, L. intermedius, L. macrophtalmus, L. platydorsus, L. truttiformis, L. tsanensis, L. nedgia L. dainellii, L. surkis, L. gorgorensis, L. crassibarbis, L. gorguari, L. megastoma* and *L. longissimus* were collected during the sampling period. *Labeobarbus intermedius, L. tsanensis, L. platydorsus, L.brevicephalus and L. megastoma* were dominant species in most of the sampling sites, but *L. gorguari, L. acutirostris* and *\L. longissimus* were not caught at the southern part of the lake (Bahir Dar site). *Labeobarbus intermedius, L. nedgia, L. tsanensis, L. platydorsus, L. megastoma and L. crassibarbis*, were found in all sampling sites in both dry and rainy seasons.

Table 1: Fish distribution among four sampling sites during both rainy and dry seasons (NB: present, +, absent, -)

		Species														
Site	**Season**	**Int**	**Ac**	**Brv**	**Cras**	**Tsa**	**Ply**	**Ned**	**Ma**	**Go**	**Gorg**	**Tu**	**Su**	**Me**	**Lo**	**Danil**
Bahir Dar	Rainy	+	-	+	+	+	+	+	+	+	-	-	-	+	-	+
	Dry	+	-	+	+	+	+	+	+	+	-	+	+	+	-	-
Gorgora	Rainy	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-
	Dry	+	-	+	+	+	+	+	-	+	-	-	+	+	+	-
Gumara	Rainy	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-
	Dry	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-
Kunzla	Rainy	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
	Dry	+	-	-	+	+	+	+	-	+	-	+	+	+	+	-

Note; Brv-, *L. brevicephalus,* Ac- *L. acutirostris,* Cras- *L. crassibarbis,* Danil- *L. dainellii,* Go- *L. gorgorensis,* Gorg- *L. gorguari,* Int- *L. intermedius,* Lo- *L.longissimus,* Ma- *L. macrophtalmus,* Mega- *L. megastoma,* Ned- *L. nedgia* Ply- *L. platydorsus,* Tsa- *L. tsanensis,* Tu- *L. truttiformis and* Su-*L.surkis*

Table 2: Catch composition of *Labeobarbus* species in dry and rainy season

Species	Dry	Rainy	Total	Percentage composition
L.*brevicephalus*	127	153	280	10.5 %
L. *acutirostris*	2	9	11	0.4%
L. *crassibarbis*	45	46	91	3.4%
L. *dainellii*	0	1	1	0.03%
L. *gorgorensis*	17	31	48	1.8%
L. *gorguari*	0	1	1	0.03%
L. *intermedius*	442	610	1032	38.8%
L. *longissimus*	6	6	12	0.5%
L.*macrophtalmus*	2	12	14	0.5%
L. *megastoma*	88	87	175	6.6%
L. *nedgia*	44	29	73	2.7%
L. *platydorsus*	178	170	348	13.1%
L. *tsanensis*	177	317	494	18.6%
L. *truttiformis*	12	43	55	2.1%
L. *surkis*	15	10	25	0.9%

3.1.1 Experimental catch

In this study, *L. intermedius* was the most abundant species, constituting 38.8 % of the total number of catch, followed by *L. tsanensis* (18.6%) *and L. platydorsus* (13.1%) (Table2). As shown from above table2 L. *gorguari and* L. *dainellii* were the two rarely occurred species which contained a catch composition of 0.03 and 0.03 (Table2) respectively from the total catch.

3.1.2 Commercial catch

The commercial catch was collected at the landing site of all sampling sites. Even if there was some difference in catch composition of each 15 *Labeobarbus* fish species individually, there was similar or proportional catch composition to the fish cached in our experimental gillnet. This indicates the species that was contain the highest percentage from total catch composition in commercial catch was the most commercially importance *Labeobarbus* fish in Lake Tana (these species is usually captured by the local fishermen and other fishing corporation in there fishing trips). So these species are relevant in food consumption and marketing value for the local fishermen and other fishing corporation at the whole part of the lake). Similar finding was observed in commercial catch composition of each of 15 *Labeobarbus* species with our experimental catch composition since, *L. intermedius* was the most abundant specie, contains 44.2 % of the total number of catch followed by *L. tsanensis, L. platydorsus, L. brevicephalus,* 18.35%, and 11.7% 11%. But L. *dainellii* and *L. gorguari* were the two reared species and these species were found in relative abundance of 0.04%, and 0.04% (Table 3).

Table 3: Commercial catch composition of fish species in dry and rainy season

Labeobarbus	**Dry**	**Rainy**	**Total**	**Catch composition**
L.brevicephalus	251	80	231	11%
L. acutirostris	9	1	10	0.3%
L. crassibarbis	41	40	81	2.7%
L. dainellii	0	1	1	0.04%
L. gorgorensis	22	13	35	1.2%
L. gorguari	0	1	1	0.04%
L. intermedius	978	351	1329	44.2%
L. longissimus	9	11	20	0.66%
L.macrophtalmus	19	2	21	0.7%
L. megastoma	71	46	117	3.9%
L. nedgia	42	20	62	2.1%
L. platydorsus	242	109	351	11.7%
L. tsanensis	412	140	552	18.35%
L. truttiformis	9	46	55	1.8%
L. surkis	24	16	40	1.4%

3.2 Relative Abundance of *Labeobarbus* fish species of Lake Tana

Table 4: Index of Relative Importance (IRI) of fishes at four sampling sites during rainy and dry season

Labeobarbus	**Site**	**Season**	**N**	**%N**	**W**	**%W**	**F**	**%F**	**IRI**	**%IRI**
L.*intermedius*	Bahir Dar	Rainy	41	23.4	4038	23.2	3	13	605.8	24.3
		DRY	161	38.6	13661500	26.9	3	15	987	37.1
	Gumara	Rainy	343	52.4	70839	36.8	3	8.3	740.36	45.8
		Dry	107	39.8	18772	33.6	3	12.5	917.5	42.4
	Gorgora	Rainy	104	30	12612	19.9	4	12.1	603.8	27.7
		Dry	83	33.88	13973	33.5	3	13.64	919.1	34.85
	Kunzla	Rainy	122	35	18300	23.2	4	11.8	686.8	33
		Dry	71	34.5	15112	23.2	3	13	754	33
L. *tsanensis*	Bahir Dar	Rainy	64	36.6	5828	33.5	3	13	911.3	36.5
		Dry	69	16.54	7649,9000	15.1	3	15	474.6	17.8
	Gumara	Rainy	119	18.2	34363	17.8	3	8.3	298.8	18.5
		Dry	31	11.5	6005	10.7	3	12.5	277.5	12.8
	Gorgora	Rainy	71	20.5	11957	18.8	4	12.1	475.5	21.8
		Dry	44	17.96	7314	17	3	13.64	476.9	18.08
	Kunzla	Rainy	122	35	18300	23.2	4	11.8	686.8	33.7
		Dry	33	16.2	7946	12.2	3	13	369.2	16.4
L.*platydorsus*	Bahir Dar	Rainy	20	11.4	1945	11.2	3	13	293.8	11.8
		DRY	51	12.2	10246,1000	20.2	3	15	486	18.3
	Gumara	Rainy	42	6.4	28311	14.7	3	8.3	175.1	10.8
		Dry	37	13.8	6998	12.5	2	8.3	218.3	10.1
	Gorgora	Rainy	61	17.6	11528	18.1	4	12.1	432	19.8
		Dry	62	25.3	10013	24	3	13.64	672.5	25.5
	Kunzla	Rainy	47	13.5	14839	18.8	4	11.8	381.1	18.7
		Dry	28	13.7	22870	35.1	3	13	634.4	28.1
L.megastoma	Bahir Dar	Rainy	9	5.1	1435	8.2	3	13	172.9	6.9
		DRY	24	5.8	9170,9000	18.1	2	10	239	9
	Gumara	Rainy	37	5.6	14645	7.6	3	8.3	109.6	6.8

		Dry	33	12.3	12638	22	2	8.3	284.7	13.1
	Gorgora	Rainy	32	9.2	13964	22	4	12.1	377.5	17.3
		Dry	22	8.98	5592	13.4	3	13.64	305.3	11.56
	Kunzla	Rainy	9	2.6	2215	2.8	3	8.8	47.5	2.3
		Dry	9	4.4	7946	2.8	2	8.7	62.4	2.8
L.*brevicephalus*	Bahir Dar	Rainy	24	13.7	2468	14.2	3	13	362.7	14.5
		DRY	67	16	398,7600	7.9	3	15	358.5	13.5
	Gumara	Rainy	39	6	2447	2.2	3	8.3	68.1	4.2
		Dry	19	7.1	1259	2.3	3	12.5	117.5	5.4
	Gorgora	Rainy	35	10.1	2262	3.6	2	6.1	83.6	3.8
		Dry	14	5.7	1522	3.6	2	9.1	84.6	3.21
	Kunzla	Rainy	55	15.8	2885	3.7	3	8.8	171.6	8.4
		Dry	27	13.3	1575	2.4	2	8.7	136.6	6.1
L. *nedgia*	Bahir Dar	Rainy	5	2.9	475	2.7	2	8.7	48.7	2
		DRY	22	5.3	31900,000	6.3	1	5	58	2.2
	Gumara	Rainy	7	3.4	1730	2.7	1	4.3	26.2	1.2
		Dry	4	1.5	508	0.9	1	4.2	10.1	0.47
	Gorgora	Rainy	4	1.2	720	1.1	1	3.1	5.4	0.2
		Dry	11	4.49	1478	3.5	3	13.64	109	4.13
	Kunzla	Rainy	13	3.7	7660	9.7	3	8.8	117.9	5.8
		Dry	7	3.4	1730	2.7	1	4.3	26.2	1.2
L. *macrophtalmus*	Bahir Dar	Rainy	1	0.57	335	1.9	1	4.3	10.6	0.4
		DRY	1	0.2	525,000	1	1	5	6	0.23
	Gumara	Rainy	3	0.5	1085	0.6	1	2.8	3.1	0.2
		Dry	1	0.4	645	1.2	1	4.2	5.8	0.27
	Gorgora	Rainy	2	0.6	290	0.5	2	6.1	6.7	0.3
		Dry	-	-	-	-	-	-	-	-
	Kunzla	Rainy	6	1.7	1937	2.5	2	5.9	24.8	1.2
		Dry	-	-	-	-	-	-	-	-
L. *longissimus*	Bahir Dar	Rainy	-	-	-	-	-	-	-	-
		DRY	-	-	-	-		-	-	-
	Gumara	Rainy	2	0.3	1210	0.6	2	5.6	14.6	0.9
		Dry	2	0.7	87	0.2	1	4.2	3.8	0.18
	Gorgora	Rainy	1	0.3	180	0.3	1	3.1	1.9	0.1
		Dry	-	-	-	-	-	-	-	-
	Kunzla	Rainy	3	0.9	895	1.1	2	5.9	11.8	0.6
		Dry	3	1.5	2180	3.3	1	4.3	20.6	1
L. *gorgorensis*	Bahir Dar	Rainy	6	3.4	455	2.6	2	8.7	52.2	2.1
		DRY	7	1.7	741,9000	1.5	1	5	16	0.6
	Gumara	Rainy	16	2.4	5315	2.8	3	8.3	43.2	2.7
		Dry	-	-	-	-		-	-	-
	Gorgora	Rainy	4	1.2	2245	3.5	2	6.1	28.7	1.3
		Dry	1	0.4	160	0.4	1	4.55	5.4	0.2
	Kunzla	Rainy	5	1.4	670	0.8	2	5.9	13	0.6
		Dry	2	1	441	0.7	1	4.3	7.3	0.3
L. *gorguari*	Bahir Dar	Rainy	-	-	-	-		-	-	-
		DRY	-	-	-	-		-	-	-
	Gumara	Rainy	-	-	-	-		-	-	-
		Dry	-	-	-	-		-	-	-
	Gorgora	Rainy	-	-	-	-		-	-	-
		Dry	-	-	-	-		-	-	-
	Kunzla	Rainy	1	0.3	980	1.2	1	2.9	4.4	0.2
		Dry	-	-	-	-		-	-	-
L. *truttiformis*	Bahir Dar	Rainy	-	-	-	-		-	-	-
		DRY	6	1.4	459,4000	0.9	1	5	11.5	0.4
	Gumara	Rainy	1	0.2	160	0.1	1	2.8	0.84	0.1
		Dry	3	1.1	256	0.5	2	8.3	13.3	0.6
	Gorgora	Rainy	3	0.9	410	0.6	2	6.1	9.15	0.4
		Dry	2	0.8	332	0.8	1	4.55	7.3	0.28
	Kunzla	Rainy	6	1.7	360	0.5	2	5.9	13	0.64
		Dry	4	2	297	0.5	1	4.3	10.8	0.5
L. *surkis*	Bahir Dar	Rainy	-	-	-	-		-	-	-
		DRY	2	0.5	625,000	1.2	1	5	8.5	0.3
	Gumara	Rainy	31	4.7	16970	8.8	3	8.3	112.1	6.9
		Dry	1	0.4	188	0.3	1	4.2	3	0.14
	Gorgora	Rainy	5	1.4	2865	4.5	2	6.1	36	1.7
		Dry	-	-	-	-	-	-	-	-
	Kunzla	Rainy	7	2	6448	8.2	2	5.9	60.2	3

		Dry	9	4.4	2667	4.1	2	8.7	74	3.3
L. *acutirostris*	Bahir Dar	Rainy	-	-	-	-		-	-	-
		DRY	-	-	-	-		-	-	-
	Gumara	Rainy	7	1.1	1765	0.9	1	2.8	5.6	0.4
		Dry	-	-	-	-		-	-	-
	Gorgora	Rainy	2	0.6	380	0.6	1	3.1	3.7	0.2
		Dry	-	-	-	-	-	-	-	-
	Kunzla	Rainy	-	-	-	-	-	-	-	-
		Dry	2	1	2470	3.8	2	8.7	41.8	1.9
L. *crassibarbis*	Bahir Dar	Rainy	4	2.3	275	1.6	2	8.7	33.9	1.4
		DRY	7	1.7	445,5000	0.9	1	5	13	0.5
	Gumara	Rainy	8	1.2	9971	5.2	1	2.8	18	1.1
		Dry	24	8.9	7030	12.6	3	12.5	268.8	12.4
	Gorgora	Rainy	22	6.3	3775	5.9	3	9.1	111	5.1
		Dry	5	2.04	995	2.38	3	13.64	60.3	2.29
	Kunzla	Rainy	12	3.4	7670	9.7	2	5.9	77.3	3.8
		Dry	9	4.4	5966	9.2	2	8.7	118.3	5.2
L. *dainellii*	Bahir Dar	Rainy	1	0.57	155	0.6	1	4.3	5	0.2
		DRY	-	-	-	-	-	-	-	-

(NB: %Wi and %Ni = percentages in weight and number of each species of total catch. %Fi = percentage frequency occurrence of each species in total number of settings. %Wj and Nj = percentages in weight and number of total species in total catch. Fj = percentage frequency of occurrence of total species in total number of settings

3.3 Spatio-temporal distribution of Lake Tana *Labeobarbus* species

Labeobarbus fish species of Lake Tana were area dependant, since these species showed significant variation in catches at four sampling site (P< 0.01) (Table5). Abiotic factors are the controlling factors for aquatic life, since they shape most of the biological functions of aquatic life [23].

Table 5: Distribution of *Labeobarbus* species at four sampling site Chi-Square Tests

	Species													
Site	***L.int***	***L.acu***	***L. bre***	***L.cra***	***L.tsa***	***L.pla***	***L.ned***	***L.mac***	***L.gor***	***L.meg***	***L.tur***	***L.lon***	***L.dan***	***L.goru***
Bahir Dar	202^a	0^a	91^b	11^a	133^b	71^a	27^a	2^a	13^a	32^a	2^a	0^a	1^a	0^a
Gorgora	187^a	2^a	49^a	27^a	115^b	123^b	15^a	2^a	5^a	54^b	5^a	2^a	0^a	0^a
Gumara	450^b	7^a	58^a	32^a	150^b	79^a	11^a	4^a	23^b	70^b	32^b	4^a	0^a	0^a
Kunzla	193^a	2^a	82^b	21^a	96^a	75^a	20^a	6^a	7^a	18^a	16^a	6^a	0^a	1^a

Note; L.bre-, *L. brevicephalus,* L.acu- *L. acutirostris*, L.cra- *L. crassibarbis,* L.dan- *L. dainellii,* L.gor- *L. gorgorensis,* L.*goru- L. gorgorensis,* L.int- *L. intermedius,* L.lon- *L.longissimus,* L.mac- *L. macrophtalmus,* L.mega- *L. megastoma,* L.ned- *L. nedgia* L.pla- *L. platydorsus,* L.tsa- *L. tsanensis,* L.tur- *L. truttiformis and* L.sur-*L.surkis.*

The % value of *Labeobarbus* in four sampling site gives different subscript letters was significantly different.

All *Labeobarbus* which collected in the experimental gillnet and the commercial catch showed significant variation in number of catches between dry and rainy seasons (P<0.01) (Tables 6 and Table7). There might be several reasons for variation in abundance between rainy and dry seasons. Variation in available nutrients and habitats, temperature, fishing effort, fish behavior, size and life history stages of fishes and others might have contributed to the variation in abundance of the catches.

Table 6: Distribution of *Labeobarbus* fish species in dry and rainy season Chi-Square Tests

	Species													
Season	***L.int***	***L.acu***	***L. bre***	***L.cra***	***L.tsa***	***L.pla***	***L.ned***	***L.mac***	***L.gor***	***L.meg***	***L.tur***	***L.lon***	***L.dan***	***L.goru***
Dry	442^a	2^a	127^a	45^a	177^a	178^a	44^b	2^a	17^a	88^a	12^a	6^a	0^a	0^a
Rainy	610^b	9^a	153^b	46^a	317^b	170^a	29^a	12^a	31^b	87^a	43^b	6^a	1^a	1^a

Note; L.bre-, *L. brevicephalus,* L.acu- *L. acutirostris*, L.cra- *L. crassibarbis,* L.dan- *L. dainellii,* L.gor- *L. gorgorensis,* L.goru- *L. gorgorensis,* L.int- *L. intermedius,* L.lon- *L.longissimus,* L.mac- *L. macrophtalmus,* L.mega- *L. megastoma,* L.ned- *L. nedgia* L.pla- *L. platydorsus,* L.tsa- *L. tsanensis,* L.tur- *L. truttiformis and* L.sur-*L.surkis.*

Labeobarbus Species %value in dry and rainy season gives different subscript latter were significantly different.

Labeobarbus macrophtalmus, L. longissimus, L. platydorsus, L. crassibarbis, L. acutirostris, L. megastoma, L. gorguari and L. *dainellii* were not seasonally dependant but *L. intermedius, L. tsanensis, L. brevicephalus, L. nedgia, L. gorgorensis; L. truttiformis* were significantly more abundant in rainy season than dry season

Table 7: Distribution of *Labeobarbus* species in dry and rainy season Chi-Square Tests in commercial catch

	Species													
Season	***L.int***	***L.acu***	***L. bre***	***L.cra***	***L.tsa***	***L.pla***	***L.ned***	***L.mac***	***L.gor***	***L.meg***	***L.tur***	***L.lon***	***L.dan***	***L.goru***
Dry	351^a	1^a	80^a	40^a	412^a	109^a	20^a	2^a	13^a	56^a	12^a	9^a	0^a	0^a
Rainy	978^c	9^b	251^b	41^a	440^b	224^b	42^b	19^b	22^a	71^b	43^b	46^b	1^a	1^a

Note; L.bre-, *L. brevicephalus,* L.acu- *L. acutirostris*, L.cra- *L. crassibarbis,* L.dan- *L. dainellii,* L.gor- *L. gorgorensis,* L.goru- *L. gorgorensis,* L.int- *L. intermedius,* L.lon- *L.longissimus,* L.mac- *L. macrophtalmus,* L.mega- *L. megastoma,* L.ned- *L. nedgia* L.pla- *L. platydorsus,* L.tsa- *L. tsanensis,* L.tur- *L. truttiformis and* L.sur-*L.surkis.*

The *Labeobarbus* species %value in rainy and dry season gives different subscript letter were significantly different. *Labeobarbus crassibarbis, L. gorguari, L. dainellii, L. surkis* and *L. gorgorensis* species *distribution* were not season dependant, but *Labeobarbus acutirostris, L.brevicephalus, L. tsanensis, L. platydorsus, L. nedgia, L.macrophtalmus, L. megastoma, and L. truttiformis* were significantly more abundant in rainy season than dry and also *L. intermedius* was significantly more abundant in rainy season than dry season.

3.4 Species Diversity

The maximum possible diversity of four sampling sites shown in (Table 8) the highest *J`* value was obtained at Gumara site with the value of 0.5. This number is closer to 1 as compared from other site '*J'* value, since it means that the observed diversity (1.53, 1.87) in rainy and dry season, respectively is approach to the possible maximum diversity at this site.

It is interesting to note that these sites are closest to the River mouth. It is reasonable, thus, to see higher diversity at sites which are close to the origin of "dispersal", although the diversity may be dependent on the intensity of sampling, the type of gears used in sampling and the period of sampling. The total number of fish species at this site was 924 followed by Bahir Dar 592.

Table 8: Shannon diversity index (H`), number of fish species N` and Evenness index J`

Season	H`/N, *J`*	Sampling sites			
		Bahir Dar	Gumara	Kunzla	Gorgora
Dry	H`	1.45	1.53	1.42	1.38
	N	11	13	10	10
Rainy	H`	1.48	1.87	1.57	1.65
	N	10	14	14	14
	J` value	0.45896	0.49795	0.468358	0.47943

4. Dissections

The highest number of catch in all *Labeobarbus* fish species of Lake Tana was collected at the river mouth in this study. Cyprinids are riverine in their origin and have adapted to live in lakes or lacustrine environments. Different studies conducted in other tributaries of Lake Tana also revealed temporal segregation in *Labeobarbus* species [24, 25, 26]. Reported the aggregation of *Labeobarbus* species at different times during the spawning season in Gumara, Gelgel Abay, Gelda, Ribb, and Megech. As we try to describe from the above *L. intermedius* was the most dominant *Labeobarbus* fish species in Lake Tana at all sampling site in this study.

There are two reasons that help to decided why *L. intermedius* species was the dominant rather than other. The first one is all *Labeobarbus* species which was difficult to identify during the study was included under in this species and secondly this species was the common ancestor all *Labeobarbus* fish species of Lake Tana. Due to this reason this specie was dominants the whole part of Lake Tana. In agreement to this, *L. intermedius* was the dominant species in Arno-Garno River [26] also reported a similar result from Megech and Dirma Rivers. In agreement with [25] in Gelda, Gelgel Abay, Gumara and Rib rivers. But in the present study, the two *Labeobarbus* species *L. gorguari* and *L. dainellii* were reared species in Lake Tana; since these species contains a negligible percentage (0.04%) catch composition) at the whole part of the lake than other. These species may spawn in the lake (lacustrine spawners) or they may be migrate to smaller temporary tributaries.

From previous studies on spawning migration of *Labeobarbus* species of Lake Tana, seven species (*L. dainellii, L. nedgia, L. surkis, L. gorgorensis, L. gorguari, L. crassibarbis,* and *L. longissimus*) were reported as missing species from both river mouths and upstream areas of Gumara, Gelda, Ribb, Megech and Dirma Rivers [24, 27, 28]. Therefore, the missing *Labeobarbus* species in this study (*L. gorguari, L. dainellii)* might 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 [29]. Only one *L. gorguari* and one *L. dainellii* were caught in the present study. This indicates the number of unique Lake Tana *Labeobarbus* species reduce, so this has a great impact on the Lake Tana fish biodi ersity. From previous studies on spawning migration of *Labeobarbus* species of Lake Tana, seven species (*L. dainellii, L. nedgia, L. surkis, L. gorgorensis, L. gorguari, L. crassibarbis,* and *L. longissimus*) were reported as missing species from both river mouths and upstream areas of Gumara, Gelda, Ribb, Megech and Dirma Rivers [24, 25, 26, 27].

The %IRI value of *L. intermedius* was higher in dry season than rainy season at Gorgora and Bahir Dar but it was higher in rainy season at Gumara and Kunzla. This variation in this sampling site was due to the presence of Abay and Gumara River and during rainy season this species migrate to at the mouth part of the river for spawning. *Labeobarbus intermedius* and *L. tsanensis* were the first species to aggregate at the river mouth starting from July and reached their peak in the third week of September. *Labeobarbus brevicephalus* started to aggregate at the river mouth in the third week of August and reached its peak in the third week of September [30]. *Labeobarbus nedgia* was the last species to aggregate starting from the first week of September and reached its peak in the first week of October. All *Labeobarbus* species showed a declining pattern in catch from October to December [30].

Labeobarbus species of Lake Tana have certain requirements in choosing their spawning places in rainy season. Fast flowing, clear, highly oxygenated water, and gravel-bed streams or rivers are preferred places for *Labeobarbus.* Spawning migrations of Lake Tana's *Labeobarbus* were focused on Gumara river since this species were temporally distributed to spawn at this sites. Deposition of eggs in the gravel or pebble beds protects the juvenile from being washed away by riffle, so the highest catch composition of most *Labeobarbus* species of Lake Tana was obtained at this site. A similar observation was made by [26] in Megech mouth, but migrate to the upstream areas. *Labeobarbus acutirostris, L. macrophtalmus, L. megastoma, L. tsanensis and L. truttiformis* were riverine spawners in Gumara River and its tributaries [24, 25]. The main reason for the variation in abundance and composition of *Labeobarbus* species of Lake Tana in rainy and dry season were due to spawning and migratory behavior at the mouth of its tributary river of the Lake. Moreover, water level [19] and turbidity of water may also affect abundance. The aggregation patterns of the *Labeobarbus* species at the river mouth varied during the spawning months.

The main reason for this variation was the aggregation patterns of the *Labeobarbus* species at the river mouth, since the presence of Gumara River all *Labeobarbus* fish species of Lake Tana migrates to this site. Due to the presence of Abay River at Kunzla site contains the highest value of *J (*0.5)

(Table8) next to Gumara site. Most of these species still migrate to the mouth of the river to spawn in tributary rivers which indicate that they are not still fully adapted to the lake environment. *Labeobarbus crassibarbis* and *L. longissimus* were no significant variation ($P > 0.05$) in H' and N among all the sampling sites in both seasons. The number of fish species was 1135 in dry season and 1526 in rainy seasons respectively. Shannon diversity index (H') value was generally higher in rainy season than dry season at all the sampling sites. Different studies conducted in some tributary rivers of Lake Tana such as Gelgel Abay, Gelda and Gumara Rivers [24, 25, 27] and Ribb, Dirma and Megech Rivers [26, 31] showed the upstream spawning migration of some lacustrine *Labeobarbus* species.

At all sampling sites the number of fishes was high during rainy season than dry season. The reason for such variations could be probably due to in rainy season all of the *Labeobarbus* species migrates the mouth of Tributary River of the lake and the shoreline area of the lake. The aggregation patterns of the *Labeobarbus* species at the river mouth varied during the dry and rainy season. Even if during rainy season, there was higher water discharge; fishes could have highly dispersed in the large volume of water in this season as compared to the dry season and it became difficult to catch like Tilapia species, the *Labeobarbus* species didn't have such type of problem. Even though considerable proportions of *Labeobarbus* species were found in breeding condition, their proportion was much lower than the main breeding seasons.

Even if the variation gillnet efficiency and time of setting of gillnet Wood logs, leaves, roots and grasses which were brought by flooding, could have decreased the efficiency of gillnets during the rainy season, the *Labeobarbus* species can easily caught by entangled or directly interring in the gillnet when they migrate to spawn. During the study period (213.5kg) and (352.74kg) total biomass of specimens were collected during dry and rainy seasons, respectively. Rainy season showed higher values than dry season in terms of weight (kg) and number of specimens of fishes.

5. Conclusions

All of the 15 *Labeobarbus* fish species of Lake Tana were collected and their distribution were different during the dry and rainy season. Even if all of the 15 *Labeobarbus* fish species of Lake Tana were collected their distribution both in our experimental gillnet and from the commercial catch were different. The main reason for the variation in abundance and composition of *Labeobarbus* species of Lake Tana in rainy and dry season were due to spawning and migratory behavior at the mouth of its tributary river of the Lake. The most surprising finding in this study was only 1specimen of *L. dainellii* and 1 specimen of *L. gorguari* were caught at all sampling sites, since this indicates the number of unique 15 *Labeobarbus* fish species of lake Tana has been reduced. So *L. gorguari* and *L. dainellii* were the two reared *Labeobarbus* species in Lake Tana that contain a negligible percentage in the present study and *L. intermedius* were the most dominant species that contain highest percentage at the whole part of the Lake. *Labeobarbus intermedius, L. tsanensis* was the two most commercially importance *Labeobarbus* fish in Lake Tana. Shannon diversity index (H') value was generally higher in rainy season than dry season at all sampling sites.

6. Recommendations

- There is some change in regional fisheries regulation and proclamation at spawning migration seasons and grounds especially around Bahir Dar and Kunzla but there are some fishermen who didn't stop fishing during spawning migration seasons at Nabega site, therefore, the government should take some measurement at this side.
- Other study on the two reared species should be done why these species decline in this Ethiopian largest lake and the solution that regenerate these species to its original position should be determined.
- The community, governmental and non-governmental organizations, policy makers and fishers should be aware the reproductive strategy of the migratory fishes and human impacts for sustainable utilization of the resources.
- Lake Tana *Labeobarbus* species need to be conserved and protected so the government should be continue the starting fishery management measure like, close area, close season measure but it should be included other management measures like; gear restriction, gear selection and other management measure that needed for fishery management.
- The juvenile of the rarely cached *Labeobarbus* fish species like *gorguari* and *L. dainellii* should release to the lake in order to conserve the endemism of Lake Tana fishery resource.
- Only effort control regulations, limiting the gillnet fishery in spawning seasons and/or areas, will be appropriate to prevent the *Labeobarbus* fish species of lake Tana from undergoing the same fate as the cyprinids in other African lakes.
- There are some fishermen who use mesh size of 4 and 6 cm and 8 cm monofilament at all part of the lake so these fishermen and other fishing corporation should be restricted from using a gillnet of 4, 6 and 8 cm mesh size.

7. Acknowledgements

I would like to thank major advisor Dr Wassie Anteneh, Co – advisor Mr. Shewit Gebremedhin (Assistant Professor) and, 3rd Co –advisor: Dr Gebeyehu G/Michaiel, all Bahir Dar University Fisheries Wetlands and Wildlife management staff members, Biniam Hailu and finally my family. The Exploratory Fishery Sampling Program was funded by International Foundation for Science (IFS) and Critical Ecosystem Partnership Fund (CEPF).

8. References

1. Abebe Getahun. Systematic studies of the African species of the genus *Garra* (Pisces Cyprinidae). Ph.D. Thesis, City University of New York, 2000.
2. Eshete Dejen, Osse JWM, Sibbing FA. Ecological position of 'small barbs' and their potential for fisheries: An option to reduce fishing pressure on 'large barbs' of Lake Tana (Ethiopia)? Aquatic Ecosystem Health and Management. 2003; 6:337-342.
3. Akewake Geremew. Taxonomic revision, relative abundance, and aspects of the Biology of some species of the genus Garra, Hamilton 1922 (Pisces: Cyprinid) in Lake Tana, Ethiopia. MSc. Thesis, Addis Ababa University, Ethiopia, 2007.
4. Nagelkerke LAJ. The barbs of Lake Tana, Ethiopia: morphological diversity and its implications for

taxonomy, trophic resource partitioning and fisheries. PhD thesis, Agricultural University Wageningen, The Netherlands, 1997.
5. Kornfield I, Carpenter KE. Cyprinids of Lake Lanao, Philippines: taxonomic validity, evolutionary rates and speciation scenarios. In: *Evolution of Fish Species Flocks*, pp. 69–83, (Echelle, A.A. and Kornfield, I., eds), Orono Press, Maine, 1984.
6. Nagelkerke LAJ, Sibbing FA. The large barbs (*Barbus* spp., Cyprinidae, Teleostei) of Lake Tana (Ethiopia), with a description of a new species, Barbus osseeinsis. Netherlands Journal of Zoology. 2000; 50:179-214.
7. De Graaf M, Machiels MAM. Tesfaye Wudneh and Sibbing, F.A, 2003. Length at maturity and gillnet selectivity of Lake Tana's *Barbus* species (Ethiopia): Implications for management and conservation. Aquatic Ecosyst. Health, 2000; 6(3):325-336.
8. Armstrong DW, Ferro RST, MacLennan DN, Reeves SA. Gear selectivity and the conservation of fish. J. Fish. Biol. 1990; 37(suppl. A):261-262.
9. Eshete Dejen J, Nagelkerke LAJ, Sibbing Vijverberg FA. Temporal and spatial distribution of micro crustacean zooplankton in relation to turbidity and other environmental factors in large tropical lake (Lake Tana, Ethiopia). Hydrobiologia, 2004; 5(13):39-49.
10. De Graff M, Marcel AM, Machiels M, Tesfaye Wudneh, Sibbing FA. Declining stocks of Lake Tana's endemic *Barbus* species flock (Pisces: Cyprinidae): natural Variation or human impact? Biol. Cons. 2004; 1(16):277-287.
11. Mohr PA. The geology of Ethiopia. University College of Addis Ababa Press, Addis Ababa, Ethiopia, 1962.
12. Abebe Getahun, Eshete Dejene. *Fishes of Lake Tana, a Guide Book*, Addis Ababa University Press, Ethiopia, 2012.
13. Tesfaye Wudneh T. Biology and management of fish stocks in Bahir Dar Gulf, Lake Tana Ethiopia. PhD. Thesis, Wageningen, 1998.
14. Ayalew Wondie, Eshete Dejen, Minwyelet Mengistu S, Vijverberg E. Seasonal variation in primary production of a large high altitude tropical lake (Lake Tana, Ethiopia): effects of nutrient availability and water transparency. Aquatic Ecol. 2007; 41:195-207.
15. Gordon MS, Tadesse. Marketing systems for fish from Lake Tana, Ethiopia: opportunities for improved marketing and livelihoods, 2007.
16. Eshete Dejen E, Sibbing FA. Vulnerability to a small-scale commercial fishery of Lake Tana's (Ethiopia) endemic *Labeobarbus* compared with African catfish and Nile tilapia: An example of recruitment overfishing? Fisheries Research, 2006; 82:304-318.
17. Teshale Aragaw B, Lee R, Zawdie G. *Development initiatives and challenges for sustainable resource management and livelihood in the Lake Tana region of Northern Ethiopia*. Proceedings of the wetland awareness creation and activity identification workshop in *the* Amhara National Regional State. 23rd January, Bahir Dar, Amhara National Regional State, Wetlan Action/EWNRA, 2001, pp. 33-45.
18. Snoeks J. The non-cichlid fishes of the Lake Malawi system In: the cichlid diversity of the Lake Malawi: identification, distribution, and taxonomy, Snoeks, J. (Ed), Cichlid Press, El Paso, Texas, 2004, pp. 20-26.
19. Berie Z. Diversity, relative abundance and Biology of fishes in Beles and Gilgel Beles Rivers of Abay basin. MSc. Thesis, Addis Ababa University, 2007, pp: 112.
20. Joint Ethio-Russian Biological Expedition. Fish diversity in the main drainage systems of Ethiopia. Addis Ababa, Ethiopia, 2007.
21. Pielou. *The Relative Importance of Natural Disturbances and Local Site Factors on Woody Vegetation Regeneration Diversity across a Large, Contiguous Forest Region*, 1966.
22. Golubtsov AS, Dgebuadze Yu, Mina MV. Fishes of the Ethiopian Rift Valley, pp: 167-258. In: C. Tudorancea and W.D. Taylor (eds.) Ethiopia Rift valley Lakes. Biology of Inland waters Series, pp: 167-258. Backhuys publisher, Leiden, Holland, 2002.
23. Murdoch T, Martha C. *The Stream Keeper's Field Guide: Watershed Inventory and Stream Monitoring Methods. A Product of the Adopt-A-stream Foundation*. Everett, WA, 1999, 296 pp.
24. Palstra AP, De Graaf M, Sibbing FA. Riverine spawning in a lacustrine yprini species flock, facilitated by homing? Animal Biology, 2004; 54:393-415.
25. De Graff M, Nentwich D, Osse JWM, Sibbing FA. Lacustrine spawning: is this a new reproductive strategy among "large" African Cyprinid fishes? J. Fish Biol. 2005; 66:1214-1236.
26. Wassie Anteneh. The spawning migration of *Labeobarbus* (*Cyprinidae*: Teleostei) of Lake Tana to Dirma and Megech Rivers, Ethiopia, 2008.
27. Nagelkerke LAJ, Sibbing FA. Reproductive segregation among the large barbs (Barbus intermedius complex) of Lake Tana, Ethiopia. An example of intra lacustrine Speciation Fish Biol, 1996; 49:1244-1266.
28. Dgebuadze YY. Lake Tana large barbs: phenetics, growth and diversification. J. Fish. Biol. 1996; 48:383-404.
29. Sewmehon Demissie. Socio-economic study on Lake Tana fishery it contribute to the Livelihood of the surrounding people. MSc thesis for international management. Collage of Fisheries science, Universities (Tromso) Norway, 2003.
30. Mills CA. Reproduction and life history. In: *Cyprinid Fishes, Systematics, Biology and Exploitation,* pp. 483–529, (Winfield, I.J. and Nelson, J.S., eds), Chapman and Hall, London, 1991.
31. Shewit Gebremedhin, Minwyelet Mingist, Abebe Getahun, Wassie Anteneh. Spawning migration of Labeobarbus species of Lake Tana to Arno-Garno River, Lake Tana sub-basin, Ethiopia. SINET: Ethiopina Journal of Science. 2012; 35:95-106.
32. Abebe Getahun. Freshwater eco-regions of Ethiopia. In: Theime *et al.* (Ed.) Freshwater eco Region of Africa: A conservation assessment. Island press, Washington D.C., USA, 2005a.