JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

COLLEGE OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGY

Fish diversity, relative abundance and some related environmental parameters of Gilgel Gibe and Gojeb rivers, Omo-Turkana Basin, Southwest Ethiopia

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A thesis submitted to the Department of Biology, College of Natural Sciences, Jimma University in partial fulfillment for the requirement for the degree of Master of Science in Biology (Ecological & Systematic Zoology)

December, 2014
Jimma, Ethiopia

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November, 2014
Jimma, Ethiopia

Acknowledgements

First and foremost my thanks go to my research advisers Mr. Mulugeta Wakjira and Dr. Argaw Ambelu, for their encouragement, advice, assistance and unreserved support both during the preparation of the proposal and the write up of the thesis work. Their continuous encouragement, willingness to provide field equipment and above all in sharing their knowledge and experiences is greatly acknowledged. I treasure their advices which have contributed a great deal to the success of this work. Without their advice the accomplishment of the thesis work would have been impossible.

My next thanks go to Jimma zone Teachers Association Office for their continuously encouragement to join this program and Jimma University department of biology for opening this program. I would like to thank Mr. Tokuma Negisho for his encouragement and special comments during proposal and progress reports. I would like to express my deepest gratitude to my instructors and all members of Biology Department for their kind cooperation and assistance throughout my stay at the campus. I would like to appreciate the National Meteorological Agency, Jimma Branch for providing rainfall data of the study area. My due thanks also goes to a fisherman Kedir A/Diga who kindly assisted in the field work.

My everlasting gratitude goes to my father **Mohammed Amdihun, my mother Buzu Yusuf,** all my brothers and sisters whose words of encouragement, affection and prayer served me as a source of strength and inspiration throughout my study.

Lastly, my gratitude goes to all those who contributed in one way or another to the successful realization of this study and who deserve deepest appreciation.

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Acronyms

BD - Body Depth

CCA - A canonical correspondence analysis

CPD-Caudal Peduncle Depth

CPL – Caudal Peduncle Length

DFL- Dorsal Fin Length

DO - Dissolved Oxygen

ED - Eye Diameter

FCF- Fulton Condition Factor

GPS-Geographical Positioning System

HL- Head Length

IOW - Inter-Orbital Width

IRI- Index of Relative Importance

JERBE- Joint Ethio-Russian Biological Expedition

PAL - Pre-Anal fin Length

PDL- Pre dorsal length

SE - Standard Error

SL- Standard Length

SnL- Snout Length

SPSS-Statistical Package for Social Sciences

TL- Total Length

TW- Total Weight

Abstract:

Fish diversity, relative abundance, length-weight relationship, condition factor, sex ratio, and some environmental parameters of Gilgel Gibe and Gojeb rivers were studied in two seasons. A total of 256 fish specimens were collected from both rivers during wet and dry seasons using appropriate gears. Nine fish species were identified which were included in eight genera and six families. The represented families include Mormyridae, Alestiidae, Cyprinidae, Bagridae, Clariidae and Cichlidae. Family Cyprinidae was the most diverse consisting of four species (44.4%) and all the remaining families were the least diverse represented only with one species each. The diversity of fish species in Gojeb (H'=0.691) was higher than that of Gilgel Gibe River (H' =0.636). Labeobarbus intermedius (52.04 % IRI) in Gilgel Gibe River and (34.81 % IRI) in Gojeb River, Bagrus bajad (13.54 % IRI) in Gojeb River and Labeo forskalii (8.30 % IRI) in Gojeb River were the first three most abundant fish species, respectively. Raiamas senegalensis in Gojeb River stood the least abundant species with 0.62 % IRI. The length-weight relationships fitted for Labeobarbus intermedius (in Gilgel Gibe and Gojeb rivers), Bagrus bajad and Labeo forskalii (both in Gojeb River) using a power function.. The mean Fulton condition factor (FCF) for Labeobarbus intermedius was 1.12) in Gilgel Gibe River and 1.19 in Gojeb River. There was no significant variation (ANOVA, P > 0.05) in mean FCF of Labeobarbus intermedius in the two rivers. Bagrus bajad and Labeo forskalii that occurred in Gojeb River had mean FCF of 1.23 and 1.09 respectively. Males were more numerous than females in both rivers throughout the study period with the exception of Labeobarus intermedius fish species collected from Gojeb River. Statistically significant variation was observed between males and females for Labeobarus intermedius fish species collected from Gojeb River (Chi-square, P < 0.05). However, in case of Labeobarus intermedius collected from Gilgel Gibe River, Labeo forskalii and Bagrus bajad (both collected from Gojeb River). Statistically no significant variation was observed between males and females fish species (Chi-square, P > 0.05) from the theoretical 1:1 ratio during the study period.

Key words: *Gilgel-Gibe River, Gojeb River, Fish diversity, Relative abundance, Length-weight relationship, Condition factor, Sex ratio.*

1. Background

1.1. Introduction

Fish consists of a heterogeneous group of aquatic chordates including hagfishes, lampreys, sharks, rays, chimaeras, and the bony fishes. Like many other forms of life, fishes are of immense value to humans. For instance, they have long been a staple item in the diet of many people. Today they form an important element in the economy of many nations while giving incalculable recreational and psychological value to the naturalist, sports enthusiast, and home aquarist. They are also used as general indicators or summators of pollution, partly to the direct benefit of humans and partly to protect what people consider a valuable and necessary part of their heritage and life (Nelson, 2006).

Fishes live in almost every conceivable type of aquatic habitat where water of reasonable integrity exists. Many fishes are restricted to pure freshwater, many are restricted to normal oceanic salinity, some occur in both habitats at different times of their lives, and some occur and are even restricted to areas of intermediate salinity, such as estuaries (Helfman, 2001). Their habitats include deep sea to the depths of 8000 m, and high mountain streams and lakes to 5000 m altitude.

Fishes constitute more than 27,000 of the known 54,000 species of living vertebrates and are divided taxonomically into three major groupings: jawless fishes (agnathans), cartilaginous fishes (chondrichthyans), and bony fishes (osteichthyans) (Helfman *et al*., 2009; Nelson, 2006). Freshwater fishes are the most diverse groups of fishes in the world, exhibiting extraordinary taxonomic breadth, endemism, and geographic scope in their distribution (Leveque *et al.,* 2008). While marine fishes make up 58% of all species (covering 70 % of Earth's surface**)**, freshwater species make up 41% (covering < 1 % of Earth's surface), and 1% of fishes move regularly between the ocean and fresh water (Helfman, 2001). Rivaling the taxonomic diversity of freshwater fishes is the wide range of morphological, behavioral, and life history attributes that characterize the constituent species. The rich taxonomic and functional diversity of freshwater fishes stem largely from the fact that streams, rivers, lakes, and wetlands are embedded in According to Leveque *et al.* (2008) South America is the leading continent in terms of freshwater fish by possessing 4,035 species belonging to 74 families. While Asia and Africa are the second and third next to South America with 3,553 and 2,945 species in 85 and 48 families, respectively. Africa harbors a well-diversified fish fauna, resulting from a long history of complex climatic and geological events that resulted in geographic isolation followed by speciation for some populations, or extinction for others (Leveque, 1997).

Ethiopia could be called the "water tower of northeastern Africa" on a continent where aridity is the rule. Inland water bodies of Ethiopia are estimated to be about 7400 km^2 of lake area and about 7000 km of river length (Wood and Talling, 1988), with diversified fish species. According to Golubstov and Darkov (2008) there are 113 fish species belonging to 66 genera and 26 families within the White Nile drainage basin, 77 species in 37 genera and 16 families within Blue Nile drainage basin, the Omo-Turkana drainage basin comprises 76-79 species within 42 genera and 20 families, the Atbara-Tekeze drainage basin has 34 species in 22 genera and 10 families, Shebelle-Juba drainage basin also contain 33 species belonging to 21 genera and 12 families while the Rift valley drainage basin has 28-31 species of fish in 18 genera and 11 families.

According to Roberts (1975) the freshwater fish fauna of Ethiopia contains a mixture of Nilo-Sudanic, East African and endemic forms. The Nilo-Sudanic forms are related to West African fishes, hence supporting the hypothesis that the Nile has been historically connected to the central and West African river systems (Getahun, 2002).

Generally, the knowledge of the diversity of the Ethiopian fish fauna is far from complete. Many of the drainage basins, especially the rivers, are not exhaustively explored (Getahun, 2007). Gojeb and Gilgel Giber rivers are no exceptions to the scenario. To this effect the present study aimed an exhaustive systematic research on the diversity, abundance and some environmental parameters of fishes in these two rivers.

1.2. Statement of the problem

Although Ethiopia presumably has high fish productivity and diversity, little work has been done on its freshwater systems. Ethiopia appears to be the least explored for its ichthyofauna of all the regions of Africa (Golubtsov *et al*., 1995). Gilgel Gibe and Gojeb rivers are among the tributaries of the Omo-Turkana Basin. These rivers are presumed to have high diversities of fish fauna

(Getahun, 2003), but like other most rivers in Ethiopia they are poorly explored. No exhaustive systematic study on the fish diversity, relative abundance and environmental parameters of Gilgel Gibe and Gojeb rivers has been undertaken. Therefore, the present study has been undertaken with the aim of providing preliminary information on the fish diversity and relative abundance as well as physico-chemical parameters of Gilgel Gibe and Gojeb rivers.

1.3. Objectives of the study

1.3.1. General objective

The study generally aimed at assessing diversity and some biological characteristics of fishes of Gilgel Gibe and Gojeb rivers as well as some related environmental characteristics that would help in the proper and sustainable exploitation of the fish fauna.

1.3.2. Specific objectives

The study had the following specific objectives:-

- To assess the diversity of fish species in Gilgel Gibe and Gojeb rivers
- To study relative abundance of fish in Gilgel Gibe and Gojeb rivers
- To assess the length-weight relationships and condition factor of the most abundant fish species in Gilgel Gibe and Gojeb Rivers.
- To study sex ratio of the most dominant fish species in Gilgel Gibe and Gojeb Rivers.
- To investigate the relationship of fish species composition with environmental parameters such as dissolved oxygen, water temperature, pH and conductivity.

1.4. Significance of the study

Moreover, studies on diversity, relative abundance, as well as information on environmental characteristics of Gilgel Gibe and Gojeb rivers were virtually non-existent. Therefore, this study was aimed at assessing diversity, relative abundance and some biological characteristics of fishes of Gilgel Gibe and Gojeb rivers as well as some related environmental characteristics that would help in the proper and sustainable exploitation of the fish fauna. The information provided by the study can be useful in the proper and sustainable exploitation of the fish resources of Gilgel Gibe and Gojeb rivers.

2. Literature Review

2.1. Composition of Ethiopian Freshwater Fish fauna

According to Getahun (2003) the freshwater fish fauna of Ethiopia is of particular interest since it contains a mixture of Nilo-Sudanic, East African, and endemic forms. The Nilo-Sudanic forms are represented by a large number of species found in the Baro-Akobo, Omo-Gibe, and Abay drainage basins (e.g. members of the genera *Alestes, Bagrus, Citharinus, Hydrocynus, Hyperopisus, Labeo, Mormyrus* etc.). The southern Rift valley (Lakes Abaya and Chamo), and the Shebele-Genale Basins also have elements of these forms. It is believed that these lakes and river basins had former connections with the upper White Nile (through Lake Rudolf in the former case) as recently as 7500 years ago (Getahun, 2007). These Nilo-Sudanic forms are related to West African fishes and this is believed to be due to past connections of the Nile to Central and West African river systems (Boulenger, 1905).

The highland east African forms are found in the northern Rift Valley lakes (e.g. Lakes Hawassa, Ziwai, Langano), the highland lakes (e.g. Tana and Hayq), and associated river systems, and the Awash drainage basin. These include members of the genera *Barbus, Labeobarbus, Clarias, Garra, Oreochromis,* and *Varicorhinus.* They are related to fishes of eastern, northern and southern Africa. Some elements are shared with waters of western Africa. For example, *G. dembeensis* is a widely distributed cyprinid species found in 6 countries (Ethiopia, Kenya, Egypt, Tanzania, Cameroun and Nigeria). Niloticus fishes are almost entirely absent from the Awash and northern rift valley lakes (Getahun *et al*., 2008).

2.2. The Ethiopian Drainage Basins and Fish diversity

The first review on Ethiopian freshwater by Tedla (1973) listed 93 fish species. Getahun and Stiassny (1998) undertook extensive field work and revisional studies in a large number of the country's drainage basins from 1995 to 1997. They identified 65 species belonging to 19 genera and 9 families with large proportion of the species coming from the cyprinid family and occurring in Abay (Blue Nile) drainage basin. Review papers by Getahun (2003 and 2007), mentioned the occurrence of 153 and 152 valid indigenous fish species and subspecies in 25 and 24 families in Ethiopian freshwater systems respectively and also 10 exotic and 40-41 endemic species and subspecies were described.

Since mid-1980s the freshwater biology group of Joint Ethio-Russian Biological Expedition (JERBE) has undertaken extensive study for 20 years in the country's main drainage basins. This group recently reports the number of indigenous species in the drainage basins to be 180 in 70 genera and 29 families with only 4 or 5 introduced species. According to the JERBE report, the Baro-Akobo basin (the white Nile basin within the limits of Ethiopia) has the most diverse fish fauna, in terms of the total number of species, followed by the Abay (Blue Nile) the Omo-Turkana Basins respectively (Golubstov and Darkov, 2008).

Based on similarities of the fauna (especially the fish fauna) and following the model of Fresh water ecoregions of Africa (Getahun, 2008) the freshwater systems of Ethiopia can be conveniently placed under five freshwater ecoregions. These are the Ethiopian Highlands (includes streams, rivers and lakes in the highlands of Ethiopia, but excluding Lake Tana, because of its unique fish fauna), the Northern Rift (rift valley lakes excluding Lakes Abaya and Chamo because of the Nilo-Sudanic affinities of their fish fauna), the Lake Turkana (includes the Omo River and its tributaries as well as Lakes Abaya and Chamo), the Shebele Juba catchments (includes tributaries of Wabi Shebele, Genale, Dawa, and Fafan), and the Red Sea coastal (the Awash system and the saline lakes of northern Ethiopia that includes Lakes Abbe, Afambo, Afdera, and Asale) drainage basins. According to Getahun (2007) the drainage pattern in Ethiopia is the result of the uplifting during the Tertiary period, which created the Rift Valley and consequently the two separate highlands. Since water bodies found in one drainage basin are somehow interconnected, similarity in their biota is evident.

According to JERBE (2007) these freshwater ecoregions can further be divided into six major drainage basins. These are: Tekeze-Atbara, Blue Nile (Abay, Lake Tana, and Lake Hayq), White Nile (Baro-Akobo), Omo-Gibe-Turkana (Gojeb), Shebele-Juba (Ghenale) and Rift valley (Awash, Bishoftu crater lakes, Zeway, Langano, Abijata, Hawassa, Abaya, Chamo, Chew Bahir or Stephanie) Figure.1

Figure 1. Drainage basins of the country (systematic drawing of the hydrographic network within the limits of Ethiopia) (From: Golubstov and Darkov, 2008).

2.2.1. White Nile (Baro-Akobo) Basin

According to Getahun (2003) the southwestern highlands, south of the Abay trough, are relatively small mountain remnants, rounded in form, with few areas above 2500 m, and dissected by mature river valleys. Many of the tributaries of Baro-Akobo Basin arise from these mountains and hills. The major river systems of the basin include: Alwero, Gilo, Baro, Akobo, Baro Kela, Sore, Geba, Birbir, Bonga and Jejebe Rivers. The Sobat, as the Baro-Akobo is named outside of Ethiopia, derives its water supply mainly from the southern Ethiopian plateau. The Sobat carries a fine mineral (volcanic) sediment of whitish color which persists in the White Nile downstream and may be one of the reasons for the color difference between the White and Blue Nile (Rozska, 1976).

Only eight species were reported from the White Nile drainage system within the limit of Ethiopia prior to the JERBE studies (Tedla, 1973). 113 species belonging to 26 families and 60 genera were identified by JERBE during the past 20 year studies (Golubstov and Darkov, 2008).

The White Nile basin within the limits of Ethiopia far exceeds all other regions of the country in diversity of fish fauna. There are six families (Anabantidae, Channidae, Cromeriidae, Nothobranchiidae, Notopteridae, Protopteridae) which are absent in other drainage systems (Golubstov and Darkov, 2008). According to Mina (2001) in the upper part of this basin the diversity of fish decreases drastically like in other Ethiopian basins. The most commercially important fish species are *Oreochromis niloticus, Clarias* sp., *Polypterus bichir, `Heterotis niloticus, Gymanrchus niloticus, Malapterurus* sp. *Lates niloticus, Alestes* sp. *Hydrocynus* sp. *Mormyrops* sp. *Bagrus* sp., *Barbus* sp. and *Labeo horei*. There are about six endemic species and there is no data on exotic fish species in this drainage basin. The diverse fish fauna of the lowland part of this drainage basin is an extremely valuable resource for fish culture development in Ethiopia (Golubstov and Darkov, 2008).

2.2.2. The Blue Nile Basin

The Blue Nile, which arises from Lake Tana, drains to the central and northwestern plateaus of Ethiopia. According to Getahun (2003) it is the major river of Ethiopia with a length of 1000 km between Lake Tana and the Sudan border and its annual discharge is around 50 billion cubic meters. It receives a great number of tributaries in its upper course in Ethiopia and two further, the Dinder and Rahad, in its lower, Sudanese, course. Although the total drainage area is relatively small, 324,000 km2, it supplies 58% of the total water of the Nile system and almost all the sediment that has built up the alluvial river valley and the Delta in Egypt (Rzoska, 1976). The major supply of the Blue Nile flood is derived from the lower part of the basin especially from the Jamma, Guder, Didessa and Dabus Rivers. Didessa and Dabus on the left bank, rise in the high rainfall region of the southwest region of the country (Tudorancea *et al.*, 1999). The other major tributaries include Belessa, Dabena, Anger, Muger, Beshilo, and Wonchit.

From the Blue Nile drainage within the limits of Ethiopia 30 fish species has been reported (Tedla, 1973), while JERBE recorded 77 fish species belonging to 16 families and 37 genera. The family Cyprinidae is the more diverse group of fish. The Blue Nile drainage basin is characterized by high percentage of endemic species (which is at least 24 endemic species). A quarter of the total number of species recorded consisted of the cyprinids endemic to Lake Tana Basin. Golubstov and Mina (2003) also reported three fish species as introduced into Ethiopia part of the Blue Nile drainage system.

In Lake Tana, the families Cichlidae and Clariidae are represented by only one species each, *Oreochromis niloticus* and *Clarias gariepinus,* respectively. *Afronemacheilus abyssinicus* is an endemic species belonging to the family Balitoridae and inhabit the littoral areas of Lake

Tana.The largest fish family in the lake is Cyprinidae, represented by four genera, *Barbus, Garra, Varicorhinus* and *Labeobarbus.* The genus *Barbus* includes the "small" barbs and is represented by three species, namely, *B. humilis, B. pleurograma* and *B. tanapelagius* (de Graff *et al.,* 2000). *Varicorhinus* is represented by a single species, *V. beso.* The genus *Garra* is represented by four species, G. *dembecha*, *G. dembeensis*, *G. regressus* and *G. tana* (Stiassny and Getahun, 2007).

The *Labeobarbus* and *Barbus* genera have great number of species in the drainage systems which are belonging to the Cyprinid family (Nagelkerke, 1997). The Nile tilapia (*Oreochromis niloticus*) of Lake Tana belongs to a widespread species and has an endemic subspecies, *Oreochromis niloticus tana* within the drainage system (Seyoum & Kornfield, 1992). The only river loach (family Balitoridae) known from Africa, *Afronemacheilus abyssinicus,* was described from Lake Tana in 1902 and rediscovered in 1992 in the lake and in the upper Omo River (Dgebuadze *et al*., 1994) and reported from Sor River at Metu (Getahun and Stiassny, 1998). There are 15 species of *Labeobarbus* forming a unique species flock in Lake Tana, the only cyprinid species flock in the world, after the ones in Lake Lanao vanished because of overexploitation.

The most significant genus of the family Cyprinidae in Lake Tana is *Labeobarbus.* The *Labeobarbus* species of Lake Tana have previously been classified under the genus *Barbus.* However, large, hexaploid African *Barbus* are renamed as *Labeobarbus* (Skelton, 2001). The new genus name better reflects their phylogenetic distance from other members of the overly lumped genus *Barbus. Labeobarbus species* differ not only in their resource partitioning (feeding) but also in their reproductive strategies (de Graff *et al.,* 2005).

2.2.3. The Tekeze- Atbara Basin

This basin includes the Tekeze, the Angereb and the Goang sub-basins. The three rivers form together the Atbara River (in Sudan), which is a tributary of Nile River; entering the Nile at 322 km downstream from Khartoum. Its tributary sources are not far from the Blue Nile in the Ethiopian High Plateau east and west of Lake Tana (Getahun, 2003).

According to Tedla (1973) and before the JERBE surveys of the region nothing was known about the fish fauna of the Tekeze-Atbara drainage system. JERBE reported 34 fish species belonging to 10 families and 22 genera from the Tekeze- Atbara drainage system and the presence of three endemic species and two introduced (exotic) species in this system within the limits of Ethiopia.

2.2.4. Omo-Turkana Basin

Lake Turkana (Rudolf) and the Omo River, the only permanent tributary of the lake, form an isolated basin in the north-eastern part of sub-Saharan Africa. There is evidence that a connection between this basin and the Nile occurred more than once during wet periods in the course of paleoclimatic fluctuations (Beadle, 1981).

The Lake Turkana catchment area is 130,860 km in both Ethiopia and Kenya. The lake is Africa's fourth largest lake, and the world's largest desert lake. The lake is located in Kenya within an area inhabited by interesting and predominantly pastoralist people. The lake is sustained by the inflows of Ethiopia's Omo River, which alone provides 90% of the lake inflow. The Omo Basin is Ethiopia's second largest river system, accounting for 14% of Ethiopia's annual runoff, and being second only to the Blue Nile in runoff volume. Lake Turkana is a closed basin, hence the inflows are totally evaporated over time, and hence the lake waters are almost saline, unfit for consumption, and unsuitable for agriculture. However, the lake has a thriving and diverse fish population (Yu *et al*., 1994).

The Omo River flows south into Lake Rudolf (Lake Turkana) on the border with Kenya. Some rivers such as Gibe River in the Omo River watershed drain the southwestern part of the western highlands of the country (Roberts, 1975). The Omo-Turkana Basin comprises 76-79 fish species belonging to 20 families and 42 genera. Within the Omo River system there are up to eight endemic fish species which are almost a quarter of the fish fauna within the system and no introduced species have yet been recorded (Golubstov and Darkov, 2008).

2.2.5. Shebelle-Juba Basin

According to Basnyat and Gadain (2009) the Juba River is known as the Genale Dawa River within Ethiopia. Wabi Dawa, Genale and Wabi Gestro are the main tributaries of Juba River in its upper catchment which all flow southeastwards. Gestro and Genale unite to form the Juba River just north of Dolo in Ethiopia, and the Dawa joins the Juba River at Dolo having formed the Kenya-Ethiopia border and the Somalia–Ethiopia border in the area west of Dolo.

The Shebelle River flows southeastwards to the Somali border at the border of town of Ferfer. Shebelle and Laga Dera Rivers join Juba River before it reaches the sea although most of the little water left in the two rivers is lost in the swamps before reaching the Juba with the exception during high rainfall. Both Shebelle and Laga Dera are part of the Juba Basin (Basnyat and Gadain, 2009).

Shebele and Juba Drainage Basins are the largest in catchment area and least explored in respect to its fish fauna among basins of the country. Tedla (1973) reported 14 fish11species and the works of JERBE group have described 33 fish species within 21 genera and 12 families. This region is inhabited with the most distinct ichthyofauna species of the East Africa fish taxa (such as the Characid *Alestes affinis* the Cyprinid *Neobola bottegoi* and the Cichlid (*Oreochromis spilurus*) and has two–three exotic species.

2.2.6. Rift Valley Basin

The rift valley system constitutes the rift valley drainage basin consisting of Awash River and various lakes including lakes in the Afar triangle, Bishoftu crater lakes, Zeway, Langano, Abijata, Hawassa, Abaya, Chamo, Chew Bahir (Stephanie). The highlands in Ethiopia gradually slope to the lowlands of Sudan on the west and the Somali plains to the southeast. The Ethiopian Rift Valley is a dominant feature of the Ethiopian geography which divides the highlands of central Ethiopia before it widens and falls to and below sea level in the Afar depression, from which rifting continues in two arms as the Red Sea and the Gulf of Aden. North-eastwards from the Lake Koka the land drops very steeply, and a number of small lakes including Lake Metahara (Beseka) and Lake Hertale are strung along the valley of the Awash River, which ends in series of lakes (e.g. Lake Gamari, Lake Abe) and saline swamps in the Afar Depression. Another group of saline lakes (e.g. Lake Afdera; Lake Assale) lies in the Danakil Depression which extends to more than 100m below sea level in the Afar region (Abegaz, 2010).

There are many isolated basins within the Ethiopian Rift valley, making it distinct from the other regions of the country. Most of the country's inland water bodies are confined within the rift valley, forming a spectacular chain of lakes and large feeder rivers that originate from the adjacent highlands. The permanent rift valley lakes are mainly found in the central and southern parts of the Ethiopian rift. Most of the Ethiopian rift valley lakes are productive, containing indigenous population of edible fish and supporting a variety of aquatic and terrestrial wildlife. According to Golubtsov and Mina (2003) the Ethiopian Rift valley are home for about 30 different native species of fish fauna. However, the distribution of fish diversity within the Rift valley is extremely uneven.

The Awash River basin alone comprises 11 fish species, which is about 37% of the fish fauna in the Ethiopian Rift Valley and the southern Ethiopian Rift valley (Lake Abaya and Chamo) comprises the highest diversity of fish fauna, 20 fish species (Golubtsov and Mina, 2003). Generally, the Ethiopian rift valleys harbor 28-31 species in 11 families and 18 genera. It also includes at least five endemic species and four introduced species.

2.3. Physico-chemical parameters

Each freshwater body has an individual pattern of physical and chemical characteristics which are determined largely by the climatic, geomorphological and geochemical conditions prevailing in the drainage basin and the underlying aquifer. Characteristics, such as total dissolved solids, conductivity and redox potential provide a general classification of water bodies of a similar nature. Mineral content, determined by the total dissolved solids present, is an essential feature of the quality of any water body resulting from the balance between dissolution and precipitation. Oxygen content is another vital feature of any water body because it greatly influences the solubility of metals and is essential for all forms of biological life (UNEPA, 1991)

2.3.1. Temperature

Temperature is an important parameter in aquatic environments as it influences many aspects of stream physical, chemical, and biological health. Most aquatic organisms have limited optimal temperature ranges which affect survival, spawning success and metabolic rates. In cold water systems, small fluctuations in temperature can have profound effects on an individual’s vital rates, which at the population level can mediate connectivity patterns (Laurel and Bradbury, 2006). The temperature response for fish is highly variable among species and populations, necessitating the measurement of temperature effects on a species-by species basis. Annual temperature changes provide the stimulus for emergence of insects and spawning of fish. Because the high specific heat of water results in relatively slow rates of temperature change, aquatic species are buffered from the wide variations in temperature (Pepin, 1991).

2.3.2. pH

A pH is an important variable in water quality assessment as it influences many biological and chemical processes within a water body and all processes associated with water supply and treatment. A pH level is an important parameter that affects the abundance of zooplankton population (Chapman, 1996). A pH value outside the range 6.5 to 8 reduces the biodiversity in a lake because it stresses the physical system of most organisms and can reduce reproduction. Low pH can also allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals thereby producing conditions that are lethal to aquatic life, particularly to sensitive species (USEPA, 1991).

2.3.3. Dissolved oxygen

The dissolved oxygen concentration depends on the physical, chemical and biochemical activities in the water body, and its measurement provides a good indication of water quality. Changes in dissolved oxygen concentrations can be an early indication of changing conditions in the water body. DO is one of the most important parameter. Its correlation with water body gives direct and indirect information e.g. bacterial activity, photosynthesis, availability of nutrients, stratification etc (Premlata, 2009).

Variations in DO can occur seasonally, or even over 24 hour periods, in relation to temperature and biological activity (i.e. photosynthesis and respiration). Biological respiration, including that related to decomposition processes, reduces DO concentrations. Waste discharges high in organic matter and nutrients can lead to decreases in DO concentrations as a result of the increased microbial activity (respiration) occurring during the degradation of the organic matter In the progress of summer, dissolved oxygen decreased due to increase in temperature and also due to increased microbial activity (Moss, 1972). The high DO in summer is due to increase in temperature and duration of bright sunlight has influence on the % of soluble gases (O_2 & CO_2). During summer the long days and intense sunlight seem to accelerate photosynthesis by phytoplankton, utilizing CO_2 and giving off oxygen. This possibly accounts for the greater qualities of O_2 recorded during summer (Krishnamurthy, 1990).

Determination of DO concentrations is a fundamental part of a water quality assessment since oxygen is involved in, or influences, nearly all chemical and biological processes within water bodies. Concentrations below 5 mg l-1 may adversely affect the functioning and survival of biological communities and below 2 mg l-1 may lead to the death of most fish. The measurement of DO can be used to indicate the degree of pollution by organic matter, the destruction of organic substances and the level of self-purification of the water. Its determination is also used in the measurement of biochemical oxygen demand (BOD) (UNEPA, 1991).

2.3.4. Conductivity

The ability of water to conduct an electric current is known as conductivity or specific conductance and depends on the concentration of ions in solution. Conductivity is measured in millisiemens per meter (1 mS m-1=10 μS cm-1 = 10 μmhos cm-1).Conductivity shows significant correlation with ten parameters such as temperature, pH value, alkalinity, total hardness, calcium, total solids, total dissolved solids, chemical oxygen demand, chloride and iron concentration of water (Navneet and Sinha , 2010).

Electrical conductivity can be used as an index of total dissolved solids and, in some cases, as a predictor of concentrations for individual ions. EC can also be used to interpret the changing sources of run off on both diurnal/storm event and seasonal time scales, and to provide information about the contrasting hydrologic behavior of specific catchments. Because ground water commonly differs chemically from stream water, ground water discharge zones often coincide with relatively rapid changes in water chemistry along a stream, which can be detected by measuring along-stream variations in EC. Inferences regarding ground water discharge can be made more confidently by combining EC measurements with other observations, such as hydraulic gradients across the streambed, water temperature, and stream flow Measurements (Moore and Richards,. 2008*)*.

2.3.5 Secchi Depth

Turbidity is a measurement of the cloudiness in water and is caused by suspended sediments and plankton. Clarity for ponds, lakes, estuaries, and oceans is measured with a Secchi Disk. The measurement is referred to as a Secchi Disk Transparency. For freshwater lakes the black and white Secchi Disc should be used. Normally a Secchi Disk 20 cm in diameter is used. For large, deep, oligotrophic freshwater lakes it may be more suitable to use an all white oceanographic disc. For salt-water bodies of water, such as oceans, bays, or estuaries, use an oceanographic Secchi Disc (all white) with a standard diameter of 51cm (CWTGC, 2010).

Water clarity is primarily affected by algae and suspended sediments. Algae are naturally occurring microscopic plant life found in most water bodies. Algae, mostly growing as single cells or in colonies, are part of a healthy lake ecosystem. Their photosynthetic processes are a source of oxygen for the lake and its organisms. Also, many lake organisms depend on algae as a basic food source (Simpson, 1991).

2.3.6. Related habitat character

Varies type of plants with different size from single Algae to large plants (tree, shrub and herbs) can grow in and out of water body. Aquatic weeds are those unabated plants which grow and complete their life cycle in water and cause harm to aquatic environment directly and to related eco-environment relatively. Aquatic weeds often reduce the effectiveness of water bodies for fish production. Aquatic weeds can assimilate large quantities of nutrients from the water reducing their availability for plank tonic algae. They may also cause reduction in oxygen levels and present gaseous exchange with water resulting in adverse fish production. Although excessive weed growth may provide protective cover in water for small fish growth it may also interfere with fish harvesting (Lancar *et al*., 2002)

3. Materials and Methods

3.1. Description of the study area

The study encompassed Omo Nada and Shebe Sombo districts of Jimma Zone in Oromia Regional State, Southwestern Ethiopia. Omo Nada district (Gilgel Gibe River site) is one of the eighteen districts in Jimma Zone located some 227 km of Addis Ababa and at 57 km East of Jimma town. It is approximately located between 07º45.396'N latitudes and 037º13.329'E longitudes (Figure-2). Shebe Sombo district (Gojeb River site) is also one of the eighteen districts of Jimma zone. It is located at the border between the Oromia Regional State and South Nation Nationalities and Peoples Regional state at some 409 km of southwest of Addis Ababa and 75 km west of Jimma town. It is approximately located between 07º24.805'N latitudes and 036º22.516'E longitudes.

The major types of vegetation available in the Omo Nada district include Coffee, *Croton macrostachyus*, *eucalyptus* tree and riparian vegetations. As to wild life, there are different species of wild animals in the district. Some of the major types of wild animals in the district include Baboon, Vervet Monkey, Colobus Monkey, Wild Pig, Porcupine, Fox, Aardvark, Blue Monkey, different species of birds and Duiker/Antelope (Courtney, 2005).

Fishing occurs on both Gilgel-Gibe and Gojeb Rivers largely for household consumption and for sale to earn income by the local people. Fishing is much prevalent mainly during the rainy season. Fishing gears employed in the area include hooks, traps (fish baskets) and rarely gillnet made from nylon rope. Fishing crafts used in Gilgel Gibe River are local wooden boats. However, in Gojeb River there are no boats; the fishermen instead use floats obtained from old vehicle tires. There are no organized fishermen at both rivers and fishing is solely an individual activity.

3.2. Climate data of the study area

The climate data for air temperature and rainfall over the last five years (2009-2013) for both of the Study Rivers was obtained from Jimma meteorology station. The maximum and minimum annual temperatures of (Gojeb) Shebe-Sombo district is 26.88°C and14.22°C, respectively (Figure 2). The maximum and minimum annual rainfall of the District is 1580.84mm/year, with high variation from year to year. The rainfall pattern is uni-modal, with low rainfall during January and February and the highest rainfall between June and August (Figure 4).

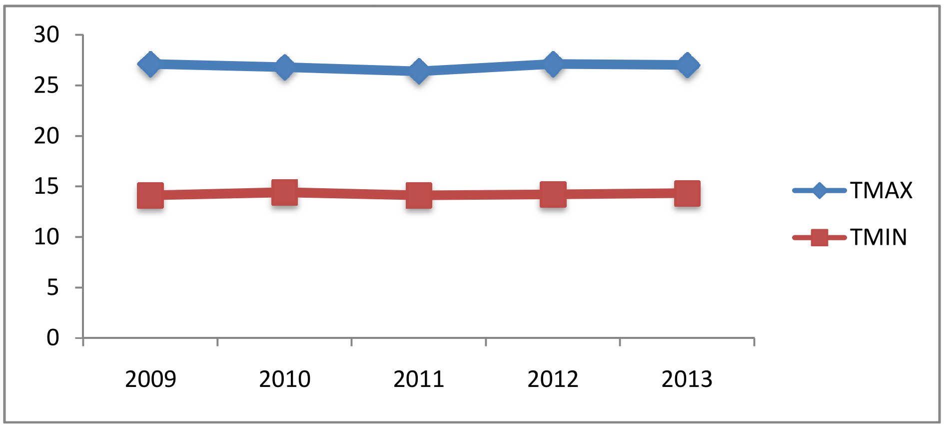


Figure 2. The mean annual minimum (Min) and maximum (Max) temperature at Gojeb (shebe Sombo) from 2009-2013 (National Meteorological Agency, Jimma Branch, 2014)

The mean maximum and minimum annual temperatures of Asandabo (Omo nada) district was27.86°C and11.62°C, respectively (Figure 3).

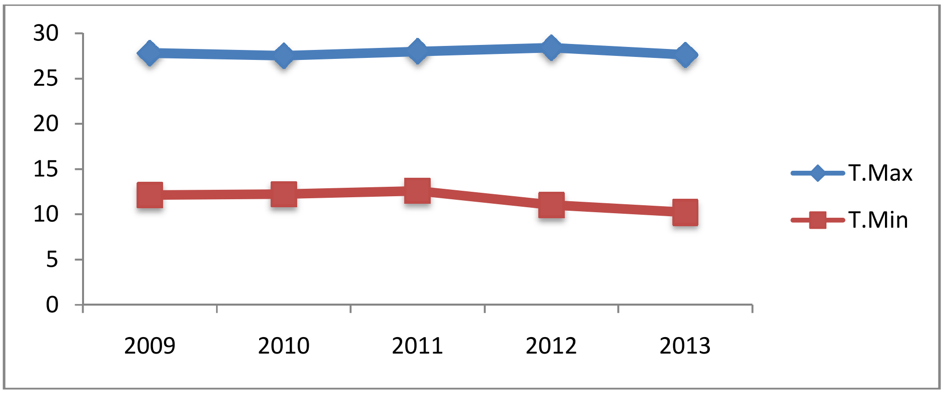


Figure 3. The mean annual minimum (Min) and maximum (Max) temperature at Omo nada from 2009-2013 (National Meteorological Agency, Jimma Branch, 2014

The mean annual rainfall of the Omo nada District is 1081.18 mm/year with high variation from year to year (Figure 4). The rainfall pattern is uni-modal, with low rainfall during January and February and the highest rainfall between June and August (National Meteorological Agency, Jimma Branch, 2014).

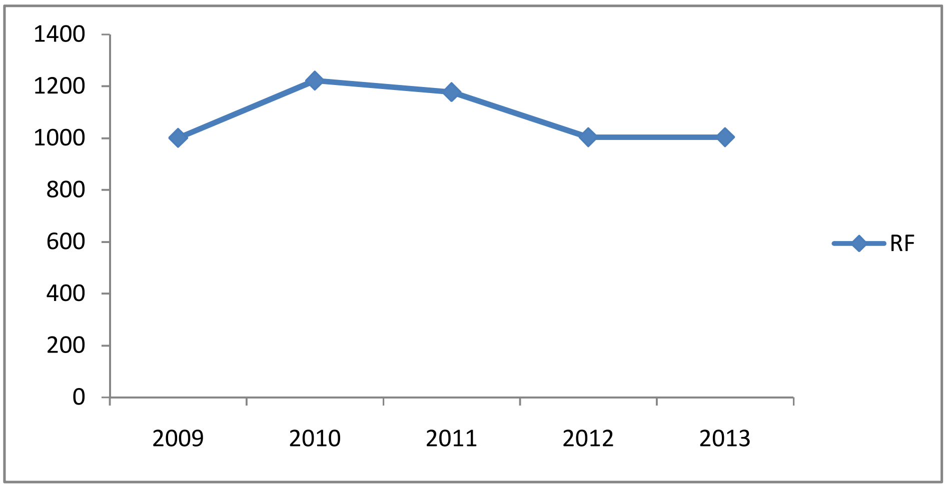


Figure 4. The mean annual Rainfall of Omo nada District from 2009-2013 (National Meteorological Agency, Jimma Branch, 2014)

3.3. Site selection

Gilgel Gibe and Gojeb rivers were each sampled at two major localities which in turn were sampled at two sub-sites. Selection of the sampling localities and sites were mainly based on accessibility, habitat type (pool/riffle) and substrate type (muddy, sandy, etc). The sampling localities and sites were fixed using Geographical Positioning System (GPS).

Table 1.Sampling sites

River	Site & Code	Habitat type	Width (m)	Coordinate (3D GPS)	Altitude (m asl)
Gilgel Gibe	Ture (Gg1-1)	Pool, riffle, Turbid water, gravel and muddy	47	07º46.363'N 037º12.467E	1680m
	Ture (Gg1-2)	Pool, riffle, Turbid water,	49	07º46.461'N 037º12.433'E	1679m
	Mankaros (Gg 2-1)	Gravel and muddy pool,reffile	45	07º46.567'N 037º12.382'E	1676m
	Mankaros (Gg 2-2)	Pool, riffle, Turbid water	44	07º46.692'N 037º12.412'E	1676m
Gojeb	Belete (Gj 1-1	Pool, riffle, Turbid water,	56.36	07º24.990'N 036º22.740'E	1289m
	Belete (Gj 1-2)	Gravel and muddy, pool, riffle	54	07º25.126'N 036º22.746'E	1287m
	Getachew (Gj 2-1)	Pool, riffle, Turbid water,	44.5	07º25.200'N 036º22.762'E	1290m
	Getachew (Gb 2-2)	Gravel , muddy, pool, riffle	42.75	07º25.217'N 036º22.877'E	1291m

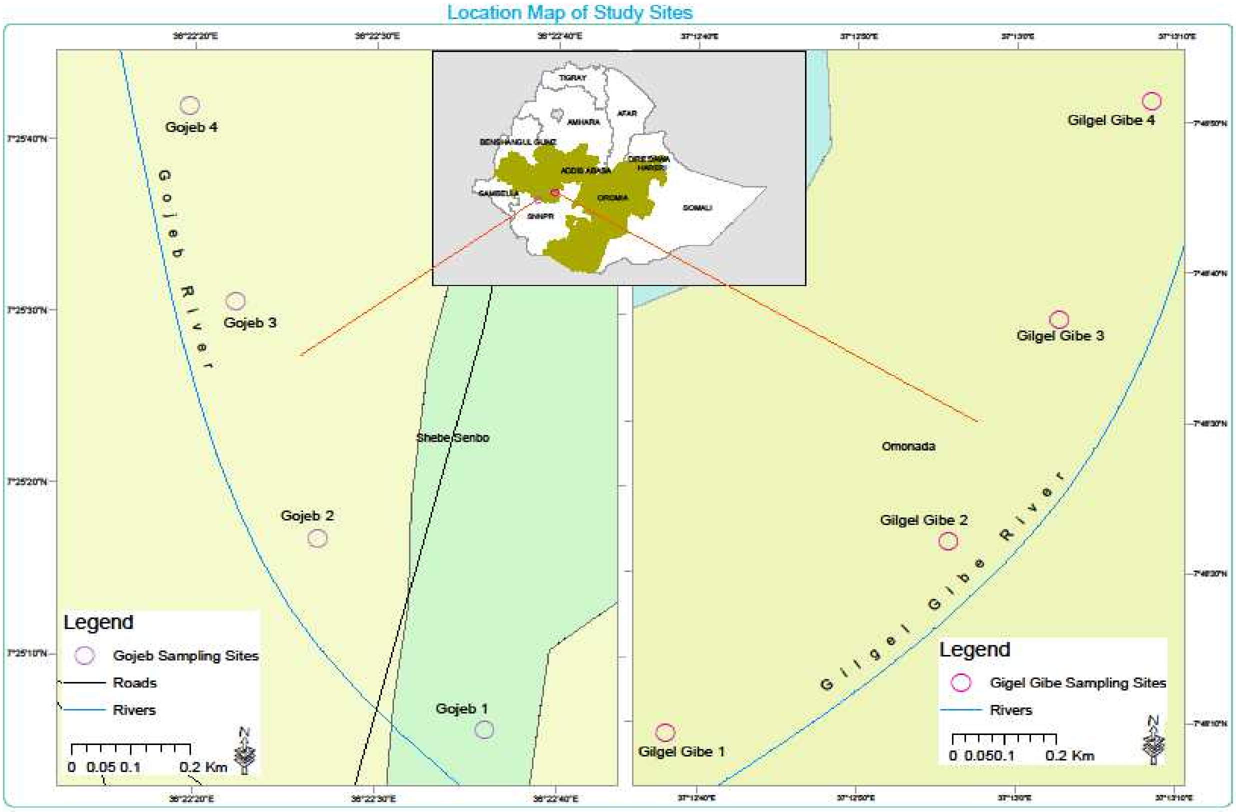


Figure 5.Map of the study sites

3.4. Fish Sampling

Fish specimens were collected from each site during two seasons: dry season (January to March 2014) and the wet season (June to August 2014). Samples were collected using gillnet of various mesh sizes (4, 6, 8, 10 and 12 cm stretched mesh) and hooks. All gill nets were set by using local fishermen across the width of the river during dry sampling period when the water volume is less and parallel to the river flow during wet season when the water discharge was high. Gillnets were set late in the afternoon and then collected in the next day. Immediately after capture, total length (to the nearest 0.1 cm), and total weight (to the nearest 0.1g) of all specimens were measured at the sampling sites. Fish specimens from each species were preserved in 10% formalin for further investigation in the laboratory.

3.5. Fish Identification

Fish identification was made to species level using relevant taxonomic keys (Tedla, 1973; Golubtsov *et al.*, 1995; Stiassny and Getahun, 2007; Habteselassie, 2012). Morphometric and meristic characters of the identified fish species was summarized (Appendix 4-9). Moreover, the specimens were compared with figures and illustrations found in different literature and figures from the internet. Finally, the specimens were labeled and deposited at the Zoological Laboratory, Department of Biology, Jimma University.

Plate-1. Laboratory identification of fish Species

3.6. Physico-chemical parameters and related habitat characters

The Physico-chemical parameters such as water temperature, pH, conductivity, dissolved oxygen and Secchi depth were measured directly in situ at all sampling sites concurrently during the fish sampling. Water temperature and dissolved Oxygen (DO) were measured using an oxygen meter provided with a built in Oxygen and temperature sensor (970 DO meter, England), pH with pH meter (370 pH meter England) and Secchi depth was measured by using black and white Secchi Disc. Various habitat characteristics such as (pool/riffle) and substrate type (muddy, sandy, etc) of the study sites were summarized by taking estimation of the relative composition.

3.7. Data Analysis

Data were analyzed using the SPSS for Windows version 16 and Microsoft Excel for windows 7. Variations in the mean values of Physico-chemical parameters between the two rivers were analyzed using One Way ANOVA. Moreover, various specific variables were computed as described below. The association between fish composition and environmental variables was analyzed using canonical correspondence analysis (CCA) in CANOCO software version 4.5.

3.7.1. Diversity Index

Shannon - Weiner diversity index (H') was used for estimating the diversity of fish species for each sampling site and the whole basin (Begon *et al*., 1990).

$$H' = -\sum_{i=1}^{n}(\mathrm{ni/N})(\mathrm{lnni/N})$$

Where,

Where, i = number of 1 to n

ni = number of individuals of species "i"

N = total number of individuals of all species

H' = the Shannon- Weiner Diversity Index

3.7.2. Relative Abundance

Relative abundance is the number of organisms of a particular kind as a percentage of the total number of organisms of a given area or community. Estimation of relative abundance of fishes in Gilgel Gibe and Gojeb Rivers were made by comparing the relative catch both in number and weight in the total sampling. Moreover, the relative contribution in number and weight of each species to the relevant catch or sample composition was computed using an index of relative importance (IRI). IRI is a measure of the relative abundance or commonness of the species based on number and weight of individuals in catches, as well as their frequency of occurrence (Kolding, 1989) and computed as:

$$\%IRI = \frac{(\%Wi + \%Ni) \times \%Fi}{\sum_{i=1}^{s}(\%Wj + \%Nj) \times \%Fj} \times 100$$

Where, j=1 to S, % W_i and % N_i are percentage weight and number of each species of total catch, respectively; % F_i is percentage frequency of occurrence of each species in total samplings. % W_j and % N_j are percentage weight and number of total species of total catch, respectively. % F_j is percentage frequency of occurrence of total species in total number of samplings and S is the total number of species.

3.7.3. Length-Weight Relationship

The relationship between total length and total weight of the dominant fish species of Gilgel Gibe and Gojeb rivers were fitted using power function as shown below (Bagenal and Tesch, 1978):

$$W = a (L_t)^b$$

Where, W is total weight of fish in gram, Lt is total length of fish in cm, and “a” and “b” are constants of the equation.

The degree of W-Lt relationship was tested using a linear regression run on the log10 linearzed form of the data as:

$$\text{Log } W = \text{Log } a + b \text{ Log } Lt$$

Where, LogW = Y, Log Lt = X, Log a= intercept, and b is slope of the regression line.

3.7.4. Condition Factor

Condition factors are used for comparing fatness or well-being of fish, based on the assumption that heavier fish of a given length are in better condition. It is known that condition factor parameters depend on factors including biological and environmental, as well as geographical and temporal, such as the age and condition of the fish or the season of year when samples are collected (Ferreira *et al*., 2008; Vaslet *et al*., 2008; Nowak *et al*., 2009). Generally, higher condition is associated with higher energy content, adequate food availability, reproductive potential and favorable environmental conditions (Pauker and Coot, 2004).

The well-being of dominant fish species of the Gilgel Gibe and Gojeb was investigated by using Fulton's condition factor (Lecren, 1951; Bagenal and Tesch, 1978). Fulton's condition factor (FCF) was calculated by using the following formula:

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

3.7.5. Sex-ratio

Sex ratio is the proportion of females to males. Each specimen was dissected and the gonads were removed after dissection. The sex of each specimen was identified by visual examination of the gonads. In adults, eggs are usually obvious in the ovaries and in males the testes are typically smooth, whitish organs along the dorsal surface of the body cavity. The sex organs of immature fish appeared as long, thin organs along the dorsal surface of the body cavity; females were a pinkish color while males were translucent to whitish. The actual number of fish whose sexes were successfully determined was considered for sex ratio and the sex ratio expressed as the ratio of number of males to females was analyzed. The significant Variations from the hypothetical 1:1 ratio were determined using Chi square test at 5 % significance level.

$$Sex\ ratio = \frac{number\ of\ males}{number\ of\ females}$$

4. Results

4.1. Fish species diversity

A total of nine fish species included in seven genera, six families and five Orders were identified from Gilgel Gibe and Gojeb rivers during the study period (Table 2). Among these fish species, *Oreochromis niloticus* were collected from only Gilgel Gibe River while *Labeobarbus nedgia*, *Bagrus bajad*, *Heterobranchus bidorsalis*, *Brycinus macrolepidotus*, *Mormyrus kannume and Raiamas senegalensis* were collected from only Gojeb River. *Labeobarbus intermedius* and *Labeo forskalii* were recorded from both Gilgel Gibe and Gojeb rivers.

Table 2.Fish species of Gilgel Gibe and Gojeb rivers

Order	Family	Species	Local Names	Site/River
Osteoglossiformes	Mormyridae	*Mormyrus kannume*	Elektirikii	Gojeb
Characiformes	Alestiidae	*Brycinus macrolaidatus*	-	Gojeb
Cypriniformes	Cyprinidae	*Labeo forskalii*	Garbittii	Gilgel Gibe & Gojeb
		Labeobarbus intermedius	Adii	Gilgel Gibe & Gojeb
		Labeobarbus nedgia	-	Gojeb
		Raiamas senegalensis	Magaadee	
Siluriformes	Bagridae	*Bagrus bajad*	Najjillee	Gojeb
	Clariidae	*Heterobranchus bidorsalis*	Ambaza	Gojeb
Perciformes	Cichlidae	*Oreochromis niloticus*	Qoroso	Gilgel Gibe

The Shannon diversity index (H’) was computed for fishes of the Gilgel Gibe and Gojeb rivers using PAST software as summarized in Table 5.

Table 3. Shannon diversity index for Gilgel Gibe & Gojeb rivers for the study period (N = the total number of specimens, NS =total number of species for each river).

River	N	NS	H'
Gilgel Gibe	134	3	0.636
Gojeb	122	8	0.692

4.2. Description of Fish species

4.2. 1. *Oreochromis niloticus* (Linnaeus, 1758)

Synonyms: (Roskov *et a*l., 2014)
Chromis guentheri Steindachner, 1864

Chromis nilotica (Linnaeus, 1758)

Chromis niloticus (Linnaeus, 1758)

Description: Dorsal fin with XVI-XVII Spines and 11-13 soft rays (average 17 spines and 13 soft rays; number of lateral line scales average of the arch; villiform teeth on the jaw; single nostrils on each side of head; body covered with ctenoid scales; black spot on the upper part of each operculum; pectoral fin relatively shorter and rarely extending to anal fin origin; caudal fin truncate in shape; thoracic pelvic fin; single nostril on each side of the snout; average total length (TL) 20.1cm; average Standard length (SL) 16.7cm.

Diagnosis: Most distinguishing characteristic is the presence of regular vertical stripes throughout depth of caudal fin

Distribution: in West Africa, the natural distribution area covers the basins of the Senegal, Gambia, Volta, Niger, Benin and Chad; *Oreochromis niloticus* is one of the African's most important fish culture species; it has been introduced in many fish culture stations, from where it has regularly escaped; therefore, it has often been reported from several coastal West African basins: in all drainage basins of Ethiopia.

Present Locality: six specimens of the species were sampled from Gilgel Gibe River during this study period.

Coloration: Body yellowish brown above, whitish below, caudal fin with narrow vertical stripes.

Habitat: Freshwater, Brackish

Plate 2. ***Oreochromis niloticus***

4.2.2. *Bagrus bajad* (Forsskål, 1775)

Synonyms:

Bagrus bayad (Forsskål, 1775)

Bagrus bayad bayad (Forsskål, 1775)

Bagrus bayad macropterus Pfaff, 1933

Bagrus bayed macropterus Pfaff, 1933

Porcus bajad (Forsskål, 1775)

Porcus bayad (Forsskål, 1775)

Porcus docmac bayad (Forsskål, 1775)

Silurus bajad Forsskål, 1775

Silurus bayad Forsskål, 1775

Description: Dorsal I spiny and 10 branched rays; gill rankers long; 11 on lower part of first gill arch; head depressed and broad; eye with a free border; sub-terminal mouth with wide and smooth above; jaws with a band of villiform teeth; snout broadly rounded, projecting beyond the lower jaw; four pairs of circum-oral barbells showing great variation in length.

Diagnosis: Distinguished by having dorsal fin rays not filamentous; the longest maxillary barbell extending nearly to base of ventral; the last rays of dorsal fin situated in advance of the center of the pelvic fin; 8 branched in dorsal fin and 11 rays in anal fin; deeply forked caudal fin with only upper lobe extending into a long filament.

Distribution: White Nile, Blue Nile, Omo-Turkana, Lake Abaya, Lake Chamo and Lake Chew Bahr basins in Southern Rift Valleys.

Present Locality: 20 specimens of the species were sampled from Gojeb River in the present study.

Coloration: Dark grey-black above, creamy-white below.

Habitat: Freshwater

Plate 3 *Bagrus bajad*

4.2.3. *Heterobranchus bidorsalis* Geoffroy Saint-Hilaire, 1809

Synonyms:

Heterobranchus geoffroyi Valenciennes, 1840

Heterobranchus intermedius Günther, 1864

Heterobranchus senegalensis Valenciennes, 1840

Hetrobranchus bidorsalis Geoffroy Saint-Hilaire, 1809

Description: Average of 38 dorsal fin rays; 38-45 rays on dorsal fin. *H. bidorsalis* is easily distinguished from the other species of the genus by its rather short adipose fin (22-27 % of standard length) and relatively long-rayed dorsal fin (37-42 % of standard length); no scale on the body; number of gill rakers on first gill arch: 17-27 (20-21 for this study); four pairs of barbers on head part.

Diagnosis: Easily distinguished from the other species of the genus by its rather short adipose fin

Distribution: White Nile and Blue Nile basin

Present Locality: four specimens are collected from Gojeb River for this study.

Habitat: Freshwater, Brackish

Plate 4 *Hetrobranchus bidorsalis*

4.2.4. *Labeo forskalii* Rüppell, 1835

Synonyms: *Labeo forskalii* (non Rüppell, 1836), *Labeo greenii* (non Boulenger, 1902

Diagnosis: Dorsal fin with ’I’ unbranched and 9-11 branched rays (9-12 total rays on dorsal fin); 38-42 scales in the lateral line; eyes are supero-lateral entirely visible from the above; it has very much developed labial fold forming a sort of sucker around the mouth; the species has horny tubercles on its snout.

Description: One minute barbell on each side of head; mouth inferior and well developed labial folds; inner surface of lips with transverse folds; the upper edge of dorsal fin is long and concave in shape; minute barbells concealed under the fold of skin in the corner of mouth; the species has abdominal pelvic fin; maximum total length (TL) 48cm and 37 cm standard length (SL) for this study.

Coloration: Dark violet or bluish above and on the sides.

Distribution: Omo Turkana, White Nile and Atbara Tekeze systems.

Present Locality: Large numbers of specimens of the species were recorded from Gojeb River (11 specimens from Gojeb River and about three specimens from Gilgel Gibe River during dry season.

Habitat: Freshwater

Plate 5 Labeo forskalii

4.2.5. *Labeobarbus intermedius (*Rüppell, 1835)

Synonyms: (Roskov *et a*l., 2014)

Diagnosis: Moderately developed dorsal spine present; body depth shallow, 28.3% of Standard Length. Mouth and body shape variable.

Description: No teeth on the jaws; body variable in shape, covered with cycloid scales; 29-30 scales in the lateral line; two pairs of small barbells on each side of the snout; both dorsal and anal fins are short; pelvic fin abdominal; forked caudal fin; total length 26cm; Standard length 20cm.

Coloration: Light yellow.

Distribution: Widely distributed in all drainage systems of the country including Lake Tana.

Present Locality: Large number of *L. intermedius* were sampled from Gilgel Gibe (76 specimen) and (16 specimen) from Gojeb River in this study (during dry season).

Habitat: Freshwater

Plate 6 Labeobarbus intermedius

4.2.6. *Labeobarbus nedgia* (Rüppell, 1835)

Synonyms: (Roskov *et a*l., 2014)

Barbus degeni Boulenger, 1902

Barbus degeni leptorhinus Bini, 1940

Barbus duchesnii leptorhinus Bini, 1940

Diagnosis: Lower lip forming a distinct median lobe and upper lip well developed; head length less than 1.2 times in body depth. It has flesh nose that curls back over the nose.

Description: Lower lip highly developed with fleshy median lobe and large flaps of the upper lip. The mouth is sub-terminal and protractile. No teeth on the jaws. 30-34 scales on lateral line; dorsal ray with I Spiny and 10-11 soft rays; a pair of barbells on each side of the snout; average Total length (TL) 33.16cm; Standard length 29.33cm.

Coloration: White yellow.

Distribution: Endemic to Lake Tana (Nagelkerke, 1997).

Present Locality: all specimens were collected from Gojeb River, Omo gibe basin.

Habitat: Freshwater.

Plat 7 *Labeobarbus nedgia*

6.2.7 *Mormyrus kannume* Forsskål, 1775

Synonyms:

Mormyrus bachiqua Valenciennes, 1847

Mormyrus hildebrandi (non Peters, 1882)

Mormyrus nacra Valenciennes, 1847

Mormyrus oxyrhynchus Lacepède, 1803

Murmyrous kannume Forsskål, 1775

Description: Snout prolonged into a proboscis, mouth small; dorsal fin with 60-74, anal with 21-29 rays; dorsal fin beginning distinctly in advance of pelvic, its base 2.4-3.4 times longer than anal-fin base; scale counts: 83-97 in lateral line and 10-15 around caudal peduncle. Body depth comprised from 4.1 to 6.1 times in standard length; caudal peduncle 2.5-4.1 longer than deep; teeth numbering 3-5 in upper, and 5-10 in lower jaw; maximum reported size: 430 mm SL. Head covered with white sheath

Diagnosis: Snout prolonged into a proboscis, mouth small; dorsal fin with 60-74.

Color: Silvery, back darker and belly lighter.

Distrubiution : Blue Nile,White Nile,Atbara Tekeze,and Omo- Turkana.

Present Locality: two specimens are collected from Gojeb River for this study in wet season

Plate.8 *Mormyrus kannume*

4.2.8 *Brycinus macrolepidotus* Valenciennes, 1850

Synonyms:

Alestes macrolepiditus (Valenciennes, 1850)

Alestes macrolepidotus (Valenciennes, 1850)

Alestes rutilus Boulenger, 1916

Description: Dorsal-fin origin behind level of pelvic-fin insertions; head flattened above. Anal fin with three spines and 12-14 branched rays. 24 scale on lateral line; lower limb of first gill arch with 14-22 gill racers.

Diagnosis: Dorsal-fin origin behind level of pelvic-fin insertions; head flattened above

Color: body with Black greenish, belly white; sides sometimes with an orange-colored.

Distribution: Omo- Turkana, Blue Nile,White Nile,and Atbara Tekeze

Present Locality: two specimens are collected from Gojeb River for this study in wet season

Plate 9. *Brycinus macrolepidotus*

4.2.9. *Raiamas senegalensis* (Steindachner, 1870)

Synonyms:

Barilius loati Boulenger, 1901

Barilius macrostoma Boulenger, 1913

Barilius senegalensis Steindachner, 1870

Barilius senegalensis orientalis Blache & Miton, 1961

Barilius senegalensis senegalensis Steindachner, 1870

Raiamas loati (Boulenger, 1901

Raiamas macrostoma (Boulenger, 1913)

Description: Sub-terminal mouth. A pair of nostril on each side of the snout; elongated body shape; dorsal head profile more or less straight; 9 soft rays in dorsal fin and 10 soft rays in anal fin. Body covered with cycloid scales. Smaller intercalary spots on the anterior portion of the body; 54 scales on the lateral line; abdominal pelvic fin; total length 28cm; Standard length 23cm.

Diagnosis: 12 vertical black bars whose height diminishes progressively from front to back of body; forked caudal fin with symmetrical pointed lobes; silvery body with greenish back.

Coloration: Silvery body with greenish back and orange fins

Distribution: Omo River and White Nile (reported as R. loati in Golubtsov *et al*., 1995), Blue Nile and Atbara Tekeze system, Southern Rift Valley.

Present Locality: Only one specimen of this species was sampled from Gojeb River.

Habitat: Freshwater

Plate 10. *Raiamas senegalensis*

4.3. Relative abundance of fishes

A total of 256 fish specimens were collected from eight sampling sites during the study period. Of the total specimens collected, 104 were caught during the wet season and 152 specimens were caught during the dry season. A total of 122 (45.45 %) from Gojeb River, 67 during dry and 55 during wet season and 134(52.549 %) from Gilgel Gibe river, 85 during dry and 49 during wet season were caught. *Labeobarbus intermedius* was the most abundant species in number both in wet and dry seasons followed by *Bagrus bajad*, *Labeo forskalii*, *Labeobarbus nedgia* and *Oreochomis niloticus* and they contributed 65.49 %, 11.76%, 5.49 % and 4.70 % of the total catch respectively. *Heterobranchus bidorsalis* had one specimen during wet season; *Brycinus macrolaidatus and Mormyrus kannume* had two specimens each and were collected only during wet season. *Raiamas senegalensis* had only one specimen collected in dry season (Table 4).

The total weight of all fish specimens were 80.07kg of which 40.86kg (51.03 %) was collected during dry season and 39.21kg (48.97 %) during wet season. A total of 46.00kg (57.45 %) was collected from Gojeb River, 20.925kg (26.132 %) during dry season and 25.08kg (31.318 %) during wet season while 34.07kg (42.55 %) was collected form Gilgel Gibe River, 19.94kg (24.89 %) during dry season and 14.132kg (17.65 %) during wet season. In both Rivers *Labeobarbus intermedius* had a total weight of 44.682kg which accounts (55.80 %) of the total weight of all specimens collected during the study period. Therefore, it was the most abundant fish species in weight. *Bagrus bajad* was the second most abundant fish species which contributed 8.768kg (10.950 %) in weight. *Labeo forskalii was* the third most abundant fish species which contributed 7.325kg (9.150 %) in weight. *Brycinus macrolepidotus* was the least abundant fish species which comprised 0.71kg (0.8 %) by weight.

The index of relative importance values that include both the number and weight of fish have been summarized in Table 4. *Labeobarbus intermedius* constituted 52.04 and 34.84 % of IRI Gilgel Gibe and Gojeb rivers respectively. *Bagrus bajad* comprised 13.54 % of IRI. *Labeo forskalii* comprised 8.30 % of IRI. *Raiamas senegalensis* was the least abundant fish species which comprised 0.62 % of IRI. Although *Labeo forskalii* occurred in both rivers it has been excluded from computation of IRI in Gilgel Gibe River due to its less number of specimens (Table-4).

Table 4. A summary of %N, %W, %Fi and %IRI of fish species collected during the study period

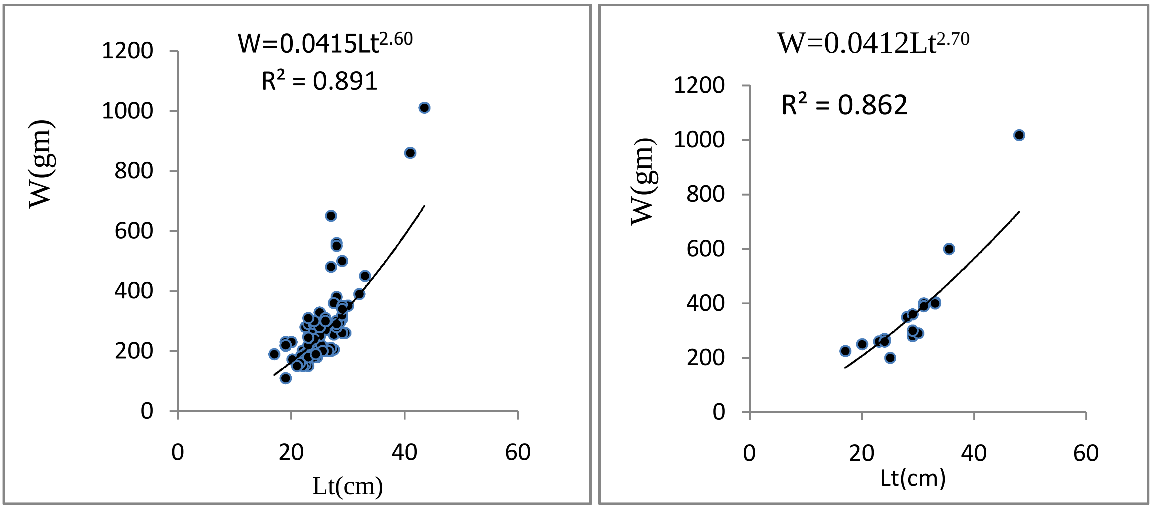
Fish species	Gilgel Gibe river				Gojeb river			
	%N	%Wi	%Fi	%IRI	%N	%Wi	%Fi	%IRI
L. forskalii	-	-	-	-	17.34	11.961	50	8.302
L. intermedius	86.57	66.36	100	43.33	52.04	70.831	100	34.81
B. bajad	-	-	-	-	30.61	17.20	50	13.547

4.4. Length Weight Relationship

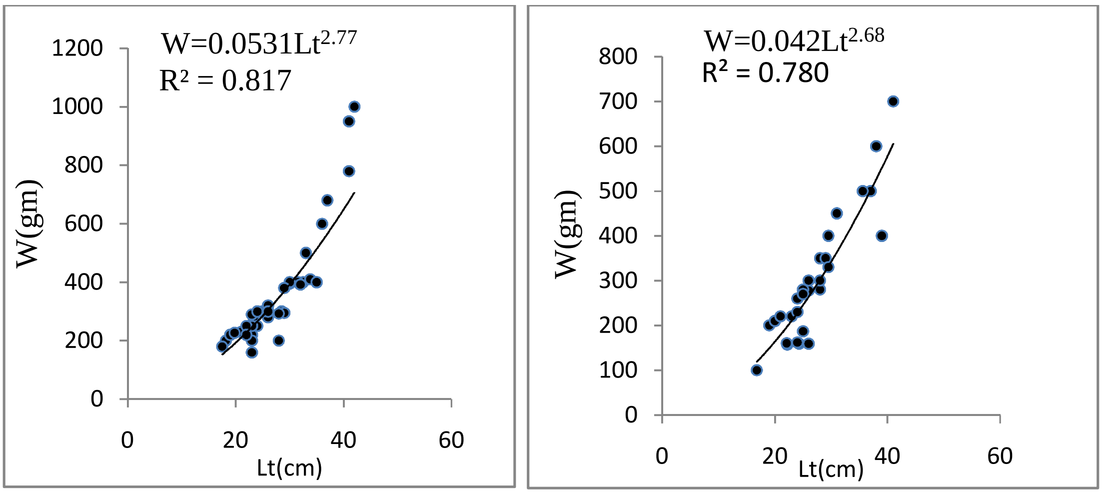
The relationship between total length and total weight for the most abundant fish species (*Labeobarbus intermedius*, *L. forskalii* and *B. bajad)* was fitted with a power regression equation (Figure 6 and Table 5).The relationship of the two variables was statistically significant (Linear regression ANOVA, $P < 0.05$). From Table-5 it can be seen that the values of the constant "b" obtained for three most abundant fish species were less than 3 showing negative allometric body growth.

Table 5. Length-weight relationships of the most abundant fish species of Gilgel Gibe and Gojeb rivers (ANOVA, $P < 0.05$)

Fish spices	River	Regression equation	R^2	P-value	Mean ±SE TL	Mean ±SE TW	N
L. intermedius	Gilgel Gibe	$W=0.0415Lt^{2.60}$	0.891	0.00	24.89±0.3	258±80.25	116
	Gojeb	$W=0.0531Lt^{2.77}$	0.817	0.00	27.49±1.12	358.14±12.2	51
L. forskalii	Gojeb	$W=0.0412Lt^{2.70}$	0.862	0.00	28.79±1.4	368.11±21.1	17
B. bajad	Gojeb	$W= 0.042Lt^{2.68}$	0.780	0.00	24.75±1.4	287.37±20.90	30



A. *Labeobarbus intermedius* (Gilgel-Gibe River) B. *Labeo forskalii* (Gojeb River)



C. *Labeobarbus intermedius* (Gojeb River) D. *Bagrus bajad* (Gojeb River)

Figure 6.The Length- weight Relationship for the most abundant fish species of Gilgel Gibe and Gojeb rivers

4.5. Fulton Condition Factor (FCF)

Fulton Condition Factor (FCF) was computed for the three most abundant fish species namely *Labeobarbus intermedius, Labeo forskalii and Bagrus bajad.* FCF *Labeobarbus intermedius* 1.12 ±0.05 and 1.19± 0.04 for Gilgel Gibe and Gojeb river respectively.1.09±0.05 and 1.23± 0.04 *L. forskalii and Bagrus bajad of Gojeb River* respectively. No statistically significant variations was observed (ANOVA, $P > 0.05$) in FCF during the study period (Table-6)

Table 6.Mean ± SE Fulton Condition Factor (FCF) for the most abundant species of Gilgel Gibe and Gojeb rivers

fish species	River	Mean ±SE FCF	P	Total FCF
L. intermedius	Gilgel Gibe	1.12±0.05	0.07	1.20±0.06
	Gojeb	1.19±0.04	0.68	1.20±0.05
L. forskalii	Gojeb	1.09±0.05	2.64	1.22±0.06
Bagrus bajad	Gojeb	1.23±0.04	0.69	1.24±0.07

4.6. Sex Ratio

For the total of nine fish species identified during the study period, males and females constituted, respectively, 76(29.803%) and 75(29.411%) during the dry season, and 55(21.568%) and 48 (18.823%) during the wet season. A single specimen of *Raiamas senegalensis* was unsexed. Sex ratio study was done for the three relatively more abundant species, *Labeobarus intermedius, Labeo forskalii* and *Bagrus bajad*. Statistically significant variation was observed between males and females for *Labeobarus intermedius* fish species collected from Gojeb River (Chi-square, $P < 0.05$). However, in case of *Labeobarus intermedius* collected from Gilgel Gibe River, *Labeo forskalii and Bagrus bajad* (both collected from Gojeb River) statistically no significant variation was observed between males and females fish species (Chi-square, $P > 0.05$) from the theoretical 1:1 ratio during the study period (Table 7).

Table 7 Sex ratio of most abundant fish species of Gilgel Gibe and Gojeb rivers during the study period

Species		Male	Female	Males: Females
Labeo forskalii		12	11	1:0.92
Labeobarus intermedius	Gilgel Gibe	63	50	1:0.79
	Gojeb	19	32	1:0.60
Bagrus bajad		16	14	1: 0.88

4.7. Physico-chemical and related habitat characters

The detailed data on the physicochemical and related habitat characteristics of the rivers sites sampled in the present study are given by Appendix-3. The average values are summarized in Table 8. Comparisons in the values of the parameters between the two rivers were done regardless of season due to insufficiency of data. Variations in the values of dissolved oxygen, temperature, pH and Secchi depth between the two rivers were statistically insignificant ($P > 0.05$).However, significant variation was observed in case of conductivity between the two rivers during both seasons of the study period ($P < 0.05$).

The mean values and observations of the various habitat characteristics of the study sites are summarized in Table 8. There were no obvious aquatic vegetations at all the sampling sites of both rivers. Instead bank vegetation was observed along all the sites and estimation of the relative composition was taken as summarized in Table 8.

Table 8.Physicochemical and related habitat characteristics of Gilgel Gibe and Gojeb rivers. The figures represent the mean values of the two subsites for each site at each river.

Parameter		Gj 1-1& 1-2	Gj2-1 &2-2	Gg 1-1 & 1-2	Gg 2-1 & 2-2
DO (mg/l)		7.76	7.36	6.66	6.85
Water T (^{o}C)		23.40	23.30	21.53	21.50
pH		8.35	8.50	8.39	8.43
Cond. (µS/cm)		102.43	126.70	150.60	149.90
Flow rate (cm/s)		0.13	0.14	0.16	0.08
Discharge (cm^3/s)		27.25	76.87	33.81	29.637
Secchi Depth (m)		3.73	0.91	0.33	0.385
Water depth (m)		3.73	7.27	4.56	8.88
Channel diameter (m)		55.18	43.62	48.00	44.50
% Pool		75.00	82.50	67.50	80.50
%Tree		35	20	42.5	20
%Shrub		27.5	42.5	22.5	42.5
%Herb		37.5	37.5	35	35
	silt	11	12	5	16.5
Substrate (%)	Sand	34.5	47	40.5	60
	Greed	9	11	12.5	15
	Pebble	7	7	14	5
	Coble	13.5	20	20	2.5
	Bolder	15	0	5	1
	Bedrock	10	3	3	0

4.8. Association between fish species and environmental variables

The canonical correspondence analysis (CCA) plot for the association between fish species is given (Figure.7)

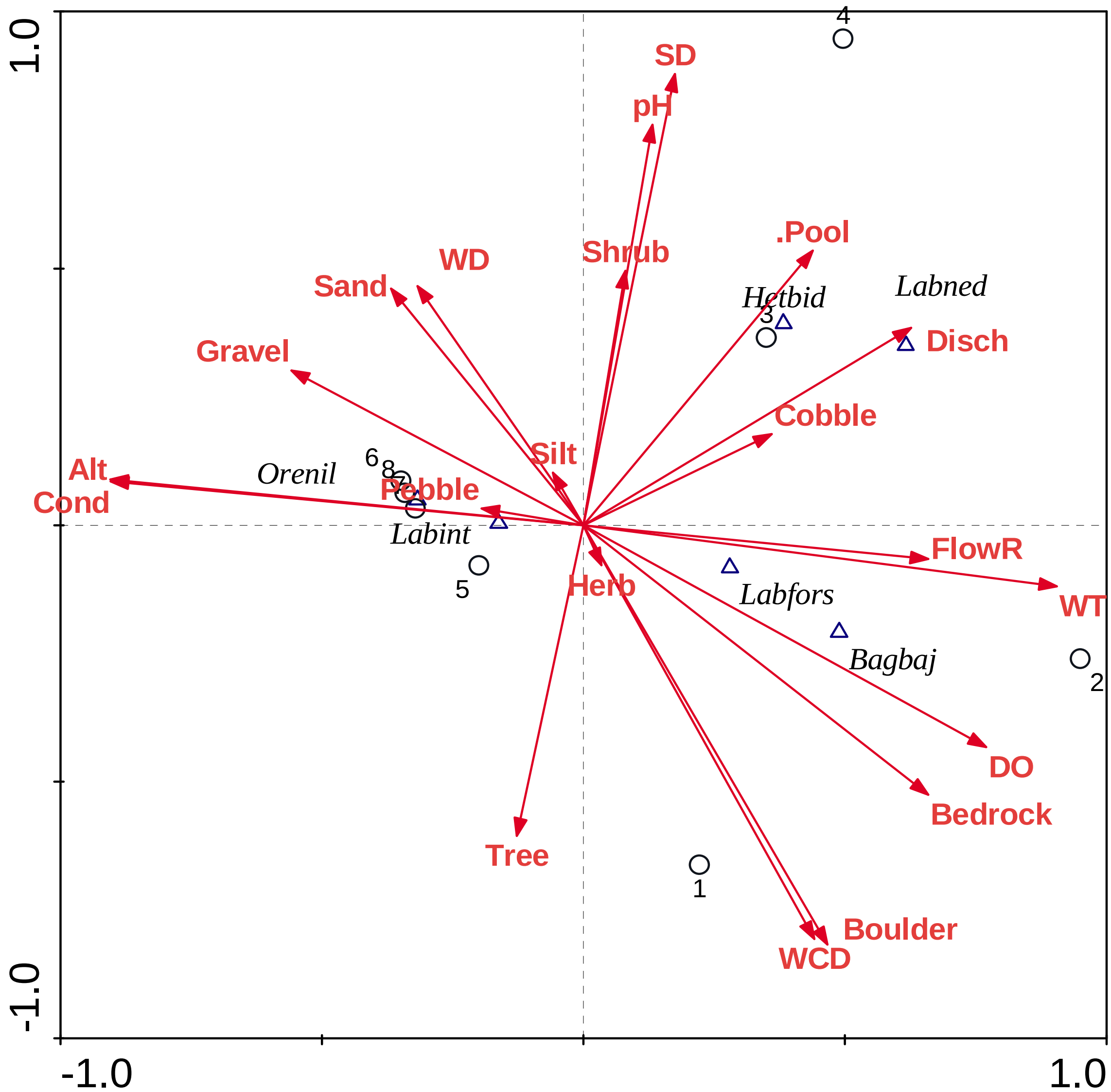


Figure 7. Association between fish composition and environmental variables of Gilgel Gibe and Gojeb rivers (1, 2, 3, 4 = Gojeb river sites; 5,6,7,8 = Gilgel Gibe River sites)

The summary of Eigen value of the correspondence analysis (CCA) is summarized in (Table-9).The weighted correlation matrix for CCA of axis 1and 2 is given in Appendix -10

Table- 9. The summary of Eigen value of the correspondence analysis (CCA) of Gilgel Gibe and Gojeb rivers

	Axes				Total inertia
	1	2	3	4	
Eigen values	0.503	0.098	0.072	0.025	
Species-environment correlations	1.000	1.000	1.000	1.000	0.722
Cumulative percentage variance of species data	69.8	83.4	93.3	96.8	

The CCA has shown that *Oreochromis niloticus* and *Labeobarbus* intermedius had higher abundance in Gilgel Gibe River sites. These species tended to associate more with higher altitude, water conductivity and pebble substrate type. On the other hand *Heterobranchus bidorsalis, Labeobarbus nedgia, Labeo forskalii* and *Bagrus bajad* had relatively higher abundance at Gojeb river sites. *Heterobranchus bidorsalis* associated positively with high pH, water clarity and shrub bank vegetation. However, *Labeobarbus nedgia, Labeo forskalii and Bagrus bajad* associated positively with high flow rate, high water temperature and high DO.

5. Discussion

5.1. Fish diversity and Relative abundance

A total of nine fish species represented in six families and eight genera were identified from Gilgel Gibe and Gojeb rivers during the study period. According to Golubstov and Darkov (2008) family Cyprinidae is taxonomically the most diverse group of the Ethiopian ichthyofauna. Similarly, in the present study, this family was the most diverse group by having three genera and four species. The genus *Labeobarbus* was represented by *Labeobarbus intermedius* (recorded from Gilgel Gibe and Gojeb rivers) and *Labeobarbus nedgia* recorded from Gojeb River. The genera *Labeo and Raiamas* were represented by *Labeo forskalii* and *Raiamas senegalensis* respectively. The diversity of fish fauna identified from the studied rivers contained a mixture of Nilo-Sudanic (*Mormyrus kannume*, *Brycinus macrolepidotus, Labeo forskalii, Raiamas senegalensis, Bagrus bajad and Hetrobancus bidorsalis,*), East African (*Labeobarbus intermedius, and O. niloticus*) and the endemic forms (*Labeobarus nedgia*). The Nilo- Sudanic forms appeared to be the dominant forms in terms of diversity substantiating the Nilo-Sudanic affinity of the Omo-Turkana drainage system (Getahun, 2003). *Labeobarbus nedgia* and *Heterobranchus bidorsalis* appear to be the new records for both the Gojeb River and Omo-Turkana system. *L. nedgia* was mentioned as occurring in Gibe and Omo rivers by Boulenger (1911). However, subsequent works tended to associate *L. nedgia* to the Nile system and it was never included in the species list of Omo-Turkana (Roberts, 1975, Hopson and Hopson, 1982, Kolding, 1989, Leveque *et al*., 1991; Baron *et al*., 1997). Therefore, the present record of this species in Gojeb River corroborates the early reports (Boulenger, 1911) of the occurrence of *L. nedgia* outside of the Nile system. *H. bidorsalis* was reported as occurring only in the Baro-Akobo (White Nile) Basin (Golubtsov and Darkov, 2008). However, identification of both *L. nedgia* and *H. bidorsalis* from Gojeb River in the present study can be a proof of the ichthyofaunal similarity of the upper part of the Omo-Turkana system to the Nile system.

The Shannon – Weiner diversity index (H') was higher in Gojeb River (0.69) than in Gilgel Gibe River (0.64). The diversity indices for the fish species indicated that there was variation in diversity between the two rivers. Artificial identification keys that would aid in the identification of the fish families and species identified form the two rivers in the present study are given in Appendix-1and Appendix-2 respectively.

In numerical terms, the cyprinid fishes such as *Labeobarbus intermedius* with 167 of which 102 in dry season and 65 in wet season individuals, followed by *Bagrus bajad* 30 of which 20 in dry season and 10 in wet season, *Labeo forskalii* 23, 14 in dry and 9 in wet season were the most abundant species in the present study (Table 4). The most important species in this study were identified by using an index of relative importance (IRI), which is a measure of the relative abundance or commonness of the species based on number and weight of individuals in catches, as well as their frequency of occurrence (Kolding 1989).According to IRI the most important species in the total catches were *Labeobarbus intermedius, Bagrus bajad* and *Labeo forskalii* (Table 4).

The number of fish specimens in Gilgel Gibe River was higher than in Gojeb River and weight of fish in Gojeb River was higher than that of Gilgel Gibe River in case of *Labeobarus intermedius* and *Labeo forskalii*. Gojeb River is higher in fish species than Gilgel Gibe River during dry and wet season which account for eight fish species. The difference in number of fish species in these rivers may have been attributed to the fact that most parts of Gilgel Gibe River is less assessable than Gojeb River probably because it has less vegetation cover and it is highly irrigated. This, in turn, may have contributed to the lack of good habitats which contains diversity of riparian vegetations.

5.2. Length-Weigh relationship, Condition factor and Sex ratio

The length – weight relationship of the two species, *Labeobarbus intermedius* and *Labeo forskalii* in the present study have shown negative allometric body growth. The b-values obtained for *Labeo forskalii* (2.70) was in agreement with the value obtained for the *Labeo forskalii* (2.76) from Angereb and Sanja Rivers, Tekeze Basin (Tesfaye,2006). However, the b-value obtained for *Labeobarbus intermedius* (2.60) was less than the result obtained for *Labeobarbus intermedius* (2.96) from River Angereb (Tesfaye, 2006) the variations of results obtained by other studies in other rivers and in the present study were probably because of the differences in number of samples, the differences in food availability, gonad development and spawning period (Bagenal and Tesch, 1978).

The mean Fulton Condition Factor (FCF) values presented in this study for *Labeobarbus intermedius* Gilgel Gibe (1.12) was nearest to the result obtained for *Labeobarbus intermedius* (1.0, 1.12) from Beles and Gelgel Beles (Berie, 2007) and from Guang, Ayima, Gendwuha and Shinfa (Twabe, 2008), respectively. However, the results obtained for *Labeobarbus intermedius (Gojeb River)* 1.19 in the present study was greater than that reported for *Labeobarbus intermedius* (1.0, 1.2). The mean FCF value obtained for *Labeo forskalii* (1.09) in the present investigation was less than the one mentioned in Angereb and Sanja Rivers, Tekeze Basin for *Labeo forskalii* (1.18) (Tesfaye, 2006). The reason for the above difference in FCF might be due to lack of in-depth sampling in the present investigation. The other reason might be due to fluctuations in factors such as food quantity and quality, water level and flow rate, rate of feeding, health of fish and reproductive activity (Payne, 1986; Tefera, 1987).

No significant variation was observed between males and females for the total fish species collected from Gilgel Gibe and Gojeb rivers during the study period (χ^2, $P > 0.05$) from the theoretical 1:1 ratio. The similarity of sex ratio might be due to similarity of fish to fishing gears used, fishing sites, habitat and segregation during spawning and feeding (Admasu, 1994).

5.3. Fish species composition and Environmental parameters

Like other land organisms, aquatic populations are also highly dependent upon the characteristics of the aquatic habitat, which supports all their biological functions (reproduction, growth, feeding and sexual maturation). Thus, abiotic factors are the controlling factors for the aquatic life, since they shape most of the biological functions of aquatic life (Hauer and Hill, 1996). Aquatic animals need dissolved oxygen (DO) to live. The amount of oxygen required is according to the species and stage of life. According to Cambell and Wildberger (1992) DO levels < 2 or 1 mgL-1 will not support fish and levels 5-6 mgL-1 are usually required for growth and other activity. Similarly in both Gilgel-Gibe (6.75mgL-1) and Gojeb (7.56mgL-1) Rivers, the mean values of DO were greater than 5-6 mgL-1 which can support growth and other activities (Hauer and Hill, 1996). The mean values of water temperature of Gilgel-Gibe and Gojeb Rivers were (21.51^0C) and (23.38^0C), respectively which is favorable for different types of aquatic organisms including fishes. A pH value outside the range 6.5 to 8 reduces the biodiversity in a lake because it stresses the physical system of most organisms and can reduce reproduction. Low pH can also allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals there by producing conditions that are lethal to aquatic life, particularly to sensitive species (USEPA, 1991). The pH value obtained from Gilgel-Gibe (8.40) and Gojeb (8.42) Rivers in the present study were within the pH range 6.5-8.2 which is optimal for most organisms (Cambell and Wildberger, 1992).

Physicochemical parameters such as dissolved oxygen, temperature and pH from both Rivers were recorded and analyzed using one way ANOVA and statistically insignificant ($P > 0.05$) in both Rivers (Table 8).

6. Conclusion and Recommendation

6.1. Conclusion

In the present study, a total of nine species representing eight genera and six families were identified from Gilgel Gibe and Gojeb Rivers. One species (*Oreochromis niloticus*) from Gilgel Gibe River only, six species from Gojeb River, and two species (*Labeobarbus intermedius and Labeo forskalii)* were identified from both Rivers.

The fish faunal diversity of Gilgel Gibe and Gojeb Rivers were dominated by cyprinid fish species. Of the total nine species four species were included in the family *Cyprinidae*. The rest were included in the family Bagridae, Clariidae, Cichlidae, Alestiidae and Mormyridae they were all represented by one species each. *Labeobarbus nedgia* and *Heterobranchus bidorsalis* are new records for both the Gojeb River and Omo-Turkana system.

Gojeb River was richer than Gilgel Gibe river interims of number of species recorded. The species diversity was also relatively higher in the Gojeb River (H' = 0.69) than in the Gilgel Gibe River (H'= 0.63) for the total catch. The number of fish specimens caught in the dry season was higher than the wet season during the study period. The family *Cyprinidae* was the most dominant family both in terms of the number and weight of specimens.

Labeobarbus intermedius 167(65.49 %), *Bagrus bajad* 30(11.76 %), and *Labeo forskalii* 23(9.019%) *were* the most diverse fish species in number. *Labeobarbus intermedius* was the most dominant fish species in number (65.49%) of all species in the total catch. It was also the most important fish species (79.18 %IRI) followed by *Bagrus bajad* (11.38 % IRI) and Labeo *forskalii* (9.43 %IRI) for total catch of the three most diverse fish species during the study period.

The relationship between total length and total weight of the most diverse fish species were showed negative allometric growth in both rivers.

The pH value obtained from Gilgel-Gibe (8.40) and Gojeb (8.42) Rivers in the present study were within the pH range 6.5-8.2 which is optimal for most organisms (Cambell and Wildberger, 1992).The mean values of water temperature of Gilgel-Gibe and Gojeb Rivers were (21.51^{0}C) and (23.38^{0}C), respectively which is favorable for different types of aquatic organisms including fishes.

6.2. Recommendations

- Due to the lack of infrastructure, logistic and financial problems the present study was carried out in Gilgel Gibe and Gojeb Rivers (not including their tributaries) by using selective gillnets and sampling sites over relatively short period of time. Therefore, extensive collection and identification of the fish fauna has yet to be conducted.
- Detailed studies and investigations are required on prospects for sustainable fish resource utilization in Gilgel Gibe and Gojeb Rivers.
- Detailed studies and investigations are required on socio-economic aspects of the two rivers.

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Appendix 1. Artificial key to fish families of Gilgel Gibe and Gojeb rivers, Omo-Turkana basin

1.aRayed dorsal and anal fins short, non –rayed long adipose fin present, deeply forked caudal fin four pairs of non-branched barbells …………………….**Bagridae (bagrid catfishes)**

b. Rayed dorsal and anal fins long ,(rayed) adipose fin present or absent, caudal fin rounded, four pairs of non-branched barbells…………………...……**Clariidae (Clariid catfishes)**

2a. Lateral line interrupted or continuous; elongate dorsal fin; short anal fin; a single nostril on each side; caudal fin rounded or truncate….…………………………………....**Cichlidae**

b. Lateral line continuous when present; spiny dorsal and anal fins elongate or short; one or two nostrils on each side; forked caudal fin..........................……….………………………. **3**

3. a. Dorsal fin deeply notched in to the anterior spinous part and the posterior soft rayed part, lateral line single (continuous), round caudal fin ,opercular bones spiny, ctenoid scales covering body ……………………………………………………………………..**4**

4. a. No teeth on the jaws …………………………………………………………...**Cyprinidae**

b. Teeth on jaws; mouth small, with restricted opening; rayed dorsal fin long or short, but when short always in the posterior half and above anal fin……...……...…..**Mormyridae**

5.a Teeth well developed. Body more or less elongate and compressed ……………………..5b

b.Teeth well developed. Body more or less elongate and compressed. All paired and vertical fins present including fin which is not rayed. Caudal fin forked; scales cycloid ………………………………………………………………………………**Alestiidae**

Appendix 2. Artificial key to Fish species of Gilgel Gibe and Gojeb rivers, Omo-Turkana basin

1. a. 50 to 64 lateral line scales; 10 to 16 vertical bars on flanks…..……..….***R. senegalensis***

   b .Less than 44 scales on lateral line; no vertical bars …………………………………....2

2. a. Short dorsal fin with less than 12 rays……………………………………………………….3

   b. Long dorsal fin with more than 12 rays……………………………………………………...4

3. a. Dorsal I 9-11 (usually 10); scales present on the body…...5

   b. Dorsal I 9-11 (usually 9); scales absent on the body …………………….***Bagrus bajad***

4. a. 28-31 rays in dorsal fin; caudal fin with regular black cross bars throughout its Length……………………………………………………….………..…***O. niloticus***

   b**.** dorsal fin12-14rays caudal fin without regular black mouth small with small teeth ……………………………………………………………………………………..…**5**

5. a. Lower lip forming a distinct median lobe; upper lip well developed, often with a median fleshy lobe; head length less than 1.2 times in body depth….***Labeobarbus nedgia***

   b. Lower lip interrupted or continuous, but not forming a distinct median lobe; upper lip always without lobes; head length is at least 1.2 times body depth………………………**6**

6. Single pair of maxillary barbells…………………………………………….….……..……7

7. a. Body depth shallow, 19-32% of standard length; moderately developed dorsal spine; ……………………………………………………………***Labeobarbus intermedius***

   b. Body rather deep; body depth 31-38% standard length; the last unbranched ray on the dorsal fin is ossified into a massive spine…………………………………......……….**8**

8. a. Dorsal fin with 9-11 branched rays 38- 40 scales on lateral line; dark violet above and on the sides ……….……………………………………………***Labeo forskalii***

   b. Dorsal fin with 8-10 branched rays; 35 to 39 scales in lateral line; dark brownish above and on the sides………………………………………………. ……………….***9***

9. a. Snout prolonged into a proboscis, mouth small. Dorsal fin with 60-74, anal with 21-29 rays. Dorsal fin beginning distinctly in advance of pelvic, its base 2.4-3.4 times longer than anal-fin base. Scale counts: 83-97 in lateral line and 10-15 around caudal peduncle………………………………………………………….. ***Mormyrus kannume***

b. Snout bent down wards; at least nearly as long as postorbital part of head, Dorsal fin originating well in advance of base of ventral fin 100 -130 scale in lateral line ………………………………………………………………………………………**10**

10. a. Dorsal-fin origin behind level of pelvic-fin insertions; head flattened above. Anal fin with three spines and 12-14 branched rays; 24 scale on lateral line……………...***Brycinus macrolepidotus***

b. Dorsal-fin originating above pelvic-fin insertions. Head not much flattened above. 12-14 branched rays. 26-33scale on lateral line……………………………………………..**11**

11. a. Adipose fin present…………………………………………………………………11b

b.Adipose fin present, No scale on the body, 38-45 rays on dorsal fin...***Hetrobranchus bidorsalis***

Appendix-3- Physicochemical and related habitat characteristics of Gilgel Gibe and Gojeb rivers

Parameter	Gj1-1	Gj1-2	Gj2-1	Gj2-2	Gg1-1	Gg1-2	Gg2-1	Gg2-2
DO (mg/l)	7.88	7.64	7.44	7.29	6.60	6.72	6.87	6.82
DO saturation (%)	95.46	100	95.50	96.60	94.95	96.70	98.15	97.3
Water T (^oC)	21.76	21.30	21.20	21.80	23.43	23.50	23.30	23.30
pH	8.15	8.55	8.42	8.58	8.38.00	8.39	8.45	8.41
Cond (μS/cm)	102.3	102.56	102.36	102.30	151.00	150.10	149.90	149.95
Flow rate (m/s)	0.10	0.1639	0.1485	0.1363	0.159	0.15	0.08	0.07
Discharge (cm^3/s)	13.9	44.16	44.5	45.449	37.215	30.50	20.8	30.03
Average Water Depth (m)	2.47	4.99	6.75	7.80	4.98	4.15	8.00	9.75
Secchi Depth (m)	Not Applicable	Not applicable	0.6230	1.20	0.3366	0.34	0.3833	0. 3870
Wetted channel width(m)	56.36	54.00	44.50	42.75	47.00	49.00	45.00	44.00
Percent pool (%)	70	80	75	90	70	65	81	80

Appendix-4: A summary of morphometric and meristic characteristics for *Labeobarus intermedius* collected from Gojeb and Gilgel Gibe rivers.

	Morphmetric character	n	Range	Mean	SD
(SL %)	Prepelvic length (PP_VL)	7	11.77-53.00	44.57429	13.68074
	Pre anal length (PAL)	7	26.56-83.28	65.02857	17.83472
	Pre pictorial length (PP_CL)	7	23.56-30.71	25.81429	2.477752
	Pre dorsal length (PDL)	7	40.11-56.14	50.15	5.089889
	Body depth (height) (BD)	7	25.29-29.85	28.06143	1.43785
	Caudal peduncle length(CPL)	7	13.95-1653	15.11571	0.858185
	Caudal depth (CPD)	7	10.40-24.07	13.04857	4.528921
	Head length(HL)	7	23.36-28.57	24.598557	1.755363
(HL%)	Snout length (pre-orbital length) (SnL)	7	31.00-46.01	39.00429	5.166648
	Orbit diameter (eye diameter) (OD)	7	17.93-29.41	22.98286	3.884709
	Post orbital diameter length (PoOL)	7	33.00-84.07	62.90	14.13013
	Inter orbital length (IOL)	7	17.50-43.92	30.63714	8.363206
	Head depth (HD)	7	52.00-77.58	63.82857	7.877393

Appendix-5.A summary of morphometric and meristic characteristics for *Labeobarbus nedgia* Collected from Gojeb river.

	Character	N	Range	Mean	SD
(SL %)	Prepelvic length (PP_VL)	3	49.7-51.15	50.41	0.59234
	Pre anal length (PAL)	3	73.08-75	74.02667	0.784063
	Pre pictorial length (PP_CL)	3	27.73-31.08	29.82	1.488243
	Pre dorsal length (PDL)	3	49.46-54.46	52.23	2.076648
	Body depth (height) (BD)	3	27.20-31.15	28.71667	1.737975
	Caudal peduncle length(CPL)	3	14.00-15.46	14.69	0.598721
	Caudal depth (CPD)	3	10.50-11.53	21.01	0.420555
	Head length(HL)	3	27.42-27.80	27.62333	0.156276
(HL%)	Snout length (pre-orbital length) (SnL)	3	14.49-40.95	31.53333	12.29925
	Orbit diameter (eye diameter) (OD)	3	14.39-16.69	15.69	0.962653
	Post orbital diameter length (PoOL)	3	60.08-66.10	62.72333	2.511763
	Inter orbital length (IOL)	3	7.1-33.66	24.25667	12.15028
	Head depth (HD)	3	52.19-56,80	55.12667	1.951074

Appendix-6 A summary of morphometric and meristic characteristics for *Oreochomis niloticus* collected from Gilgel Gibe river.

Character		n	Range	Mean	SD
(SL %)	Prepelvic length (PP$_V$L)	5	28.31-44.00	37.27	5.22479
	Pre anal length (PAL)	5	37.52-76.88	64.576	13.84838
	Pre pictorial length (PP$_C$L)	5	31.71-35.68	33.094	1.42473
	Pre dorsal length (PDL)	5	12.79-38.50	30.394	9.097915
	Body depth (height) (BD)	5	37.71-41.43	38.78	1.771192
	Caudal peduncle length(CPL)	5	9.54-13.56	11.324	1.339561
	Caudal depth (CPD)	5	13.14-14.5	13.72	0.452548
	Head length(HL)	5	28.57-33.12	30.264	1.521034
(HL%)	Snout length (pre-orbital length) (SnL)	5	13.37-41.6	30.356	9.287072
	Orbit diameter (eye diameter) (OD)	5	21.70-34.29	26.564	4.193379
	Post orbital diameter length (PoOL)	5	45.88-64	57.876	6.314053
	Inter orbital length (IOL)	5	39.60-50.89	45.684	0.095845
	Head depth (HD)	5	28.31-44.00	37.27	5.22479

Appendix-7 A summary of morphometric and meristic characteristics for *Bagrus bajad* collected form Gojeb River

Character		n	Range	Mean	SD
(SL %)	Prepelvic length (PP_VL)	4	50.29-6074	55.33825	4.244893
	Pre anal length (PAL)	4	68.83-79.53	73.5975	3.82788
	Pre pictorial length (PP_CL)	4	26.12-30.90	28.305	1.72571
	Pre dorsal length (PDL)	4	36.83-40.35	38.68	1.252877
	Body depth (height) (BD)	4	21.00-25.81	23.2125	1.846421
	Caudal peduncle length(CPL)	4	9.75-30.02	16.775	7.877868
	Caudal depth (CPD)	4	8.60-9.77	9.0475	0.467781
	Head length(HL)	4	26.17-30.13	28.1025	1.552085
(HL%)	Snout length (pre-orbital length) (SnL)	4	33.33-37.93	36.2325	1.808541
	Orbit diameter (eye diameter) (OD)	4	11.14-21.20	15.995	4.324526
	Post orbital diameter length (PoOL)	4	46.81-52.06	49.3275	2.47953
	Inter orbital length (IOL)	4	31.17-34.66	32.8825	1.505911
	Head depth (HD)	4	49.84-55.18	53.165	2.214661

Appendix-8: A summary of morphometric and meristic characteristics for *Heterobranchus bidorsalis* collected from Gojeb River

	Character	n	Range	Mean	SD
(SL %)	Prepelvic length (PP_VL)	2	45.23-48.61	46.92	1.69
	Pre anal length (PAL)	2	56.21-69.87	63.04	6.83
	Pre pictorial length (PP_CL)	2	20.5-21.61	21.095	0.595
	Pre dorsal length (PDL)	2	34.59-37.25	35.92	1.33
	Body depth (height) (BD)	2	12.25-13.47	12.86	0.61
	Caudal peduncle length(CPL)	2	10.00-12.00	11.00	1.41
	Caudal depth (CPD)	2	8.24-8.25	8.245	0.005
	Head length(HL)	2	18.83-1962	19.225	0.395
(HL%)	Snout length (pre-orbital length) (SnL)	2	35.05-36.23	35.64	0.59
	Orbit diameter (eye diameter) (OD)	2	8.42-9.51	8.965	0.545
	Post orbital diameter length (PoOL)	2	41.30-42.69	41.995	0.695
	Inter orbital length (IOL)	2	68.20-69.38	68.79	0.59
	Head depth (HD)	2	73.03-82.88	77.955	4.925

Appendix-9: A summary of morphometric and meristic characteristics for *Labeo forskalii* collected from Gilgel Gibe and Gojeb rivers

	Character	n	Range	Mean	SD
(SL %)	Prepelvic length (PP_VL)	5	49.65-53.27	51.114	1.290962
	Pre anal length (PAL)	5	71.42-84.23	78.01	4.109715
	Pre pictorial length (PP_CL)	5	22.71-24.70	23.74	0.751292
	Pre dorsal length (PDL)	5	36.8-42.12	40.604	2.451951
	Body depth (height) (BD)	5	18.08-23.90	21.266	2.426319
	Caudal peduncle length(CPL)	5	12.44-15.25	13.564	0.953784
	Caudal depth (CPD)	5	9.61-14.60	11.97	1.614522
	Head length(HL)	5	20.75-24.08	22.37	1.224222
(HL%)	Snout length (pre-orbital length) (SnL)	5	42.8-61.01	53.978	6.813282
	Orbit diameter (eye diameter) (OD)	5	9.49-35.90	20.864	10.70548
	Post orbital diameter length (PoOL)	5	55.5-74.40	67.02	6.623413
	Inter orbital length (IOL)	5	41.44-45.25	50.398	8.189433
	Head depth (HD)	5	55.00-55.90	63.222	6.588834

Appendix-10-Weighted correlation matrix (weight=sample total) for the CCA of fish composition and environmental variables.

Variables	AX1	AX2	Variables	AX1	AX2
DO	**0.7698**	-0.4325	Tree	-0.1267	-0.6053
WT	0.9052	-0.1190	Shrub	0.0801	0.4955
pH	0.1319	0.7800	Herb	0.0352	-0.0785
Cond	-0.9030	0.0856	Bedrock	0.6589	-0.5248
FlowR	0.6595	-0.0659	Boulder	0.4670	-0.8168
Disch	0.6266	0.3846	Cobble	0.3597	0.1770
WD	-0.3166	0.4660	Pebble	-0.1943	0.0322
SD	0.1749	0.8787	Grave	-0.5576	0.3015
WCD	0.4412	-0.8059	Sand	-0.3675	0.4603
Pool	0.4388	0.5344	Silt	-0.0580	0.1023

Declaration

I, the undersigned hereby declare that this thesis is my original work, has not been presented for degree in any other university and all sources of materials used for the study have been duly acknowledged.

Name Taju Mohammed

Signature _______________

Date ____________________