

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATED STUDIES

DIVERSITY, RELATIVE ABUNDANCE AND BIOLOGY OF FISHES
IN ANGEREB AND SANJA RIVERS, TEKEZE BASIN,
ETHIOPIA

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE
STUDIES, ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT
FOR THE DEGREE OF MASTER IN BIOLOGY

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June 2006

ACKNOWLEDGEMENT

I am highly indebted to my research advisors Dr. Abebe Getahun from the Department of Biology, Addis Ababa University and Dr. Eshete Dejen from the Fish and Other Aquatic Life Research Center (FOALRC), Bahir Dar, for their advice, guidance, support and time. They helped me from proposal development to the accomplishment of the study and to the development of the thesis write-up. They were once in the fieldwork and the trip to Gendawuha River during site selection was risky. It would have been impossible to complete this study without their generous help and support.

Indeed, Dr. Abebe Getahun is highly acknowledged for supplying me with literature, and securing additional fund for the realization of this study. His valuable criticisms on the manuscript and suggestions helped me a lot to complete the write-up of the thesis. Besides his suggestions in the research area, Dr. Eshete Dejen supplied me the necessary field logistics including cars for the field works. All the expenses of the field work in January 2005 was secured through his cooperative support through Bahir Dar FOALRC.

I also express my gratitude and appreciation to Belay Abdissa from Bahir Dar FOALRC who assisted me in various ways. Among others, he was engaged in all tedious field works in hostile conditions of the

study sites. He also helped me in supplying some literature related to the research. My due thanks also go to Biniam Hailu and Ayenew who kindly worked as field assistant and fishermen during the field work in November 2004. I also thank car drivers Teddy and field assistants Alemayehu and Birhan for their helpful contributions during the field sampling programs.

I am grateful to my friends and colleagues in Fisheries and Aquatic Science Stream especially Tesfaye Delelegn, Adane Siraj, Yeshi Major and Gashaw Beyene who spent many hours with me to discuss on topics related to the research. We had rewarding interactions for the past three years.

Financial support was provided by Graduate and Research Program of Addis Ababa University, Systematic Research Fund of American Museum of Natural History and Development Innovation Fund of the Zoological Natural History Museum, AAU through Dr. Abebe Getahun. Almost all logistic necessities for fieldwork were provided by Amhara Regional Agricultural Research Institute (ARARI) through its Bahir Dar FOALRC.

I praise my **LORD**.

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Abbreviations

AdFL= Adipose fin length

AFL = Anal fin length

AFR = Anal fin rays number

BD= Body depth

CPD = Caudal peduncle depth

CPL = Caudal peduncle length

CPSR= Caudal peduncle scale rows

CR = Caudal rays number

DFL= Dorsal fin length

DFRB = Dorsal fin rays branched number

DFRuB= Dorsal fin rays un-branched (Spine) number

ED = Eye diameter

HD = Head depth

HL= Head length

HW= Head width

IOW= Inter-orbital width

LLS = Lateral line scales

OD= Orbit diameter

PDL= Predorsal length

PDSR= Predorsal scale rows

PFL= Pectoral fin length

PFR = pectoral fin rays number

PLFL= Pelvic fin length

PLFR= Pelvic fin rays number

SL = Snout length

SnL= Standard length

SRLRAF = Scale rows lateral line anal fin

SRLRDF= Scale rows lateral line dorsal fin

SRLRPLF= Scale rows lateral line pelvic fin

Abstract

Diversity and relative abundance of fish species of Rivers Angereb and Sanja were studied from samples (923 specimens) collected during November 2004 to October 2005. The samples were collected in the dry season and wet season. Fish sampling was done using gill nets with various stretched mesh size, hooks and line, monofilament nets with different mesh size and cast nets. Ten fish species were identified from the two rivers and these are included in the families *Cyprinidae*, *Cichlidae*, *Mormyridae*, *Clariidae* and *Bagridae*. The fish species identified are East African and Nilo-Sudanic in forms. Cyprinid fish, *L. forskalii*, was the most dominant both in number and weight in both rivers during the two sampling seasons. Analysis of variance shows that there were significant variations both in number and weight of fish specimens between the two seasons. The three most dominant fish species in the rivers are *L. forskalii*, *L. cf. intermedius* and *L. nedgia*. The length-weight relationship for these species were found to be curvilinear and described by $TW = 0.0715TL^{2.47}$, $TW = 0.0269TL^{2.96}$ and $TL = 0.0269TL^{2.74}$ respectively in Angereb River. It was $TW = 0.01TL^{3.021}$, $TW = 0.0057TL^{3.18}$ and $TW = 0.006TL^{3.14}$ for *L. forskalii*, *L. cf. intermedius* and *L. nedgia* respectively in Sanja River. The mean FCF for *L. forskalii*, *L. cf. intermedius* and *L. nedgia* were 1.26, 1.14 and 1.18 in Angereb River and 1.09, 1.05 and 1.05 in Sanja River respectively. There was significant

variation (ANOVA, $P < 0.05$) in mean FCF of *L. forskalii* and *L. intermedius* in the two rivers. In both rivers females were more numerous (Chi-square, $P < 0.05$) than males. The mean absolute fecundity of *L. forskalii* ranging in length from 21 to 25cm FL and mean body weight of 229 gm was 48120. The smallest count was 27094 eggs in fish with 14 gm total weight and 22.2 cm fork length. The highest was 120314 eggs in fish with 1023 gm total weight and 37 cm fork length. Fecundity of the species in the rivers was linear when related to total weight, fork length and gonad weight.

Key words/phrases: Rivers, Angereb, Sanja, fish diversity, relative abundance, length-weight relationship, Fulton Condition Factor.

1. Introduction

1.1 Location and general description of Ethiopian fresh waters

Ethiopian fresh water bodies are estimated to be 7000 km length of flowing (rivers and streams) and 7400 km² of standing waters (Wood & Talling, 1988). The water bodies of the country are categorized under three main drainage systems, which are again divided into sub-drainage systems or watersheds (Shibru Tedla, 1973).

The first main drainage system is the western drainage system, which includes the watersheds of the Baro-Akobo, Blue-Nile (Abay), and the Tekeze River watersheds. The left bank tributaries of the Blue-Nile (Abay), such as Rivers Didessa and Dabus, drain the southwestern parts of the western highlands of Ethiopia (Abebe Getahun & Stiassney, 1998). The rivers in the Tekeze basin (e.g. Rivers Angereb, Tekeze and Guang) drain the northwestern parts of the western highlands of the country, north of Lake Tana (MWR, 1998). All the rivers in the western drainage system flow west to the White Nile in the Sudan.

The second system is the Rift Valley internal drainage system, composed of the Awash River system, the Rift Lakes region, and the Omo River system. The Awash River, which forms a closed basin, drains the Ethiopian Rift Valley and flows northeast to the Afar Depression and finally dissipates into swamps and Lake Abe at the Ethio-Djibouti border.

The Omo River flows south into Lake Rudolf (Lake Turkana) on the border with Kenya. However, some rivers such as Ghibe River in the Omo River watershed drain the southwester part of the western highlands of the country (Roberts, 1975). The Rift Lakes, from which greater parts of the country's fish harvest is coming (LFDP, 1996), are found within the Ethiopian Rift Valley. Based mainly on similarities of their fish fauna, these lakes can conveniently be categorized into the southern lakes (Lakes Chamo, Abaya and Chew Bahir), the northern lakes (Lakes Awassa, Shalla, Abijata, Langanu and Ziway) (LFDP, 1996) and extreme northern saline lakes (Lakes Afambo, Gamari, Afdera, Asale and parts of Abbe).

The third system is that of the Shebelle-Juba catchments. The Rivers Ghenale, Dawa and Weyb, which form the Juba in Somalia, drain the southwestern part of the eastern highlands and the Rivers Shebelle and Fafa including their tributaries drain the eastern parts of the eastern highlands of Ethiopia. The major rivers in the catchments rise from the eastern highlands in the Bale Mountains and flow into Indian Ocean (Roberts, 1975) (Fig. 1.1).

Ethiopian fresh water bodies also encompass a number of crater lakes. Some of these are the Bishoftu crater lakes in the vicinity of Debrezeit which lie in volcanic craters produced about 7000 yr B.P. (Mohr, 1961),

Lake Ziquala at the tip of Ziquala Mountain, Lake Chitu near Lake Shala, and Lake Besseka (Metehara).

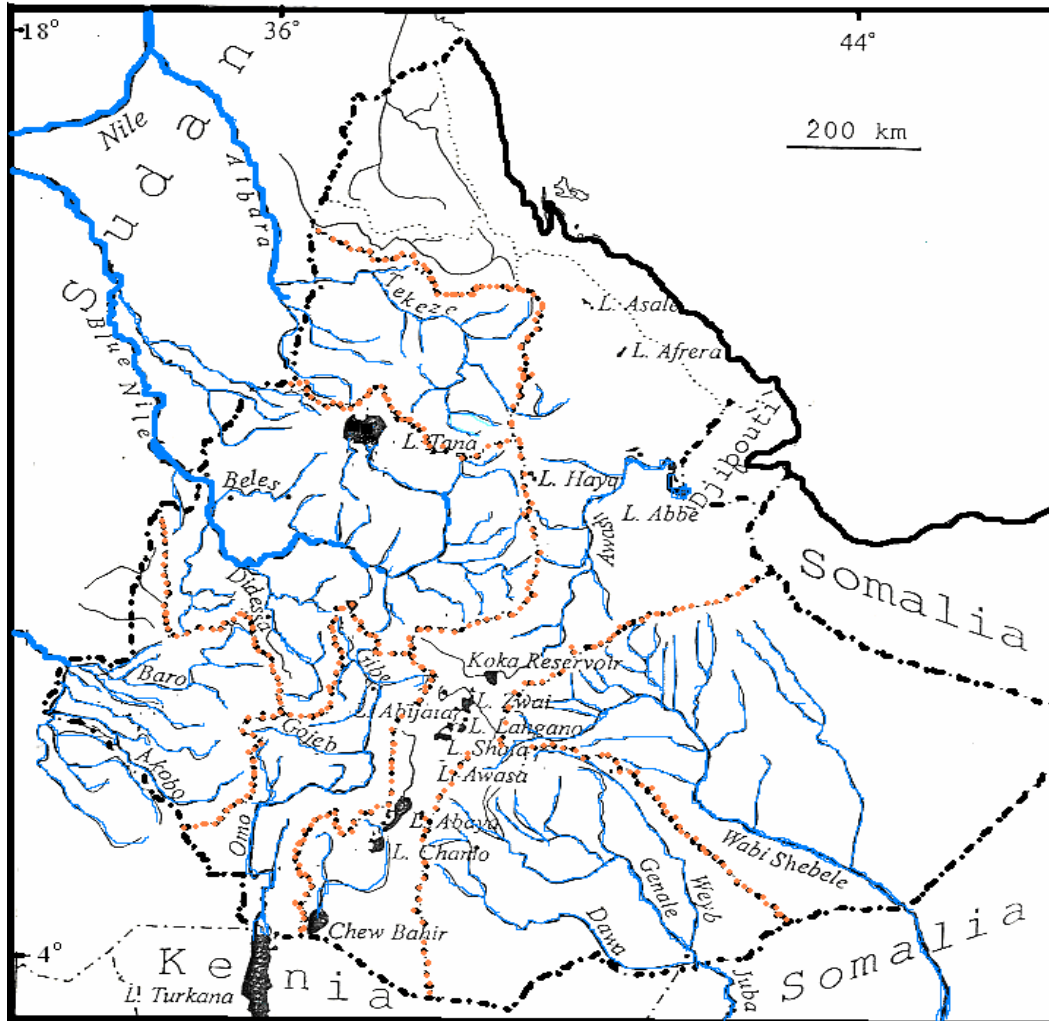


Fig. 1.1 A map showing major drainage basins of Ethiopia (Source: Golubtsov and Mina, 2003)

There are also numerous highland lakes in Ethiopia some of which are crater in nature. Of these, Lake Tana is the largest containing half of the total freshwater of the country by volume. It is located in the northwest highlands of the country (de Graaf *et al*, 2000). Other very high mountain

lakes include the Bale Mountain lakes (e.g. Lakes Garba Guracha and Orgona), Lakes Wonchi (Crater Lake) and Dandii (Table 1.1). Except Lake Garba Guratch, most of the Bale Mountain lakes are of glacial in nature or were influenced by glacial activities (Loffler, 1978). Other highland lakes of the country include Lakes Hayq (Crater Lake), Ardebo, Ashengie and Zengana in the northern highlands of the country.

There are about 30 small natural ponds in the country most of which are found in Gambella region, and about 110 artificial dams throughout the country (Abebe Getahun, 2005b).

1.2 Number and forms of fish species in Ethiopian fresh waters

About 153 valid species and sub-species of fishes belonging to 12 orders and 24 families have been reported (Abebe Getahun, 2005b). Recently, Golubtsov and Mina (2003) reported more (about 168 to 183) valid species of fishes as occurring in Ethiopian waters. Although the total number of fish species found in the country has not been known, the fish species that have so far been described can be categorized as Nilo-Sudanic, highland East African and endemic forms (Roberts, 1975). There are also about 10 exotic fish species introduced from abroad into Ethiopian fresh waters (Shibru Tedla & Fisseha H/Mesqel, 1981). The number of endemic fish species of the country is estimated to range from 37 to 57 (Golubtsov and Mina, 2003).

The Baro-Akobo, Omo-Ghibe and Blue-Nile (Abay) basins contain representatives of Nilo-Sudanic fish species. The Shebelle–Ghenale systems and the Southern Rift Valley Lakes also harbor Nilo-Sudanic fish elements (Abebe Getahun & Stiassny, 1998). These systems contain nilotic fish species because the basins had/have past and present connections with the Nile and West and Central African river systems (Roberts, 1975). Representative genera of nilotic fish species in these water bodies are *Alestes*, *Bagrus*, *Barilius*, *Citharinus*, *Hydrocynus*, *Hyperopisus*, *Labeo*, *Malapterurus*, *Mormyrus*, *Polypterus*, and *Protopterus*.

Nilo-Sudanic fish species distribution in Africa extends from Atlantic coast in the west to Indian Ocean in the east. This range includes the major drainage basins of Senegal, Niger, Chad and the Nile. The Juba and Wabi Shebelle basins are the eastern most part of the Nilo-Sudanic Ichthyological province of Africa (Roberts, 1975).

The highland East African fish forms, as recognized by Roberts (1975), are found in the Northern Rift Valley lakes of Ethiopia, the highland lakes (e.g. *Labeobarbus* of Lake Tana) and associated river systems, and the Awash drainage basin (Abebe Getahun & Stiassny, 1998). Representatives of highland East African fish species in these water bodies are included in the genera *Labeobarbus*, *Barbus*, *Clarias*, *Garra*,

Oreochromis and *Varicorhinus* (Abebe Getahun & Stiassny, 1998). Ethiopian highland riverine fish fauna also resemble South African and Arabian Peninsula fish forms. Cyprinids, for example, are the dominant fishes in highland rivers and lakes of Ethiopia and East African waters (Tudorance *et al.*, 1999). Similarly, Skelton *et al* (1991) stated that some of the species of cyprinid genera such as small *Barbus* species: *Barbus paludinosus* Peters 1852, *Barbus trimaculatus* Lévêque & Daget 1984 and *Barbus radiatus* Lévêque & Daget 1984, are widely distributed from South Africa through East Africa. There are also fish groups (e.g. *Garra spp.*) common to the Ethiopian highlands and the Arabian Peninsula. *Clarias gariepinus* Burchell 1822, *V. beso*, and *Labeo spp.* are commonly found in Ethiopian highland rivers and lakes (Abebe Getahun, 2005a).

It is believed that the saline lakes in the Afar region (e.g. Lake Afdera) were formed as an extension of the Red Sea. As a result, their fish fauna are more related to the Red Sea and Mediterranean fauna than fishes found in the southern Rift Valley lakes of Ethiopian. *Lebias dispar* Rüppell 1827, for example, which is common in Lake Afdera is found in the Red Sea and the Mediterranean. *Danakilia franchetti* Vinciguerra 1931, which is also found in Lake Afdera, is closely related to *Ironocichla hormuzensis* Coad 1982, which is found beyond the Arabian Peninsula in SW Iran (Trewavas, 1983).

1.3 Fish diversity in lakes and river basins of Ethiopia

1.3.1 Ethiopian Rift Valley Lakes

The diversity and distribution of fish species recorded from the Ethiopian Rift Valley lakes have been reported by several authors (Getachew Tefera, 1993; Demeke Ademasu & Elias Dadebo, 1997; Abebe Getahun, 2001; Golubtsov *et al.*, 2002; Golubtsov & Mina, 2003). Very recently, Golubtsov *et al.*, (2002) have described a total of 31 native and four introduced fish species from the Ethiopian Rift Valley. At least four endemic species have been doubtlessly reported; namely, *D. franchetti* Vinciguerra 193, *Lebias stiasnyae* Getahun & Lazara 2000, *Barbus ethiopicus* Zolezzi 1939 and *Garra mekiensis* Boulenger 1904 (Table 1.1). The composition of fish species varies a great deal within the Ethiopian Rift Valley. The southern Rift Valley lakes, including Lakes Abaya, Chamo and Chew Bahinr basin contain about 23 native fish species in contrast with only 12 such species recorded from central and northern part of the valley.

The higher species diversity in southern basin has been attributed to the presence of both taxa of Nilotic and East African origin (Golubtsov *et al.*, 2002).

Table 1.1 Diversity and distribution of fish taxa in the Ethiopian Rift Valley lakes (Fam.- family, Gen.- genera, Nat.- native, End.- endemic, Int.- introduced)

Lakes/basin	Region	Fam.	Gen.	Nat.	End.	Int.	Total
Awash system	North	4	8	9	1	1	11
Adjacent enclosed basin	North	4	7	5	2	1	8
Ziway basin	Central	4	7	7	2	3	12
Langano-Abijata-Shalla system	Central	4	5	5	0	1	6
Awassa-Shallo system	Central	4	5	7	0	0	7
Abaya basin	Southern	9	10	20	0	0	20
Chamo basin	Southern	9	11	18	0	0	18
Chew Bahir basin	Southern	7	10	14	0	0	14

1.3.2 Lake Tana and other small lakes

The fish fauna of Lake Tana are included in the genera *Oreochromis*, *Clarias*, ‘large’ barbs (*Labeobarbus*) ‘small’ *Barbus*, *Garra*, *Varicorhinus* and *Nemacheilus*.

O. niloticus has been described as separate sub-species *Oreochromis niloticus tana* (Seyoum & Kornfield, 1992). Boulenger (1911) described 3 species of the genus *Clarias*. However, Teugels (1986) synonymized all the three with *C. gariepinus*. Before 1990s “large” barb species of Lake Tana were considered as one large complex species *Barbus intermedius intermedius* Banister 1973 (Tesfaye Wudneh, 1998). Later, after the work of many scientists, (Alekseyev *et al.*, 1996; de Graaf, 2003; Dgebuadze *et al.*, 1999; Dixon *et al.*, 1996; Nagelkerke, 1997; Nagelkerke, *et al.* 1994; Nagelkerke, *et al.* 1995; Nagelkerke & Sibbing, 1998 Nagelkerke & Sibbing, 2000), the large barbs of Lake Tana were categorized into 15 morphotypes (species).

The “small” barbs of Lake Tana are represented by *Barbus pleurogramma* Boulenger 1902, *Barbus humilis* Boulenger 1902, *Barbus trispilopleura* Lèvêque & Daget 1984 and *Barbus tanapelagius* de Graaf *et al.* 2000. However, Eshete Dejen (2003) hypothesized that *B. humilis* and *B. trispilopleura* are not separate species. The genus *Garra* is represented in the lake by *Garra dembecha* Getahun 2000, *Garra dembeensis* Rüppell 1836; *Garra tana* Getahun 2000; and *Garra microstoma* Getahun 2000.

The genera *Varicorhinus* and *Nemacheilus* are represented by single species each, *V. beso* and *N. abyssincus*, respectively. Two exotic species, *Gambusia holbrooki* Girard 1856; and *Esox lucius* Linnaeus 1758, were brought from Italy during the late 1930s and introduced into Lake Tana (Shibru Tedla & Fisseha H/meskel, 1981). Therefore, the total number of fish species of Lake Tana is 27 or 28. See Appendix 2 for fish species found in some small lakes of the country.

1.3.3 River basins

About 28-30 fish species belonging to 11 families and 19 genera were recorded from the Shebelle-Juba Catchments within the limits of Ethiopia (Table 1.3). The system is unique in the country due to the presence of east African, Nilo-Sudanic and presence of diadromous fishes (Golubtsov and Mina, 2003; Roberts, 1975; Abebe Getahun, 2005b). Omo-Ghibe including their tributaries and Lake Turkana are home to 79 species of fishes (Table 1.2). Of these species *N. abyssinicus* is endemic fish recorded from the basin (Dgebuadze et al., 1995). The Baro-Akobo basin, the richest basin in fish fauna, is home to 91 species of fishes (Golubtsov et al., 1995) (Table 1.2). The number of fish species inhabiting the Abay (Blue-Nile) basin excluding the Lake Tana basin is about 45-46 (Golubtsov and Mina, 2003) (Table 1.2) of which 3 of them are endemic.

Table 1.2 Fish species diversity in major drainage basins within the limits of Ethiopia (Ind.: indigenous, Intro.: introduced).

River basin	Families	Genera	Ind.	Endemic	Intro.
Awash			10 ^{Ge}	3	
Wabisheblle-Juba	11	19	28-31	19	3
Omo-Turkana	19	42	79	15?	
Baro-Akobo	23	55	106	13	
Abay (Blue –Nile)			45-46	3	1
Tekeze	9	22	32	3	1-2

According to MWR (1998), the fish species found in the Tekeze River are *O. niloticus*, *C. gariepinus*, *B. intermedius*, *Barbus spp.* and *B. docmac*. The genera *Garra*: *Garra blanfordii* Boulenger, 1901; *Garra duabarbhis* Getahun 2001; *Garra dembecha* Getahun, 2000; *Garra geba* Getahun 2000; *Garra ignestii* Gianferrari, 1926 and one species of *Bagridae*; *B. docmac* are listed as existing in Tekeze basin. Some fish that are included in the genera *Synodontis*, *Mormyrus*, *Bagrus*, *Alestes* and *Labeobarbus* were sampled from River Gendawuha in the Tekeze drainage basin (Personal observation). River Zariam, one of the tributaries of the Tekeze River, is a home to some commercially valuable fish that are included in the genera *Clarias*, *Barbus*, *Varicorhinus* and *Oreochromis* (seid Muhammed and Belay Abdissa, 2002 unpublished report). They also reported the occurrence of *C. gariepinus*, *B. docmac*, *B. intermedius*, *B. nedgia* and *O. niloticus* in River Sanja. Among the fish species of the

Tekeze system, *V. beso*, and *G. ignestii* are fish species endemic to Ethiopia.

In spite of the fact that Ethiopia is endowed with large bodies of inland waters and contains edible fish species, the Baro River and its flood plains, the largest flood plains in the country, Lake Tana, and Ethiopian Rift lakes are among the few freshwater bodies in which a significant fish exploration and exploitation are realized (MWR, 1998). No adequate study has, for example, been made on estimation of the potentials of Ethiopian rivers, which are supposed to be economically important. Rivers Angereb and Sanja are among such rivers that have received no adequate attention. The importance of fish exploration of Ethiopian fresh water systems on one hand and the absence of adequate study on fish diversity, distribution, abundance, etc on the other, justifies this study on Rivers Angereb and Sanja.

2 Objectives

2.1 General objective

- To gather base-line scientific information for proper utilization and management of fishes of Rivers Angereb and Sanja so that the resource could contribute to food security in the country.

2.2 Specific objectives:

- To identify fish species composition of Rivers Angereb & Sanja.
- To estimate relative abundance of the fish species in the rivers.
- To estimate length – weight relationship and condition factor of the dominant fish species.
- To asses sex ratio of the dominant species.
- To estimate fecundity of the dominant species.

3. Study areas

3.1 The Tekeze drainage basin

There are three sub-drainage basins within the Tekeze basin itself. These are the Tekeze, Angereb, and Guang basins. They have catchments area of 63, 375 km² (of which 4, 214 km² is in Eritrea), 13, 326 km² and 6, 694 km² respectively. The Guang River becomes the Atbara after it confluences with Angereb River it becomes larger than Tekeze River in the Sudan, and its main tributary is Rivers Tekeze. The Tekeze is also called the Settit in Sudan (MWR, 1998) (Figure 1.1).

Climate: The temperature of the Tekeze basin in which the two rivers are found generally varies with altitude. The mean air temperature of the highlands varies between 16°C and 20°C, whereas the low lands have temperature range of 21°C to 27°C. The total rainfall varies from 500 mm in the western, northern and eastern, to 1000 mm in the south and 1, 500 mm in mountain areas. The wet seasons are from June – September (MWR, 1998).

3.2 The Angereb sub-drainage basin

Rivers Angereb and Sanja are found in Tach Armacho Wereda, North Gondar Administrative zone in the Tekeze drainage basin. Both rivers lie along the road to Humera highway. The Angereb river basin is about 13,300 km² excluding tributaries, which enter the Atbara beyond the

Sudanese border (MWR, 1998). Angereb River originates at the foot of Ras Dejen Mountain west of Dabat town whereas River Sanja, one of the tributaries of Angereb River, springs near Gondar town in west and confluences with the Angereb at about 81 km north of the city of Gondar (Personal communication with local people). The length from the upper reach down to the international boundary is 220 km for the Angereb River (MWR, 1998).

3.3 The study sites

General descriptions:- Rivers Angereb and Sanja are perennial despite the seasonality of rainfall in the Angereb basin. Sanja River is smaller in water volume than Angereb River. The water of Sanja is relatively clearer than the water of Angereb during the whole sampling periods. All along the length of the rivers between the sampling sites, there are chains of pools alternated by rapids. Both rivers flow through gentle slopes resulting in the absence of waterfalls along their length between the sampling sites.

Flora: The perennial open savanna grasses characterize the vegetations of the study area. These grass species grow up to 2.5 m. There are also variety of shrubs and shrub-like trees. The dominant trees are *acacia* species, which spread throughout the tall grasses. However, the riparian vegetation is dominated by the *Ficus spp.* (Sholla, in the local name) and these trees grow hanging their branches down to the water of the river.

As a result, quite a large amount of foliage from the trees and the grasses are seen floating on the water. Other tree species encountered very frequently around the rivers and the study sites are included in the genus *Boswellia* (Ye Itan Zaff in the local name).

Fauna: Nile crocodile (*Crocodylus niloticus*) and monitor lizards (*Varanus niloticus*) are very common in the waters and around the study sites. Different kinds of small snakes, large snakes (Tizira in local name) and frogs are frequently observed around the sites. However, the most diverse vertebrate animals are aquatic birds which include piscivorous birds such as pied king fisher (*Ceryle rudis*) and malachite king fisher (*Alcedo cristata*). Egyptian goose (*Alopochen aegyptiaca*) and Hammer kop (*Scopus umbretta*) are among non-piscivorous bird species around the study sites. There are also diversified aquatic and terrestrial insects in and around the study sites.

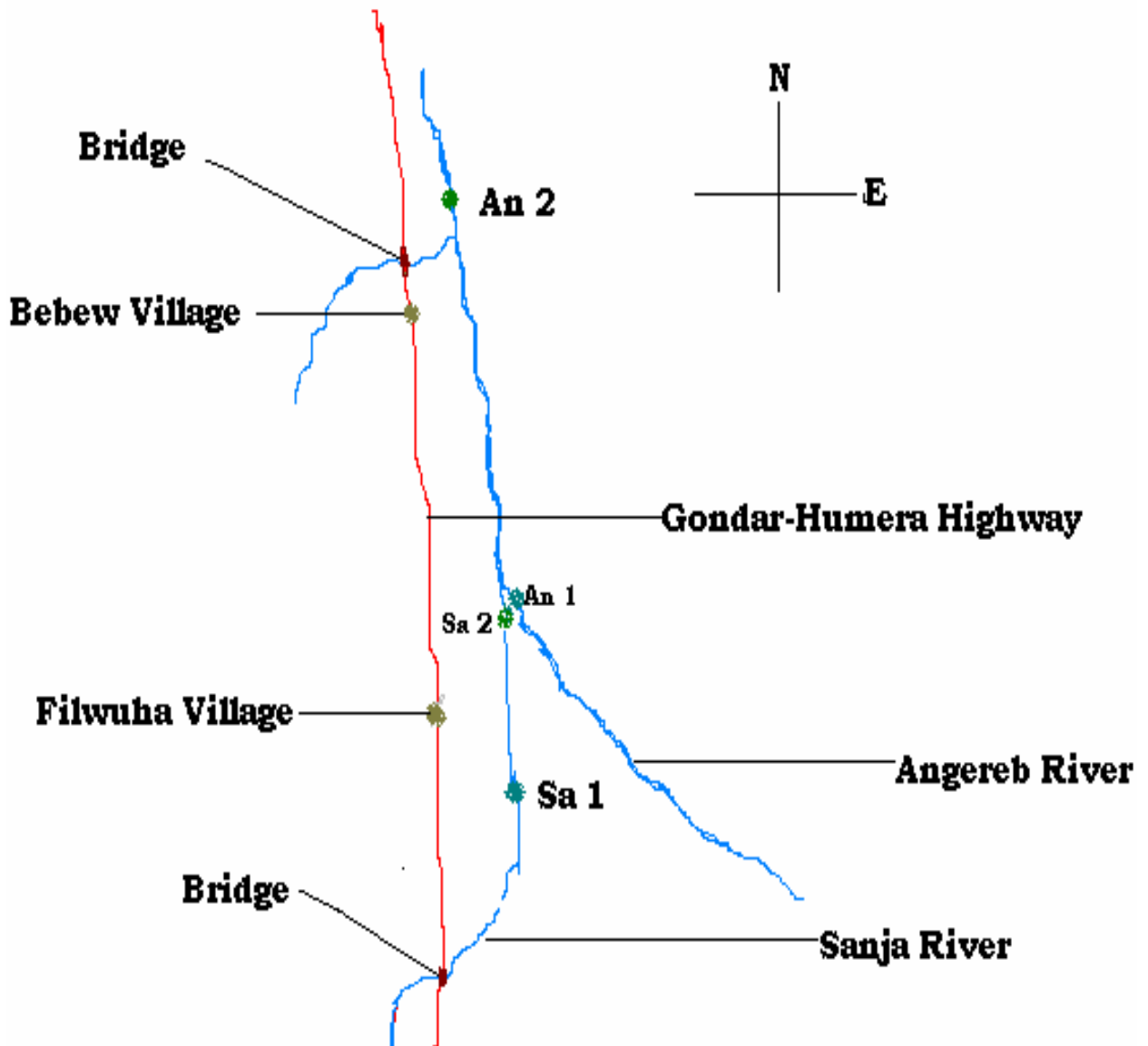


Fig. 3.1 Schematic diagram showing sampling sites in relation to the road running from Gondar to Humera.

4. Materials and Methods

A. Site selection: - Before starting regular sampling programs a reconnaissance survey was conducted together with my advisors to fix the sites. Two sampling sites were selected along each river taking into account the velocity of flow of water, habitat types, depth of the water, and substratum type. The sites were given names as follows: River Angereb site 1 (An1), River Angereb site 2 (An 2) Sanja River site 1 (Sa1) and River Sanja site 2 (Sa 2) (Fig. 3.1).

An1 (Chelemit) and Sa2 (Chelemit) (13°07'39.9"N, 37°16'10.2"E and 13°07'38.7"N, 37°16'10.4"E respectively): The sites are located 2 km northeast from Filwuha village (Fig. 1.2). The village is situated on Gondar-Humera highway about 80 km north of the city of Gondar. The stations (sites) are characterized by relatively less human interference. The two sites are very close to each other (isolated from each other only by a very tall rocky cliff) and the rivers merge into one at about 300 m down the stream from the sites. The waters of the two sites are found in very deep gorge formed by rocky cliffs. The substratum of both rivers is composed of mud, sand and pebbles. In addition, the substratum of An 1 is composed of rock bed.

Sa1 (Chiqaw Bahir) (16°06'50.1"N, 37°16'03.1"E): - This site is located at about 1 km in the southeast from Filwuha village (Fig. 3.1). Human

interference is very high, i.e. it is a place where local communities fetch water, swimming place for local children, and drinking site for cattle and herds. There are farmlands near the site and the water flows in deep and narrow gorge. Mud, sand and pebbles characterize the riverbed of the site.

An2 (Bebew) (13°09'38.2"N 37°14'25.9"E): - Angereb 2 was fixed at about 87 km north of the city of Gondar near Bebew village (Fig. 3.1). The site is about one kilometer from the village and 100 meters away from the main road of Gondar-Humera highway. Some rapids are present at this station with relatively high human interference. The vegetation cover at the site is very low except in the wet season. The riverbed is composed of mud, gravel, pebbles, sand, and bedrocks.

B. Field sampling: - Data were collected in two seasons: the wet season (end of the rainy season) (November 2004 and October 2005) and the dry season (January 2005 and May 2005). Each site was sampled eight times (four times in the wet season and four times in dry season). Samples were collected using gill nets of various mesh sizes (6, 8, 10 and 12 cm stretched mesh) and monofilament nets with various stretched mesh sizes (4-24 cm stretched mesh). Multiple hooks and line was used to catch fishes in areas where gill net setting was not suitable. The nets were set using swimmers across the river diagonally late in the afternoon

(4:30 PM) and stay in the rivers for about 15 hrs and then collected in the following day (7:30 Am). Immediately after capture, total length (TL) and total weight (TW) were measured to the nearest 0.1cm and 0.1g respectively, for each specimen. Fork length (FL) and standard length (SL) were also measured. Gonad weight of the most dominant species (*L. forskalii*) was measured for fecundity study. Finally the samples were put in plastic jars containing 10 % formalin and labeled with all necessary information. For further identifications, the specimens were transported to Fisheries Laboratory, Department of Biology, Addis Ababa University.

C. Laboratory studies: - The specimens were soaked in tap water for many days to wash the formalin from the specimens. Then, they were transferred to 75 % ethanol before species identification was conducted. The specimens were identified to species level. This was made using taxonomic keys found in different literatures such as Boulenger (1909-1916), Shibru Tedla (1973), and Golubtsov *et al.* (1995). The specimens were also compared with previously identified specimens (species) available at the fisheries laboratory, Department of Biology, Addis Ababa University. The specimens were also compared with figures and illustrations found in different literature such as Boulenger (1909-1916), Skelton (1993), Witte and Wim (1995), and figures from the internet. Finally the species were labeled and deposited at the Fisheries Laboratory, Department of Biology, Addis Ababa University.

D. Species description: Originally (both at the sites and in laboratory) the fish specimens were sorted into groups based on their general appearance. Then this sorting was further extended to smaller number of specimens for the dominant morphotypes. Therefore, the species description was based on more fish specimens than used for the present formal species description. However, all the morphotypes with few specimens were used for species description without sorting them into smaller number. Since most of meristic features and morphometric measurements are indicated in Appendix 1, all characteristics of the species were not included in formal species description (pages 26 – 40).

E. Data analysis: - Data were analyzed by the use of statistical softwares Minitab for Windows version 12 and SPSS for Windows version 12.

I. *Relative abundance:* - Estimation of relative abundance of fishes in Rivers Angereb and Sanja was made by taking the contribution in number and weight of each species in the total catch in each sampling effort.

II. *Length-weight relationship:* - The relationship between total length and total weight of the most dominant species was calculated using power functions as in Bagenal and Tesch (1978) as follows:

$$TW = a X T L^b$$

Where TW = Total weight (gm)

TL = Total length (cm)

a = Intercept of the regression line

b = Slope of the regression line

III. *Condition factor*: - The well being of the most dominant species was determined using Fulton Condition Factor (FCF) by the following equation suggested by Bagenal & Tesh (1978):

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

Where TW = Total weight

TL = Total length

IV. *Fecundity*: Fecundity was determined gravimetrically. It was calculated for specimens of female *Labeo forskalii*. Three sub-samples of 1g eggs were taken from different part of the ovary and counted, and an average of these was calculated. Then, the total number of eggs per ovary was calculated by extrapolation from the mean calculated. After calculating the relative fecundity by dividing the number of eggs per fish by its total body weight, the relationships of fecundity to some morphometric measurements were determined. This was done by relating fecundity to total length, total weight and ovary weight as in Demeke Admassu (1994) using the following formulae: -

$$\mathbf{F = a \ X \ TL^b}$$

$$\mathbf{F = a \ X \ TW^b}$$

$$\mathbf{F = a X bOW}$$

Where F = fecundity

TL = Total Length (cm)

TW = Total Weight (g)

OW = Ovary Weight (g)

a = constant.

b = exponent

V. *Sex ratio*: - Sex ratio was determined using the following formula:

$$\mathbf{Sex\ ratio = \frac{Number\ of\ female}{Total\ number\ of\ specimens}}$$

5. Results and Discussion

5.1 Fish diversity in Rivers Angereb and Sanja

Ten species of fishes were identified from Rivers Angereb and Sanja at the study sites. The species identified were: *Labeo forskalii*, *Labeo niloticus*, *Labeobarbus nedgia*, *Labeobarbus cf. intermedius*, *Varicorhinus beso*, *Mormyrus kannume*, *Oreochromis niloticus*, *Bagrus docmac*, *Clarias gariepinus* and *Hetrobranchus longifilis* (Figs. 5.1- 5.11& Table 5.1). These fish species are included in the families *Cyprinidae*, *Mormyridae*, *Cichlidae*, *Bagridae* and *Clariidae*. Among these fish species, *Mormyrus kannume* were collected only from Angereb River (Table 5.1).

Table 5.1 Fish species identified from the study sites of Rivers Angereb and Sanja (x-present: 0- absent).

Fish spp.	Rivers and the sites			
	An 1	An 2	Sa 1	Sa 2
<i>L. forskalii</i>	x	x	x	x
<i>L. niloticus</i>	x	x	0	x
<i>L. nedgia</i>	x	x	x	x
<i>L. cf. intermeius</i>	x	x	x	x
<i>V. beso</i>	x	x	x	x
<i>O. niloticus</i>	x	x	x	x
<i>M. kannume</i>	x	0	0	0
<i>H. longifilis</i>	x	x	x	x
<i>C. gariepinus</i>	x	0	X	x
<i>B. docmac</i>	x	x	x	x

5.1.1 Fish species descriptions

I. *Labeo forskalii* Rüppell, 1836 (Figure 5.1).

Diagnosis: - The species has large keratinized tubercles on its snout. It has very much-developed labial fold forming sucker around the mouth (Fig. 5.1B). Eyes are supero-lateral. The upper edge of dorsal fin is relatively long and concave in shape.

Description: Eyes are big. Mouth is inferior and protractile. Lips highly developed, upper straight-edge, lower has papillae and not much expanded (Fig. 5.1B). Rostral flap is large. It has deep crosswise groove above the snout. Predorsal relatively long (37.5 – 45.2 % SL). Minute barbells concealed under the fold of skin in the corner of mouth. Nostrils are small. Head naked and relatively short (HL<HD). Body a little compressed, covered with cycloid scales. Lateral line complete, 37 – 41 scales in the lateral line. Dorsal fin originates about halfway between tip of snout and base of caudal fin. Caudal fin emarginate. Numerous (more than 50) gill rakers on the anterior gill arc.

Coloration: Live specimens are dark greenish above and on flanks, white ventrally. In alcohol, dark above and on the flanks and white below.

Distribution in Ethiopia: - Currently *L. forskalii* is known from Blue-Nile (Abay) and Baro-Akobo basins. Large number of specimens of the

species was sampled and identified in the present investigation from Rivers Angereb and Sanja.



A.



B.

Figs. 5.1 A: Lateral view of *L. forskalii*; B: Ventral view of head region of *L. forskalii*

Comparisons: Among the species of fishes in the Rivers Angereb and Sanja at the study sites, *L. forskalii* resembles *L. niloticus* in the presence of labial fold around the mouth. Moreover, in both *L. forskalii* and *L. niloticus* caudal fin is deeply emarginated and crescent when fully spread. However, as noted above, *L. forskalii* has highly keratinized tubercles on its snout; very much developed labial fold around the mouth. It has bigger eyes than *L. niloticus*. *L. forskalii* has darker

coloration above and on the flanks, while *L. niloticus* has white-grey on its dorsum and flanks (Figs 5.1A and 5.2).

II. *Labeo niloticus*, Forsskåll 1775 (Figure 5.2)

Diagnosis: - Dorsal fin with 14-17 branched rays. 43 – 45 scales in the lateral line. Its longest dorsal fin a little longer than head. Snout rounded. Eyes perfectly laterally placed.

Description: - Eyes small (13–16 % HL). Mouth inferior and protractile. Lips less developed with many rows of papillae. Minute barbells concealed under the folds of skin in the angle of mouth. Very small nostrils situated in front of the eyes. Head naked, relatively short (HL < BD). Predorsal relatively long (35 – 40% SL). Body relatively large (about 26.67 – 27.9 % SL). Dorsal fin long (about 27 % SL). Caudal fin deeply emarginate. Body covered with cycloid scales.

Coloration: In fresh specimen dorsum and flanks whitish grey (shiny), and white ventrally. In alcohol and when exposed to light, the scales on dorsum & the flanks turn pinkish in color.

Distribution: *L. niloticus* is found in the Abaya, Chamo and Chew Bahir basins. The species is also recorded from Abay, Omo-Turkana, Baro-

Akobo basins. Very few (about 3) specimens of the species were sampled from Angereb River in the present study.



Figure 5.2 Lateral view of *L. nilotica* (From Angereb River).

III. *Labeobarbus nedgia* Rüppell 1836 (Figure 5.3).

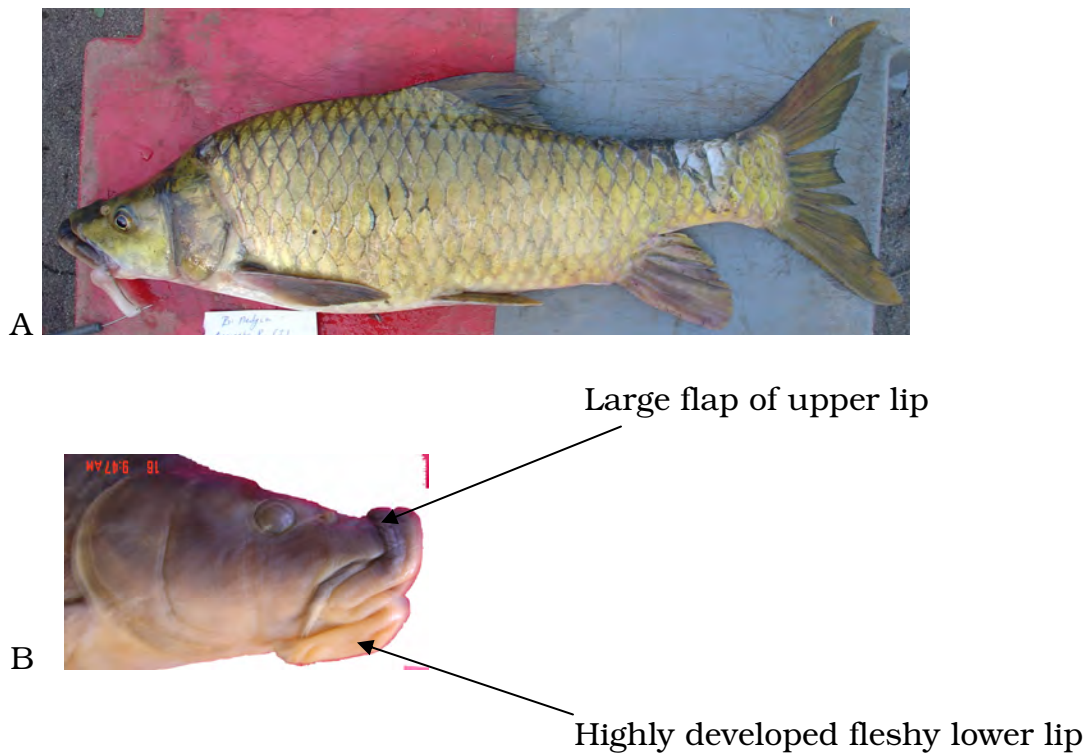
Diagnosis: - *L. nedgia* is mainly distinguished by its highly developed lips with fleshy lobe of lower lip and large flaps of the upper lip (Fig. 5.3B). It has fleshy nose that curls back over the nose.

Description: - Mouth inferior, protractile, with a large upper jaw extension. Lower with a well-developed median lobe (0.74– 3.52 cm recorded present study); jaws rounded. Very short 2 pairs of circum-oral barbells present. Eyes are relatively small (diameter 12 – 14 % in HL). Head length is a little less than body depth. It has relatively short snout (its length is about 28.13 – 36 % in HL). Body covered with cycloid scales, 31-33 in the lateral line. Dorsal fin equally distant from the tip of

snout and from the caudal. Scales longitudinally striated. Caudal fin forked.

Coloration: Although live specimens are variable in color, most of them are light yellowish. Other very common colors observed are brownish, olive-green and golden above and flanks. Preserved specimens have a bit dark dorsum and flanks, white beneath.

Distribution: The species was described as endemic to Lake Tana (Nagelkerke, 1997). However, large number of the specimens of the species was collected from Rivers Angereb and Sanja in the present study.



Figs. 5.3 A: Lateral view of *L. nedgia* B: Head region of *L. nedgia* (From Angereb River)

IV. *Varicorhinus beso* Rüppell 1836 (Figure 5.4A).

Diagnosis: It has non-protractile, inferior mouth. Its lower lip absent, replaced by a sharp horny scraping rim (Fig. 5.4 B).

Description: - Eye not visible from below (supero-lateral). Mouth wide. Minute barbells (1 pair) placed at the angle of mouth. Very small tubercles in 3 series around the snout immediately below the eye. Nostrils small, positioned in front of the eyes. Snout rounded. Head relatively short (HL < BD). Body moderately deep (about 3 times in standard length). Dorsal fin originates a little in advance of ventral. The longest pectoral fin not reaching pelvic fin origin. Caudal fin forked. Body covered by cycloid scales (radially radiating strain, and numerous black dots on the exposed surface of the scales). Chest and abdomen covered by scales. Lateral line complete, 31-36 scales in lateral line.

Coloration: Although variable most of fresh specimens are green above, yellowish or pinkish grey below. In formalin and alcohol, the dorsum is dark, light ventrally.

Distribution: *V. beso* is found in the Awash River basin, the Blue Nile system including Lake Tana and highland rivers and lakes of Ethiopia. Large number of the specimens of the species has been collected in present study from Rivers Angereb and Sanja in the Tekeze basin.



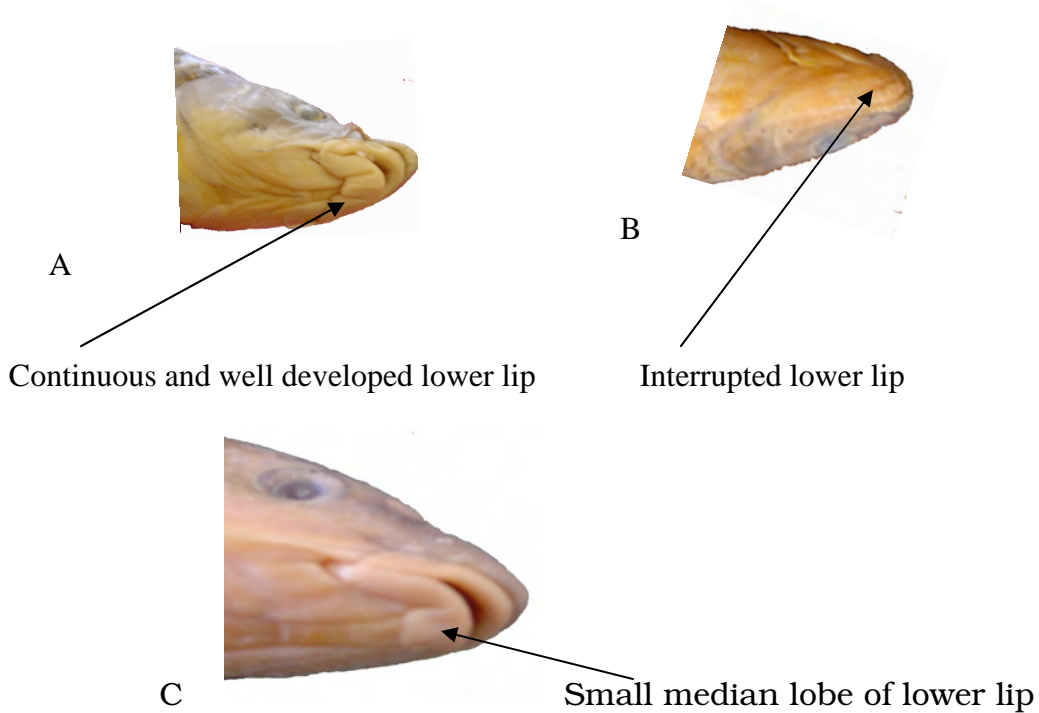
Fig. 5.4 A: Lateral view of *V. beso* B: Head region of *V. beso* (From River Sanja).

V. Labeobarbus cf. intermedius Banister, 1973 (Figure 5.6)

Description: Head naked, variable in dorsal profile. Mouth terminal and protractile. Lip development variable. Eyes small, about 14 % in head length. Barbells small, 2 pairs on the upper jaw only. No teeth on the jaws (basic characteristics of cyprinids). Body variable in shape, covered with cycloid scales. 30 – 36 scales in the lateral line. Dorsal fin originates immediately above the pelvic fin. Dorsal and anal fins short, the former with a sharp spine and the latter base shorter. No adipose fin.

Some variations in the external morphology of the morphotypes:

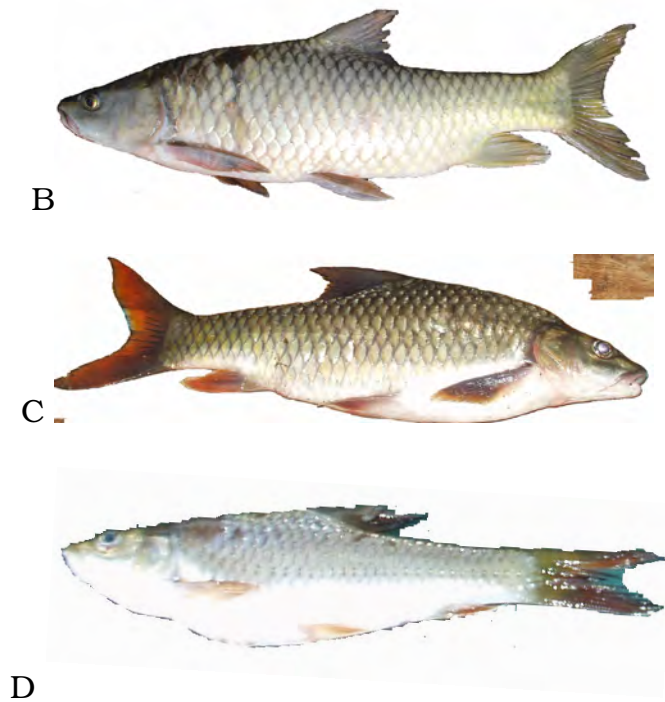
- I. Lower lip development: - In this investigation 3 different lower lip developments have been observed: continuous (Fig. 5.5A), interrupted (Fig. 5.5B) and small median lobe (Fig. 5.5C).



Figs. 5.5. Ventral views of mouth region of *L. cf. intermedius*

- II. Dorsal head profile: - 3 different profile have been observed: concave (Fig. 5.6A & D), straight (Fig. 5.6B) and convex (Fig. 5.6C)





Figs. 5.6 Dorsal head profiles of *L. cf. intermedius*

III. Body forms: extremely variable (Figs. 5.6A-D).

Coloration: - Fresh specimens show extremely variable color but the most common color observed was light yellow.

Distribution: - The species is widely distributed in Ethiopian fresh waters.

Due to these variations and similarities, as mentioned above, among the morphotypes, it was difficult to classify them into their lowest taxonomic (species) level, hence lumped as *Labeobarbus cf. intermedius* Banister 1973.

VI. *Oreochromis niloticus* Linnaeus, 1757 (Figure 5.7).

Diagnosis: The species has single dorsal fin with many spines. Lateral line divided into upper and lower sections, with 31 scales. Only one nostril on each side of the snout. Faint traces of 8 dark vertical bars on the flanks and the caudal peduncle. Gill rakers are 27 or 28 on the lower half of the first gill arc.

Description: Head naked. Snout rounded. Protuberance absent on the dorsal surface of snout. Mouth moderately large and terminal. Outer jaw contains several teeth in 4 series rows. Eyes visible from the dorsal only (supero-lateral). Body somewhat compressed laterally. Caudal peduncle depth equal to length. Scales cycloid. Lateral line interrupted. Dorsal with XIII11-XVIII12; anal III8-III9. Caudal fin truncated with 8-10 faint Vertical bars.

Coloration: Dark grayish color above, white below.

Distribution: The species is widely distributed in almost all major lakes and rivers of Ethiopia including Lake Tana, Baro River basin, Ethiopian Rift lakes, Awash River basins and Omo River. 15 specimens of the species have been collected in this study from Rivers Angereb and Sanja.



Figure 5.7 *O. niloticus* (From Sanja River)

VII. *Mormyrus kannume* Forsskåll 1775 (Figure 5.8)

Diagnosis: - Its dorsal head profile a bit curved, slopping steeply. Snout produced into a stout thick trunk. Dorsal fin long, originating above the pelvic fin and ends posterior to the anal fin, 57 – 75 dorsal rays and anal fin rays 18 – 21. 80 – 115 scales in lateral line.

Description: - The head is long, narrow, naked and curved. The mouth is non-protractile, very small and terminal. The lips are thick, the lower a little longer than the upper. The species has five teeth in the upper jaw and eight in lower jaw inserted on the lip scales. The eyes are relatively small, about 9 % of head length, and laterally positioned. Numerous black dots are seen all over each gill raker. Body elongated and strongly compressed, its depth is 19.8 – 26.86 in SL. Scales small and cycloid. Lateral line complete, 109-114 scales in the lateral line, 36-38 round

caudal peduncle. Dorsal fin rays 59-61. Caudal fin lobbed. No adipose fin.

Coloration: Both live and preserved specimens have dark brown above and on flanks, light ventral.

Distribution: *M. kannume* is known from the Nile basin. In the present study, only four specimens of the species have been collected from River Angereb in the Tekeze basin.



Figure 5.8 Lateral view of *M. kannume* (From Angereb River).

VIII. *Hetrobranchus longifilis* Valenciennes, 1840 (Figure 5.9).

Diagnosis: The species has two dorsal fins; the first rayed and the second adipose. Adipose fin is shorter than dorsal rayed. The species has knife shaped frontal fontanelle.

Description: - Head is wide (80-89 % of HL), long, strongly depressed and its upper surface is coarsely granulated. Eyes supero-lateral. Four

pairs (nasal, maxillary, outer mandibular and inner mandibular) of barbells are found around the mouth. Maxillary barbell extends to the end of pectoral fins. The species has villiform teeth, occurring in band. It has short, 24–25 gill rakers in the lower part of anterior arc. Body somewhat elongated and scale-less. Adipose fin originates immediately behind the dorsal fin and extends to the base of caudal fin. Pectoral fin short, (13.9 – 15.2 % of HL), its spine serrated on the outer border (Fig 5.8). The largest fish collected from the study sites.

Coloration: Although variable in color, most of them have olive above, and creamy white beneath. Caudal fin pale orange at the base.

Distribution: Gambella region (Baro-Akobo basin). Few specimens (20 specimens) of the species have been sampled during the present study from Rivers Sanja and Angereb.



Figure 5.9 Lateral view of *H. longifilis* (From Angereb River)

iX. *Clarias gariepinus* Burchell, 1822 (Figure 5.10).

Diagnosis:- *C. gariepinus* has scale-less slimy skin. Head is highly flattened dorso-ventrally. The skull bones above and on the sides are casque shaped. It is easily distinguished by the lack of adipose fin. The species has very long dorsal and anal fins.

Description: Eyes are relatively small, about 6.9% of head length, and are laterally placed. The head is large, depressed, and heavily boned. The mouth is quite large and sub-terminal in position. Four pairs (nasal, maxillary, outer mandibular and inner mandibular) of barbells are found around the mouth. The longest of these are outer mandibular barbells (about 11.1 cm was recorded). There are two nostrils very close to the origin of nasal barbells. The species have small pointed teeth in large bands on the upper and lower jaws. It has elongated cylindrical body forming eel shape and it tapers to the tail (angulliform shape). *C. gariepinus* has long dorsal and anal fins that extend to the origin of caudal fin, each terminate in lobe. The dorsal fin has 61-78 soft rays and anal fin has 48-57 soft rays. Pectoral fins are very strong with spines that are serrated on the outer side.

Coloration: Live specimens possess black color dorsal and cream color ventrally. Longitudinal line has been observed on either side of the head.

In alcohol and when exposed to light, the specimens turn lighter in color (Fig. 5.7).

Distribution: The species is found in almost all major lakes and rivers of Ethiopia. Five specimens of the species were collected in the present investigation from the study sites.



Figure 5.10 Lateral view of *C. gariepinus* (From Angereb River).

X. *Bagrus docmac* Forsskäll, 1775 (Figure 5.11).

Diagnosis: *B. docmac* has two dorsal fins, the first short rayed with strong spines, the second long adipose. The last caudal fin rays form filamentous extension. Anal fin short. Four pairs of un-branched circum-oral barbells present.

Description: - Head depressed, wide and smooth above. Eye small, laterally positioned. Four pairs of barbells present. Nasal barbell present. Gill rakers long, widely spaced, 9-10 on the lower part of anterior arc. Body scales, slimy and fairly elongated. Dorsal fin originates in advance

of the origin of pectoral fin. Adipose fin long (AF > BD). Anal fin has 9 branched rays. Predorsal long (about 41 % in SL). Caudal fin deeply forked.

Coloration: Dark olive above, dark grey on the flanks, creamy-white below.

Distribution: *B. docmac* is found in Lakes Chamo and Abaya, and in Abay (Blue-Nile), Baro and Omo river basins. Few specimens (only 31 specimens) of the species have been collected from Rivers Angereb and Sanja in the present investigation.



Figure 5.11 Lateral view of *B. docmac* (From Sanja River)

The fish faunal diversity from the study sites contains a mixture of Nilo-Sudanic forms (*B. docmac*, *M. kannume*, *L. niloticus*, and *L. forskalii*) and East African representatives (*L. cf. intermedius*, *L. nedgia*, *V. beso*, and *O. niloticus*). *C. gariepinus*, which is one of the species identified from the sites, is Pan-African in distribution (Roberts, 1975). The reason for the

occurrence of nilotic fishes in the rivers is probably due to the presence of connection between Angereb River and the White Nile through the Tekeze River basin. These forms of fishes are found predominantly in the White Nile basin (Roberts, 1975).

Although the occurrence of some East African fish forms in the Tekeze River basin was reported (Ethiopian Agricultural Research Organization, EARO; 2002), these forms were not recognized particularly from the Angereb basin prior to this investigation, except for the field report of Seid Muhammed and Belay Abdissa (2002). Boulenger (1905), Nichols and Griscons (1917), Roberts (1975) and Bănărescu (1995) reported the occurrence of these fish forms in the Abay drainage basin but did not report these fish forms in the Agereb drainage basin.

Garra is distributed throughout Asia and Africa but about 60 % of the African species are found in Ethiopia (Krysanov and Golubtsov, 1993). *Garra* are apparently highly resilient fishes found in large numbers even in streams that hardly flow and where there is light pollution (Abebe Getahun & Stiassny, 1998). However, during this investigation the specimens of the species of the genus *Garra* were not sampled. Similarly, the specimens of small *Barbus* spp., which are adapted to swift flowing floodwaters that occur seasonally, were no sampled during this investigation.

In most streams, there is a progressive increase in number of fish species downstream and numerous other species-specific (e.g. biomass) variables changes increase from headwater to downstream (Bistoni & Hued, 2002). However, only one additional species was recorded during this investigation in An 2, which is about 7 km down stream from An 1.

During this investigation only 10 species of fishes were identified from the study sites (Table 5.1). One of the possible reasons for less diversity of the species could be the effect of flow variability on fishes assemblage. Stream flow controls important characteristics such as depth, channel width, velocity and substrate composition (Lowe-Connell, 1977). Some times high flows, for instance, can destroy fish habitats. It can also wash the eggs of fish that have already been laid. On the other hand during the dry season, when the flow is low, and when the water level is reduced, the fishes are often trapped in very small shallow pools. This causes stress on fishes and also makes them very visible to predators. Because of these, very tolerant species such as cyprinids survive in such areas. This study showed similar result where the fish species identified from the study sites are dominated by cyprinid fish. These are resilient fishes as stated by Abebe Getahun and Stiassny (1998). Other tolerant fish species such as *C. gariepinus* and the tilapia (*O. niloticus*) were sampled from the study sites.

In many tropical rivers flow variability is low in downstream reaches and species richness gradient correlates with flow variability, i.e. diversity increases from upstream to downstream reach (Moyle, 1982). This is one of the possible reasons why Joint Ethio-Russian Biological Expedition (JERBE) team sampled more than 20 species at the lower reach of Angereb River in 2005 near Abderafi Village (Personal communication with one of the members of the JERBE team). This study was conducted at about 110 km upstream from the sampling sites of JERBE. Zeleke, who is currently working on diversity of fish species of River Beles (Mankusha), also sampled more than 13 species of fishes at the lower extreme of the river (personal communication).

Floodplain rivers are home to the largest fraction of freshwater biodiversity. Floodwaters are important because the flooding of lateral plains increase the area of food rich habitat and shelter from predators. They also provide ideal site for fish to develop and grow (Welcomme, 1979). However, floodplain areas are lacking from the study sites of the rivers. Therefore, the absence of flooded lateral areas at the study sites of the rivers probably contributed to low fish faunal species diversity at the study sites.

This study was carried out in the two seasons over relatively short periods of time. Besides, the study was conducted only at two sites along each river using selective gears. Because of these biasness some species

of fishes might have been missed. For comprehensive assessment on the magnitude of fish diversity in these rivers, investigations would have been done at least throughout the year using unselective (such as electrofishing) methods of catching the fish. Investigation would have also be done along the rivers, at least from their upper reach to the international boundary by selecting many more suitable sampling sites.

5.2 Relative abundance

5.2.1 Abundance by number

During the study periods (Nov. 2004 – Oct. 2005) a total of 923 fish specimens were collected from all the study sites (An1, An2, Sa1 and Sa2). Of the total specimens collected, 335 were caught during the wet season (after the rainy season) (Nov. 2004 & Oct. 2005) and 588 specimens were caught during the dry season (Jan. 2005 & May 2005) (Table 5.2).

In the wet season, a total number of 144 specimens of *L. cf. intermedius* were collected from all the sites thus *L. cf. intermedius* was the most abundant in number of all other species. The number of specimens of the other species is given in Table 5.2. Although *V. beso* is the fourth most abundant in number in the total catch, the specimens of the species were not caught in the wet season from all the study sites.

In the dry season, the number of specimens of *L. forskalii* in all the sites was 347 making the species, therefore, the most abundant during the dry season. The second most abundant species in number in the dry season was *L. nedgia*. *M. kannume* and *L. niloticus* showed the least number of specimens and *C. gariepinus* were not sampled in the dry season (Table 5.2).

Table 5.2 The contribution by number of each fish species in the total catch during the wet and dry seasons.

Fish	Wet season						Dry season						Overall	
Species	An1	An2	Sa1	Sa2	Total	%	An1	An2	Sa1	Sa2	Total	%	Total	%
<i>L. forskalii</i>	4	12	23	41	80	23.88	87	70	51	139	347	59.01	427	46.26
<i>L. niloticus</i>	0	1	0	0	1	0.30	1	0	0	1	2	0.34	3	0.33
<i>L. cf. intermedius</i>	54	39	15	36	144	42.99	21	9	13	21	64	10.88	208	22.54
<i>L. nedgia</i>	25	11	6	19	61	18.21	17	19	11	21	68	11.56	129	13.98
<i>V. beso</i>	0	0	0	0	0	0.00	7	33	11	30	81	13.78	81	8.78
<i>O. niloticus</i>	1	0	3	5	9	2.69	1	2	0	3	6	1.02	15	1.63
<i>M. kannume</i>	2	0	0	0	2	0.60	2	0	0	0	2	0.34	4	0.43
<i>B. docmac</i>	5	5	7	4	21	6.27	1	3	2	4	10	1.70	31	3.36
<i>H. longifilis</i>	4	0	6	2	12	3.58	0	2	4	2	8	1.36	20	2.17
<i>C. gariepinus</i>	2	0	2	1	5	1.49	0	0	0	0	0	0.00	5	0.54
Total	97	68	62	108	335	100.00	137	138	92	221	588	100.00	923	100.00

In all the sites, *L. forskalii* had a total of 427 specimens which accounts for about 46.26% of the total number of the catch. The percentage of other species in the total catch is shown in Table 5.2.

M. kannume appeared only in site 1 of Angereb River. *L. niloticus*, the least abundant in number (only 3 specimens) appeared in Angereb 1, Agereb 2 and Sanja 2. *C. gariepinus*, also one of the least abundant in number, was sampled from Angereb 1, Sanja 1 and Sanja 2. The specimens of all the other fishes appeared in both sites of the two rivers. However, *L. forskalii* was the most abundant in number in Sanja 2 and the second most abundant in Angereb 1. *L. cf intermedius* had the highest number of specimens in Angereb 1 and the second most abundant in Sanja 2 (Table 5.2).

5.2.1.1 Mean number of specimens at the sampling sites

There was significant variation (ANOVA, $P < 0.05$) in mean number of specimens between the sites during the two seasons (Table 5.3). In the wet season all the sites showed smaller number of specimens than the dry season. Sanja 2 had the highest number of specimens among all the sites in both the dry and the wet seasons (Fig 5.12).

Table 5.3 Mean \pm SD specimens' number of fish caught from the 4 study sites during the two seasons.

		Seasons			
Sites	Freq. of sampling	Wet	Dry	F	P
		Mean \pm SD	Mean \pm SD		
An 1	4	24.25 \pm 3.30	34.25 \pm 12.39	2.43	0.00
An 2	4	17.00 \pm 9.94	34.50 \pm 45.05	0.59	0.00
Sa 1	4	15.50 \pm 9.25	22.75 \pm 24.50	0.31	0.00
Sa 2	4	27.00 \pm 9.96	55.25 \pm 36.71	1.71	0.00

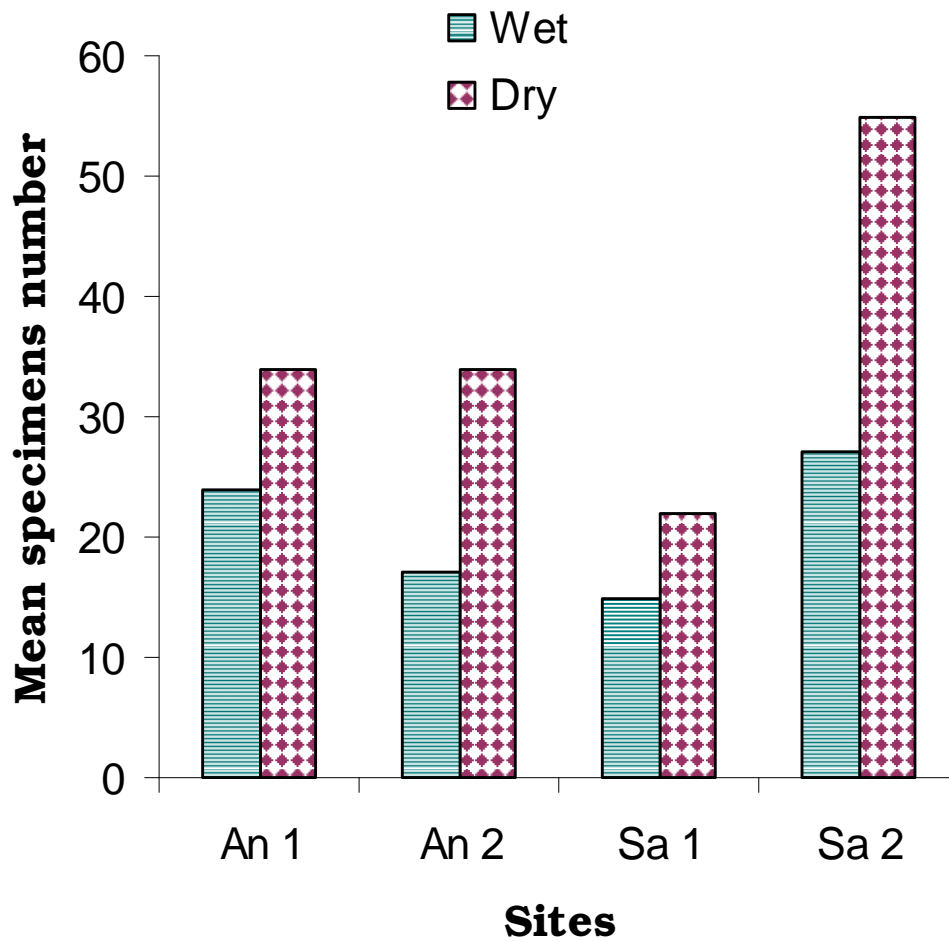


Figure 5.12 Mean number of specimens from the 4 study sites during the two seasons (Each site was sampled 4 times in the dry season and 4 times in the wet season).

5.2.2 Abundance by weight

A total of 297.4 kg of fishes was sampled during the study period. About 147.7 kg of which was sampled in the wet season and the rest (149.7 kg) was collected in the dry season. Although there was higher number of fish specimens in the dry season (588 specimens) than in the wet season (335) (Table 5.2) significant variation was not observed in the weight of fish specimens (ANOVA, $P > 0.05$) between the two seasons (Table 5.4).

In the wet season the total weight of *L. cf. intermedius* was 63.28 kg in all the sites thus the most abundant. However, in the dry season, *L. forskalii* had 82.8 kg in weight; therefore, this species was the most abundant by weight in the dry season. Other species had total weight in kg in both seasons as shown in Table 5.4.

In all the sites, *L. forskalii* had a total weight of 108.22 kg, which accounts for about 36.4 % of the total weight of all specimens examined. Therefore, this species was the most abundant in weight than the other species at the study sites. The second most abundant in weight was *L. cf. intermedius* which had 27.5 % in the total catch. The percentage in weight of other fish species is indicated in Table 5.4.

Table 5.4 The weight (kg) of fish specimens at each sampling site during the wet and dry seasons.

Fish Species	Wet season						Dry season						Over all	
	An1	An2	Sa1	Sa2	Total	%	An1	An2	Sa1	Sa2	Total	%	Total	%
<i>L. forskalii</i>	1.1	3.5	6.4	14.2	25.2	17.06	24.9	27.3	1.1	29.5	82.80	55.31	108	36.31
<i>L. niloticus</i>	0	0.5	0	0	0.5	0.34	0.7	0	0	0.9	1.60	1.07	2.1	0.71
<i>L. cf. intermedius</i>	27.2	16.9	4.7	14.4	63.2	42.79	6.6	2.9	3.9	5.2	18.60	12.42	81.8	27.51
<i>L. nedgia</i>	12	5.2	6.1	7.4	30.7	20.79	5	4	3.3	4.9	17.20	11.49	47.9	16.11
<i>V. beso</i>	0	0	0	0	0	0.00	0.8	3.9	1.4	4	10.10	6.75	10.1	3.40
<i>O. niloticus</i>	0	0	0.2	0.2	0.4	0.27	0.5	0.2	0	0.6	1.30	0.87	1.7	0.57
<i>M. kannume</i>	0.6	0	0	0	0.6	0.41	0.9	0	0	0	0.90	0.60	1.5	0.50
<i>B. docmac</i>	3.7	3.5	3.9	2.1	13.2	8.94	0.2	6.2	1.3	1.1	8.80	5.88	22	7.40
<i>H. longifilis</i>	3.2	0	4.6	2.6	10.4	7.04	1.2	1.4	4.3	1.5	8.40	5.61	18.8	6.32
<i>C. gariepinus</i>	1.9	0	1.2	0.4	3.5	2.37	0	0	0	0	0.00	0.00	3.5	1.18
Total	49.7	29.6	27.1	41.3	147.7	100.00	40.8	45.9	15.3	47.7	149.70	100.00	297.4	100.00

5.2.2.1 Mean weight (gm) of fishes at the sampling sites

There were significant differences (ANOVA, $P < 0.05$) in the mean weight of fishes between the seasons at each sampling site. There was higher mean weight in the wet season than in the dry season (Fig 5.13).

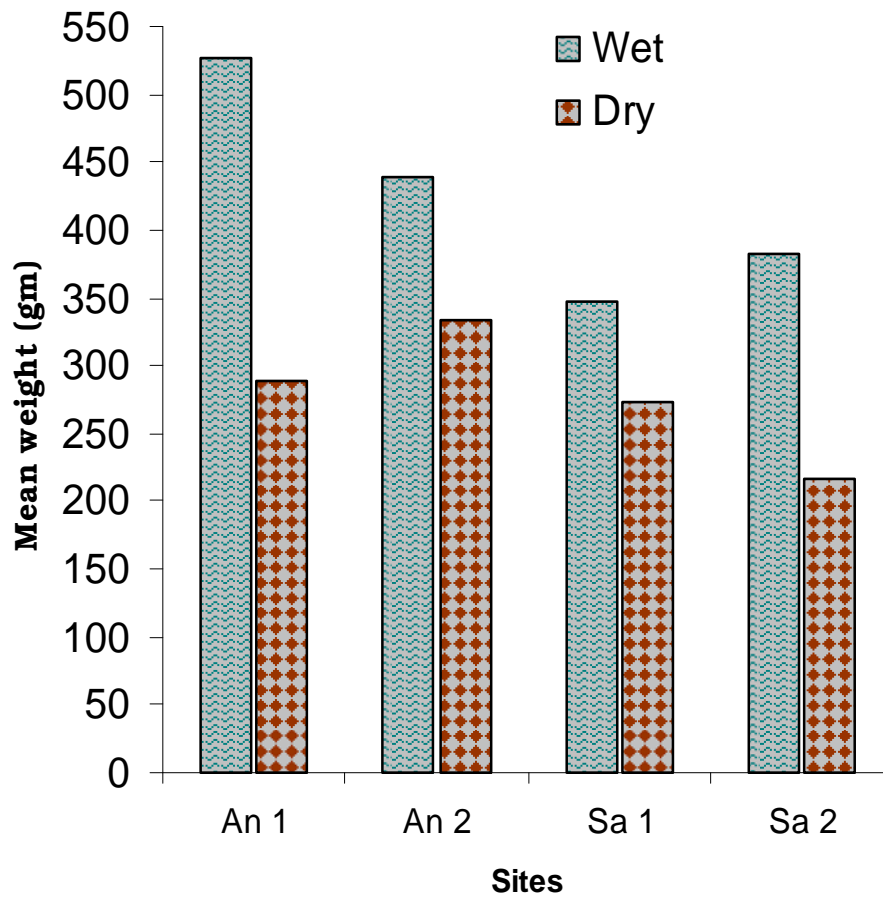


Figure 5.13 Mean weight (gm) of fishes in the 2 seasons from the 4 study sites (mean weigh was calculated in gram for fish)

5.2.3 Weight (gm) of the most common species in the two rivers

L. intermedius and *L. nedgia* showed significant variations (ANOVA, $P < 0.05$) in mean weights between the two seasons in Angereb River. However, significant differences (ANOVA, $P < 0.05$) were observed in the mean weights of *L. forskalii* and *L. cf. intermedius* between the two seasons in Sanja River (Table 5.5).

Table 5.5 Mean \pm SD weight (gm) of the most common fish species in the two rivers during the two seasons

Fish species	Rivers	Wet		Dry		F	P
		Mean \pm SD	N	Mean \pm SD	N		
<i>L. forskalii</i>	An	269.6 \pm 160.4	16	332.4 \pm 277.3	157	0.24	0.62
	Sa	322.7 \pm 141.1	64	189 \pm 214.6	190	26.6	0.00
<i>L. cf. intermedius</i>	An	467.4 \pm 286.5	93	318.9 \pm 243.5	30	6.53	0.02
	Sa	375.3 \pm 229.9	51	267.8 \pm 197.9	34	5.04	0.03
<i>L. nedgia</i>	An	489.7 \pm 394.4	36	251.5 \pm 159.4	36	11.29	0.00
	Sa	320.0 \pm 345.3	25	238.7 \pm 175.9	32	1.30	0.26

Table 5.6 Mean \pm SD weight (gm) of the most common fish species in the two rivers (combined data).

Fish species	Rivers					
	Angereb		Sanja		F	P
	Mean \pm SD	N	Mean \pm SD	N		
<i>L. forskalii</i>	329.2 \pm 268.5	173	241.9 \pm 151.9	253	18.3	0.00
<i>L. cf intermedius</i>	436.6 \pm 289.3	123	332.0 \pm 222.9	85	7.88	0.00
<i>L. nedgia</i>	364.9 \pm 327.3	72	285.7 \pm 273.3	57	2.2	0.14

There were significant variations (ANOVA, $P < 0.05$) in the mean weight of *L. forskalii* and *L. cf. intermedius* in the two rivers (Table 5.5). However, variations were insignificant (ANOVA, $P > 0.05$) for the three species of fishes between the sites of each river (Table 5.7).

Table 5.7 Mean \pm SD of weight (gm) of specimens at different sites for the most common species of fishes in the sites of the two rivers.

Rivers and the sites								
Fish species	An 1	An 2	F	P	Sa 1	Sa 2	F	P
<i>L. forskalii</i>	285.8 \pm 269.4	377.8 \pm 260.7	5.22	0.024 ^s	235.9 \pm 152.4	244.4 \pm 152.4	0.16	0.687
<i>L.cf intermedius</i>	451.3 \pm 329.2	413.7 \pm 214.0	0.49	0.484	305.4 \pm 222.8	345.0 \pm 223.8	0.59	0.444
<i>L. nedgia</i>	406.1 \pm 372.5	307.2 \pm 245.5	1.61	0.208	230.5 \pm 250.8	307.8 \pm 282.1	1.25	0.268

5.2.4 Length frequency distribution for the most common species

L. forskalii, the most abundant species both in number and weight at all the sites (Tables 5.2 & 5.4), had a total length range of 11.4 cm to 62.8 cm with a mean \pm SD of 27.9 ± 2.85 cm. *L. cf. intermedius*, the second most abundant species had total length range from 12.4 cm to 51.9 cm with a mean \pm SD 31.54 ± 4.53 cm (Table 5.8). Other species had total length ranges and total weight ranges with their mean \pm SD as shown in Table 5.8.

Table 5.8 Range and means \pm SD of weights (gm) and length (cm) of specimens sampled in Rivers Angereb and Sanja (11 specimens of *L. forskalii* & and species with few specimens were excluded from length frequency study)

Fish species	N	Range of TW (gm)	Mean \pmSD	N	Range of TL (cm)	Mean\pmSD
<i>L. forskalii</i>	426	15 -1728	277.4 \pm 10.2	416	11.4 - 62.8	27.90 \pm 2.85
<i>L.cf intermedius</i>	208	18 - 1848	393.8 \pm 18.6	205	12.4 - 51.9	31.50 \pm 4.5
<i>L. nedgia</i>	129	9 - 1670	329.5 \pm 27	126	5.6 - 53.4	28.55 \pm 8.02
<i>V.beso</i>	81	67 - 240	124 \pm 4	81	16.1- 26.8	21.70 \pm 2.16
<i>B. docmac</i>	31	100 - 5675	710 \pm 17.6	31	21.8 - 70.8	39.30 \pm 18.2
<i>H. longifilis</i>	20	267 - 1554	939 \pm 80.1	20	33.2 - 65	48.80 \pm 16.6
<i>O. niloticus</i>	15	19 - 392	110.2 \pm 28	15	9.8 - 27	15.69 \pm 11.6

L. forskalii had the highest number of specimens with total length range between 241-261 mm in Angereb River. The species had the highest number of specimens with total length range of 261-280 mm in Sanja River. *L. cf intermedius* showed highest specimens number between 301-320 mm in Angereb River. It showed the highest specimen number with total length range of 301-320 mm in Sanja River (Figs. 5.14 & 5.15).

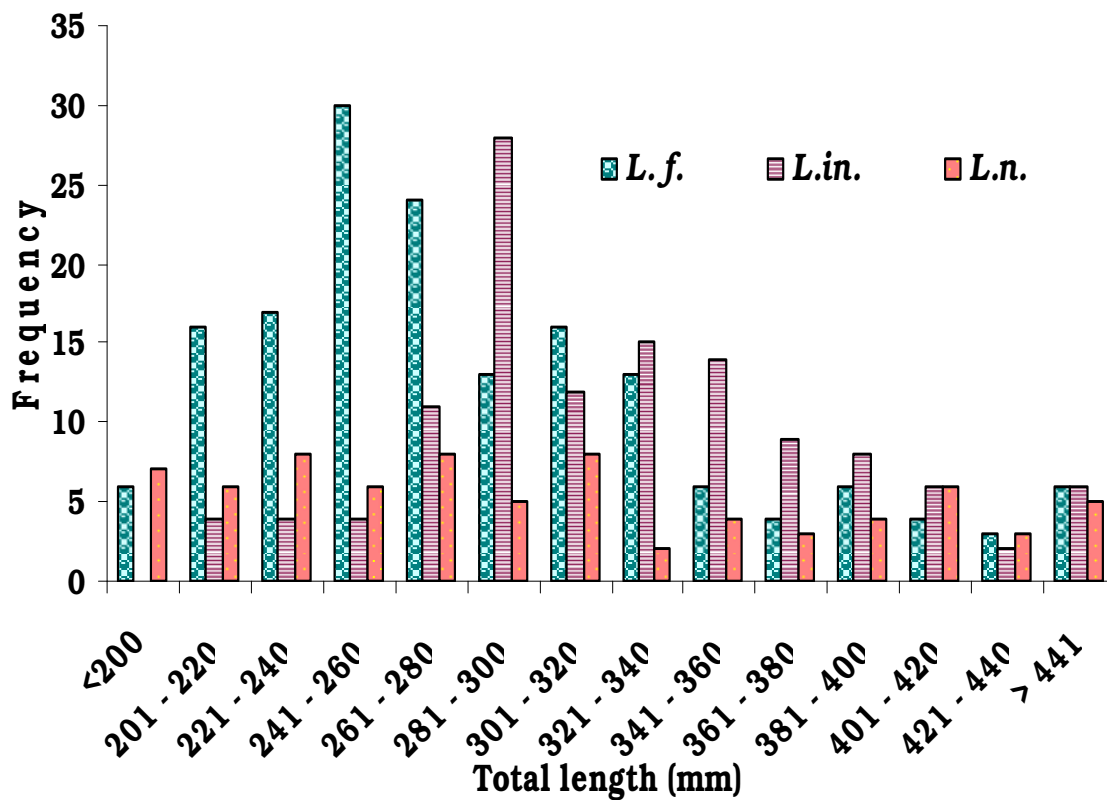


Figure 5.14 Length frequency distribution of *L. forskalii*, *L. cf intermedius* and *L. nedgia* in Angereb River with specimens number of 164, 123 and 75 respectively (**L.f.** – *L. forskalii*, **L.in.** – *L. intermedius* & **L.n.** – *L. nedgia*)

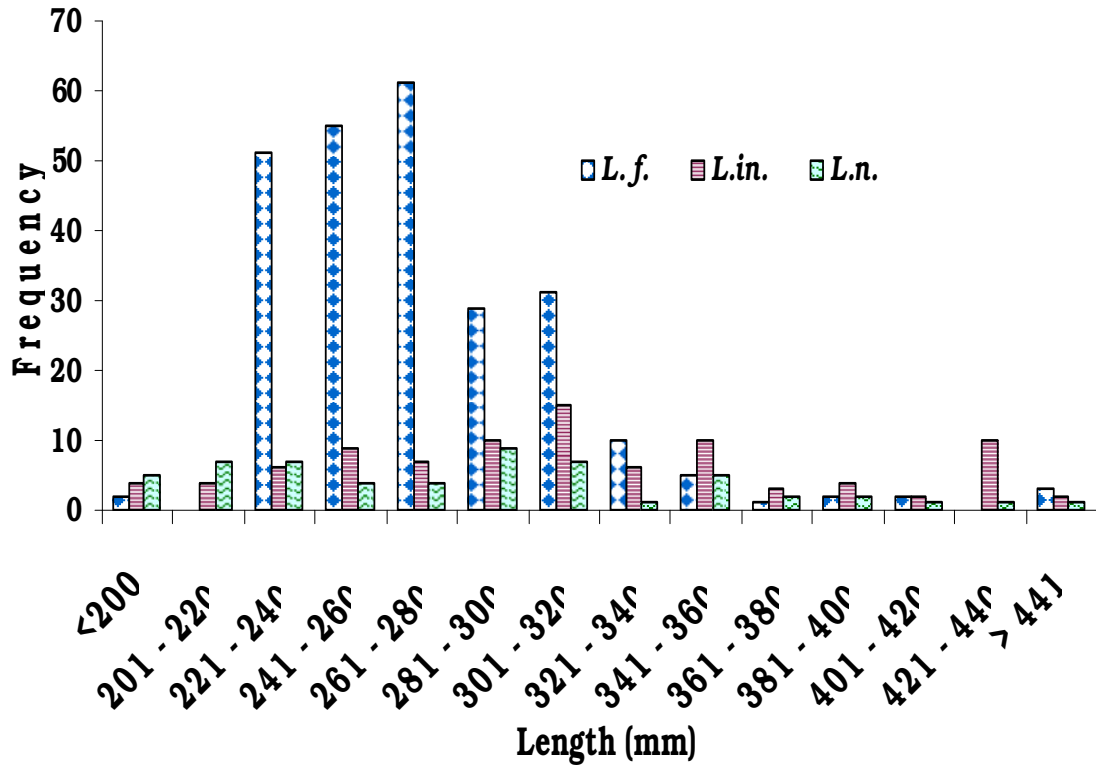


Figure 5.15 Length frequency distribution of *L. forskalii*, *L. cf. intermedius* and *L. nedgia* in Sanja River with specimen number of 252, 92 and 56 respectively (**L.f.** –*L. forskalii*, **L. in.** – *L. intermedius* & **L. n.** – *L. nedgia*).

During this study fish abundance in number was higher in the dry season than in the wet season (Table 5.2 and Fig. 5.12). In dry season, as the water level reduces, the density of fish population becomes high in the pools because the fishes are trapped in these areas. As a result, more fishes are vulnerable to the gears especially to the gill nets hence high catch. This could be one of the probable reasons for higher abundance in number during the dry season in this study.

However, the mean weight of fish was high in the wet season than in the dry season (Fig. 5.13). This is probably due to the high level in dissolved oxygen caused by increased velocity of flow of water.

In the rainy season, the lateral flow of waters seeping over the plain is enriched by nutrients mainly from decomposing materials. They also flush terrestrial nutrients into the channel. As a result, the high-water season becomes the main feeding and growing time for fishes, and fat deposits are then accumulated which keep fishes going through the dry season, when they eat little (Lowe-McConnell, 1977). This is also likely for higher mean weight of fishes in wet season than in the dry season at the study sites.

Wetlands and vegetated near shore habitats are required by fishes to complete their life cycle (spawning and nursery periods) and for foraging. These habitats contain a diversity of submergent, emergent, and floating aquatic vegetations that provide shelter, food and protection from predators (Welcomme, 1985). At the study places, particularly during the dry season, such habitats are absent. On the other hand, there are varieties of fish predator organisms such as crocodile, monitor lizards, birds and frogs. Therefore, it appears that the absence of such productive habitats on one hand and the occurrence of large number and population of fish predators on the other might have contributed to less abundance of fishes at the study sites.

Overgrazing of riverine basin and riparian areas causes sedimentation of spawning gravels, change in channel structure and complexity, loss of shading, high stream temperatures, channel notch and other harmful effects (Anonymous, 1999). Effects are particularly critical in the riparian zone where livestock tend to congregate, attracted by water, shade, cool temperatures and abundance of high quality food. In both rivers, particularly at Angereb 2 and Sanja 1, the riparian areas are highly degraded by livestock populations. These sites are places for drinking and shading for cattle. The river channels become wider and shallower due to soil modifications by domestic animals. These are also important sites for local communities to fetch water, swimming pool, and where they wash their clothes. The cumulative effects of these practices probably resulted in less fish abundance and diversity at the sites.

Effect of pollution on aquatic life brings toxicity, which kills fish at some stage of their life history or sub-lethal effects such as reducing growth. It also increases its susceptibility to diseases and may cause unsafe and unpalatable for consumption (Welcomme, 1985). Two types of toxic substances were used for mass fish killing by local fishermen in the past. Leaves of plant called “Kelhad” by the local name were used in River Sanja (Seid Muhammed & Belay Abdissa, 2002). A powerful toxic inorganic chemical “malathion” was also used in both rivers (Personal communication with the local community). This could also be one of the possible reasons for low abundance of fish of the rivers. At this time,

however, the uses of these toxic substances have been prohibited by the regional Bureau of Agriculture (personal communication).

Biases in the sapling processes were also introduced and might have resulted in low abundance of fishes due to predators such as crocodile and monitor lizards that damaged the gears and the catch during every single net setting night. It appeared that fish movements were also restricted due to these predators and led to such unsatisfactory catch.

5.3 Some biological aspects of the dominant fish species

5.3.1 Length-weight relationship

The relationship between total weight and total length determined separately for *L. forskalii*, *L. intermedius* and *L. nedgia* were curvilinear and it was statistically significant (ANOVA, $P < 0.05$). The line fitted to the data was best described by the regression equations shown in Table 5.9 & Figs. 5.16 and 5.17.

In fishes, the regression coefficient $b = 3$ describes isometric growth. The value is exactly 3 if the fishes retain the same shape and their specific gravity remains unchanged during life-time (Ricker, 1975). However, some fishes have value greater or less than 3, a condition described as allometric growth (Bagenal & Tesh, 1978). From Table 5.9, Figs. 5.16 & 17, it can be seen that *L. forskalii*, *L. cf. intermedius* and *L. nedgia* in River Sanja show isometric growth, i.e. the weight of these fishes increases as the cube of length because the b value is nearly 3 for these fish species in the river. However, the b -values obtained for the same species in River Angereb were less than 3, which is an indication of allometric growth.

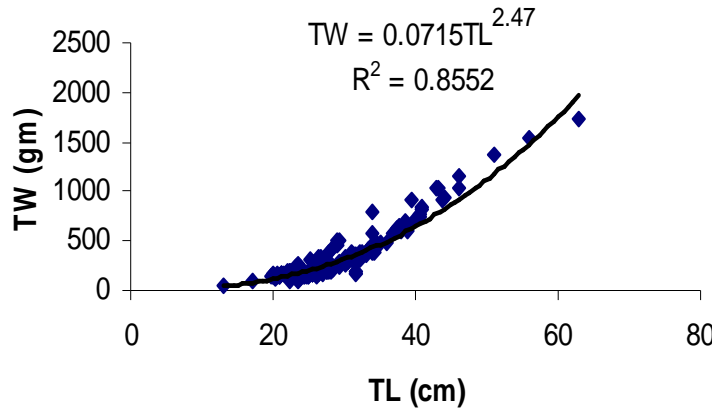
The b -value obtained in this study for *L. forskalii* in River Sanja is close to the value reported for *L. horie* from Lake Chamo (Elias Dadebo, 2000). These two species belong to the same genus, in the genus *Labeo*,

although they are two different species. Similar results (isometric growth) were obtained for *L. cf intermedius* by Demeke Admassu and Elias Dadebo (1997) in Lake Awassa and by Nagelkerke *et al.* (1994) in Lake Tana. The result obtained in this study for *L. cf. intermedius* in River Sanja was also in agreement with Wassie Anteneh (2005) in Lake Tana.

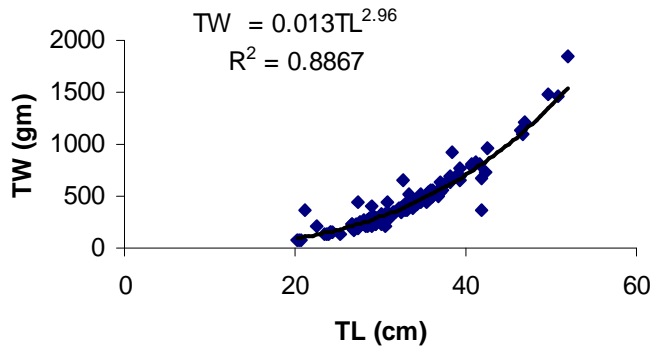
Table 5.9 Length-weight relationship of the most common fish species in Rivers Angereb and Sanja

Fish species	Rivers	Regression equation	r	P	Mean±SD TW	Mean±SD TL	N
<i>L. forskalii</i>	An	TW = 0.0715TL ^{2.49}	0.92	0.00 ^s	336.10±21.40	25.90±0.57	164
	Sa	TW = 0.0101TL ^{3.02}	0.97	0.00 ^s	241.28±9.62	27.30±0.27	251
<i>L. cf. intemedius</i>	An	TW = 0.0369TL ^{2.96}	0.94	0.00 ^s	436.60±26.1	32.00±0.57	123
	Sa	TW = 0.0057TL ^{3.18}	0.99	0.00 ^s	330.60±25.00	30.04±0.74	82
<i>L. nedgia</i>	An	TW = 0.0269TL ^{2.74}	0.97	0.00 ^s	364.90±36.6	29.47±1.15	72
	Sa	TW = 0.065TL ^{3.14}	0.98	0.00 ^s	279.50±37.20	27.50±1.08	54

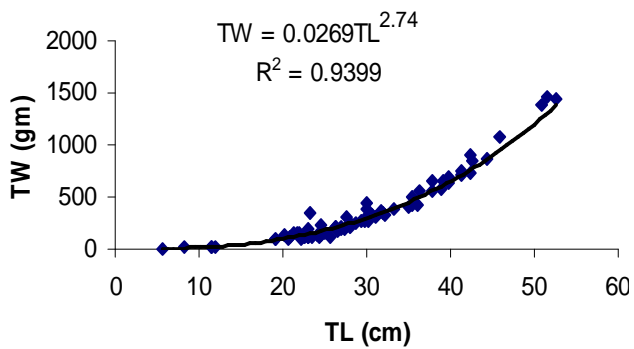
s=Significant



A

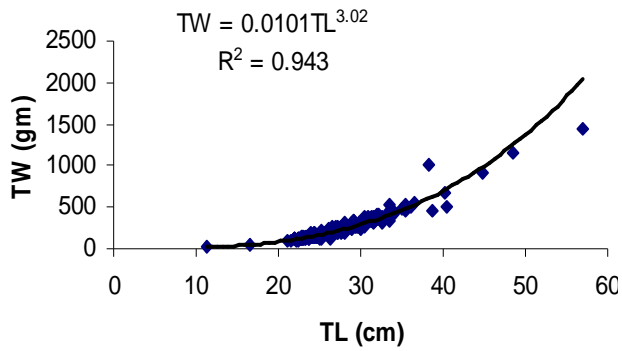


B.

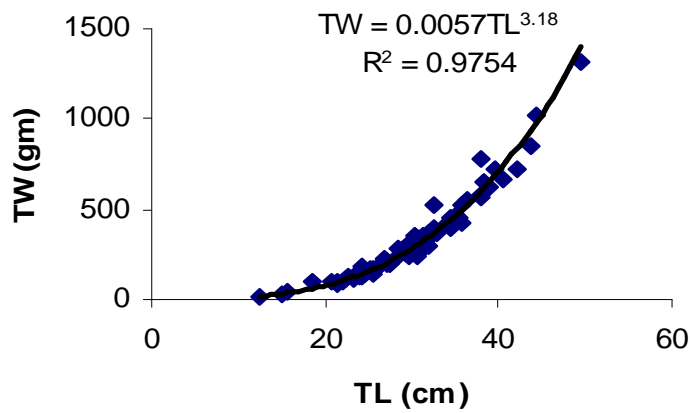


C

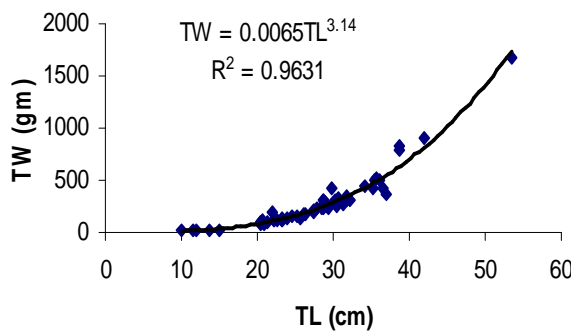
Figures 5.16 Length–weight relationship for A=*L. forskalii*, B=*L. cf. intermedius* and C= *L. nedgia* in Angereb River.



A



B



C

Figures 5.17 Length-weight relationship for A=*L. forskalii*, B=*L. cf. intermedius* and C= *L. nedgia* in Sanja River.

5.3.2 Fulton Condition Factor (FCF)

There were significant differences (ANOVA, $P < 0.05$) in the mean Fulton Condition Factor for *L. forskalii* and *L. intermedius* in Rivers Angereb and Sanja.

Table 5.10 Mean \pm SD Fulton Condition Factor (FCF) for the most common species in Rivers Angereb and Sanja.

Fish species	Angereb		Sanja		Mean	F	P
	Mean \pm SD FCF	N	Mean \pm SD FCF	N			
<i>L. forskalii</i>	1.26 \pm 0.35	164	1.09 \pm 0.13	251	1.175	48.28	0.00 ^s
<i>L. intermedius</i>	1.14 \pm 0.13	123	1.05 \pm 0.14	82	1.06	6.01	0.02 ^s
<i>L. nedgia</i>	1.18 \pm 0.54	72	1.05 \pm 0.22	54	1.12	2.82	0.10

s = Significant

However, the variation was insignificant (ANOVA, $P > 0.05$) for *L. nedgia* (Table 5.10). All the three species showed significant variations in the two seasons. In the wet season all the three species showed minor increase their mean FCF (Table 5.11).

Table 5.11 Mean±SD Fulton' Condition Factor (FCF) for the most common fish species in different seasons in Rivers Angereb and Sanja (combined data).

Fish species	Seasons					
	Dry			Wet		
	Mean ± SD FCF	N	Mean ± SD FCF	N	F	P
<i>L. forskalii</i>	1.17 ± 0.27	336	1.19 ± 0.21	80	2.67	0.01
<i>L. intermedius</i>	1.06 ± 0.26	60	2.73 ± 0.26	143	2.87	0.03
<i>L. nedgia</i>	1.13 ± 0.31	65	1.83 ± 0.56	61	0.00	0.04

The measure of fish condition can be linked to the general fish health, fat and lipid content, prey or food availability, reproductive potential, environmental conditions and water level fluctuations. In general, high condition is associated with higher energy (fat) content; increased food base, reproductive potential, or more favorable environmental conditions (Paukert & Cott, 2004). The mean FCF values obtained in the present study for the three species (1.18, 1.89 and 1.48 respectively) were lower than that of tilapia in Lake Ziway (1.89, Lake Chamo (2.03) and Lake Awassa (2.35) (Zenebe Tadesse, 1988; Yirgaw Teferi). This could be because of differences in habitat, gene and other factors. Another reason for low FCF of fishes of the rivers is probably because of fluctuations in factors such as food quantity and quality, water level and flow rate and

water temperature. Rivers in the Tekeze basins, one of which is the Angereb River, have seasonal variation in flow, caused by changes in rainfall over the year. The Rivers Angereb and Sanja, therefore, experience very long drought period (almost 10 months). With the advent of the rainy season, irregular streams start flowing again. Consequently, terrestrial nutrients (allochthonous materials) flush into the rivers especially in the headwater streams (Moyle, 1982). This will expand food resources for fish, thus fish conditions improve. On the other hand, as water levels drop during the dry season fishes are confined together in pools. As a result competition for inadequate resources is increased, thus growth rate and conditions of fish is reduced.

5.3.3 Reproductive biology

5.3.3.1 Sex ratio

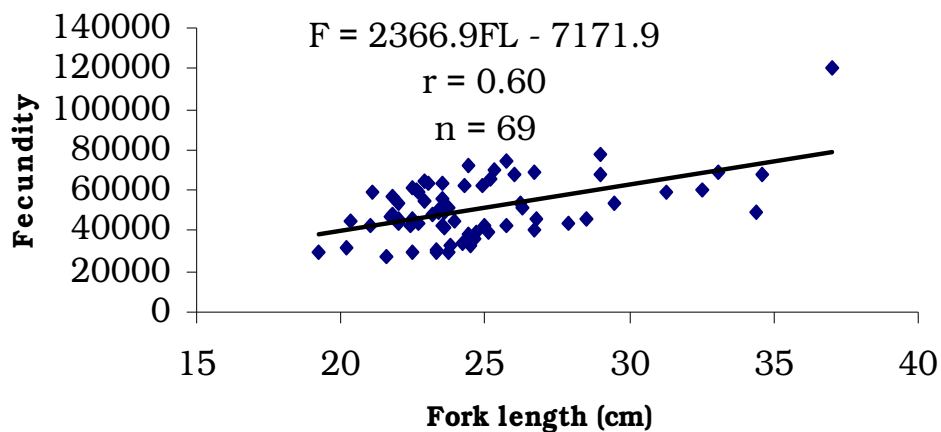
From the total number of 923 fishes collected during the study period, 75 (8.0 %) specimens were unsexed, hence excluded from sex ratio study. 848 specimens were sexed of which 502 (59.1 %) were females and 346 (40.9 %) were males. The total female to male sex ratio was 1:0.67. Females were more numerous than males (Chi-square, $P < 0.05$) in the total sexed specimens (Table 5.12) except *L. cf. intermedius*.

Table 5.12 Number of females, males and the corresponding sex ratios in samples of fish species from Rivers Angerb and Sanja

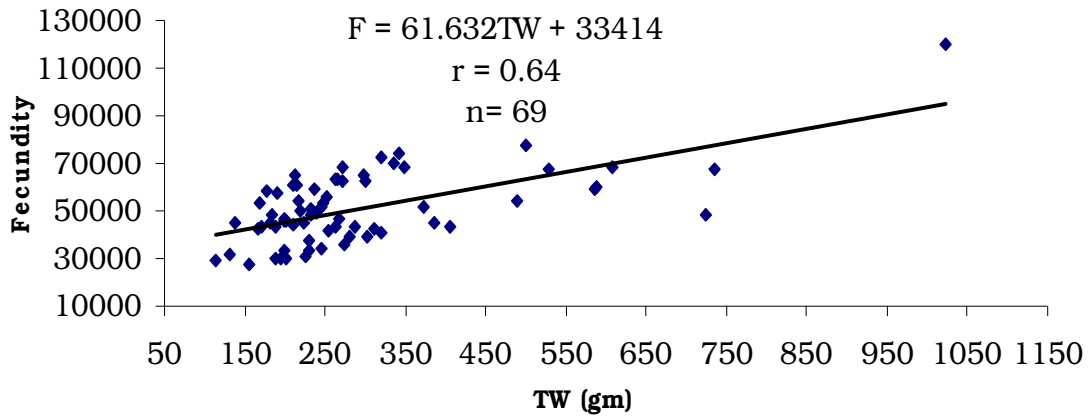
Fish species	Females	Males	Sex ratio	Chi-square	P
<i>L. fosalii</i>	250	160	1:0.64	19.27	0.00
<i>L.cf intermedius</i>	90	100	1:1.11	0.53	0.47
<i>L. nedgia</i>	67	35	1:0.52	10.04	0.00
<i>V. beso</i>	54	18	1:0.33	18.00	0.00
<i>B. docmac</i>	18	11	1:0.61	1.69	0.19
<i>O. niloticus</i>	10	5	1:0.50		
<i>H. longifilis</i>	8	11	1:1.35		
<i>M. kannume</i>	1	3	1:3.00		
<i>C. gariepinus</i>	1	3	1:3.00		
<i>L. niloticus</i>	3	0	----		

5.3.3.2 Fecundity

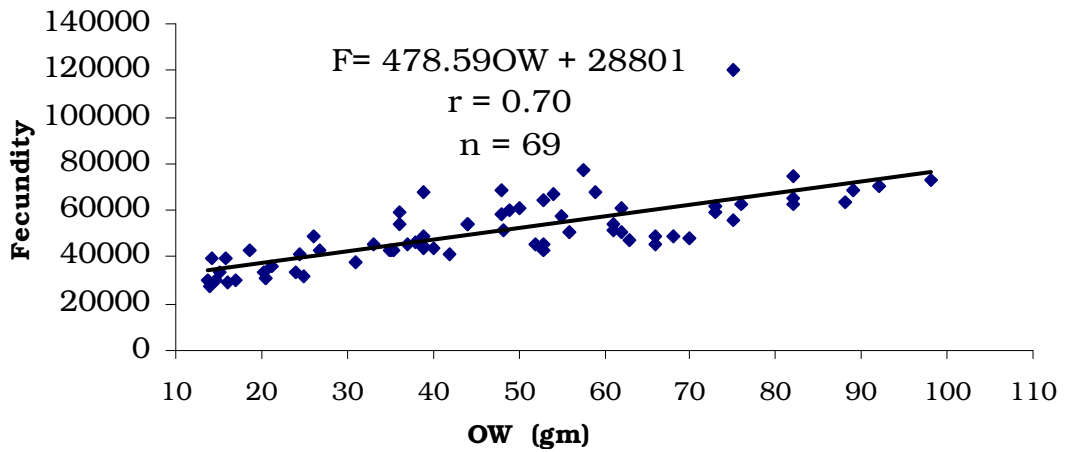
Fecundity, the number of ripe ova in the female prior to the next spawning period, as defined in Ricker (1975), was determined for *L. forskalii*. In 69 females, fecundity varied from 27094 to 120314 with mean \pm SD of 51104 ± 15124 . Fecundity was determined in fish of fork lengths 19 to 37 cm with total body weights of 113 to 1023 gm and gonad weights of 14 to 98 with mean \pm SD 47.39 ± 22.34 gm. The fecundity-fork length and fecundity-total weight relationships (Figs. 5.18) were linear, described by the equations: **$F = 2366.9FL - 7171.9$** and **$F = 61.632TW + 33414$** respectively where F is fecundity & FL is fork length in cm and TW is total body weight in gram. The fecundity-gonad weight (Figs. 5.18) relationship was also linear, described by the equation: **$F = 478.59OW + 28801$** where OW is ovary weight in gram.



A



B



C

Figures 5.18 Diagrams showing the relationship between (A) fecundity and fork length, (B) fecundity and body weight, and (C) fecundity and ovary weight in *L. forskalii*.

Table 5.13 Mean \pm SD absolute, relative fecundity and total weight of *L. forksalii* in relation to fork length.

Size class (Fork length in cm)	N	Mean body weight (g)	Mean absolute fecundity	Mean relative fecundity
15 - 20	3	127.33 \pm 12.66	35413 \pm 8414	276.7 \pm 47.5
21 -25	47	229.64 \pm 43.09	48120 \pm 11744	213.2 \pm 52.39
26 - 30	13	368.5 \pm 91.3	56483 \pm 12966	159.8 \pm 47.0
31 -35	5	648.0 \pm 74.6	60752 \pm 8017	95.00 \pm 17.33
36 - 40	1	1023	120314	118

6. Conclusions and Recommendations

Conclusions:-

- The fish faunal diversity of the two rivers is dominated by cyprinid fish species. Of the total 10 species 5 species are included in the family *cyprinidae*. The rest are included in the families *Cichlidae*, *Mormyridae*, *Bagridae* and *Clariidae*. The first three are represented by one species each and the last by two species.
- Three species (*L. forskalii*, *L. cf. intermedius* and *L. nedgia*) were the most abundant in number and weight in both rivers. Of these three species, the most dominant in number (about 46.62 % of the total catch) was *L. forskalii*. The species was also the most dominant in weight in both rivers.
- Based on this study, it can be stated that more number of fish specimens were caught in the dry season than the wet season.
- From length-weight relationship, it can be stated that the three dominant fish species show isometric growth in Sanja River. However, *L. forskalii* and *L. nedgia* exhibited negative allometric growth in Angereb River. The length-weight relationships were curvilinear for the three species in both rivers.
- Of the three most common fish species in the rivers (*L. forskalii*, *L. cf. intermedius* and *L. nedgia*), the first two showed significant variation in their mean FCF. However, all the three species showed

no seasonal variations in their FCF in the two rivers. The three most common fish species were in poor conditions in the rivers.

- Fecundity was found to be linear when related to fork length, total weight and gonad weight for *L. forkalii* in the two rivers.

Recommendations:-

Detailed studies and investigations are required on:-

- Diversity and abundance of fish species in Tekeze basin in general and in Angereb and Sanja Rivers in particular, especially at the lower reach of Angereb River.
- Ecological issues specially that of riparian corridors of the rivers.
- Taxonomy of *Labeobarbus spp.* of the rivers particularly that of *L. cf. intermedius*.
- Food and feeding behaviors of the fish species in the rivers.
- There are some indications of severe degradations of the river basins particularly the riparian areas. The most threats to the rivers are related to deforestation and overgrazing by domestic animals in the river valleys. Therefore, sustainable utilization and conservation measures should be taken in the two river valleys.
- Prospect for sustainable fish resource utilization must be investigated in these rivers.
- Socio-economic aspects of the two rivers must be investigated.

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Appendix 1. Morphometric & meristic measurements of the fish species in the two rivers

Morphometric measures		Characteristics of the species																	
		<i>Labeobarbus intermedius</i>						<i>Labeobarbus nedgia</i>						<i>Varicorhinus beso</i>					
		Ave.	Medi.	Min.	Max.	Std	N	Ave.	Med.	Min.	Max.	Std	N	Ave.	Med.	Min.	Max.	Std	N
% IN SL	BD	29.0	29.2	26	31.8	1.9	10	28.9	28.6	27.8	30.5	1.1	8	31.2	30.95	30.1	32.8	1.0	6
	HL	25.7	25.6	24.4	27.6	0.9	10	28.2	28.3	26.2	30.2	1.5	8	21.9	22.1	20.5	23.1	1.0	6
	PDL	50.7	50.5	48.4	53.7	1.8	10	52.8	53.2	50	54.8	1.6	8	44.0	44.5	41	46.2	2.3	6
	DFL	21.3	20.8	19.2	24.5	1.8	10	16.2	16.2	12.5	20.6	2.8	8	17.9	18.0	16.6	19.1	0.9	6
	PFL	20.2	20.2	18.9	21.5	0.8	10	7.4	7.3	5	10.9	2.2	8	5.0	4.65	4.1	6.4	0.8	6
	AFL	18.6	18.8	16.7	20	1.1	10	12.9	13.2	8.3	17.2	4.1	8	8.5	8.2	7.6	9.8	0.8	6
	PLFL	17.9	17.8	14.6	20.5	1.7	10	6.6	6.4	4.4	9.5	1.8	8	5.2	5.2	4.6	5.8	0.5	6
	CPL	17.8	17.6	16.3	20.5	1.4	10	16.8	16.4	15.4	19	1.3	8	18.7	17.8	16.5	22	2.1	6
CPD	12.6	12.5	11.7	14	0.7	10	12.9	12.6	11.6	16.5	1.5	8	12.1	11.75	11.5	13.2	0.7	6	
% IN HL	HD	50.3	48.5	45.8	55.6	3.8	10	57.1	57.0	53.3	60.9	2.6	8	80.8	81.05	75.6	84.4	3.0	6
	HW	52.8	55.3	32.2	67.3	10.8	10	50.7	49.1	46	56.5	4.4	8	74.0	74.7	69.4	77.1	2.6	6
	SnL	24.1	24.8	16.7	27.8	3.4	10	38.9	37.9	26.1	56	12.1	8	42.5	42.5	40	45.7	2.0	6
	IOW	36.9	37.7	32	40	2.6	10	35.8	36.4	30	40	3.7	8	50.1	50.5	45	55.1	4.1	6
	OD	19.1	18.3	15.6	29	3.7	10	16.9	16.3	14.4	20	2.4	8	18.6	18.15	17.5	20	1.1	6
	ED	13.5	13.3	10.9	17.8	1.8	10	13.3	13.5	12	14.8	1.1	8	15.4	15.2	14.3	17.1	0.9	6
	Meristic features	DRuB	3.3	3	2	5	0.8	10	3.9	3.5	3	6	1.1	8	2.7	3	2	3	0.5
DRFB		8.9	9	8	9	0.3	10	8.9	9	8	9	0.4	8	9.8	10	8	11	1.2	6
AFR		6.2	6	6	8	0.6	10	6.4	6	6	7	0.5	8	7.2	7	7	8	0.4	6
PeFR		14.9	14.5	13	17	1.3	10	14.3	14	13	16	1.3	8	15.5	15	14	18	1.4	6
PLFR		9.3	9	9	11	0.7	10	8.5	8.5	8	9	0.5	8	9.2	9	8	10	0.8	6
CR		22.4	22	21	26	1.4	10	21.5	21	19	23	1.4	8	21.2	21	20	22	0.8	6
LLS		31.6	31	30	36	1.8	10	32.4	32	31	34	0.9	8	33.2	33.5	30	36	2.3	6
CPSR		13.2	14	12	14	1.0	10	12.5	12	10	14	1.4	8	5.7	6	5	6	0.5	6
SRLLED		6.55	6.5	6	7	0.4	10	6.7	6.5	6.5	7	0.3	8	5.2	5	5	6	0.4	6
SRLPLF		3.25	3.25	3	3.5	0.3	10	3.0	3	3	3.2	0.1	8	3.3	3	3	4	0.5	6
SRLAF		4	4	3.5	5	0.4	10	4.0	4	3.5	5	0.5	8	4.0	4	3	5	0.6	6
PDSR		12.9	13	11	15	1.2	10	21.5	21	19	23	1.4	8	12.3	12.5	11	14	1.2	6

Characters of the species

Morphometric measures		<i>Labeo foscalii</i>						<i>Labe niloticus</i>					
		Ave.	Medi.	Min.	Max.	Std	N	Ave.	Med.	Min.	Max.	Std	N
% IN SL	BD	25.8	26.2	20.8	30.9	3.0	10	27.3	27.3	26.7	27.9	0.9	2
	HL	23.6	24.5	17.4	28.8	3.8	10	19.8	19.8	17.4	22.2	3.4	2
	PDL	41.7	42.05	37.5	45	2.2	10	37.4	37.4	34.9	40.0	3.6	2
	DFL	25.7	26.2	21.7	28.6	2.2	10	27.8	27.8	26.7	28.9	1.6	2
	PFL	20.6	20.4	19	23	1.2	10	5.0	5.0	4.2	5.8	1.1	2
	AFL	17.3	17.1	14.3	19.2	1.5	10	8.5	8.5	6.9	10.0	2.2	2
	PLFL	19.7	19.85	17.1	23.7	2.0	10	4.9	4.9	4.6	5.1	0.4	2
	CPL	14.0	13.5	12	18	2.1	10	16.2	16.2	16.0	16.4	0.3	2
	CPD	12.8	12.85	11.5	14	0.8	10	14.2	14.2	39.9	14.4	0.4	2
% IN HL	HD	62.0	56.9	47	80	13.6	10	82.9	82.9	75.0	90.7	11.1	2
	HW							79.0	79.0	78.0	80.0	1.4	2
	SnL	49.5	50.5	40	60	7.3	10	37.5	37.5	35.0	40.0	3.5	2
	IOW	48.3	48.1	40	58	5.6	10	54.5	54.5	49.0	60.0	7.8	2
	OD	15.2	15	10	20	3.4	10	18.5	18.5	17.0	20.0	2.1	2
	ED	13.2	13.2	10.6	16.3	1.8	10	14.5	14.5	13.0	16.0	2.1	2
Meristic features	DFRUB	2.5	3	1	3	0.7	10	3.0	3	3	3	0.0	2
	DFRB	9.6	10	9	10	0.5	10	16.0	16	15	17	1.4	2
	AFR	7.3	7	6	8	0.7	10	7.5	7.5	7	8	0.7	2
	PFR	15.5	15.5	13	17	1.2	10	17.0	17	17	17	0.0	2
	PeLFR	9.0	9	8	10	0.8	10	10.0	10	10	10	0.0	2
	CPRT	22.1	22	20	25	1.4	10	22.0	22	22	22	0.0	2
	LLS	39.3	39	37	41	1.4	10	43.5	43.5	43	44	0.7	2
	CPSR	16.4	16	16	18	0.8	10	23.5	23.5	23	24	0.7	2
	SRLLED	6.4	6	6	8	0.7	10	8.5	8.5	8	9	0.7	2
	SRLLEDF	4.8	5	3	6	1.0	10	6.0	6	6	6	0.0	2
	SRLLEDF	4.6	4.5	4	6	0.7	10	6.3	6.25	6	6.5	0.4	2
	PDSR	16.5	16	15	18	1.1	10	13.5	13.5	13	14	0.7	2

Characters of the species													
Morphometric measures		<i>Oreochromis niloticus</i>						<i>Mormyrus kannume</i>					
		Ave.	Medi.	Min.	Max.	Std	N	Ave.	Med.	Min.	Max.	Std	N
% IN SL	BD	41.6	41.2	39.1	44.3	1.9	8	25.0	25.9	20	28.2	3.6	4
	HL	32.6	32.2	28.7	35.7	2.5	8	25.1	25.1	24.5	25.8	0.6	4
	PDL	33.2	32.4	26.7	40.3	4.9	8	44.5	44.5	41.1	47.8	2.8	4
	DFL	71.9	72.4	67.6	75.9	3.1	8	48.4	47.4	46.8	52.1	2.5	4
	PFL	9.7	9.6	8.3	11.4	1.1	8	2.4	2.1	1.6	3.6	0.9	4
	AFL	20.6	20.2	18.0	26.7	2.7	8	12.2	12.3	10.9	13.2	1.2	4
	PLFL	14.1	14.5	10.8	17.2	2.0	8	2.4	2.1	1.6	3.6	0.9	4
	CPL	12.1	11.9	10.7	15.0	1.5	8	26.9	26.8	25.2	29	1.6	4
CPD	13.3	13.9	8.3	15.5	2.1	8	8.9	8.7	8.4	9.7	0.6	4	
% IN HL	HD	88.8	89.2	78.3	95.7	5.3	8	63.3	62.1	48.8	80	13.9	4
	HWD	54.7	54.8	43.5	67.8	6.9	8	54.5	53.0	49	62.9	6.0	4
	SnL	39.7	40.0	37.9	41.3	1.2	8	47.5	47.9	44.1	50	2.5	4
	IOW	41.6	41.7	36.2	45.7	3.2	8	27.6	25.3	23.6	36	5.7	4
	OD	22.3	22.5	17.4	25.8	2.9	8	12.2	12.5	7.8	16	3.5	4
	ED	21.3	20.3	17.0	26.3	3.5	8	9.0	7.8	6.3	14	3.5	4
Meristic features	DFRUB	16.9	17	15	18	1.0	8	59.3	59.5	57	61	1.7	4
	DFRB	11.8	12	11	12	0.5	8						
	AFR	11.8	12	11	12	0.5	8	17.3	18	15	18	1.5	4
	PFR							12.8	13	11	14	1.3	4
	PLFR	6.0	6	6	6	0.0	8	6.3	6	6	7	0.5	4
	CPRT	16.6	17	16	17	0.5	8	21.0	22	17	23	2.7	4
	LLS	33.1	33	31	35	1.7	8	112.0	112.5	109	114	2.2	4
	CPSR	14.9	14.5	14	16	1.0	8	36.0	36	34	38	1.6	4
	SRLLDF	5.2	5.25	4	6	0.6	8	25.0	25	25	25	0.0	4
	SRLLPLF	11.3	11.75	8	13	1.8	8	22.0	22	21	23	1.2	4
	SRLLAF	8.1	8	7	9	0.8	8	21.3	21	21	22	0.5	4
	PDSR	10.8	10.5	9	13	1.5	8	37.3	37	37	38	0.5	4

Morphometric measures		Characters of the species																	
		<i>Bagrus docmac</i>						<i>Hetrobranchus longifilis</i>						<i>Clarias gariepinus</i>					
		Ave.	Medi.	Min.	Max.	Std	N	Ave.	Med.	Min.	Max.	Std	N	Ave.	Med.	Min.	Max.	Std	N
% IN SL	BD	23.9	23.4	20.0	28.2	2.8	8	15.3	15	14.4	17.1	1.0	8	13.5	13	12.2	15.5	1.4	5
	HL	29.5	29.2	27.5	31.8	1.5	8	22.8	24.4	18.9	25.5	2.6	8	21.3	21.2	20.3	22.9	1.0	5
	PDL	40.2	40.1	38.6	41.6	1.1	8	39.4	38.8	37.3	44.2	2.2	8	34.7	35.7	32.5	36.5	2.0	5
	PFL	10.2	8.3	3.0	22.7	7.	8	34.1	34.6	27.9	38.2	3.0	8	59.9	58.8	55.4	64.3	3.5	5
	DFL	37.2	41.3	15.4	62.5	18.8	8	5.9	5.7	5	7.3	1.0	8	4.0	3.8	3.3	5.1	0.7	5
	AFL	21.0	13.5	8.8	38.7	13.6	8	39.6	39.5	37.8	41.5	1.2	8	41.7	41.3	37.7	45.2	2.9	5
	PLFL	12.3	5.5	4.6	40.9	13.8	8	4.4	4.2	3.7	4.8	0.4	8	3.0	2.9	2.6	3.6	0.4	5
	CPL	17.9	18.0	16.1	20.0	1.2	8	4.1	4	2.9	5.1	0.9	8	4.4	4.3	2.5	6.4	1.4	5
	CPD	29.4	12.6	9.8	83.3	32.2	8	9.3	9.2	8.5	10.2	0.6	8	8.3	8.3	7.5	8.7	0.5	5
AdFL							33.4	33.6	30.9	36.6	2.2	8							
% IN HL	HD	42.7	41.2	37.0	54.5	5.3	8	34.39	35.3	30.9	36	1.7	8	10.0	10	8.7	11.9	1.4	5
	HW	74.2	72.7	60.0	86.4	9.3	8	89.78	89.65	85	95	2.8	8	19.1	18.8	17.5	21.6	1.5	5
	SnL	42.9	39.9	36.4	53.3	7	8	31.48	31.6	28.6	34	2.1	8	7.3	7.5	6.4	8.3	0.8	5
	IOW	42.2	38.6	32.9	57.9	10	8	63.54	63	60	68.2	3.4	8	12.5	12.5	12.2	13.1	0.4	5
	OD	23.6	20.9	11.8	37.5	11.8	8	6.113	5.8	4	8.2	1.5	8	1.9	1.9	1.8	2	0.1	5
	ED	17.0	10.6	7.1	32.4	10.8	8	5.863	6.05	4	7.6	1.2	8	1.4	1.5	1.2	1.6	0.2	5
Metetric features	DFRuB	1.0	1	1	1	0.0	8												
	DFRB	9.4	9	9	11	0.7	8												
	AFR	10.0	10	9	12	0.9	8												
	PFR	10.4	10	10	11	0.5	8												
	PLFR	6.0	6	6	6	0.0	8												
	CR	23.0	23	20	29	2.8	8												

Appendix 2 Fish species in some small lakes of Ethiopia (X= presence or absence of fish species is not known: Source: - EARO, 2002)

Lake	Location	Fish species
Hayq	Northern highland	<i>O. niloticus</i> , <i>C. gariepinus</i>
Ashengie	Northern highland	<i>O. niloticus</i> (introduced) Common carp (introduced)
Ardebo	Northern highland	<i>O. niloticus</i>
Zengena	Northern highland	Common carp (introduced) Tilapia sp.
Bishoftu Lakes	Near Debreziet town	<i>O. niloticus</i> <i>C. gariepinus</i> <i>A. antinorii</i> <i>G. quadrimaculatus</i>
Metehara	Ethiopian Rift Valley	<i>O. niloticus</i> <i>C. gariepinus</i>
Wonchi	Central highland	<i>O. niloticus</i> (introduced) <i>T. zillii</i> (introduced) <i>T. rendalii</i> (introduced)
Dandii	Central highland	X
Bale Mountain lakes	South Eastern highland	X