

## Diversity, Length-Weight Relationship and Condition Factor of Fishes in Gilo River and its Nearby Wetlands in Akobo District, Gambella Region, Ethiopia

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Received: 25.10.2019 / Accepted: 27.03.2019 / Published online: 03.03.2019

### Abstract:

Ethiopia has a rich diversity of ichthyofauna in its lakes, rivers and reservoirs. This study was conducted to identify fish species composition, estimate relative abundance, and assess length–weight relationship and condition factor for the dominant fish species in Gilo River and its nearby wetlands in Akobo district, Gambella Region, Ethiopia. Baro River in Gambella region is documented as the most diverse in fish species. Besides this, its nearby wetlands, tributaries and lakes which are expected to have rich fish species are least explored for their fish diversity. Samples were collected from selected sites using gill nets of various mesh sizes and hooks and lines. Fish sampling was done twice in dry season (December, 2016 and March, 2017) and twice in wet season (May and June, 2017). A total of 911 specimens were collected. These were identified into 27 species, 21 genera, 17 families and five orders. The Shannon diversity index (2.28) of fish species was higher in river than in wetlands (1.85); the same is true for the index of evenness for river (0.69) was also higher than the wetlands (0.67). The length-weight relationship of most of the species evaluated demonstrated positive allometric growth. Seasonal variations in the mean FCF of the most dominant species were statistically insignificant ( $p>0.05$ ) except for *Clarias gariepinus* and *Citharinus citharus*. All the species identified in this study are new report to Gilo River and its nearby wetlands representing a baseline data for the study area. Anthropogenic activities i.e. fishing, farming, construction and other domestic activities were observed in the study sites. Plausible management options have to be encouraged to ensure sustainable utilization of the fisheries resources of the study area.

**Keywords:** Condition factor; Fish diversity; Gilo River; Length-weight relationship; Wetlands

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## Introduction

### Background and justification

In older usage, the term “fish” traditionally denotes a mixed assortment of water-dwelling animals ranging from invertebrates to vertebrates (Cleveland et al., 2008). Today, fish is recognized as an aquatic vertebrate with gills, appendages in the form of fins, and usually a skin with scales of dermal origin (ibid). Because fishes live in habitats that are less accessible to humans, people have rarely appreciated its remarkable diversity. Nevertheless, whether appreciated or not, the world’s fishes have enjoyed an effusive proliferation that has produced an estimated 32, 600 living fish species, in 536 families and 85 orders, more than all other species of vertebrates combined (Nelson et al., 2016).

The territory of Ethiopia embrace parts of the two oceans separated by the northern Great African Rift. Two major biogeography units, the Nilo-Sudan and the East coast ichthyofaunal provinces are in contact to this region (Golubtsov et al., 2002). However, a recent analysis by Paugy (2010) has modified the boundaries and numbers of ichthyofaunal provinces occurring within the Ethiopian territory as Nilo-Sudanic, East Coast, Ethiopian Rift Valley, Coastal Red Sea (CRS) and Lake Tanan hotspot provinces.

Ethiopia, with its different geological formations and climatic conditions, is endowed with considerable water resources and wetland ecosystems, including river basins, major lakes, many swamps, floodplains and man-made reservoirs (Tadlo Awoke, 2015). Though Ethiopia is endowed with large bodies of inland waters which are supposed to contain a rich diversity of ichthyofauna, they are poorly known. Most of the studies done on the Ethiopian water bodies were concentrated on large lakes and rivers. The medium to small sized water bodies of the country remain less explored. Therefore, the importance of fish exploration of Ethiopian water bodies on one hand and the absence of adequate

study on fish diversity, distribution and abundance on the other hand, justifies this study on Gilo River and its nearby wetlands.

## Materials and Methods

### Description of the study area

The study was conducted in Gilo River and its nearby wetlands located in the lowland of Gambella floodplain, Akobo Wereda, Gambella Regional State. The region is estimated to have an area of approximately 34,063 km<sup>2</sup> of which, more than 7.3 % is wetland (Abegaz et al., 2010). The region is mainly plain and has altitude ranging from 300-2300m a. s. l. The annual rainfall of the areas ranges from 900 – 2100 mm, which depends on altitude. The mean monthly temperature ranges from 27°C– 33°C with maximum up to 45°C in mid March and minimum 10.3°C in December (Gambella meteorological center).

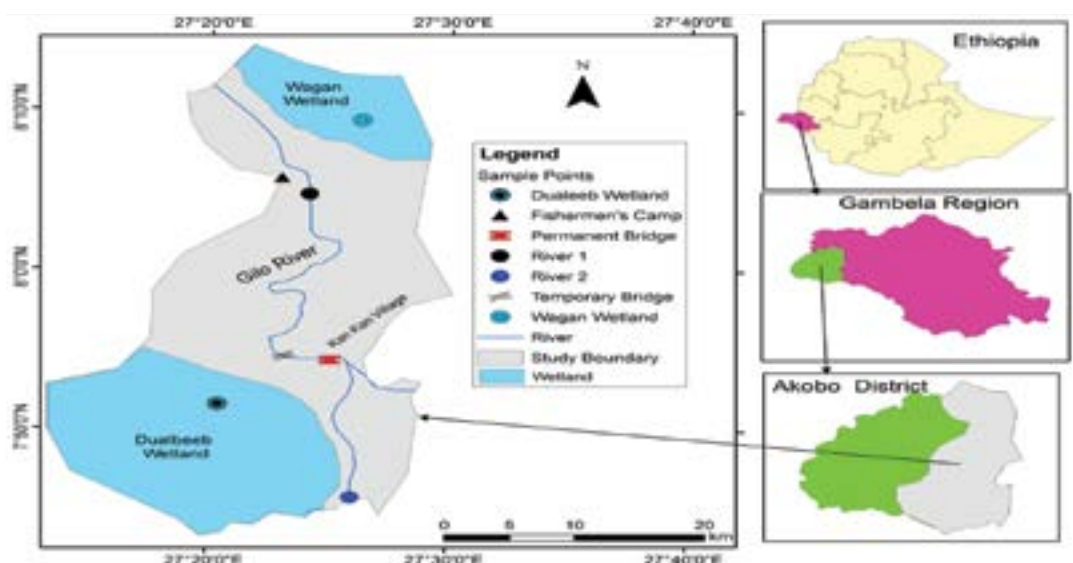
Gilo River flows to west and join the Pibor River on Ethio-South Sudan border. The combined waters then join the Sobat River. Gilo River has a width of 37 m and a depth of about 4 m. The two wetlands; apparently, Dualbeeb and Wagan (two wetlands covered under the present study) are located at the either sides of Gilo River. Wagan wetland has an area of 3.5 km<sup>2</sup> and a maximum depth of 3 m and Dualbeeb covers an area of 2 km<sup>2</sup> and has a maximum depth of 4 m.

### Sampling sites

A reconnaissance survey was conducted and two sampling sites (**Figure 1**) on the main Gilo River (R1 and R2) and one sampling site on each of the two surveyed wetlands (Dualbeeb and Wagan) were fixed using GPS.

### Fish sampling and identification

Fish samples were collected from each site using gill nets of various stretched mesh sizes (12, 16, 20, 24 and 28 cm). Multiple hooks and lines were used where gill net setting was not suitable.



**Figure 1:** A Map of the study area and sampling sites.

The gillnets were set late in afternoon at 17:00 local time and remained overnight in the water until 6:00 morning the next day (Melaku, 2013; Tadesse, 2016). Hooks and line were used at any time of the day. The samples were collected twice in each season of the study period, December and March in dry season and May and June in wet season.

Field level identification was done using relevant taxonomic keys (e.g. Golubtsov et al., 1995; Paugy, 2003; Habtesilassie, 2012). Following the identification Total Length (TL) and Total Weight (TW) of fish species were measured to the nearest 0.1 cm and 0.1 g, respectively. Ultimately, the samples were labeled with all necessary information and preserved in plastic jars containing 10% formalin solution. The specimens were transported to Zoological Sciences Laboratory, Department of Biology, Jimma University, for verification.

### Habitat characteristics

Basic and important habitat characteristics such as river channel width and depth, composition and extent of bank and aquatic vegetation, substrate type (muddy, silt, sand, gravel, pebble, cobble, etc), habitat type (pool/rifle) for the river, type of anthropogenic activities at the sampling sites were recorded by using a standard protocol adopted from Jon et al. (2009). The physico-chemical parameters were measured directly in all sampling sites during each sampling period using appropriate meters. Water temperature deep water aquarium/fish tank 0°C-50°C glass thermometer temperature), pH and water electric conductivity (AD131 pH/MV/EC/Temperature meter, Hungary) was measured in all sampling sites during sampling period using appropriate measuring tools.

### Fishery activities

Basic features of fishery activities were collected using questionnaires and through personal observation. The respondents were selected randomly from the fishers.

### Data analysis

**Diversity indices:** Shannon-Wiener diversity index ( $H'$ ) (Begon et al., 1990) was calculated for estimating the diversity of fish species in each sampling site. It was computed as:

$$H' = -\sum_{i=1}^s p_i \ln p_i$$

Where:  $P_i$ =the proportion of species "i",  $\ln$ =natural logarithm,  $S$ =Species richness

Shannon-Wiener index of evenness ( $J'$ ), a measure of equitability or fairness of representation of each individual in a community, was computed as:

$$J' = \frac{H'}{H'_{\max}}$$

Where,

$H'$ =Shannon-Wiener diversity index, and

$H'_{\max}$ =Natural logarithm of the absolute number of species in the community ( $\ln(S)$ ).

**Relative abundance:** Relative abundance was studied by calculating Index of Relative Importance (%IRI) in which high value of this index shows the most important species (Jutagate et al., 2005). IRI is a measure of the relative abundance or commonness of a species based on number and weight of individuals in catches. It gives a better representation of the ecological importance rather than the weight, number or frequency of occurrence alone (Sanyanga, 1996). The %IRI for each species was computed as:

$$\%IRI_i = \frac{(\%W_i + \%N_i) \times \%F_i}{\sum_{i=1}^s (\%W_i + \%N_i) \times \%F_i} \times 100$$

Where,  $i=1$  to  $S$  (species richness),  $\%W_i$  and  $\%N_i$  are percentage weight and number of each species,  $\%F_i$  is percentage of frequency of occurrence of each species.

$$\%F_i = \frac{\text{Frequency of occurrence of species in each sampling event}}{\text{total number of sampling events}} \times 100$$

**Length-weight relationship:** The relationship between Total Length (TL) and Total Weight (TW) of the most dominant species was computed using power function as in Bagenal and Tesch (1978) as follows:

$$TW = a TL^b$$

The relationship between the total weight and the total length was also tested using the linear regression equation

$$\text{Log TW} = \text{Log } a + b \text{ Log TL}$$

Where:  $TW$ =Total weight (g),  $TL$ =Total length (cm),  $\text{Log } a$ =Intercept of the regression line and  $b$ =Slope of the regression line.

The statistical significance of relationship between the total weight and the total length was also tested using Regression ANOVA in Microsoft Excel 2010.

**Fulton condition factor (FCF):** Condition factors are used for comparing the condition, fatness, or well-being of fish, based on the assumption that heavier fish of a given length are in better condition. FCF was determined by the following equation suggested by Bagenal and Tesch (1978):

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

Where:  $TW$ =Total weight (g) and  $TL$ =Total length (cm)

Significant variations in FCF between seasons and sites were tested using two-way Analysis of Variance (ANOVA) in SPSS (version 16).

## Results and Discussion

### Fish diversity and distribution in Gilo River and its associated Dualbeeb and Wagan Wetlands

A total of 911 specimens were collected in the whole study period. These were identified into 27 species belonging to 21 genera, 17 families, and 6 orders (Table 1).

The Shannon diversity ( $H'$ ) and evenness ( $J'$ ) indices of fish species for Gilo River and its two nearby Wetlands are summarized in Table 2 as shown below.

### Relative abundance

The most numerous species are *C. gariepinus* (36.44%), *H. niloticus* (21.46%), *D. nefasch* (8.89%) and *G. niloticus* (7.14%). While the least numerous species are *P. endlicheri* (0.11%), *A. dentex* (0.11%), *H. brevis* (0.11%), *B. docmak* (0.11%) and *S. galilaeus* (0.11%). *H. niloticus* (33.42%), *C. gariepinus* (29%), *G. niloticus* (11.04%), *L. niloticus* (4%) and *O. niloticus* (2.56%) are the species with the highest biomass, while *A. dentex* (0.01%) and *B. docmak* (0.01%) are the species with the least biomass; *H. niloticus* (100%), *D. nefasch* (100%) and *C. gariepinus* (100%) were the most frequent species, while *P. endlicheri* (12.5%), *A. dentex* (12.5%), *H. brevis* (12.5%), *D. brevipinnis* (12.5%), *B. docmak* (12.5%), *S. nigrata* (12.5%) and *S. galilaeus* (12.5%) were the least frequent species. The Index of Relative Importance (IRI), a comprehensive index that combines these three parameters, for the whole species is summarized in **Table 3** below. *Heterotis niloticus* had the highest %IRI value in dry season in both ecosystems. While, *C. gariepinus* had the highest value of %IRI in Wet season in both ecosystems. In the contrary, *A. dentex* (0.02%), *B. docmak* (0.02%) and *S. galilaeus* (0.02%) were the least important species during the whole study period.

The representative sample of each species collected in the present study is shown in the **Figure 2** below.

### Length-weight relationships

The important parameters of the length-weight relationships of the six most dominant species for the Gilo River and the associated wetlands for each season (dry and wet season) are summarized in **Table 4**.

The length-weight relationships were statistically significant except for *D. nefasch* in dry season and *O. niloticus* in wet season.

### Fulton condition factor (FCF)

The mean values and associated parameters of Fulton Condition Factor (FCF) for the six dominant fish species sampled in the Gilo River and the associated wetlands are summarized in **Table 5**.

Seasonal variations in the mean FCF were statistically significant ( $p < 0.05$ ) for *C. gariepinus* and *C. citharus*. *C. gariepinus* had higher mean value of FCF during the dry season in both ecosystems while *C. citharus* had higher mean FCF value in Gilo River during the wet season and higher mean value in the

**Table 1:** Fish diversity and distribution in Gilo River and its nearby Dualbeeb and Wagan Wetlands in dry and wet seasons. (Where 'x' = present and '-' = absent).

Order	Family	Genus	Species	Dry season		Wet season	
				River	Wetlands	River	Wetlands
Polypteriformes	Polypteridae	<i>Polypterus</i>	<i>P. bichir</i>	x	x	x	x
			<i>P. senegalus</i>	-	x	x	-
			<i>P. endlicheri</i>	x	-	-	-
Osteoglossiformes	Osteoglossidae	<i>Heterotis</i>	<i>H. niloticus</i>	x	x	x	x
	Gymnarchyidae	<i>Gymnarchus</i>	<i>G. niloticus</i>	x	x	x	-
	Mormyridae	<i>Mormyrus</i>	<i>M. niloticus</i>	x	x	x	x
			<i>M. kannume</i>	-	-	x	x
			<i>Mormyrops</i>	<i>M. anguilloides</i>	x	x	-
Characiformes	Alestidae	<i>Alestes</i>	<i>A. dentex</i>	x	-	-	-
			<i>Hydrocynus</i>	<i>H. brevis</i>	x	-	-
	Distichodontidae	<i>Distichodus</i>	<i>D. brevipinnis</i>	-	-	x	-
			<i>D. rostratus</i>	x	x	x	-
			<i>D. nefasch</i>	x	x	x	x
	Citharinidae	<i>Citharinus</i>	<i>C. citharus</i>	x	x	x	-
Cypriniformes	Cyprinidae	<i>Labeo</i>	<i>L. niloticus</i>	x	-	x	-
			<i>L. forskalii</i>	x	-	x	-
Siluriformes	Bagridae	<i>Bagrus</i>	<i>B. docmak</i>	x	-	-	-
	Clariidae	<i>Clarias</i>	<i>C. gariepinus</i>	x	x	x	x
	Malapteruridae	<i>Malapterurus</i>	<i>M. minjiriya</i>	x	-	-	-
	Mockokidae	<i>Synodontis</i>	<i>S. nigrata</i>	x	-	-	-
			<i>H. membranaceus</i>	x	-	x	x
	Auchenoglanididae	<i>Auchenoglanis</i>	<i>A. biscutatus</i>	-	-	x	x
	Schilbeidae	<i>Schilbe</i>	<i>S. mystus</i>	x	-	x	-
Perciformes	Channidae	<i>Parachanna</i>	<i>P. obscura</i>	x	x	-	-
	Latidae	<i>Lates</i>	<i>L. niloticus</i>	x	x	-	-
	Cichlidae	<i>Oreochromis</i>	<i>O. niloticus</i>	x	x	x	x
			<i>Sarotherodon</i>	<i>S. galilaeus</i>	x	-	-

wetlands during dry season. The site-season effect was not tested for *G. niloticus* as no specimens were sampled from the wetlands during wet season.

### Environmental parameters

The measured habitat variables and some physico-chemical parameters are summarized in **Tables 6 and 7** respectively.

### Fishery activities

From the 50 surveyed fishers, 82% were men and 18% were women. Their ages ranged from 15-75 years with majority (65%) of them in age group 25-40 years. About 70% of the surveyed fishers go to school and they know how to read and write, 26% did not go to school and 4% have advance diploma and they are

interested to become fishers in order to solve their economic problem using income from fishing.

Most of the fishermen fish individually. Very few organized themselves in to small groups as fishing gears are not sufficient. The fishing status is predominantly seasonal in the study area. They fish in dry season and they are off fishing during wet season as the fishing areas become over flooded during the heavy rainfall months.

All fishers have other means of livelihood like farming and cattle keeping. Most (56%) of them started fishing activities during childhood, especially those who live near the river. While some few started fishing recently. Most of the fishers (73%) came from far distant, some of them from South Sudan and preferred these fishing areas because it is safer and more secure.

**Table 2:** Summary of H' and J' of fish species in Gilo River and its nearby Wetlands.

	Dry season		Wet season		Dry and Wet seasons	
	River	Wetlands	River	Wetlands	River	Wetlands
Diversity (H')	2.05	1.64	2.06	1.83	2.28	1.85
Evenness (J')	0.65	0.64	0.74	0.79	0.69	0.67

**Table 3:** Summary of the %IRI of fish species of Gilo River and its nearby Dualbeeb and Wagan wetlands in dry and wet season.

Fish species	Dry season				Wet season				Total			
	River		Wetlands		River		Wetlands		River		Wetlands	
	IRI	%IRI	IRI	%IRI	IRI	%IRI	IRI	%IRI	IRI	%IRI	IRI	%IRI
<i>Polypterus bichir</i>	199.17	1.07	226.30	1.20	70.26	0.39	318.91	1.68	137.88	0.79	262.76	1.44
<i>Polypterus senegalus</i>	0.00	0.00	20.16	0.11	146.49	0.81	0.00	0.00	35.81	0.21	5.85	0.03
<i>Polypterus endlicheri</i>	32.98	0.18	0.00	0.00	0.00	0.00	0.00	0.00	9.08	0.05	0.00	0.00
<i>Heterotis niloticus</i>	8314.87	<b>44.78</b>	7268.90	<b>38.51</b>	1239.44	<b>6.88</b>	2442.10	<b>12.89</b>	5371.78	<b>30.92</b>	5578.79	<b>30.62</b>
<i>Gymnarchus niloticus</i>	1936.33	<b>10.43</b>	706.54	<b>3.74</b>	4341.68	<b>24.09</b>	0.00	0.00	2854.88	<b>16.44</b>	228.55	1.25
<i>Mormyrus niloticus</i>	87.80	0.47	52.70	0.28	0.00	0.00	291.12	1.54	50.55	0.29	139.76	0.77
<i>Mormyrus kannume</i>	0.00	0.00	0.00	0.00	60.60	0.34	116.57	0.62	12.28	0.07	23.66	0.13
<i>Mormyrops anguloides</i>	35.16	0.19	68.18	0.36	0.00	0.00	0.00	0.00	9.79	0.06	21.69	0.12
<i>Alestes dentex</i>	24.24	0.13	0.00	0.00	0.00	0.00	0.00	0.00	6.24	0.04	0.00	0.00
<i>Hydrocynus brevis</i>	32.98	0.18	0.00	0.00	0.00	0.00	0.00	0.00	9.08	0.05	0.00	0.00
<i>Distichodus brevipinnus</i>	0.00	0.00	0.00	0.00	291.77	1.62	0.00	0.00	59.45	0.34	0.00	0.00
<i>Distichodus rostratus</i>	39.53	0.21	28.50	0.15	38.18	0.21	0.00	0.00	39.17	0.23	8.84	0.05
<i>Distichodus nefasch</i>	380.00	<b>2.05</b>	1051.63	<b>5.57</b>	3859.52	<b>21.41</b>	1752.14	<b>9.25</b>	1834.50	<b>10.56</b>	1292.58	<b>7.10</b>
<i>Citharinus citharus</i>	229.75	1.24	1495.65	<b>7.92</b>	231.67	1.29	2370.67	<b>12.51</b>	224.36	1.29	1751.85	<b>9.62</b>
<i>Labeo niloticus</i>	32.98	0.18	0.00	0.00	382.37	<b>2.12</b>	0.00	0.00	182.35	1.05	0.00	0.00
<i>Labeo forskalii</i>	24.13	0.13	0.00	0.00	197.10	1.09	0.00	0.00	84.60	0.49	0.00	0.00
<i>Bagrus docmak</i>	24.24	0.13	0.00	0.00	0.00	0.00	0.00	0.00	6.24	0.04	0.00	0.00
<i>Clarias gariepinus</i>	4615.58	<b>24.86</b>	7266.85	<b>38.49</b>	5580.91	<b>30.96</b>	8899.36	<b>46.96</b>	5100.62	<b>29.36</b>	7801.04	<b>42.82</b>
<i>Malapterurus minjiriya</i>	419.32	<b>2.26</b>	0.00	0.00	0.00	0.00	0.00	0.00	119.97	0.69	0.00	0.00
<i>Synodontis nigrita</i>	173.07	0.93	0.00	0.00	0.00	0.00	0.00	0.00	48.07	0.28	0.00	0.00
<i>Hemisyndontis membranaceus</i>	36.25	0.20	0.00	0.00	104.37	0.58	323.83	1.71	66.97	0.39	65.52	0.36
<i>Auchenoglanis biscutatus</i>	0.00	0.00	0.00	0.00	1026.39	<b>5.69</b>	844.82	<b>4.46</b>	226.92	1.31	166.12	0.91
<i>Shilbe mystus</i>	49.57	0.27	0.00	0.00	53.96	0.30	0.00	0.00	51.32	0.30	0.00	0.00
<i>Parachanna obscura</i>	24.24	0.13	19.90	0.11	0.00	0.00	0.00	0.00	6.24	0.04	5.76	0.03
<i>Lates niloticus</i>	1467.24	<b>7.90</b>	358.74	1.90	0.00	0.00	0.00	0.00	447.86	<b>2.58</b>	117.61	0.65
<i>Oreochromis niloticus</i>	357.50	1.93	313.64	1.66	399.16	<b>2.21</b>	1589.83	<b>8.39</b>	366.54	<b>2.11</b>	763.66	<b>4.19</b>
<i>Sarotherodon galilaeus</i>	29.70	0.16	0.00	0.00	0.00	0.00	0.00	0.00	8.02	0.05	0.00	0.00



**Table 4:** Summary of length-weight relationship of the most common fish species of Gilo River and Dualbeeb and Wagan wetlands (ANOVA,  $p < 0.05$ ); \*Stands for statistically non-significant p-values; SD: Standard Deviation; Dry: Dry season; Wet: Wet season; N: Total number of specimens. The length-weight relationships were statistically significant except for *D. nefasch* in dry season and *O. niloticus* in wet season. Alphabetes indicate the parameters.

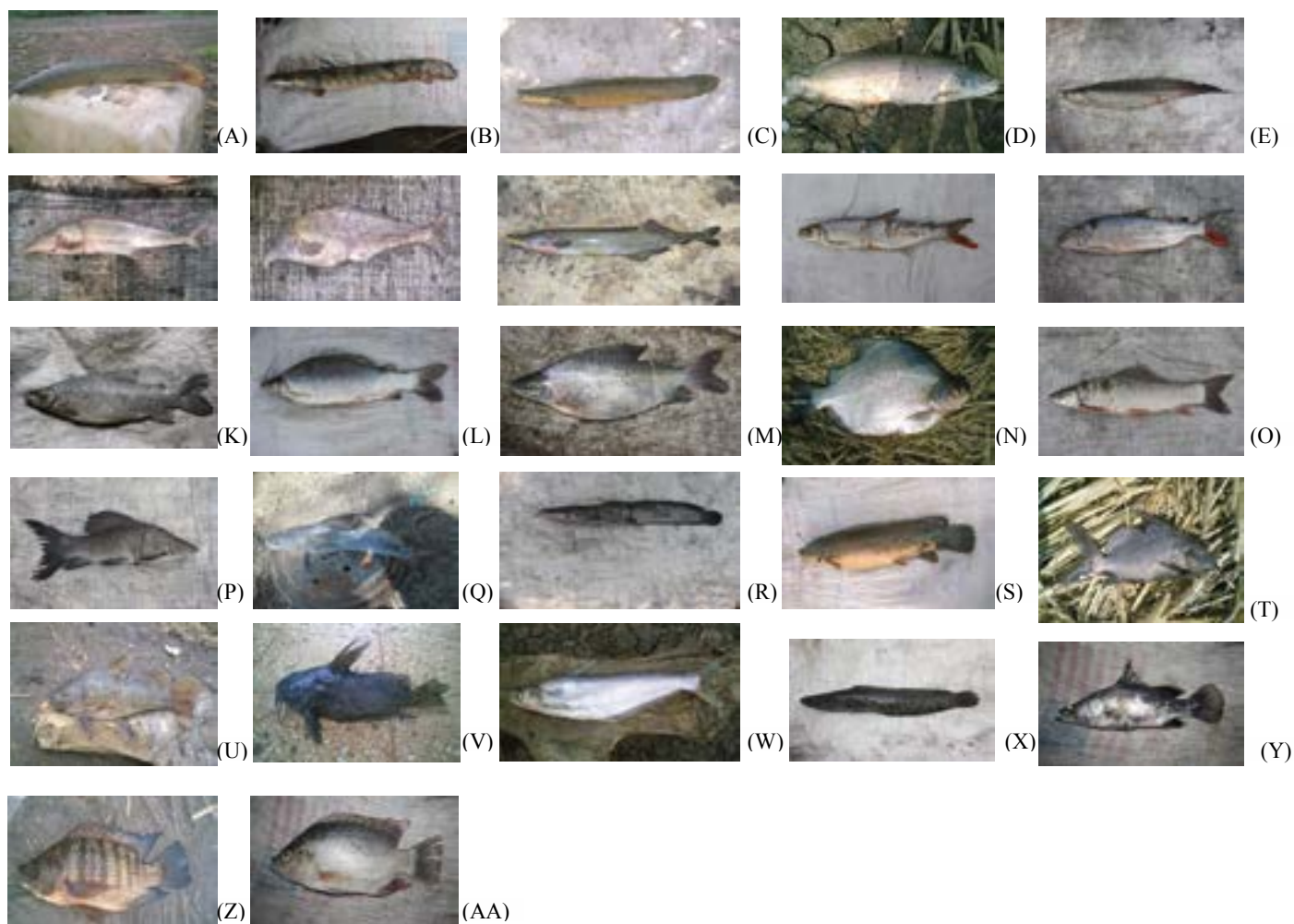
Species	Sites	TW = aTL <sup>b</sup>		R <sup>2</sup>		Mean ± SD TW		Mean ± SD TL		p value		N	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
<i>H. niloticus</i>	Gilo River	0.007TL <sup>3.03</sup>	6x10 <sup>-08</sup> TL <sup>5.82</sup>	0.73	0.93	2580.25 ± 903.94	2205.56 ± 896.68	66.62 ± 6.44	65.56 ± 4.64	0.00	0.00	81	9
	Wetlands	0.000TL <sup>3.58</sup>	4x10 <sup>-08</sup> TL <sup>5.89</sup>	0.72	0.73	2857.65 ± 988.91	1715.00 ± 868.01	67.88 ± 5.94	61.15 ± 5.22	0.00	0.00	85	20
<i>C. gariepinus</i>	Gilo River	0.038TL <sup>2.61</sup>	3x10 <sup>-09</sup> TL <sup>6.47</sup>	0.58	0.83	1944.23 ± 786.01	728.06 ± 583.43	62.40 ± 6.34	56.15 ± 6.76	0.00	0.00	52	72
	Wetlands	0.001TL <sup>3.51</sup>	4x10 <sup>-07</sup> TL <sup>5.32</sup>	0.77	0.53	1658.04 ± 976.72	1040.05 ± 1053.50	58.37 ± 7.96	56.05 ± 6.94	0.00	0.00	112	96
<i>C. citharus</i>	Gilo River	1x10 <sup>-06</sup> TL <sup>5.29</sup>	3.27TL <sup>1.53</sup>	0.77	0.98	885.71 ± 254.48	1100.00 ± 215.06	45.29 ± 2.29	44.80 ± 5.81	0.01	0.00	7	5
	Wetlands	0.000TL <sup>3.95</sup>	0.015TL <sup>2.94</sup>	0.89	0.93	2716.67 ± 1279.82	2540.00 ± 1431.81	53.28 ± 6.29	56.53 ± 11.76	0.00	0.00	18	15
<i>D. nefasch</i>	Gilo River	5x10 <sup>-12</sup> TL <sup>8.32</sup>	0.0001TL <sup>3.59</sup>	0.57	0.82	1360.00 ± 887.69	1193.75 ± 1113.74	53.00 ± 3.46	51.35 ± 9.54	0.19*	0.00	5	40
	Wetlands	2x10 <sup>-05</sup> TL <sup>4.59</sup>	0.000TL <sup>4.04</sup>	0.52	0.93	1482.35 ± 885.46	1028.95 ± 1242.34	51.35 ± 6.91	46.95 ± 12.31	0.00	0.00	17	19
<i>O. niloticus</i>	Gilo River	2x10 <sup>-07</sup> TL <sup>6.06</sup>	0.46TL <sup>1.94</sup>	0.80	0.24	608.33 ± 219.33	785.00 ± 275.93	37.00 ± 3.07	45.40 ± 4.01	0.00	0.25*	12	10
	Wetlands	2x10 <sup>-05</sup> TL <sup>4.88</sup>	0.000TL <sup>3.61</sup>	0.94	0.73	925.00 ± 574.24	1058.82 ± 552.33	36.67 ± 5.32	46.88 ± 6.38	0.00	0.00	6	17
<i>G. niloticus</i>	Gilo River	0.002TL <sup>3.12</sup>	9x10 <sup>-07</sup> TL <sup>4.76</sup>	0.93	0.88	2805.56 ± 1746.08	2500.00 ± 1019.37	91.33 ± 14.92	95.66 ± 9.44	0.00	0.00	18	18
	Wetlands	0.002TL <sup>3.08</sup>	-	0.82	-	2450.00 ± 900.49	-	87.44 ± 9.26	-	0.00	-	29	-

**Table 5.** Summary of the FCF for the most dominant fish species of the study area; \*stands for statistically significant p-values at 5 % level of significance (two-way ANOVA); Dry = Dry season; Wet = Wet season; SD = Standard deviation.

Species	FCF (Mean ± SD)						F	p value
	Gilo River		Wetlands		Site*Season			
	Dry	Wet	Dry	Wet				
<i>Heterotis niloticus</i>	0.85 ± 0.15	0.75 ± 0.17	0.88 ± 0.17	0.70 ± 0.20	1.45	0.23		
<i>Clarias gariepinus</i>	0.78 ± 0.17	0.35 ± 0.16	0.77 ± 0.21	0.54 ± 0.54	6.83	0.01*		
<i>Citharinus citharus</i>	0.93 ± 0.17	1.25 ± 0.24	1.67 ± 0.29	1.25 ± 0.22	18.95	0.00*		
<i>Distichodus nefasch</i>	0.86 ± 0.48	0.73 ± 0.22	0.98 ± 0.32	0.68 ± 0.20	1.23	0.27		
<i>Oreochromis niloticus</i>	1.14 ± 0.29	0.84 ± 0.29	1.64 ± 0.49	0.95 ± 0.27	3.56	0.07		
<i>Gymnarchus niloticus</i>	0.34 ± 0.04	0.27 ± 0.06	0.35 ± 0.06	-	-	-		

**Table 6:** Summary of the environmental variables for Gilo River and its two nearby wetlands.

Sampling sites	Depth (m)	Substrate types	Aquatic vegetation	Bank vegetation	Anthropogenic activities near bank/catchment
Gilo River 1 (R1)	4	25% muddy, 75% sandy	Tuy-tuy	Grass	Fishing activities
Gilo River 2 (R2)	4	25% muddy, 75% sandy	Tuy-tuy	10% Scattered trees, 90% Grass	Fishing activities, farmlands, bridge construction and other domestic activities
Dualbeeb Wetland 1 (W1)	1.5	Muddy	none	Grass	Fishing activities
Wagan Wetland 2 (W2)	1.5	Muddy	none	Grass	Fishing activities



**Figure 2:** Fish species collected from Gilo River and its nearby Wetlands. (A) *P. senegalus* (B) *P. enlicheri* (C) *P. bichir* (D) *H. niloticus* (E) *G. niloticus* (F) *M. niloticus* (G) *M. kannume* (H) *M. anguilloides* (I) *A. dentex* (J) *H. brevis* (K) *D. rostratus* (L) *D. nefasch* (M) *D. brevipinnis* (N) *C. citharus* (O) *L. niloticus* (P) *L. forskalii* (Q) *B. docmak* (R) *C. gariepinus* (S) *M. minjiriya* (T) *S. nigrita* (U) *A. biscutatus* (V) *S. membranaceus* (W) *S. mystus* (X) *P. obscura* (Y) *L. niloticus* (Z) *O. niloticus* (AA) *S. galileaus* respectively.

**Table 7:** Physico-chemical parameters of Gilo River and its two nearby wetlands in both dry and wet season.

Sampling sites	Dry season			Wet season		
	pH	Water Temp (°C)	Conductivity (µS/cm)	pH	Water Temp (°C)	Conductivity (µS/cm)
Gilo River 1 (R1)	6.5	29	855	6.4	28	83.2
Gilo River 2 (R2)	6.5	28	791	66.5	27	84.4
Dualbeeb Wetland 1 (W1)	6.6	31	876	6.4	26	177.3
Wagan Wetland 2 (W2)	6.6	29	731	6.4	27	139.9

The fishermen dried their catch as post harvest handling mechanism. They transport their dried fish to the nearby local market and sell it (one kilogram of dried fish cost 15 birr). The price of fresh fish is variable depending on the size and type of fish mostly preferred by the consumer. They use gillnets, hooks and line and spear as fishing gears. Very few of them had traditional boats (canoes) made of wood as their fishing vessels. The fishers indicated that they need modern fishing gears and fishing vessels to improve their fishing career.

## Discussion

In the present study, a total of 27 species belonging to 21 genera, 17 families and six orders were identified. The species composition in this study is relatively less diverse compared to other intensive studies which had covered most tributaries of the Baro-Akobo drainage basins (White Nile). *Polypterus bichir*, *Polypterus endlicheri*, *Gymnarchus niloticus*, *Heterotis niloticus*, *Mormyrops anguilloides*, *Hydrocynus brevis*, *Bagrus docmak*, *Auchenoglanis biscutatus*, *Clarias gariepinus*, *Oreochromis niloticus* and *Sarotherodon galilaeus* were reported in this study

and their presence in the same basin was also reported by Tesfaye Melak and Abebe Getahun (2012).

All species reported in this study except *O. niloticus* are reported for the first time in Gilo River and its nearby wetlands, despite their presence in the Nile basin (Tedla, 1973; Golubtsov et al. 1995; Getahun and Stiassny, 1998; Golubtsov and Mina, 2003; Getahun, 2007; Golubtsov and Darkov, 2008).

Species diversity in Gilo river increased through time and higher ( $H' = 2.28$ ) in this study than previous study ( $H' = 2.03$ ) (Melak and Getahun, 2012). Despite the presence of *Labeo forskalii*, *Bagrus docmak* and *Oreochromis niloticus* in Geba, Sor (Melaku, 2013) and Gilo (this study) rivers of Baro-Akobo basin, the diversity is higher in Gilo ( $H' = 2.28$ ) followed by Geba ( $H' = 1.50$ ) and Sor ( $H' = 1.10$ ) rivers respectively. This is because fish diversity decreases rapidly in the upper parts of the White Nile basin (Golubtsov and Mina, 2003). The reasons for the less diversity in the present study are because; firstly, the study was conducted in a very short period of time (two months in each season). Secondly, the present study was conducted from only one of the tributaries (Gilo River and its nearby wetlands) of the Baro-Akobo basin where only some of the species in this basin are inhabited.

The fish species reported in this study were Nilo-Sudanics and East African forms. It has been reported by Brook Lemma (2008) that there were 13 endemic species from the White Nile drainage basin within the limits of Ethiopia. However, no endemic species was recorded in this study. Low level of endemic species is probably due to the fact that Baro Basin is connected with the Nile, west and central African river systems and as a result, most fish fauna are Nilo-Sudanic forms (Getahun, 2007).

High species diversity was observed in Gilo River ( $H' = 2.28$ ) than in the wetlands ( $H' = 1.85$ ). This difference in fish diversity could relate to their natural differences as lentic and lotic ecosystems resulting in variation in habitat diversity. Deeper water, wider surfaces and more discharges downstream are factors to increase diversity parameters (Horwitz, 1978). Gilo River has scattered near bank vegetation and grasses which provide food and refuge for fish species dwelling in it, whereas wetlands have only seasonal grasses which dry up during dry season. Terrestrial and aquatic vegetation such as ripe fruits, seeds, terrestrial and aquatic insects are food sources for fish species that inhabit river habitats (Ambak and Jalal, 2006). The same is true for the Shannon index of evenness which is also higher in Gilo River ( $J' = 0.69$ ) than in Wetlands ( $J' = 0.67$ ). This indicates that species in the Gilo River are fairly represented by almost equal number of individuals than the species found in the Wetlands.

Taxonomically, family Cyprinidae is the most diverse group of the Ethiopian ichthyofauna (Golubtsov and Darkov, 2008). However, family Polypteridae, Distichodontidae and Mormyridae were the most diverse family in the present study each represented by three species. Where as family Osteoglossidae, Gymnarchyidae, Citharinidae, Bagridae, Clariidae, Malapteruridae, Auchenoglanididae, Schilbeidae, Channidae and Latidae were the least diverse each represented by only one species.

Numerically, *C. gariepinus* with 332 individuals and *H. niloticus* with 192 individuals were the most abundant species in wetlands and Gilo River, respectively. While *P. endlicheri*, *A. dentex*, *H. brevis*, *B. docmak*, *S. nigrita* and *S. galilaeus* were the least abundant each represented by only one individual in both season in Gilo River. *H. niloticus* and *C. gariepinus* were the most abundant species by weight in the present study. *H. niloticus* (30.92% IRI) and *C. gariepinus* (42.82% IRI) were the most important species in dry and wet season respectively.

Relative abundance shows variation with season and sites. Higher relative abundance (in weight and number) of the most dominant species was recorded in wetlands in dry season. This could be because river is a flowing body of water and fish migration is not hindered and they escape the predation risk and harsh environment, while wetlands are land locked body of water where fish movement is blocked. So that, in dry season when water level dropped, fish species accumulated in one pool letting them to be caught in large number as they do not have any outlet to escape. Less number of fish caught during wet season is attributed to low water temperature, high run-off, high turbidity and an increase in water level (Melaku, 2013). There is also higher water discharge during wet season so fishes could be highly dispersed in the large volume of water than dry season and it becomes difficult to catch (Tsfaye, 2006).

The length-weight relationships of the most dominant species show allometric growth as indicated by the regression equation. None of the fish from the most dominant species exhibit isometric growth, a condition where 'b' value is equal to three. *H. niloticus* showed positive allometric growth in river and wetlands in both seasons. *C. gariepinus* had positive allometric growth in river for wet season and in wetlands in both seasons. *C. citharus* showed positive allometric growth in dry season both in river and wetlands, and negative allometric growth in wet season for both river and wetlands. The growth pattern for *D. nefasch* was allometrically positive in river and wetlands for both seasons. *O. niloticus* showed positive allometric growth in wetlands for both seasons and in river for dry season while its growth is allometrically negative in river for wet season. *G. niloticus* has positive allometric growth in river in both seasons and wetlands in dry season.

Measuring fish condition is directly linked to the general fish health. Generally, high condition is associated with higher energy (fat) content; increased food base, reproductive potential, more favorable environmental conditions (Paukert & Coot, 2004). *C. gariepinus* had higher FCF in Gilo River ( $0.78 \pm 0.17$ ) and wetlands ( $0.77 \pm 0.21$ ) in dry season, when compared to wet season for both ecosystems, indicating that the species is in better condition during dry season. These values have contradicted to 'b' value of the same species which is greater than three except for Gilo River (2.61) in dry season, showing a more rotund growth in fish as length increase (Jones et al., 1999).

Mean condition of specimens as well as the difference in condition between small and large specimens vary between seasons, localities and years, resulting in different length-weight relationships (Froese, 2006). *C. citharus* had higher FCF in Gilo



River ( $1.25 \pm 0.24$ ) during the wet season, and higher FCF in the wetlands ( $1.67 \pm 0.29$ ) during dry season. This higher FCF agree with the 'b' value greater than three in wetlands during dry season, telling that the species is in better wellbeing as it is more robust in its increased length. These variations in condition factors and 'b' values among different species and within the same species at different rivers or water bodies were probably because of the differences in seasons, locality, age, sampling time, food availability, and gonad development and spawning period (Bagenal and Tesch, 1978).

The mean value of FCF for the species in Gilo River under the present study is much less than the mean FCF value of *V. juba* (1.25), *L. degeni* (1.89), and *L. cylindricus* (1.46) in Awata River and *V. juba* (1.32), *L. degeni* (4.24), and *L. cylindricus* (1.28) in Genale River (Tesfaye Tadesse, 2016) respectively, Wabishebele-Genale Basin. Moreover, the mean FCF value in the present study is also lower than the mean FCF value of *L. forskalii* (1.18), *L. intermedius* (1.89) and *L. nedgia* (1.48) reported by Tesfaye (2006) in Angereb and Sanja Rivers, Tekeze Basin. This difference in mean FCF value could relate to the difference in fish habitat and physiological aspects as they are different species. Condition factor parameters depend on factors including biological and environmental, as well as geographical, age, the season of year when samples are collected (Nowak et al., 2009).

Fishing in the present study areas is predominantly seasonal. Most fishers carry out fishing activities in the dry season and engaged on other activities such as crop cultivation and cattle keeping in wet season due to the natural anticipated flood disaster repeatedly happened in the area due to which people displaced to safer area in wet season.

## Conclusion and Recommendation

From this study, it is concluded that Gilo river and its nearby wetlands contains substantially diverse fish species ( $H' = 2.10$ ) of which the river fish community is more diverse ( $H' = 2.28$ ) than the wetlands ( $H' = 1.85$ ). Moreover, the individual species in Gilo River is evenly distributed than those in wetlands.

Among the 17 families recorded; Polypteridae, Distichodontidae and Mormyridae are the most diverse families represented by three species each.

With the exception of *O. niloticus*, all other species reported in this study are new report for Gilo River and its nearby wetlands. Therefore, the present study represents a baseline study for Gilo River and its nearby wetlands.

Among the dominant species recorded in this study, the most importance species in decreasing order are *C. gariepinus* (42.82% IRI), *H. niloticus* (30.92% IRI), *G. niloticus* (16.44% IRI), *D. nefasch* (10.56% IRI), *C. citharus* (9.62% IRI) and *O. niloticus* (4.19% IRI).

The length-weight relationships of the most dominant fish species in the present study show allometric growth in both Gilo River and wetlands in both seasons.

Seasonal variations in the mean FCF of the most dominant

species were statistically insignificant ( $p > 0.05$ ) except for *C. gariepinus* and *C. citharus*. Fishing activities in the present study areas is predominantly seasonal.

Intensive study which covers a wide range of Gilo River including its tributaries and all its surrounding wetlands is recommended in order to explore and document these areas which are presumably rich in ichthyofauna.

Detailed studies on water quality need to be undertaken in order to assess the status of habitat parameters and their effect on the ichthyofaunal diversity which could contribute to the development of our country.

Detailed studies and investigations are needed to be undertaken on food and feeding habits and reproductive behaviors of fish species in Gilo River and its surrounding wetlands.

Detailed studies on biological and socioeconomic aspects of fishes need to be undertaken to understand the supportive and beneficial contribution of these water bodies in poverty alleviation in the country.

Organizing fishermen in cooperations, providing training to fishermen and introduction of aquaculture technologies in the study area are highly recommended to enhance benefits from fish resources.

Possible management options have to be encouraged to ensure the sustainable utilization of fishery resources in the study area.

## Acknowledgments

I am very grateful to Mulugeta Wakjira (PhD) and Girum Tamire (PhD) for their constructive comments, Debre Berhan University Postgraduates studies for providing budget, Gambella University for its cooperation and providing necessary instruments for measuring physico-chemical parameters, Jimma University for further verification of species identification in their zoological science laboratory. Thanks also go to Mr. Samson Warkaye, Ethiopia Maps Agency, Addis Ababa, for preparing the study area's map. Family members and other personel also deserve thanks for their direct and indirect contribution in this study. Above all, thank goes to super natural, the creator who makes everythings possible.

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