

Research Article

Current Status of Fish Species Diversity and Relative Abundance of Beko and Gacheb Rivers, Southwest Ethiopia: Implication for Fishery Opportunity

Tsegay Fisseha* , Andinet Asfaw , Ayalew Zeleke 

Natural and Computational Sciences, Department of Biology, Mizan-Tepi University, Mizan-Tepi, Ethiopia

Abstract

Ethiopia, a landlocked country, relies on inland waters for fish, a vital low-cost protein source. Its standing water bodies span 7000 km², with rivers extending 8,065 km, supporting diverse aquatic life. The fish production potential is estimated at 94,500 tons per year, with around 200 species, 191 native and 9 introduced, and yet thorough investigation is in need. Despite progress, research on Ethiopian fish diversity remains incomplete due to the country's vast area (1.1 million km²) and limited surveys. Therefore, this study investigated fish species diversity and relative abundance in the Beko and Gacheb Rivers, highlighting implications for sustainable fish production. This study was carried out using cross-sectional observational study, and a total of 193 fish samples were collected during dry (April-May 2017) and wet (October-November 2017) seasons using gill nets with varying mesh sizes. Fish samples were identified to species level using taxonomic keys, and their total length and total weight were measured to the nearest 0.1 cm and 0.1g, respectively. Samples were preserved in 10% formalin and stored at Mizan-Tepi University Zoological-Sciences Laboratory. Relative abundance was determined by diversity indices and well-being of fish species was determined by using Fulton's condition factor. The study recorded three fish species (*Lates niloticus*, *Lates forskalii*, and *Oreochromis niloticus*), with *L. forskalii* being the most abundant. Three species from the same family were identified, with a diversity index ($H=2.52$) indicating higher diversity than reported in other studies. The evenness index showed fair representation of species by individuals. The diversity and abundance indices revealed slight variations between sampling sites, with no dominant species observed, indicating complete evenness. Water quality parameters were within acceptable limits for aquatic life. Fish distribution was influenced by physicochemical factors and human activities, while promising fishery opportunities exist due to the presence of commercially important species, high demand, year-round water availability, and a strong fish market. These findings highlight the need for sustainable resource management and further research on fish biology and socioeconomic aspects.

Keywords

Beko and Gacheb Rivers, Fish Diversity, Fishery Opportunity, Relative Abundance

*Corresponding author: tsegayf2012@gmail.com (Tsegay Fisseha)

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1. Introduction

Ethiopia is a land locked country that relies only on inland water resources for the supply of fish as a low cost protein source. The country is endowed with sizable amount of running and standing water bodies with a high diversity of aquatic fauna [7, 14]. The total estimated reservoirs, floodplain and lake area (7000km²) and river length about (8,065 km) of the country provide high fish production potential, which is estimated at 94,500 t yr⁻¹ [26]. As reported by [7], Ethiopia is home to approximately 200 fish species, with 191 classified as valid indigenous (native) species and 9 categorized as introduced species. These diverse fish species are found throughout the various drainage basins of the country [7, 16]. The highest fish species diversity has been recorded from Baro-Akobo basin (119 species), followed by Omo-Turkana (79 species), Abay (Blue Nile) (61 species), Tekeze and Awash-Rift Valley system (36 species each) and Shebelle-Genale (33 species) [7]. The highest diversity could be attributed to the presence of diverse and rich habitat in terms of food availability, connection with other ecosystem and a relatively higher degree of exploration done on these inland water bodies. Meanwhile, highest species endemism has been recorded in Abay basin [24]. The highest species endemism in Abay basin (25 species) is attributed to the endemic flock of *Labeobarbus* in Lake Tana [3, 16, 18, 28].

Despite progress, research on the diversity of Ethiopian fish fauna remains incomplete, primarily due to the vast geographical area (1.1 million km²) and limited surveys conducted. Many drainage basins, especially rivers, have not been thoroughly investigated [1]. The Bako and Gacheb Rivers are such rivers that lack comprehensive studies on the diversity, abundance, and associated biological characteristics of their fish populations. Therefore, this study aimed to address this gap by serving as a baseline assessment of fish diversity, relative abundance, potential fishery opportunities, and various biological traits in the rivers examined. This effort seeks to support conservation initiatives for their fish fauna.

2. Materials and Methods

2.1. Description of Study Area

The present study was carried out in Bako and Gacheb Rivers. Bako River is a well-known river that crosses four different zones of South West Ethiopia namely Kaffa, Sheka, Bench-Sheko; and the Majange zone of Gambella Regional State. The river has a big tributary river named as Dama River which flows starting from Kaffa zone and reaches into Sheka Zone. Bako River is one of the most important tributaries of largest river known as Baro-Akobo. The Bako River is situated in a region characterized by a plain and slopy topography, with an altitude of 1,300 meters above sea level. The area experiences a mean annual temperature of 23°C and a mean annual rainfall of 1,520 mm. The prevailing wind direction is

mainly from northwest to southeast, and flooding is significant natural constraint for the town's physical expansion. Similarly, Gacheb River is the other most invaluable and largest aquatic resources in Bench Sheko Zone. The river is originated in north (semen) Bench woreda 16 km from the centre. Semen-Bench is one of well-known district in Bench-Sheko Zone (Appendix I). The river is the main source of drinking water supply for Mizan-Aman town since 1986 G.C. The study area experiences an average air temperature ranging from 13 to 27°C [25] and has a unimodal annual rainfall pattern, with the rainy season occurring from mid-March to mid-November. The average annual rainfall depth in Mizan Teferi (at an elevation of 1440m a.s.l.) is 1780 ± 270mm y⁻¹, while the annual reference evapotranspiration amounts to 1259 ± 12 mm y⁻¹. The Gacheb River sampling sites are located relatively at higher altitude (>1400 m above sea level) than the Bako River sites which are located below 1300m above sea level. The channel diameter of the sampling sites ranged from 22.5 to 37.65 m with a mean value of 30.075m. Besides, all the sampling sites of both rivers, had turbid water with largely muddy bottom. Most parts of both rivers were highly irrigated and had high vegetation cover.

2.2. Sample Site Selection

Based on the information collected during preliminary survey, the actual study was designed based on the assumptions of traditional fishing practices of the community, boarder kebeles from three zones, velocity of flowing rivers, accessibility and suitability of the area. Three sampling sites were selected from both rivers based on flow nature and accessibility (Appendix I). The Bako River included Site-1 from Sheka Zone (Kommy Kebele named BS-1), Site-2 from Bench -Sheko Zone (Jenjeka Kebele, named JS-2), Site-3 from Bench Sheko Zone (Haybera Kebele, named HS-3). Additionally, one sampling site from Gacheb River at Fajika Kebele in Bench-Sheko Zone was selected and fixed for actual sampling. During the selection of study sites, various forms of information were utilized, including indigenous knowledge, recorded data, and common fishing locations provided by different stakeholders to ensure the validity of the study.

2.3. Fish Sample Collection and Identification

Fish samples were collected from each sampling site using gill net of varying mesh sizes from 6cm-12cm and using monofilament net with varying mesh sizes from 6cm-24cm. The gill net and monofilament nets were set late in the afternoon at 4:30pm and remained overnight in the water until 6:00 morning of the next day. Traditional fishing vessels such as multiple hooks and lines were also used to collect fish samples where gill net setting was not available. Two rounds of data collection were made in each season (December, 2016 to

February, 2017 for the dry season; and September to October, 2017 for the wet season) and a total of 16 samples were taken during the study period as a whole (Appendix II). Data were also collected in relation to the existing fishery activities and other related issues from the study area through interviews and discussion from agricultural expertise, local kebele leaders and fishermen in all data collection sites.

Fish specimen identification was done by using keys developed by [11] and by comparing the sample characters with taxonomic keys found in literatures and specimens deposited. In line with identification, total length (TL) and total weight (TW) of collected fish species were measured to the nearest 0.1cm and 0.1g, respectively. After carefully taking the required measurements, samples were labelled and preserved in 10% formalin solution, and taken to Zoological Sciences Laboratory of Mizan-Tepi University, Tepi where they are deposited.

2.4. Diversity Indices

Abundance difference of the dominant fish groups between sampling months, sites and habitats were determined using their corresponding number of catches. Shannon diversity index (H') for the collected specimens in Gacheb and Beko Rivers was calculated to indicate diversity at different sampling sites of the rivers to illustrate the variety and the relative abundance of species as stated in [17].

H' was calculated as:

$$H' = \sum P_i * \ln P_i \quad (1)$$

Where, H' = the Shannon diversity index, P_i = fraction of entire population made up of the species i S = number of species encountered Σ = sum from species 1 to species S .

Species equitability or evenness Index (J') that refers to the degree of the relative dominance of each species in the sampling station was calculated according to formula stated in [19] as follows:

$$J' = H'/H'_{\max} \quad (2)$$

Where, H' = Shannon-Weiner diversity index and H'_{\max} = natural logarithm of the absolute number of species in the community ($\ln(S)$).

Furthermore, condition factor of fish species was determined using Fulton's Condition Factor and computed using the formula recommended by [20]

$$\text{Percentage of FCF} = TW/TL^3 * 10 \quad (3)$$

Where TW= total weight (g) and TL = total length (cm)

2.5. Data and Statistical Analysis

Data analysis was conducted by SPSS Statistical Software Version 20. Fish diversity was performed using Shan-

non-Weiner diversity indices and the well-being of fishes were assessed by Fulton's condition factor. The significant difference of species relative abundance during wet and dry season were analysed by ANOVA.

3. Results

3.1. Fishes Species Diversity

In the present study, a total of 193 fish specimens were collected from Beko and Gacheb Rivers in the whole study period. Three fish species were recorded in the current study which belong to the same family *Cyprinidae* and order *Cypriniformes* namely *Labeo niloticus*, *Labeo forskalii* and *Oreochromis niloticus*. These specimens were identified into 3 species belonging to 2 genera, 2 family, and 2 orders as stated in Appendix III.

The Shannon index of evenness (J') revealed that each species in the two rivers was fairly represented by an equal number of individuals. The Shannon-Weiner diversity (H') and Pielou's evenness (J') indices of fish species in the current study are summarized in Appendix IV.

The value of Shannon diversity index indicated that there was a variation in between the two rivers as well as among the various sampling sites of the rivers. This is evident that there was species variation among the sampling sites and seasons, indicating all the three fishes species are adapted to live in all the sampling sites. The Shannon-Weiner diversity index ($H' = 2.52$) also showed that fish diversity of the study area was far greater than the result reported in other studies of Ethiopian riverine ecosystems. According to the principle of Pielou's evenness index (J') interpretation species evenness ranges from 0-1 with zero signifying no evenness and 1 a complete evenness. The less evenness in communities between the species (the presence of the dominant species), the lower J' is and vice versa. Therefore, as shown in Appendix (V) and Appendix (VI) the value of Pielou's evenness index (J') showed in all sites of the river as well as between the two season's ranges 0.8 up to 1 which indicate there was no dominant species among the four sites and rivers or the three species has complete evenness.

3.2. Species Composition (Abundance by Number)

A total of 193 fishes that belong to three different species were caught in two seasons from four different study sites as presented in Appendix VII. Hence, the three species that were collected during dry and wet seasons were different in their number, weight and size. From a total of 193 species, 109 species were collected during wet season, of which 54.1% ($n=59$) were male and 45.8% ($n=50$) were female. Of the total, 84 fishes were collected during dry season. In the dry season, the number of specimens of *L. forskalii* in all sites were 43

specimens making the species, the most abundant during the dry season. *L. niloticus* was the second most abundant species in number and *O. niloticus* was the least fish specimens caught in both season. In all sites, *L. forskalii* had made a total of 89 specimens which accounts nearly 47.59% of the total. There might be several reasons for variation in abundance between wet and dry seasons such as water potential, flooding variation and other environmental factors.

3.3. Species Abundance by Weight

In the present study, total of 56.774kg of fishes were sampled during the study period in four sites. Of which, nearly 29.706kg was sampled in wet season and 27.068kg was sampled in dry season. There was variation among total average weight of individual species collected in the study periods, the largest weight observed was in L.F (27.573kg) followed by L.N (nearly 23.433kg) and lowest weight observed in O.N species (nearly 5.769kg). There was significant difference in mean weight of fishes between seasons at each sampling site as stated in Appendix VIII. The mean weight of fish was high in wet season than in dry season. This was probably due to high level in dissolved oxygen caused by increased velocity of flow of water. In the rainy season, the lateral flow of waters seeping over plain is enriched by nutrients mainly from decomposing materials. Besides, the data indicated that total weight variation among the four data collection sites the highest weight observed in BS-1 about 33% followed by JS-2 which accounts to 27 percent and the lowest observed in GS-4 is 20 percent of the total mass caught during the study period as presented in Appendix IX.

3.4. Physiochemical Properties of Rivers

In the present study, the physicochemical parameter of the river (BS-1) indicated that no significant differences was recorded in dissolved oxygen, temperature, and pH. However, according to the data recorded turbidity, depth, and flow rate of the river had significant variation among sites and seasons and all of the parameters were within normal level which is suitable for aquatic community in general and fish community in particular. The physiochemical properties of the rivers were measured in-situ using appropriate digital multimeter-probe and summarized as in Appendix X.

4. Discussion

This study investigated fish species diversity and abundance as well as some physicochemical parameter of the river water in relation to fisheries opportunity of Beko and Gacheb rivers. Three different species that belong to same family cyprinidae and order Cypriniformes (*L. niloticus*, *L. forskalii* and *O. niloticus*) were recorded. These fish species are common in most Ethiopia drainage system and commercially important fish and hence they make the main constituent of

fishery activities in Ethiopia. Besides, species composition and diversity of the current study was not high as compared to most researches conducted in rivers of different parts of the country. However, this finding is in agreement with the study reported by [15] in Sor Rivers and Baro-Akobo basin. The study revealed that there were similar species types, but different in species abundance. The author also reported that a total of nine fish species represented in four families and seven genera were identified from Geba and Sor Rivers that belong to similar species where it is complementary with the present study in terms of commercial value.

Besides, this study recorded that fish species that belong to a mixture of Nilo-Sudanic *L. niloticus*, and *L. forskalii*) and East African forms (*O. niloticus*). Similarly, this finding was in lined with the study reported by [10, 15] where the freshwater fish fauna of Ethiopia contains a mixture of Nilo-Sudanic, East African and endemic forms. The Nilo-Sudanic forms were related to West African fishes, hence supporting the hypothesis that the Nile River has been historically connected to the central and West African River systems. Moreover, the finding of this study was in agreement with the study conducted in Baro-Akobo basin and these species were belonging to the Nilo-Sudanic forms where they were the dominant forms in terms of diversity and were represented by a large number of species found in the Basin.

Generally, the study also identified the species composition, and the number of particular groups were not as expected as the river is tributary of Baro-Akobo which is well known for its highest fish species diversity. This might be due to number of different anthropogenic factor such as the use of highly traditional fishing practice, the use of locally prepared plant chemical for fishes catching after killing them in the water, wide spread deforestation, and poor attention given by the local government for the effects of climate change. According to the findings of [5, 6], the highest species diversity in Ethiopia has been recorded from Baro basin, followed by Abay, Wabishebele and Omo-Gibe basins. It appeared that high diversity was attributed by the presence of diverse and rich habitats, past connection with other systems and also due to relatively higher degree of exploration and collection done on these water bodies.

This study also found that there were significant difference in abundance of fish specimens between seasons and study-sites ($P < 0.05$). This might be attributed to various reasons such as magnitude of variation of the river flow rate, difference in terms of increasing size and flooding effect which are associated with variation in different environmental factors. In line with these, combined environmental factors, *L. Forskalii* was the highest fish species in abundance followed by *L. niloticus* the second abundant. This finding was in agreement with several scientific research conducted in different parts of the country. There might be several reasons for changes in abundance between wet and dry seasons. This might include variation in available nutrients and habitats, fishing effort, fish behaviour, and size and life history stages of fishes might all contribute to variations in the

catches. The other reasons that could influence fish abundance in the catches might be water level and discharge [12]. Furthermore, this study was complementary in terms of species type with different number of species according to a study conducted by [2] on abundance and species compositions of the fishes in blue Nile River, where total of eight species were identified. The species were reported namely *L. intermedius*, *L. forskalii*, *M. kannume*, *L. nedgia*, *L. crassibarbis*, *C. gariepinus* and *O. niloticus*. They were represented by a single class Actinopterygii (ray-finned fishes), 4 orders (Cypriniformes, Osteoglossiformes Siluriformes and Perciformes), 5 families (Cyprinidae Cichlidae, Bagridae, Clariidae and Mormyridae) and 6 genera.

The present study found similar result with the current declining of species as a result of ecological degradation and human impact with most study conducted in different aquatic resources of Ethiopia. The result of this study matched with most findings as freshwater biodiversity has declined faster than either terrestrial or marine biodiversity over the past 30 years and it was also irresponsibly misused to describe population dynamics of a location or community [5, 6, 8]. Furthermore, declining of river flow rates (discharge) have been a major cause of species loss, and are likely to be further reduced by fluctuating water temperatures, reduced precipitation and increased water withdrawal for agriculture and other human uses [13]. The streams and rivers were facing number of environmental problems throughout the world largely associated with anthropogenic activities in their catchment areas [6, 29]. In order to understand the direct impact of season variability on distribution and abundance of fish species, this research investigated and found that fish abundance in number was higher in the wet season than in the dry season. This study found that wet season, as the water level increased, the density of fish population become high in the pools because the fishes were trapped in these areas. As a result, more fishes were vulnerable to the gears especially to the gill nets hence high catch. This could be one of the probable reasons for higher abundance in number during the wet season in this study. However, this finding was in contrary with a study conducted on Sanja River and Angereb River where fish abundance in number was higher in the dry season than in the wet season. As a result, the high-water season become the main existing potential of feeding and suitable for reproduction as well as growing time for fishes, and fat deposits were then accumulated which fishes keep going through the dry season, when they eat little [5, 6].

In general, there might be several reasons for changes in catches between wet and dry seasons. For example, variation in available habitats and gill net efficiency might contribute to variations in the catches. The higher number of species recorded during dry season than wet season might be attributed to a wider range of sampled habitat, due to high turbidity, speedy run-off, and low temperature [15]. This was mainly due to habitats suitable for gill net sampling during dry season. However, during wet season trees that grow hanging their branches down to the water on either side of the riverbank

hinder reaching residency of fish in their habitats. Similarly, habitats targeted to gill nets were seldom deep water areas where some fish often reside dislocated by current of rivers during wet seasons. In addition, during wet season the efficiency of gill nets were decreased by logs, leaves, roots etc. that were brought by flooding into Gacheb and Boko rivers. Thus, differences recorded in the data between wet and dry season may be due to differences in available habitats and gill net efficiency. The association between fish community and water quality parameters have been investigated along the various sites of the rivers has been explained in relation to fisheries perspectives.

In addition to that, it is clear that physicochemical parameters such as water temperature and dissolved oxygen are significant parameters that restrict survival, growth and distribution of fish. High water temperature may generate high physiological demands apart from reducing the dissolved oxygen levels in a water body. This phenomenon indicated the importance of dissolved oxygen and its relationship with water temperature [27]. The present study evaluated the physicochemical parameter of the two rivers in relation to fishes species distribution and their abundance by taking into account the permissible level of the various physicochemical variables. So that, according to the finding of this research, the average pH value of four study sites was recorded during dry season 7.3 and 6.77 during the wet season respectively. Besides, the lowest and highest pH value recorded during the dry and the wet season has no significant differences which was 6.4 and 7.4, respectively. Therefore, the recorded pH value of the two rivers was within the ranges of standard limits, therefore, suitable for production of fish and most of aquatic lives and development. As compared to other ecological habitat, these riverine habitat are endowed with promising and conducive ecological suitability that might be because of less-exposure to various factor such devastating pollution, habitat degradation, siltation and expansion of alien species. In addition to that, these riverine habitat in general and, Boko River in particular, is characterized with long rainy season and under exploited aquatic resource for various purpose.

Similarly, the recorded pH measurement of these study sites was within the acceptable range. It is known that pH is understandable to influence the physiological functions of fish and other aquatic lives. In line with, in fresh water rivers, pH is among the most important factors predicting benthic macro-invertebrate assemblages. At around pH 7, the nutrients are easily assimilated by most of the plant organisms and the food chain can develop normally. The pH of water is important because many biological activities can occur only within a narrow range. Thus, pH range for diverse fish production is between 6.5 and 9. Any variation beyond acceptable range could be fatal to many aquatic organisms [9]. Similarly other studies have determined that fish move away from alkaline waters when pH levels approach 9.06-10.0, unless more important survival factors outweigh avoidance, including food availability or lower predation levels. These factors

are responsible for distribution of organisms in different fresh water habitats according to their adaptations, which allow them to survive in a specific habitat [21, 23]. Similarly average value of salinity unit during dry and wet season was 0.1905 and 0.175, TDS 246.2 and 244 and temperature 27.7 and 23.68, (Appendix X), respectively. The finding of this study was supported by various researches conducted in Ethiopia [4, 8]. In addition to the aforementioned major indicators of water quality parameters, dissolved oxygen measurements were within permissive level for fish survival and reproduction. Furthermore, the total dissolved solids was within the permissible range where fish and other aquatic lives thrive without challenge. This was supported by the scientific report done by [22], where a maximum value of 400 mgL⁻¹ of total dissolved solids is permissible for diverse fish population. Indeed, many ecologists have revealed a positive correlation between total dissolved solids and turbidity [21, 23].

As stated above, even though the measured water quality parameters of the study site were currently with in the permissible limit, the rivers are currently facing challenges like pollution from manucipal wastes, agricultural activities and coffee pulping firms by the local community. The increasing use of agricultural fertilizer and locally-made chemical for killing fishes can pose adverse effects on the abundances and species diversity if any measure is not taken. Besides, the effect of agricultural activities and deforestation on the river headwaters, has a pronounced effect on both females and immature fishes.

5. Conclusion and Recommendations

In the present investigation, three different fish species that belong to the same family namely *Lates niloticus*, *Lates forskalii* and *Oreochromis niloticus* were recorded. Fish diversity of the two rivers appeared to be low as compared to the other most studied rivers in Ethiopia. The fish species faunal diversity of both rivers was dominated by cyprinid fish species with *Lates niloticus*, *Lates forskalii* and *Oreochromis niloticus* being the most abundant fish species. Similarly, based on the index of relative importance (IRI), *L.forskalii* was the most abundant species during both seasons. Besides to species composition and their richness across the two rivers, seasonal variation has also significant difference between rivers and seasons. Species diversity index and abundance of species indicated that there was slight variation between the two rivers as well as among the various sampling sites of the rivers in species diversity but no dominant species among the four sites and rivers or the three species has complete evenness. This study also found that the synergistic effect of physicochemical parameters and anthropogenic activities was a determinant factor for the distribution of fishes in the rivers. Moreover, the current finding indicated that, production and maximization of fishery products is highly promising there is huge existing fishery opportunity to maximize the fish production contributed by the presence of commercially important species, better de-

mand for fish in the area, no seasonal and religious effects on fish consumption, pattern and availability of water throughout the year very long rainy season, better fish market and suitability of the water quality. Since this research is poineer investigation for this ecosystem, additional extensive studies are needed on food and feeding, reproductive biology and behaviors of fish species, and fisheries opportunitities and socioeconomic aspects of the two rivers.

Limitation of the Study

This study provides a valuable and pioneering investigation of fish species diversity and abundance in the Beko and Gacheb Rivers; however, certain limitations should be acknowledged. The research offers a snapshot of the current fish populations but does not capture long-term seasonal or interannual variations. Sampling constraints, including restricted access to some river sections and gear limitations, may have influenced species representation and abundance estimates. Additionally, environmental factors such as fluctuating water flow and pollution, along with human activities, could have affected fish distribution during the study period. Although we used morphological identification, greater taxonomic accuracy may require molecular analysis. Furthermore, the study primarily focuses on ecological aspects, with limited coverage of the socioeconomic factors influencing local fisheries. The absence of historical data on these rivers also restricts the ability to analyze long-term trends in fish diversity and stock fluctuations.

Highlights

- 1) Healthy Aquatic Conditions for Fish Community: Water quality parameters meet acceptable standards for fish life.
- 2) Even Species Distribution: No dominant species found; complete evenness across samples.
- 3) Seasonal Variations Noted: Slight differences in diversity and abundance between dry and wet seasons was observed.
- 4) There is sustainable fisheries potential: Findings highlight significant and promising opportunities for fisheries production.

Abbreviations

BS-1	Kommy Kebeles-Site-1
JS-2	Jenjeka Kebeles-Site-2
HS-3	Haybera Kebeles-Site-3
GS4	Gacheb Site-4
TW	Total Weight
TL	Total Length
FCF	Fulton's Condition Factor
LF	Lates Forskalii
LN	Lates Niloticus
ON	Oreochromis Niloticus

IRI	Index of Relative Importance
TDS	Total Dissolved Solutes
DO	Dissolved Oxygen

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Declarations

Ethical approval and Consent to Participate. All authors have read, understood, and have complied as applicable with the statement on "Ethical responsibilities of Authors" as found in the Instructions for Authors and are aware that with minor exceptions, no changes can be made to authorship, once the paper is submitted. Moreover the study was carried out in accordance with the Ethiopian Criminal Code No. 414/2004 that bans inhumane treatments being inflicted on animals in public places.

Consent for Publication

All authors need to publish the research paper entitled "Current Status of Fish Species Diversity and Relative Abundance of Beko and Gacheb Rivers, Southwest Ethiopia: Implication to Fishery Opportunity".

Appendix

Appendix I: Maps of Yeki Woreda at Kommy Kebele in Beko River, Sheka Zone

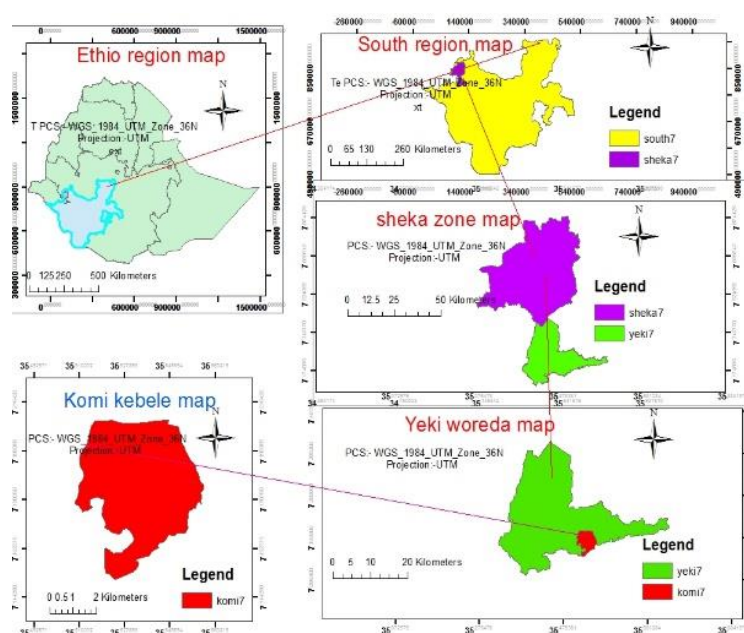


Figure 1. Maps of Yeki Woreda at Kommy Kebele in Beko River, Sheka Zone.

Author Contributions

Tsegay Fisseha: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Andinet Asfaw: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Ayalew Zeleke: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft

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Data Availability Statement

Not applicable.

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix II. Sampling Sites



Figure 2. Selected sampling sites of study areas.

Appendix III. Taxonomy of Fish Species in Boko and Gacheb Rivers in Dry and Wet Seasons

Table 1. Taxonomy of fish species in Boko and Gacheb Rivers in dry and wet seasons.

Class	Order	Family	Genus	Species	Dry season	Wet season
Actinopterygians	Cypriniformes	Cyprinidae	Labeo	Niloticus	Present	Present
	Cypriniformes	Cyprinidae	Labeo	Forskali	Present	Present
	Perciformes	Cichlidae	<i>Oreochromis</i>	Niloticus	Present	Present

Appendix IV. The Shannon-Weiner Diversity (H') and Pielou's Evenness (J') Indices During Wet and Dry Season in Each Sites of the Rivers

Table 2. The Shannon-Weiner diversity (H') and Pielou's evenness (J') indices during wet and dry season in each sites of the Rivers.

Season	$H'/N/J'$	Sampling site					
		BS-1	JS-2	HS-3	GS-4	Over all H'	Over all J'
Dry	H'	2.7	2.45	2.40	2.3	2.46	
	N	3	3	3	2	2.75	
	J'	0.9	0.816	0.8	1.15	0.9	1.141
Wet	H'	2.543	2.62	1.764	3.159	2.52	
	N	3	3	2	3	2.75	
	J'	0.847	0.873	0.882	1.053	0.9137	0.9137
Overall		2.81	2.76	2.29	2.615	2.618	1.0273

Appendix V. The Overall Shannon-Weiner Diversity (H') and Pielou's Evenness (J') Indices During Wet and Dry Season

Table 3. The overall Shannon-Weiner diversity (H') and Pielou's evenness (J') indices during wet and dry season.

Indices	Dry Season	Wet Season	Overall
Diversity (H')	2.46	2.52	2.49
Evenness (J')	1.141	0.9137	1.0273

Appendix VI. Fish Species Identified from Beko and Gacheb Rivers

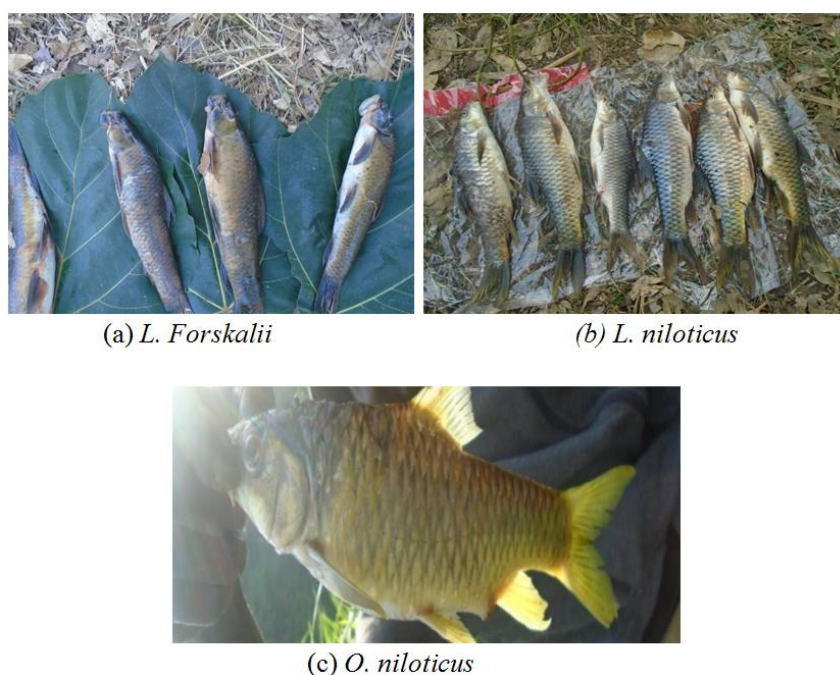


Figure 3. Fish species identified from Beko and Gacheb Rivers.

Appendix VII. Fish Distribution Among Four Sampling Sites During Wet and Dry Seasons

Table 4. Fish distribution among four sampling sites during wet and dry seasons.

Study sites	Season	Species types									Total		
		<i>Labeo niloticus</i>			<i>L. forskalii</i>			<i>O. niloticus</i>					Total
		F	M	Total	F	M	Total	F	M	Total	F	M	
BK-1	Dry	4	5	9	8	3	11	2	2	4	14	10	24
BK-2		4	5	9	3	9	12	1	1	2	8	15	23
BJ-3		3	2	5	5	7	12	-	3	3	8	12	20
GS-4		3	6	9	4	4	8	-	-	-	8	10	17

Study sites	Season	Species types									Total		Total
		<i>Labeo niloticus</i>			<i>L. forskalii</i>			<i>O. niloticus</i>					
		F	M	Total	F	M	Total	F	M	Total	F	M	
Sub Total		14	18	32	20	23	43	0	6	9	38	47	84
BK-1		6	10	16	6	4	10	2	2	4	14	16	30
BK-2		5	7	12	6	5	11	2	1	3	13	13	26
BJ-3	Wet	3	5	8	5	9	14	-	-	-	8	13	21
GS-4		6	6	12	5	6	11	4	5	9	15	17	32
Sub Total		20	28	48	22	24	46	8	8	16	50	59	109
Overall		34	46	80	42	47	89	8	14	25	88	106	193

Appendix VIII. Total Weight (in Gram) of Species During Hot and Wet Season of the Study

Table 5. Total weight (in gram) of species during hot and wet season of the study.

	Cold season			Dry season			Wt. of all fishes (g)
	L.F	L.N	O.N	L.F	L.N	O.N	
Total weight (g)	13708	12624	3374	13865	10809	2394	56774
Total	46	48	16	42	32	9	193
Average weight (g)	298	263	210.8	330.1	337.78	266	294.17
Sub total		29706			27068		56774
Average weight of the species	270.05			326.12			294.17

Appendix IX. ANOVA Result from the Analysis by Number of Fishes in Four Sites (BS-1, JS-2, HS-3 and GS-4) During the Study Period in Boko and Gacheb Rivers

Table 6. ANOVA result from the analysis by number of fishes in four sites (BS-1, JS-2, HS-3 and GS-4) during the study period in Boko and Gacheb Rivers.

Weight of species in sites			Sum of Squares	df	Mean Square	F	Sig.
Between Groups	(Combined)		6.886	1	6.886	.777	.471
	Linear Term	Unweight	6.886	1	6.886	.777	.471
		Weighted	6.886	1	6.886	.777	.471
Within Groups			17.714	2	8.857		
Total			24.600	3			

Appendix X. Physicochemical Properties of Study Rivers During Dry and Wet Season

Table 7. Physicochemical properties of study rivers during dry and wet season.

Data collection sites	Season	Water quality parameters					
		pH	Temp.	DO (mg/L)	TDS (mg/L)	Depth (m)	Salinity unit (mg/L)
BS-1	Dry	7.4	28.79	6.22	251	2-5	0.195
JS-2		6.8	26.76	6.42	245	1-3	0.185
HS-3		7.3	27.38	6.02	243	2-3	0.193
GS-4		7.8	27.84	6.31	246	2-6	0.187
Average		7.3	27.7	6.24	246.2		0.1905
BS-1	Wet	6.9	24.77	5.34	233	5-9	0.174
JS-2		7.3	23.42	6.12	249	3-6	0.167
HS-3		6.4	22.02	5.65	256	4-7	0.184
GS-4		6.8	24.52	5.74	239	3-5	0.175
Average		6.77	23.68	5.7	244		0.175

References

- [1] Abebe, G. G. (2014). Off-farm income and technical efficiency of smallholder farmers in Ethiopia.
- [2] Awoke, T., Mingist, M., & Getahun, A. (2015). Abundance and species composition of the fishes in Blue Nile River below the Tiss Issat fall, Ethiopia. *International Journal of Fisheries and Aquatic Studies*, 2(6): 334-33. <https://doi.org/10.59411/y789cz15>
- [3] de Graaf, M., Dejen, E., Osse, J. W. M., & Sibbing, F. A. (2008). Adaptive radiation of lake Tana's (Ethiopia) Labeobarbus species flock (Pisces, Cyprinidae). *Marine and Freshwater Research*, 59(5), 391-407. <https://doi.org/10.1071/MF07123>
- [4] Erarto, F., Getahun, A., & Mingist, M. (2020). Fish diversity and relative abundance at mesohabitat level in Gumara River, Lake Tana Sub-basin, Ethiopia. *J Fish Res.* 2020; 4 (1): 5-13 *J Fish Res* 2020 Volume 4 Issue 1, 6. <https://doi.org/10.35841/fisheries-research.4.1.5-14>
- [5] Getahun, A. (2002). The Nile basin: Riverine fish and fisheries. Department of Biology Addis Ababa University, Ethiopia. 19pp.
- [6] Getahun, A. (2007). An overview of the diversity and conservation status of the Ethiopian freshwater fish fauna. *Journal of Afrotropical Zoology*, special issue, 87-96. <https://doi.org/10.5772/intechopen.1004602>
- [7] Getahun, A. (2017). The freshwater fishes of Ethiopia: diversity and utilization. View Graphics & Printing Plc.
- [8] Getahun, A., Bereie, Z., & Dejen, E. (2020). Diversity of fishes in Beles and Gilgel beles Rivers, abay basin, Ethiopia. *International Journal of Aquaculture and Fishery Sciences*, 6(2), 68-73. <https://doi.org/10.17352/2455-8400.000059>
- [9] Harrison, T. D., & Whitfield, A. K. (2004). A multi - metric fish index to assess the environmental condition of estuaries. *Journal of Fish Biology*, 65(3), 683-710. <https://doi.org/10.1111/j.0022-1112.2004.00477.x>
- [10] Hirpo, L. A. (2017). Fisheries production system scenario in Ethiopia. *International Journal of Fisheries and Aquatic Studies*, 5(1), 79-84.
- [11] Holden, M. J., & Reed, W. (1972). West African freshwater fish. (No Title). <https://lccn.loc.gov/74170516>
- [12] Karege, L., & Kolding, J. (1995). Inshore fish population and species changes in Lake Kariba, Zimbabwe. In *The impact of species changes in African lakes* (pp. 245-275). Springer. https://doi.org/10.1007/978-94-011-0563-7_12
- [13] Lawson, O. E., & Olusanya, O. M. (2010). Fish diversity in three tributaries of River Ore, South West, Nigeria. *World Journal of Fish and Marine Sciences*, 2(6), 524-531.
- [14] Lemma, B. (1987). The present status and potentials for future development of inland fisheries in Ethiopia. *Proceeding of Management of Water and Natural Resource to Increase Food Production in Africa*, 99-108.
- [15] Melaku, S., Getahun, A., & Wakjira, M. (2013). Diversity, relative abundance and some biological aspects of fishes in Geba and Sor rivers, Baro-Akobo Basin, southwest Ethiopia. M. Sc. thesis, Jimma University, Jimma. <https://doi.org/10.59411/1a8q5g79>

- [16] Mengesha, T. A. (2017). Review on the natural conditions and anthropogenic threats of Wetlands in Ethiopian. *Global Journal of Ecology*, 2(1), 6-14.
<https://doi.org/10.17352/gje.000004>
- [17] Næsje, T. F., Hay, C. J., Nickanor, N., Koekemoer, J. H., Strand, R., & Thorstad, E. B. (2004). Fish populations, gill net catches and gill net selectivity in the Kwando River, Namibia. NINA Project Report, 27, 1-64.
- [18] Nagelkerke, L. (1997). The barbs of Lake Tana, Ethiopia: morphological diversity and its implications for taxonomy, trophic resource partitioning, and fisheries. Wageningen University and Research.
- [19] Pielou, E. C. (1966). Species-diversity and pattern-diversity in the study of ecological succession. *Journal of Theoretical Biology*, 10(2), 370-383.
[https://doi.org/10.1016/0022-5193\(66\)90133-0](https://doi.org/10.1016/0022-5193(66)90133-0)
- [20] Schrader, W., Reinhardt, L., Hernandez, K., & Hohman, C. (2015). Process and methods for assigning ages to anadromous salmonids from scale samples.
- [21] Scott, D. M., Lucas, M. C., & Wilson, R. W. (2005). The effect of high pH on ion balance, nitrogen excretion and behaviour in freshwater fish from an eutrophic lake: a laboratory and field study. *Aquatic Toxicology*, 73(1), 31-43.
<https://doi.org/10.1016/j.aquatox.2004.12.013>
- [22] Selleslagh, J., & Amara, R. (2008). Environmental factors structuring fish composition and assemblages in a small macrotidal estuary (eastern English Channel). *Estuarine, Coastal and Shelf Science*, 79(3), 507-517.
<https://doi.org/10.1016/j.ecss.2008.05.006>
- [23] Serafy, J. E., & Harrell, R. M. (1993). Behavioural response of fishes to increasing pH and dissolved oxygen: field and laboratory observations. *Freshwater Biology*, 30(1), 53-61.
<https://doi.org/10.1111/j.1365-2427.1993.tb00788.x>
- [24] Stiassny, M. L. J., & Getahun, A. (2007). An overview of labeonin relationships and the phylogenetic placement of the Afro-Asian genus *Garra* Hamilton, 1922 (Teleostei: Cyprinidae), with the description of five new species of *Garra* from Ethiopia, and a key to all African species. *Zoological Journal of the Linnean Society*, 150(1), 41-83.
<https://doi.org/10.1111/j.1096-3642.2007.00281.x>
- [25] Tadesse, M., Alemu, B., Bekele, G., Tebikew, T., Chamberlin, J., & Benson, T. (2006). Atlas of the Ethiopian rural economy. Intl Food Policy Res Inst.
- [26] Tesfaye, G., & Wolff, M. (2014). The state of inland fisheries in Ethiopia: a synopsis with updated estimates of potential yield. *Ecohydrology & Hydrobiology*, 14(3), 200-219.
<https://doi.org/10.1016/j.ecohyd.2014.05.001>
- [27] Thiel, R., Cabral, H., & Costa, M. J. (2003). Composition, temporal changes and ecological guild classification of the ichthyofaunas of large European estuaries—a comparison between the Tagus (Portugal) and the Elbe (Germany). *Journal of Applied Ichthyology*, 19(5), 330-342.
<https://doi.org/10.1046/j.1439-0426.2003.00474.x>
- [28] Wendimu, A., Tekalign, W., & Woldesenbet, A. (2024). Fish fauna and fishery in Ethiopia, Africa.
<https://doi.org/10.5772/intechopen.1004602>
- [29] Young, R. G., Townsend, C., & Mathaei, C. (2006). Functional indicators of river ecosystem health-results from regional case studies of leaf decomposition. Cawthron Institute, Nelson, New Zea.