



FEEDING HABITS AND REPRODUCTIVE BIOLOGY OF THE AFRICAN BIG BARB,  
*Labeobarbus intermedius* (RÜPPELL, 1836) (PISCES: CYPRINIDAE) IN RIVER  
BELES, ETHIOPIA

MASTERS OF SCIENCE (MSc.) THESIS BY HAYMANOT ATENAFU SEMENHE

HAWASSA UNIVERSITY, HAWASSA, ETHIOPIA

NOVEMBER, 2023

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THESIS SUBMITTED TO THE  
DEPARTMENT OF AQUATIC SCIENCES, FISHERIES, AND AQUACULTURE (ASFA)  
HAWASSA UNIVERSITY COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES,  
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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS  
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ADVISOR: PROFESSOR ELIAS DADEBO

NOVEMBER, 2023

HAWASSA UNIVERSITY  
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DEPARTMENT OF AQUATIC SCIENCES, FISHERIES AND AQUACULTURE (ASFA)  
ADVISOR APPROVAL SHEET

This is to certify that the thesis entitled “**Feeding habits and reproductive biology of the African big barb, *Labeobarbus intermedius* (Rüppell, 1836) (Pisces: Cyprinidae) in River Beles, Ethiopia**” submitted in partial fulfillment of the requirements for the degree of Master of Science with specialization in **Aquaculture and Fishery Management** in the Department of **Aquatic Sciences, Fisheries and Aquaculture (ASFA)**, was carried out by **Haymanot Atenafu Semeneh ID:GpFiAqR/0002/14**, under my supervision. Therefore, I declare that the student has the ability to fulfill the requirements and hence, hereby he can submit the thesis to the Department of Aquatic Sciences, Fisheries and Aquaculture (ASFA).

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We, the undersigned, members of the Board of Examiners of the thesis open defense by **Haymanot Atenafu Semeneh** have read and evaluated his thesis entitled “**Feeding habits and reproductive biology of the African big barb, *Labeobarbus intermedius* (Rüppell, 1836) (Pisces: Cyprinidae) in River Beles, Ethiopia**”, and examined the candidate. This is, therefore, to certify that the thesis has been accepted for partial fulfillment of the requirements for the degree of Master of Science in **Aquaculture and Fishery management (AFM)**.

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## DECLARATION

I hereby, confirm that this is my own research work and that I have followed all technical and ethical principles of scholarship in the beginning of title selection, preparation, data collection, data analysis, and the writing of this thesis. This thesis has been submitted in partial fulfillment of the requirements for the Degree of MSc in Aquaculture and Fisheries Management at Hawassa University. All scholarly materials that were included in the thesis have been given recognition through appropriate acknowledgements and references. Copies of this thesis will be deposited in the Hawassa University Library to be made available for end-users and borrowers at the university's library under the rules and regulations of the library. Moreover, I declare that this thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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## LIST OF ACRONYMS (ABBREVIATION)

BGRS:	Benishangul Gumuz Regional State
Fam:	Family
FL:	Fork Length
GERD:	Grand Ethiopian Renaissance Dam
GSI:	Gonado-Somatic Index
GW:	Gonad weight
FCF(K):	Fulton Condition Factor
SDOI:	Schoener Diet Overlap Index
SL:	Standard Length
SPP:	Species
TL:	Total Length
TW:	Total Weight

## ABSTRACT

*Labeobabus intermedius* is the 3<sup>rd</sup> most important fish species in Ethiopian water bodies and the most important in Beles River. The study aimed on reproductive biology, feeding habits and condition factor of *L. intermedius* were investigated in Beles River based on samples collected from February 2023 to July 2023. The findings of this study were given using figures, Tables, frequency of occurrence, and volumetric methods of analyses. A total of 464 fish samples were caught, ranging from TL 13.5 cm to 49.3 cm and TW 19 g to 1,278 g, for males and TL 11.6 cm to 48.2 cm, and TW of 18 g to 1491 g for females using long lines. Detritus (42.1%), phytoplankton (41.5%), macrophytes (7.2%), insects (4.3%), gastropods (1.5%), and zooplankton (3.4%) were using frequency of occurrence and volumetric analyses, respectively. The overall male-to-female sex ratio was significantly different from 1:1 ( $\chi^2 = 4.2^*$ ,  $p < 0.01$ ).  $L_{m50}$  for males and females was 28.6 cm and 26.4 cm TL, respectively. GSI values ranged from 0.15 to 28.8 % for males and 0.1 to 40.43 % for females. The fish breeds throughout the sampling period, with intensive breeding in February. The length-weight relationship was found to be curvilinear ( $TW = 0.01 TL^{2.88}$ ). The FCF was ranged from 0.4 to  $1.02 \pm 0.01$  for males and 0.38 to  $1.004 \pm 0.01$  for females. In general, FCF and ripe gonad were inversely proportional, and compared to other studies the fecundity *L. intermedius* in Beles River were relatively high. There was no observable variation in the food items between dry and wet months, but noTable ontogenetic variation was seen in the diet. Fish under 28.2cm should be protected from unwise exploitation. The study offers crucial insights into the ecological role and life history of *L. intermedius* in the Beles River ecosystem, thereby aiding in its conservation in Ethiopia.

**Key words: Beles River, Feeding habits, *L. intermedius*, Reproductive biology,**

# 1. INTRODUCTION

## 1.1. Background of the Study

The genus *Labeobarbus* (Family *Cyprinidae*) is one of the most commonly known fish species widely distributed in African fresh waters including Ethiopia water bodies (Cambray, 1983; Gashaw Tesfaye and Wolff, 2014). The African big barb *Labeobarbus intermedius* (Rüppell, 1836) is among fish species which are widely distributed in Ethiopian highland and rift valley lakes, Baro Akobo basin, Genale-Wabeshebele and Abay River basins (Demeke Admassu and Elias Dadebo, 1997; Gashaw Tesfaye and Wolff, 2014). Lake Tana harbors a unique and endemic *Labeobarbus* flock of big barb species from other highland lakes (Tadlo Awoke *et al.*, 2015). Among the commercially important fish species in Ethiopia *L. intermedius* constituting about 9% of the total catch per year in Ethiopia (Gashaw Tesfaye and Wolff, 2014). *L. intermedius* is also found in most lakes and rivers of Ethiopia like Lakes Ziway, Hawassa, and other rift valley lakes in addition to highland lakes of Ethiopia (De Graf *et al.*, 2004; Gashaw Tesfaye and Wolff, 2014). Therefore, *L. intermedius* is among the commercially important fish species in fishery production in Ethiopia.

The total *L. intermedius* production from all inland water bodies was estimated to be about 1625 ton per year (Gashaw Tesfaye and Wolff, 2014). It is commercially one of the most important fish in the capture fishery of the country. The fish is also commercially the most important in Beles River (personal obs.). The reproductive biology of *L. intermedius*, has been studied and documented by different authors in relation to abundance and diversity (Gizachew Teshome *et al.*, 2015; Agumassie Tesfahun and Mathewos Temesgen, 2017; Simagne Melaku *et al.*, 2017; Mathewos Temesgen *et al.*, 2018; and Shewit Gebremedhin *et al.*, 2019). These authors indicated that *L. intermedius* reproduces throughout the year, but the species reproduces intensively at certain months of the year especially during wet the season (Dereje Tewabe, 2014; Shewit Gebremedhin *et al.*, 2014; Gizachew Teshome *et al.*, 2015). Other authors have also reported the

reproductive biology of the species in Dirima and Megech Rivers (Wassie Anteneh *et al.*, 2007), head Blue Nile River (Dagneu Mequanent *et al.*, 2014).

*L. intermedius* from different Ethiopian lakes showed omnivorous feeding habits mainly feeding on gastropods, phytoplanktons, macrophytes, insect, detritus, and nematodes with the tendency to shift to piscivory as it grows older (Demeke Admassu and Elias Dadebo, 1997; Sibbing, 1998; Zerihun Desta *et al.*, 2006). The finding of Kassahun Assaminew (2005) and Elias Dadebo *et al.* (2013) from Lake Koka opposes the piscivores feeding habits of the fish. Where stated that, the gut contents were composed of macrophytes detritus, insects and nematodes. Substantial body of information is available on the reproductive biology and feeding of this fish in different parts of Ethiopia but very little information is available on the reproductive biology and feeding habits of *L. intermedius* from western part of Ethiopia including Beles River. So the aim of this study was to study some aspects of reproductive biology, feeding habits and condition factor of *L. intermedius* in Beles River. Such area specific information is important for proper management and utilization of the stock in a sustainable way.

## **1.2. Statement of the problem**

In Ethiopia, the fishery exclusively comes from inland water bodies which is mainly both artisanal and subsistence. Despite the existence of high fish diversity, only few fish species are targeted and constitute the bulk of the commercial catches. The current production is still far below the estimated potential yield, which suggests scope for further expansion of fishery. Since *L. intermedius* of Beles River is considered as over fished and tributary of Blue Nile (Abay) which makes GERD, The information on the reproductive biology of *L. intermedius* in Beles River is lacking which is vital for the proper utilization of the river fishery. The lack of such knowledge for the population hinders rational exploitation and management. Even though *L. intermedius* is the third most commercially important fish species in Ethiopia next to *Oreochromis niloticus* and

*Clarias gariepinus* (Gashaw Tesfaye and Wolff, 2014) and also the most important species in Beles River fishery (personal obs.), little research has been done on the biology and ecology of *L. intermedius* from the western region of Ethiopia, and little work has been done on the rivers that feed the Abay River, especially from the Benishangule Gumuz Region, Metekel, Ethiopia. Such an opportunity is provided by Beles River, which is one of the feeding Rivers of River Abay. Beles River harbors *C. gariepinus*, *L. intermedius* and two tilapia species (*O. niloticus* and *Coptodon zillii*) (Zelege Berie 2007). Therefore, the main objective of the present study is to obtain information from Beles River on both feeding habit and reproductive biology of *L. intermedius*.

### **1.3. Objectives**

#### **1.3.1. General objective**

- To study some aspects of reproductive biology, feeding habits and some morphometric parameters of *Labeobarbus intermedius* in River Beles which is important for proper management and conservation of the fish and fisheries.

#### **1.3.2. Specific objectives**

- To determine reproductive biology of *Labeobarbus intermedius* in Beles River.
- To assess the food and feeding of *Labeobarbus intermedius* in Beles River.
- To estimate some morphometric parameters of *Labeobarbus intermedius* in Beles River

### **1.4. Significance of the study**

The study was conducted at a remote area of the northwestern part of Ethiopia Region in Beles River that feeds Abay in the northeast part of Benishangule Gumuz Regional State (BGRS), Metekel Zone. Even though Beles is one of the feeding rivers of Blue Nile (Abay) River, which is the river making the Great Ethiopian Renaissance Dam (GERD) and *L. intermedius* is important fish spp. in the river, no enough research has been done on the biology of *L. intermedius*. So this study is important for having information on *L. intermedius* on its feeding and reproductive biology from

the tributary Rivers of Abay like Beles, as well as to expand the research areas from tributary rivers to the main River of Abay. Once the information is made available, the data will be used for doing stock assessment and developing appropriate management for fish and fisheries as well as the local people can be aware about the biology and feeding habits of the species to manage the stock properly in a sustainable way. They use aquatic resources sustainably without endangering the stock should be envisaged in any research study. In this regard the study on reproduction, feeding and condition factor of *L. intermedius* is urgently needed and of paramount importance.

### **1.5. Scope of the study**

The present study focused only on *L. intermedius* from the Beles River between February 2023 and July 2023 sampling months. The study focused only on six sampling months due to squurity issue as well as legislation of university. The study elaborated on various aspects such as reproductive biology (sex ratio, gonado-somatic index, length at first maturity, breeding month, fecundity); feeding habits (diet composition, ontogenetic dietary shift and monthly variation); and morphometric relationships (length-weight, and length-length) of *L. intermedius* in addition to condition factor of the spp. in Beles River within six sampling months.

### **1.6. Limitation of the study**

Some of the limitations of the study were access to the laboratory as it is far from the sampling sites; the data were only of six months due to: shortage of budget, shortage of time due to university legislation, lack of transportation, difficulty of sampling time due to security and difficulty of getting sampling instruments.

## 2. LITERATURE REVIEW

### 2.1. Description and distribution

Lake Tana harbors *L. intermedius* which is a big, hexaploidy species with a well-diversified range and ecology. The species lacks teeth in the oral jaws, has a small pharyngeal cavity in the shape of a slit, and lacks a stomach, all of which suggest that they are not well suited for fish consuming (De Graaf, 2003). They are riverine and beginning to get acclimated to living in lacustrine or lake habitats. According to Tomasson *et al.* (1984) and Skelton *et al.* (1991), the majority of these species still move upstream to spawn in river tributaries, indicating that they have not yet fully adapted to the lake habitat. As the De Graaf (2003) report shows *L. intermedius* is found throughout the Lake Tana but its abundance decreases towards the shore. Most of Ethiopian lakes were dominated by *L. intermedius* before human interference including highland Lakes, rift valley lakes and Rivers like Lake Tana, Lake Hawassa, Langano and Ziway (Demeke ademassu and Elias Dadebo, 1997).

### 2.2. Reproductive biology

#### 2.2.1. Breeding season

The maturity of eggs and the breeding (spawning) season are influenced by hormones, diet of the female and external (ecological) variables (Agumassie Tesfahun, 2018). Welcomme (1985) claimed that a variety of circumstances, including the rising water level or flood and the availability of food affected the spawning of cyprinids. According to research done on the species, gravel beds and highly oxygenated water are two general criteria that *L. intermedius* spp. must have in order to reproduce as a result of their critical role in the development of both eggs and larvae (De Graaf, 2003; De Graaf *et al.*, 2005). It appears that *L. intermedius* reproduces throughout the year because of the reason that the seasonal fluctuations in water temperature and photoperiod are generally very low in the tropics (Agumassie Tesfahun, 2018).

### **2.2.2. Size at first maturity**

According to FAO (1984), the minimal size at which a certain fish species can be harvested is the size of the fish at its half of maturity. Males mature rationally earlier and at a lower size than females. According to Dawit Yemane *et al.* (2005), the population with high levels of exploitation and disruption had smaller bodies but displayed quicker gonad development. Males mature at an earlier age and at a lesser size than females, as reported by Agumassie Tesfahun and Mathewos Temesegen (2017) research, were TL for males and females were 32.4 cm and 34.5 cm, respectively. But most of the literature shows females were matured at smaller size compared to males of the same stock. The average length at first maturity for *L. intermedius* was 22.6-34.5 cm TL for males and 22.1-32.4 cm TL for females (Gizachew Teshome *et al.*, 2015; Agumassie Tesfahun and Mathewos Temesegen, 2017; Simagne Melaku *et al.*, 2017; Mathewos Temesegen *et al.*, 2018; and Shewit Gebremedhin *et al.*, 2019) in different water bodies of Ethiopia.

In general, under these circumstances, many species may spawn at any time of the year. Every fish species, however, has a different peak breeding period that is primarily controlled by biological and ecological factors like the availability of food and the temperature of the water (Pawiroredjo, 2001). According to Agumassie Tesfahun (2018), more fish had ripe gonads during the wet season than during the dry season. Similarly other scholars like Shewit Gebremedhin *et al.* (2012;2013; 2014); and Gizachew Teshome *et al.* (2015) who conducted similar research on *L. intermedius* reported that wet season was the time of intensive breeding. Furthermore, numerous reports are available from Dirima and Megech Rivers (Wassie Anteneh *et al.*, 2007), Blue Nile River (Dagne Mequanent *et al.*, 2014), Lake Langeno (Mathewos Temesegen *et al.* (2018) that indicated the intensive breeding season of the fish during wet season in Ethiopia.

### **2.2.3. Gonado-Somatic Index (GSI)**

Fish development, spawning season, and larval survival were significantly influenced by temperature (Hontela and Stacey 1995). But for the majority of tropical freshwater fish, especially those in the Cyprinid family, the rainy season was the best time for mating (de). The start of the rainy season and a slight shift in water temperature trigger the spawning period for many tropical fish (Hontela and Stacey 1995). According to Dagnew Mequanent *et al.* (2014), September was the month with the highest record of GSI of the majority of *L. intermedius* species from Gilgel Abay River and its tributaries. In accordance with Mathewos Temesgen *et al.* (2018), GSI values for *L. intermedius* from the Lake Langano varied from 2.31 to 5.98 (mean 3.44, 1.09) for females and 1.89 to 5.18 (mean 3.69, 1.07) for males, with the maximum and lowest GSI values occurring in July and December, which was highly rainy and dry months of the year at the area respectively. It was also reported that 86.4% of the total catch had ripe gonads from August to October (Shewit Gebremedhin *et al.*, 2014) in Arno-Garno River, Lake Tana and 64% of the total catch from August to November had ripe gonads (Shewit Gebremedhin *et al.*, 2013) in Lake Tana.

### **2.2.4. Fecundity**

There is less information on the fecundity of *L. intermedius* as compared with the more studies tropical fish like *L. intermedius* species in Africa did not have as much information accessible on their fecundity as *O. niloticus* and *C. gariiepinus* (Agumassie Tesfahun, 2018). According to Skelton *et al.* (1991), *L. intermedius* fecundity is moderately high in other African lakes in comparison to Ethiopia. In the Vaal Orange River drainage system, other genus barbus species had fertility up to 60000 eggs per female on average (Skelton, 2001). However, it is much lower in Ethiopia than it is in other African lakes (De Graaf *et al.*, 2005; Shewit Gebremedhin *et al.*, 2014). Gonadal weight has a stronger correlation with reproductive ability than fish size and species weight, according to Claudine *et al.* (2013) and Shewit Gebremedhin *et al.* (2014). Paterna *et al.*

(2002) documented that early maturation, high fecundity, and rapid growth were the characteristics of *L. intermedius* stock.

In contrary to Skelton *et al.*, 1991; Skelton, 2001, Some authors in Ethiopia have reported total fecundity (27094–120314) of *L. intermedius* (Genanaw Tesfaye, 2006) from Angereb and Sanja Rivers, which was nearly similar to the report Skelton *et al.* (1991) from other African countries. There were other reports on fecundity from Ethiopia, including those by Wassie Anteneh *et al.* (2007) from the Dirma and Megech tributary rivers of Lake Tana; Zeleke Berie (2007) from the Beles and Gilgel Beles Rivers; Shewit Gebremedhin *et al.* (2013) from the Infranz River; and Dagnaw Mequanent *et al.* (2014) from the Gilgel Abay River and its Tributaries. Shewit Gebremedhin *et al.* (2014) found that *L. intermedius* fecundity was strongly and positively correlated with its gonad weight, fork length, and body weight. Also Dagnaw Mequanent *et al.* (2014) in Gilgel Abay River and its Tributaries have all reported a positive relationship between fecundity and morphometric measurements.

#### **2.2.5. Sex ration**

The sex distribution of *L. intermedius* has been documented in various Ethiopian water bodies, including Beles and Gilgel Beles Rivers (Zeleke Berie, 2007); Aveya River, (Shewit Gebremedhin *et al.*, 2012); Infranz River (Shewit Gebremedhin *et al.*, 2013); Arno-Garno River (Shewit Gebremedhin *et al.*, 2014); Blue Nile River, (Tadlo Awoke *et al.*, 2015); Geba and Sor Rivers (Agumassie Tesfahun and Mathewos Temesgen, 2017) Most of the researchers study the sex ratio in relation to abundance of the spp. and reported that females were slightly more numerous than males.

## **2.3. Feeding biology**

### **2.3.1. Food and feeding habits of family Cyprinid**

Cyprinids lack a stomach and have toothless jaws, but they can effectively chew food using their pharyngeal teeth by pressing the food against the chewing plate created by the progression of their skulls (Nelson, 2006). In addition to protractible upper jaws and a fleshy palatal organ that opposes the bronchial sieve, which can be used for food sorting and transportation, these groups of fish are known to be opportunistic feeders (Sibbing, 1991). Because cyprinids lack a distinct stomach, carbohydrate-digesting enzyme, and oral teeth, they are not well suited for piscivores feeding habits (Hofer, 1991). The contribution of ingested prey micro-organisms in digesting plant cell walls was negligible, and therefore, they only rely on mechanical breakdown for plant utilization (Nagelkerke, 1997). Voluminous and long intestines are needed for the digestion of long indigestible polymers in addition to long time. In cyprinid fish, intestinal length ranges from 2.5 times the standard length in macro-herbivores to 17 times the standard length in micro-herbivores (diatom feeders) (Hofer, 1991). According to Wotton (1990), the relative gut length will typically increase as dietary quality declines. According to Karmar and Bryant (1995), the average gut length for teleost fish larger than 10 cm in length was between 0.7 and 0.9 SL for specialized carnivores, 1.2 and 2.2 SL for omnivores, and 5 and 29 SL for specialized herbivores.

Even though the anterior part of the gut was extended, the lack of a distinct stomach in cyprinid fish may reduce storage capacity for large animal prey like fish (Nagelkerke, 1997). The family Cyprinid has the capacity to withstand a wide range of environmental conditions, and they can survive and persist in a wide range of habitats (Burger, 2008; Tuzen, 2009). Most cyprinids mainly feed on invertebrates and vegetation, probably due to a lack of teeth and gut acidity (Zerihun Desta *et al.*, 2006). As Sibbing and Nagelkerke (2001) documented that cyprinid fish were poor competitors for prey fish due to the absence of an oral jaw and teeth. Cambray (1983) described

that piscivores were rare in Cyprinids due to a lack of teeth in their oral jaws and a gut with a low pH to digest prey items.

Because of their feeding behaviors, cyprinid fish have highly organized palatal and sublingual organs lining their pharynx (Sibbing, 1982; Cabana *et al.*, 1994). According to Sibbing (1982), these organs were used to feed on benthos, and cyprinids consume sediment by mixing and sucking it up. Small species eat common frog larvae (Banister, 1973). According to De Graaf (2003) and Eshete Dejen (2003), some species have become experts at feeding on fish. For instance, eight of the 15 large barbs in Lake Tana developed piscivorous feeding habits (De Graaf, 2003). They prey mainly on *Barbus humilis*, *Barbus tanapelagius*, and small benthic *Garra* species (De Graaf, 2003).

There piscivores with large barbs prey primarily on *B. tanapelagius* in the pelagic area, while large barbs primarily prey on the littoral dwelling *B. humilis* (De Graaf, 2003). Piscivores were prevalent in Lake Tana because other common African piscivores weren't present. Because of this, the *L. intermedius* of Lake Tana are now able to utilize their potential for trophic diversification (De Graaf, 2003).

### **2.3.2. Food and Feeding habits of *L. intermedius***

Although *L. intermedius* are facultative feeders with distinct preferential diets, they can also alter their feeding behaviors (Demeke Admassu and Elias Dadebo, 1997; Sibbing and Nagelkerke, 2001; Elias Dadebo *et al.*, 2013). According to Nagelkerke *et al.* (1994), Demeke Admassu and Elias Dadebo (1997), and Zerihun Desta *et al.* (2006), insect larvae and pupae were the most crucial food sources for *L. intermedius* species. They also feed on gastropods (Zerihun Desta *et al.*, 2006) and other food items such as crustaceans, ostracods, bivalve fish, macrophytes, and shoots of aquatic plants (Nagelkerke *et al.*, 1994). Sand and detritus were found in the diet of *L. intermedius*, which vary seasonally and size of the fish (Mulugeta Wakjira, 2013). Various authors studied the food and feeding habits of *L. intermedius* in *Ethiopian* water bodies ( Mulugeta Wakjira, 2013; Elias Dadebo

*et al.*, 2013; and Filipos Engdaw, 2014). They reported that *L. intermedius* feeds on different types of food items based on the environment in which they live, most probably tending towards omnivore feeding habits. The food items consumed by the fish include aquatic macrophytes, zooplankton, phytoplankton, detritus, insects, fish scales, and nematodes (Elias Dadebo *et al.*, 2013). However, the type of food items consumed by *L. intermedius* depends on prey availability, season, habitat differences, and size of the fish (Agumassie Tesfahun and Mathewos Temesgen, 2017).

Demeke Admassu and Elias Dadebo (1997) reported that, the diet composition of the species in Lake Hawassa was phytoplankton, insects, detritus, macrophytes, gastropods, and fish, with the tendency to piscivory with the size of the fish. In the same way, Zerihun Desta *et al.* (2006) have also studied the feeding habits of *L. intermedius* from Lake Hawassa in connection with its mercury concentration and reported that the food items of the species include gastropods, aquatic insects, detritus, macrophytes, fish fry, and fish eggs. According to Sibbing (1998), *L. intermedius* in Lake Tana consumed benthic invertebrates, primarily insect larvae and debris. The diet of *L. intermedius* included macrophytes, detritus, insects, nematodes, fish, fish eggs, and fish scales from Lake Koka, according to Kassahun Assaminew (2005) and Elias Dadebo *et al.* (2013).

Detritus was the most common food source for *L. intermedius* from Lake Tana Gulf of Gorgora, followed by insects, phytoplankton, and gastropods; the least common were zooplankton, ostracods, macrophytes, and nematodes. (Filipos Engdaw, 2014). The authors also indicated that mollusks were the dominant prey items in all size classes and in all habitats, while insects were highly constituted in small individuals, particularly in the littoral habitats, but progressively declined in larger individuals.

### **2.3.3. Seasonal Variation in Diet Composition**

There are authors have discussed how the types of foods and their proportions in the diet of *L. intermedius* vary seasonally. For example, Elias Dadebo *et al.*, 2013 in Lake Koka reported that

there was a significant variation in the type of diet and the proportions of food consumed by *L. intermedius* at the different seasons of the year. During the dry period, detritus and insects were the most important food items, followed by macrophytes , phytoplankton, ostracods , fish scales , and zooplankton, whereas during the wet months, macroinsects made a negligible contribution (Elias Dadebo *et al.*, 2013).

They make up 9.8% of the total food items in volume. The contribution of foods from plants was very significant during the rainy months. During wet months, the contribution of foods of plant origin was very high, while the contribution of animal prey was low (Elias Dadebo *et al.*, 2013). As Mulugeta Wakijira (2013) reported that, macrophytes were the most important food type consumed during the wet season, whereas aquatic insects, detritus and zooplankton were the largest food items consumed during the dry seasons in Gilge Gibe reservoir. In Lake Hawassa, however, fish, and phytoplankton were the most dominant food items consumed during the dry season, followed by aquatic insects and mollusks, whereas insects and macrophytes (25%) were the most important food items consumed in the wet season (Demeke Admassu and Elias Dadebo, 1997).

According to Zerihun Desta *et al.* (2006), detritus and insects were the most significant food items of *L. intermedius* in Lake Hawassa during the dry period. They also noted seasonal variations in the type of food and its proportion during the dry and wet periods of the year. They also noted that the species had an omnivorous nature and a propensity to consume fish. The ventral mouth projection of the fish is designed for benthic feeding, which likely helped them pick insects out of the sediment. During the wet period of the year, macrophytes and detritus were the most important food items (Adeyemi, 2009).

#### **2.3.4. Ontogenetic dietary shifts**

Fish digestive systems and guts grow longer and more developed as they get bigger. The absolute rate of food consumed rises, whereas the feeding rate relating to body weight declines (Wakil *et al.*,

2014). According to Otieno *et al.* (2014), fish primarily eat foods that fit in their mouths and those they can digest. It was clear to see that the diet of *L. intermedius* varied slightly throughout size classes due to ontogenetic differences (Mulugeta Wakjira, 2013). Regardless of size, the importance of macrophytes, debris, and insects was predominant, but the contributions of ostracods, phytoplankton, zooplankton, and fish scales were minimal.

The slight variation observed was that macrophytes were relatively unimportant in the diet of the small size classes, while they were dominant food items in larger sizes. Moreover, insects that were dominant in the smallest-sized class were relatively unimportant in larger-sized classes. In Ethiopia, *L. intermedius* showed various ontogenetic dietary shifts in different water bodies. In Lake Hawassa, for instance, the feeding habits for length groups of <20 cm TL showed that aquatic insects, mollusks, and fish eggs, were the most important food items identified, whereas for the length range of 20–29.9 cm, mollusks, insects, fish prey, and fish eggs contributed the largest volume of the fish diet. For the length group between 30–39.9 cm, however, mollusks, fish prey, and insects accounted for the largest proportion of the diet, and for the size class >40 cm, fish prey (56%), detritus, mollusks, and fish eggs, contributed the largest volume to the diet of the fish (Zerihun Desta *et al.*, 2006).

According to Zerihun Desta *et al.* (2006), *L. intermedius* Lake Hawassa shifted from insectivorous to piscivorous feeding habits as the size of fish increased. Also, Elias Dadebo *et al.* (2013), studying food and feeding habits, reported that macrophytes, detritus, and insects were significant food items in all size classes of *L. intermedius* from Lake Koka, while the contribution of ostracods, phytoplankton, zooplankton, and fish scales was changed regardless of their size in Lake Koka. For instance, detritus was the most important food item reported in the diet of fish with <20 cm and 20–29.9 cm, whereas macrophytes and detritus were the dominant food items by volume in

fish with a total length between 30 and 39.9 cm and above 40 cm. This indicates that *L. intermedius* from Lake Koka shifted its feeding behavior from detritus feeders to macrophyte feeders.

In Lake Tana, however, phytoplankton, detritus, and insects were important food items preferred by fish less than 20 cm. For the size, class, and length group above 20cm, detritus is the most important food item, and it constitutes the bulk of the diet of the fish in volume (Filipos Engdaw, 2014).

This author further stated that *L. intermedius* from Lake Tana shifted their feeding habits from phytoplankton to detritus as the fish increased in size. However, the feeding habits of *L. intermedius* in this lake do not show a considerable ontogenetic diet shift, where small and large-sized fish consume similar food items. Generally, detritus, phytoplankton, and insects form the food items in smaller fish, while macrophytes are the most preferred food items in larger fish. The size-related shifts in food preferences of *L. intermedius* Ethiopian water bodies seem to depend upon physiological requirements, whereas the seasonal changes in dietary pattern might rather reflect the opportunistic feeding behavior of the species (Agumassie Tesfahun and Mathewos Temesegen, 2017).

#### **2.4. Fulton's Condition Factor**

The condition factor, which is represented by the body condition coefficient, conveys the level of fish wellbeing in their habitat. Variations between populations in the rivers and reservoirs were shown by the *L. intermedius* condition factor. Comparatively, Fulton's condition factors were reported from the Angereb and Sanja Rivers (1.14 and 1.05), respectively (Genanaw Tesfaye, 2006); Gilgel Beles (1.12) and Beles (1.0) Rivers (Zelege Berie, 2007); Lake Koka (1.0) (Elias Dadebo *et al.*, 2013); and Nile River (0.99) (Tadlo Awoke *et al.*, 2015).

Higher energy levels, adequate food availability, reproductive potential, and favorable environmental factors are all linked to better conditions. Shewit Gebremedhin et al. (2012), Mathewos Temesgen et al. (2018), Aveya River (1.22), Geba and Sor Rivers (1.21), and Simagnew Melaku et al. (2017) all exhibited considerably higher condition factors in comparison to other lakes. The mean Fulton condition factor for this species in Lake Koka was greater in the dry season (1.1) than in the rainy season (0.9), according to Elias Dadebo et al. (2013). The Arno-Garno River showed comparable seasonality in condition parameters (Shewit Gebremedhin et al., 2012).

Also, the values were higher (1.39 in dry) than wet season (1.28 wet) in Lake Koka. However, a comparatively higher condition factor during the wet season than during the dry season was also observed in the Angereb and Sanja Rivers (Genanaw Tesfaye, 2006) and the Aveya River (Shewit Gebremedhin *et al.*, 2014). The condition factor of the species did not vary very much between the seasons in the Geba and Sor Rivers (Simagnew Melaku *et al.*, 2017), Beles and Gilgel Beles (Zelege Berie, 2007), and Nile River (Tadlo Awoke *et al.*, 2015). Additionally, Filipos Engdaw (2014) in Lake Tana reported a small condition factor of *L. intermedius*, next to the report of Shewit Gebremedhin *et al.* (2013).

The energy requirements for egg development in females and sperm production in males during the peak spawning season have an impact on fish body condition (Ighwela *et al.*, 2011; Shewit Gebremedhin *et al.*, 2012). According to Shewit Gebremedhin *et al.* (2012), male fish in the Aveya River were found to be in better condition (1.36) than female fish (1.28). However, Beles River (Zelege Berie, 2007) and Aveya River (Shewit Gebremedhin and Minwyelet Mengist, 2014) females were in better condition. In Lake Ziway, female fish showed a higher mean condition factor (1.88) than males (1.52) (Lemma Abera, 2016). Whereas in Lake Koka (Elias Dadebo *et al.*, 2013), the condition factor did not vary considerably among the sexes, which means there was noTable variation between sexes.

### 2.5. Length weight relationship (LWR)

The length-weight relationship was one of the most essential biological tools in fishery management. It was used to establish the normal weight at which a fish can reach a particular length (Lawson *et al.*, 2013). The relationship between the two variables is also a sign of fish health (Hamid *et al.*, 2015). found that the regression coefficients were close to or equal to the cube value ( $b = 3$ ), which defines isometric growth, when the relationship between a fish's length and total weight was curvilinear.

This suggests that the pace at which weight increases is approximately a cube of length expansion. The isometric growth pattern was reported by Gizachew Teshome *et al.* (2015) in some tributaries of Lake Tana; Tadlo Awoke *et al.* (2015) in head Blue Nile River. A negative growth pattern or negative allometric growth ( $b < 3$ ) of *L. intermedius* was reported in the Geba and Sor Rivers of the White Nile system by Simagnew Melaku *et al.* (2017). Positive allometric growth has been reported in the populations of Gelgel Beles and Koka. The nearly isometric growth pattern is most common for this species, both in riverine and lacustrine environments Reservoirs (Elias Dadebo *et al.*, 2013).

### 2.6. Length-length relationships

Very little information is available about the length-length relationships of *L. intermedius* in rivers but there were higher information on the species in lakes in relation to river. However, Filipos Engdaw (2014), Agumassie Tesfahun (2018) and Feven Zerihun (2020) have reported a linear and strong relationship (highly correlated) between TL, FL, and SL from the Lake Tana gulf of Gorgora, Lake Koka, and Lake Hwassa respectively.

### 3. MATERIALS AND METHODS

#### 3.1. Description of the study area

The study was conducted in Beles (Kusa) River of Mandure district in the Metekel Zone of the Benishangul-Gumuz Regional State (BGRS). The sampling area is located 50 km to the west of Gelgel Beles town, which is the capital of Metekel Zone at 11° 00' N latitude to 35° 45' E longitude. The Beles River flows around Gilgel Beles town and Mankush (formerly Guba) District in Babizenda Kebeles, 541 km and 696 km northwest of Addis Ababa, respectively. The central part of the Beles River catchments encloses the wide, gently undulating, flat plain of the Pawi area. The headwaters of the Beles River originate close to the western part of Lake Tana, on the border of Amhara and BGRS. The Beles River has a large watershed area of 3,474 km<sup>2</sup> (FDROE, MOWR, 2000). The shape of the catchments of the Beles River is elongated along the main course of the river, broadening towards the south-west as more tributary streams join the main river. The river is broken here and there by many rivers. The most important tributary rivers are Abat Beles, Gilgel Beles, Durra, Ardi, Alaltu, Dondor, Qarsa, and Shar Rivers, which flow west to the Abay River. Zeleke Berie (2007) reported, t different types of phytoplankton that are found in the Beles River, including Cyanophyceae (cyanobacteria), Chlorophyceae (green algae), Bacillariophyceae (Diatoms), Dinophyceae (Dinoflagellates), Cryptophyceae (Cryptophyta), and Euglenophyceae (Euglenophyta). The river is basically dominated by large populations of rotifers, copepods, cladocerans, ostracoda, and dipterans (chloropodous) insects. The Cilliophorans, especially Paramecium, were also represented by quite a number of species (Zeleke Berie 2007)

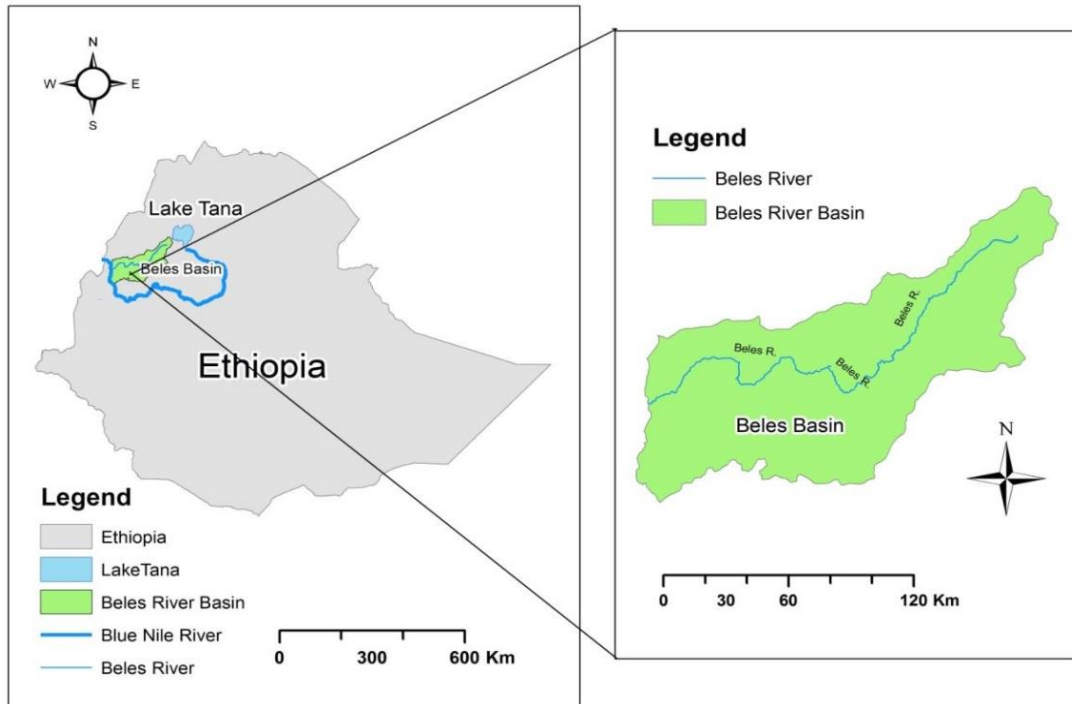


Figure 1. Location map of Beles River with its basin

### 3.2. Data collection and sampling

464 Fish samples were purchased from the landings of the fishermen for six consecutive months, including three during the dry season and three during the rainy season. Total length (TL), fork length (FL), and standard length (SL) were measured to the nearest 0.1 centimeter for both smaller and larger fish. The total weight (TW) of juveniles and adults was measured to the nearest 1 g.

Gut contents of sampled fish were removed and preserved in a 5% formalin solution. Identification of large food items was performed visually, whereas a dissecting microscope and a compound microscope were used to identify microscopic food items. After dissecting the fish, sex and gonadal maturation were rated with the naked eye to determine the

maturation stage, and the ripe ovaries were preserved in 5% formalin and brought to the laboratory for further analysis.

### 3.3. Reproductive biology

#### 3.3.1. Determination of breeding season of the fish

The breeding season of *L. intermedius* was determined from monthly frequency of fish with ripe gonads and gonado-somatic index (GSI). The fish were dissected to see the gonads. The GSI for each fish were computed as the weight of the gonads as the percentage of total body weight using exploration:

$$GSI = (GW/TW - GW) \times 100 \text{ -----} (3)$$

Where, GSI = Gonado-somatic index

GW = Gonad weight in g.

TW = Total weight in g.

The breeding month was determined by looking at the monthly variation of the ripe gonads. Sampling months of February, March, and April, were represented as dry months whereas May, Jun, and July were represented as rainy month at the sampling time

#### 3.3.2. The length at first maturity

The sizes at first maturity of *L. intermedius* were obtained by determining the average size at which 50% of the fish became mature. To know this, the fish were measured morphometric at the site of sampling and dissected to examine the maturation stage. The sizes at which 50% of both sexes reach maturity ( $L_{m50}$ ) were determined from the percentages of mature fish that were grouped into the different length classes as described by the logistic function (Echeverria, 1987).

$$P = e^{(\alpha + \beta)} / (1 + e^{\alpha + \beta} L) \text{ -----} (2)$$

Where  $\alpha$  and  $\beta$  were estimated using Marquardt's (1963) algorithm for non-linear least squares regression.

The values of  $L_{m50}$  were estimated from the expression the regression formula:  $L_{m50} = -\alpha/\beta$ . The individuals of fish in the estimation of  $L_{m50}$  were collected during the spawning month of the fish. The proportion of mature fish for each length class was calculated for both males and females also the proportions of data were obtained from dissection of all fishes from sampling area.

### **3.3.3. Estimation of fecundity**

The fish were dissected to get its gonad. The fecundity data were calculated from taken ripe gonads. It was estimated using gravimetric methods (Nielsen and Johnson, 1983). All the eggs were weighed and preserved in 5% formalin solution. Three (1g) subsamples were taken from each ovary and the eggs were counted and some of the ripe females having less than 5g OW were counted directly. The average number of the three sub-sample eggs from each gonad was calculated. Then the total number of eggs per female was calculated using extrapolation:

### **3.3.4. Sex ration**

Sex-ratio (male: female) was calculated for each month, for different length classes and for the total sample. Chi-square test was employed to test if sex ratios were varied from 1:1 in monthly samples, in various size classes and in the total sample. (Demeke Admassu, 1994)

## **3.4. Food and feeding habits**

### **3.4.1. Gut content analysis**

After morphometric measurement was taken contents of the entire gut were taken and preserved in 5% formalin. The gut contents were examined and prey items were identified. Large food items, especially macrophytes (fruit), was identified visually; however, the simple and small food items were examined under the microscope and identified to the lowest possible taxa (Demeke Ademasu

and Elias Dadebo, 1997; Zerihun Desta *et al.*, 2006; Elias Dadebo *et al.*, 2013; Demeke Admassu *et al.*, 2015). The relative importance and contribution of each food item to the diet of *L. intermedius* were determined using the standard methods, i.e., the frequency of occurrence method and volumetric analysis (Hyslop, 1980).

#### **3.4.2. Frequency of occurrence**

The number of gut samples containing one or more of a given food items was expressed as a percentage of all non-empty guts examined from dissected fish (Bagenal and Braum, 1978). The proportion of the population that feeds on certain food items was estimated by this method.

#### **3.4.3. Volumetric analysis**

Food items that were found in the gut were sorted into different food categories, and the water displaced by a group of items in each category was measured in a partially filled graduated cylinder (Bowen, 1983). The volume of water displaced by each category of food item was expressed as a percentage of the total volume of the gut contents (Bowen, 1983). The importance of different food categories in relation to the size of fish was determined by categorizing the TL of the fish into different size classes and by observing the volumetric contribution of different food items to each size class.

#### **3.4.4. Ontogenetic dietary shift**

Ontogenetic dietary shift of *L. intermedius* was studied based on the volumetric contribution of each food item within each length group. To study ontogenetic dietary shift the study classifies the fish in to eight categories using 5cm interval with 3 main categories as: - small (<25TL), medium (25-35) and large (>35) to minimize ambiguity as reported from literature (Eliad Dadebo *et al.*, 2013). The relative importance of each food items in each size class were estimated by taking the mean percentage volume of each category of food items to the total volume in that size class.

### 3.4.5. Estimation of seasonal diet composition

Seasonal difference in food habit of *L. intermedius* was studied from the frequency of empty gut and also from results on relative contribution of major items as determined from frequency of occurrence, and volumetric analysis.

### 3.5. Some morphometric parameters

#### 3.5.1. Condition factor (K)

The wellbeing of *L. intermedius* was determined using Fulton's condition factor from the data of morphometric measurement such as total length and total weight (Bagenal and Tesch, 1978).

Fulton's condition factor (K) is calculated as follows: -

$$FCF (K) = TW/TL^3 \times 100, \text{-----} (5)$$

Where, "TW" is the total body weight and "TL" is the total length.

#### 3.5.2. Length-weight and length-length relationship

The study was used TL and TW to calculate length-weight relationship using the following formula: -

$$TW = aTL^b \text{-----} (6)$$

Where TW is in g and TL in cm; a and b are parameters

The relationships between total length (TL) and fork length (FL), and TL and SL were calculated using linear regression as:

$$TL = aFL^b \text{ or } TL = aSL^b \text{-----} (7)$$

Where, TL = total length, SL = standard length, a = intercept and b = slope

### **3.6. Data analysis**

#### **3.6.1. Morphometric relationships analysis**

A non-linear relationship was used to determine the relationships between TL and FL, TL and SL where TL is total length, FL is fork length and SL is standard length

Where TW is total weight (g), TL is total length (cm), and “a” and “b” are intercept and slope of the length-weight regression equation, respectively.

#### **3.6.2. Statistical analysis and interpretation**

The collected data were analyzed, interpreted and were presented in descriptive statistics by using statistically developed software known as STATA to know the relation between this quantitative data and qualitative data of the sampled fish species. When Data analysis was done with the use of STATA, Microsoft excel statistical developed application package was used to save data and the differences at  $P < 0.05$  were considered significant in statistics for 95% confidence interval and  $P < 0.1$  were considered as significant in statistics for 99% of confidence interval (Zar, 1999). Length weight relationship and growth performance of fish were done using morphometric relationship analysis Chi-square test, were used to compare frequency of occurrences and percentage volume of the different food categories during the dry and wet months (Sokal and Rohlf, 1995).

## 4. RESULTS

### 4.1. Reproductive biology

#### 4.1.1. Determination of breeding months

*L. intermedius* in Beles River had its breeding season in all sampling months from February to July where 0% to 72.7% of males and 4.3% to 43.3% of the females had ripe gonads (Fig.1). The less intense breeding occurred on April where 0% of males and 4.3% of females had ripe gonads. Highly intensive breeding from sampling month occurred in the month of February for both males and females with 72.7% and 43.3% respectively.

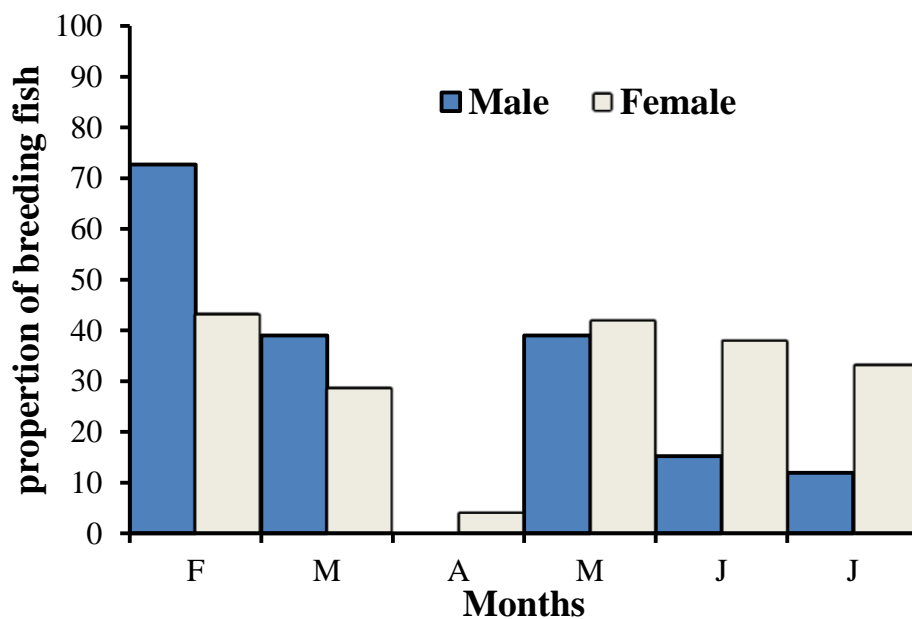
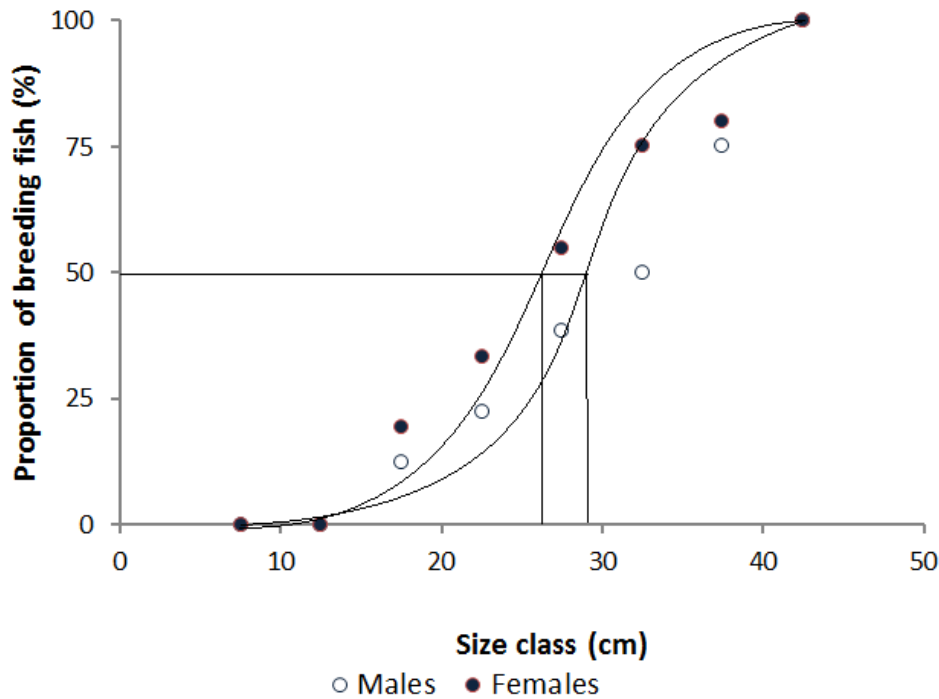


Figure 2. Breeding months of *L. intermedius* in Beles River

#### 4.1.2. Length at first maturity

The length at 50% sexual maturity ( $L_{m50}$ ) obtained in Beles River was 28.6 cm TL for males and 26.4 cm TL for females (Fig 2). The smallest male with rip gonad was 16.1cm TL and wigh TW of 42 g and the smallest female caught with rip gonad was found to be 17.1 cm TL, and 46 g TW.



**Figure 3. Length at first maturity of *L. intermedius* in Beles River**

#### **4.1.3. Gonado-somatic Index (GSI)**

The Gonad Somatic Index (GSI) ranged from 0.15 to 28.8 for males and 0.1 to 40.43 for females. The mean GSI values ranged from 0.8 to 4.8 in the months of April and May, respectively. The value has significant variation (ANOVA  $p < 0.05$  (0.0026) between sampling months in both females and males). But there was no significant variation between sexes (ANOVA  $p > 0.05$  (0.4) at 95% CI). High GSI were gained from February to March and May to July, with the peak value of GSI in the month of May (Fig. 3). The patterns of both months' fluctuations in the frequency of ripe fish and in GSI were relatively similar. (Figure 3 and average rain fall pattern Figure 4) Thus, relatively lower frequencies of ripe fish coincided with lower GSI values in the month of April.

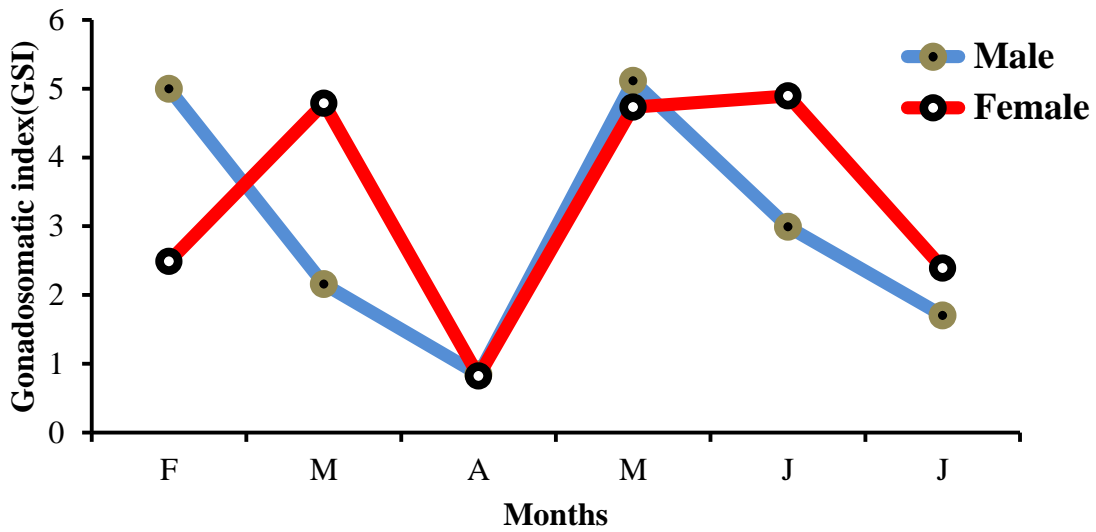


Figure 4. Gonado Somatic Index (GSI) of *L. intermedius* in Beles River for the months of February to July, 2023

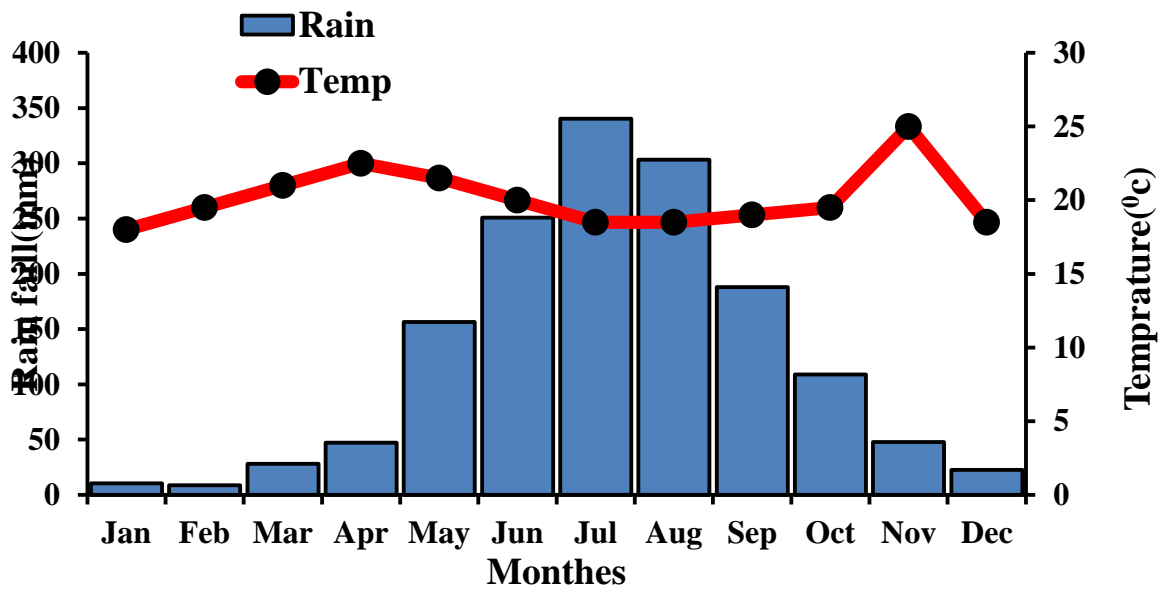
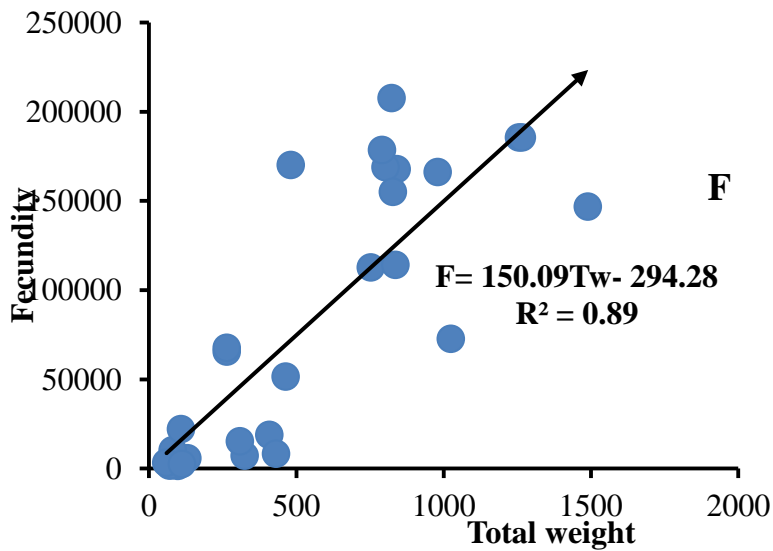


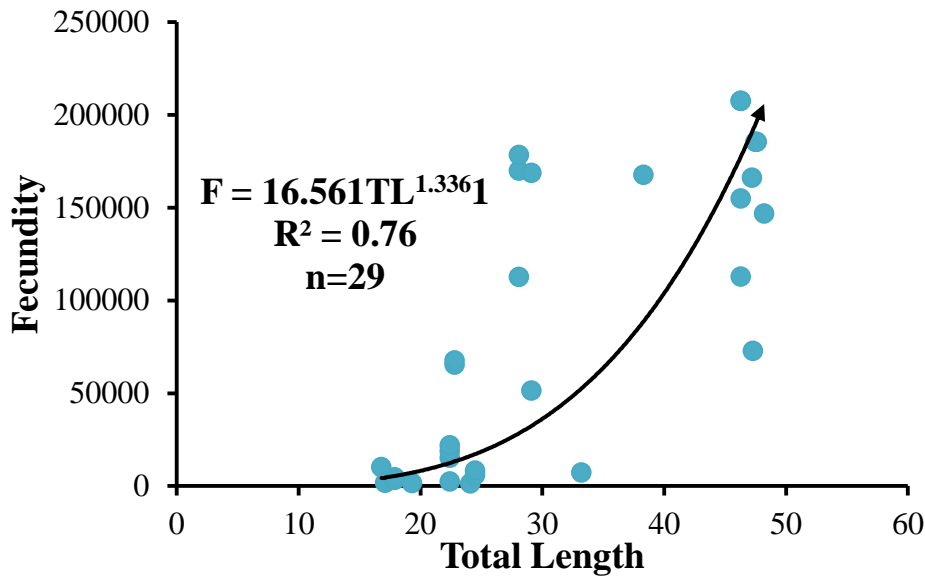
Figure 5. Average rainfall pattern and temperature of Benishangul Gumuz Regional State from 2018-2022

#### 4.1.4. Fecundity

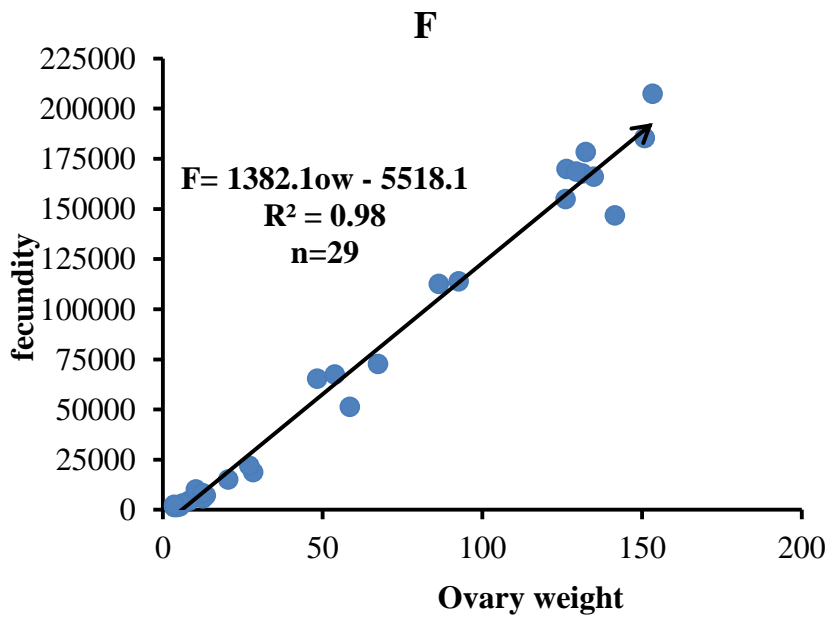
Out of 254 females sampled, only 29 (11.4) fish contained ripe ovaries. The number of eggs in ripe ovaries ranged from 1394 to 207,477, and the mean was 76,359. The number of eggs per gram of preserved wet weight of ovary ranged from 410 to 1,424 with a mean number of 1050. The fish with the lowest fecundity contained 1394 and measured 24.1 cm total length and 99 g total weight. The ovaries of this fish weighed 2.8 g (11.68 % of the body weight). The highest fecundity of eggs 207,477 was in a fish measuring 46.3 cm TL and 845 g TW. The ovaries of this fish weighed 145.7 g (17.2% of the body weight). The relationships between fecundity and TL were curvilinear. While the relationship between fecundity and Tw, and ovary weight, was linear and highly significant using both ANOVA and correlation at a 95% confidence interval ( $p < 0.05$ ) (Figure 6, 7 and 8).



**Figure 6. The relationship between fecundity and total weight of *L. intermedius* in Beles River**



**Figure 7. The relationship between fecundity and totale length of *L. intermedius* in Beles River**



**Figure 8. Relationship between fecundity and ovary weight of *L. intermedius* in Beles River**

#### 4.1.5. Sex ratio

Out of the total 464 *L. intermedius* fish sampled from Beles River, 210 (45.3%) were males while the remaining 254 (54.7%) were females. The male to female sex ratio (1:1.2) was statistically different from theoretical value 1:1 ( $\chi^2= 4.2^*$ ,  $p<0.01$ ) (Table 1.). But, in relation to month there was no significant variation at the time of sampling months. The variation was highly significant by testing using Chi square ( $\chi^2= 4.2^*$ ,  $p<0.01$ ) where females were more numerous than males in addition there was no significant variation between different size class except length class between 20 to 24.9 TL ( $\chi^2=4.9^*$ ) and 25 to 29.9 TL ( $\chi^2=10.8^*$ ) from all sampled sizes. Over all the sex ratio was significantly different from ideal sex ratio (1:1) (Table 1 and 2.).

**Table 1. Sex ratio of *L. intermedius* sampled in different months in Beles River**

Month	Male	Female	Total	Sex ratio	$\chi^2$
Feb	22	30	52	1:1.4	1.24
Mar	42	51	93	1:1.2	0.87
Apr	36	44	80	1:1.2	0.8
May	35	39	74	1:1.1	0.22
Jun	33	42	75	1:1.3	1.08
Jul	42	48	90	1:1.14	0.4
<b>Total</b>	210	254	464	1:1.2	4.2*

**Table 2. Sex ratio of different size classes of *L. intermedius* sampled from in Beles**

Size classes(cm)	Male	Female	Sex ratio	$\chi^2$
10.0-14.9	13	22	1:1.7	2.3
15.0-19.9	116	98	1:0.8	1.5
20.0-24.9	55	81	1:1.5	4.9*
25.0-29.9	13	36	1:2.8	10.8*
30.0-34.9	4	4	1:1.0	0
35.0-39.9	3	5	1:1.7	0.5
40.0-44.5	2	0		0
45.0-49.9	4	8	1:2.0	1.34

#### 4.2. Feeding habits

##### 4.2.1. Diet composition

A total of 464 gut samples were collected during the period of investigation. Of these, 65 guts (14.1%) were empty. The remaining 399 (85.9%) guts contain a wide variety of food items of plant and animal origin. Food items of animal origin were insects, zooplankton, and gastropods, while food items of plant origin were macrophytes, phytoplankton, and others that are detritus. . Insects identified from the gut included *Chironomidae* larvae, *Trichopterans*, *Anisoptera*, and *Ephemeroptera*.

##### A. Percentage frequency of occurrence

The The frequency of occurrence showed that detritus and phytoplankton were found to be the most important food items and occurred in 90.6% and 87.7% of the guts respectively. (Table 3.) The

high frequency of occurrence phytoplankton was mainly due to green algae. The others next to detritus and phytoplankton were macrophytes (fruit, bark, and root), followed by insects and gastropods occurring in 52.4%, 37.7%, and 30.2 of the guts examined, respectively, and zooplanktons (5.8%) were less important than others in number. The high frequency of insects, which was more than half of the frequency of occurrence, was due to *chronomidiea* larvae followed by *Ephemeroptera*, and *Anisoptera* and *Tricoptera*, respectively, and the high frequency of gastropods was due to *Mellanoides* and *Bullinus*.

#### **B. Volumetric analysis**

Volumetrically, detritus was the most important food item constituting 42.1% of the total volume followed by phytoplankton with 41.5% of total volume of the gut contents, respectively. Macrophytes (7.2%), insects (4.3), zooplankton (3.4) and gastropods (1.5) were constituted relatively low volumes compared the above food categories (Table.3) Food items which contain insects A *Tricoptera* and *Anisoptera* in high volume. And the Gastropods (1.5%) were mainly content *Mellanoides* and *Bullinus*

**Table 3. Major food categories identified in the gut content of *L. intermedius* in Beles**

<b>River</b>				
Food item	frequency	Percent	volume	Percent
Phytoplankton	<b>350</b>	<b>87.7</b>	<b>339.6</b>	<b>41.5</b>
Zooplankton	<b>23</b>	<b>5.8</b>	<b>19.9</b>	<b>3.4</b>
<b>Insect</b>	151	37.9	26.9	4.3
<b>Chironomidae</b>	105	26.3	12.8	2.1
Ephemeroptera	58	14.5	5.4	0.86
<b>Trichopteran</b>	28	7.1	3.8	0.6
Anisoptera	31	7.8	4.9	0.78
<b>Gastropods</b>	<b>121</b>	<b>30.3</b>	<b>12.3</b>	<b>1.5</b>
Melanoides	93	23.3	6.5	0.78
Bulinus	71	17.8	5.8	0.72
<b>Macrophytes</b>	208	52	<b>50.4</b>	7.2
Roots	98	24.5	15.1	2.1
Shoots	81	20.3	9.6	1.4
Fruits	204	51.1	25.7	3.7
<b>Detritus</b>	<b>361</b>	<b>90.6</b>	<b>344.3</b>	<b>42.1</b>

#### 4.2.2. Ontogenetic dietary shift

The size of *L. intermedius* with food in their guts ranged from 11.6 cm to 49.3 cm, and for a better understanding, fish were grouped into eight length classes with five centimeters interval, with further grouping of the fish into three broad classes as small

(<25), medium (25–35), and large (>35) to get a clear description. There is difference in the volumetric contribution of the different food categories between the size classes compared. The noticeable change observed was that the contribution of insects, gastropods, and zooplankton decreased with increase in the size of the fish. Over 50% of insects are consumed at sizes class less than 15cm TL, with larger food groups like phytoplankton, detritus, and macrophytes being consumed as size increases. Gastropods are also highly consumed in smaller sizes. Fish food items shift towards phytoplankton and macrophytes as the fish grow. length groups of less than 25 TL showed that insects (28.5%), gastropods (26.8%), zooplankton (19.9%), phytoplankton (9.6%), detritus (8.5%), and macrophytes (6.6%) were the most important food items identified in their total diet, whereas for the length range of 25–34.9 cm, insects (16.1%), gastropods (13.7%), zooplankton (15.1%) phytoplankton (18.2%), macrophytes (16.25%) and detritus (20.65%) contributed the largest volume of the fish diet. For the length group greater than 35cm, however, insects (7.2%), gastropods (7.5%), zooplankton (8.6%) phytoplankton (23.5%), detritus (23.1%) macrophytes (30.1%) were the most important food items of the fish. (Figure 2)

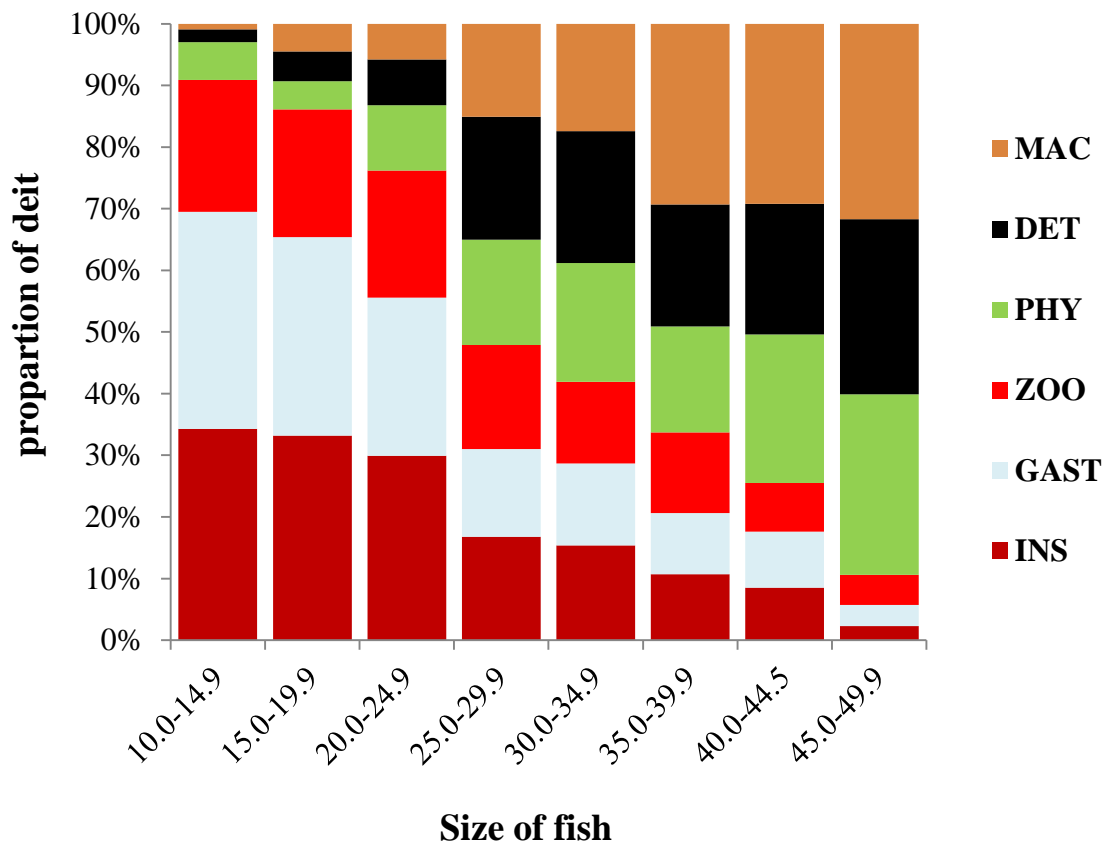


Figure 9. Ontogenetic dietary shift of *L. intermedius* in Beles River

Where (MAC- Macrophytes, DET- Detritus, PHY- Phytoplankton, ZOO- Zooplankton, GAST- Gastropods, INS- Insects)

#### 4.2.3. Seasonal variation in the diet composition of the fish

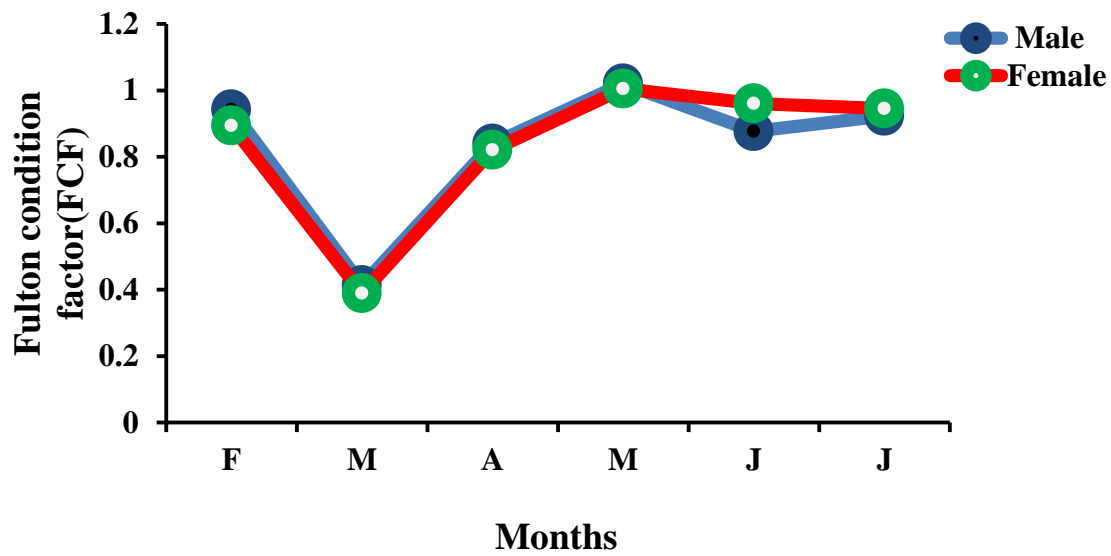
There was no variation in the type of food consumed and a slight variation in the proportions of the volume of the diet consumed by *L. intermedius* was observed between the dry and wet months. Generally, except for insects and detritus, the contributions of all food categories were slightly higher during the wet season. The volumetric contribution of insects and detritus was higher in the dry month than in the rainy months. In addition, except for detritus and zooplanktons, all food items increase in frequency of occurrence during wet months (Table 4).

**Table 4. Variation in seasonal diet composition of *L. intermedius* in Beles River**

Food item	Dry Month		Wet Month	
	Frequency (%)	Volumetric (%)	Frequency (%)	Volumetric (%)
<b>PHY</b>	74.4	39	86.9	43.6
<b>ZP</b>	5.2	1	3.8	2.3
<b>INS</b>	31.2	5.3	37.2	4.6
<b>GAST</b>	28.1	1.2	31.4	2.8
<b>MAc</b>	61.3	7.6	63.8	7.9
<b>DET</b>	82.1	45.9	74.4	38.8

#### 4.3. Fulton's condition factor (FCF)

Mean FCF in this study ranged from 0.4 to  $1.02 \pm 0.01$  for males and 0.38 to  $1.004 \pm 0.01$  for females. The minimum and maximum average FCF was recorded in the month of March and May that were 0.38 and 1.01, respectively. The mean combined condition factor for both sexes was 0.83. The smallest mean condition factor value was recorded in March for both males and female. The values did not vary significantly (ANOVA  $p > 0.05$ ) between sexes. The interaction between month was significantly different from each other (ANOVA  $p < 0.05$ ) that there was FCF difference between months this also suggests that similar seasonal fluctuation pattern was observed in the condition factor (growth pattern) of both males and females (figure 12).



**Figure 10.** Variation of Fulton's condition factor of *L. intermedius* for different months in Beles River

#### 4.4. Length weight and length -length relationships

The length-weight relationships showed highly significant, and the growth pattern is slightly negative allometric, between 2.84 and 2.89 for both male and female, respectively. There was no significant variation between sexes or between months, and they were correlated with each other. (ANOVA  $p < 0.05$ ) with a 95% confidence interval; therefore, an equation combined for sexes was fitted and shown in Figures 11, 12, 13.

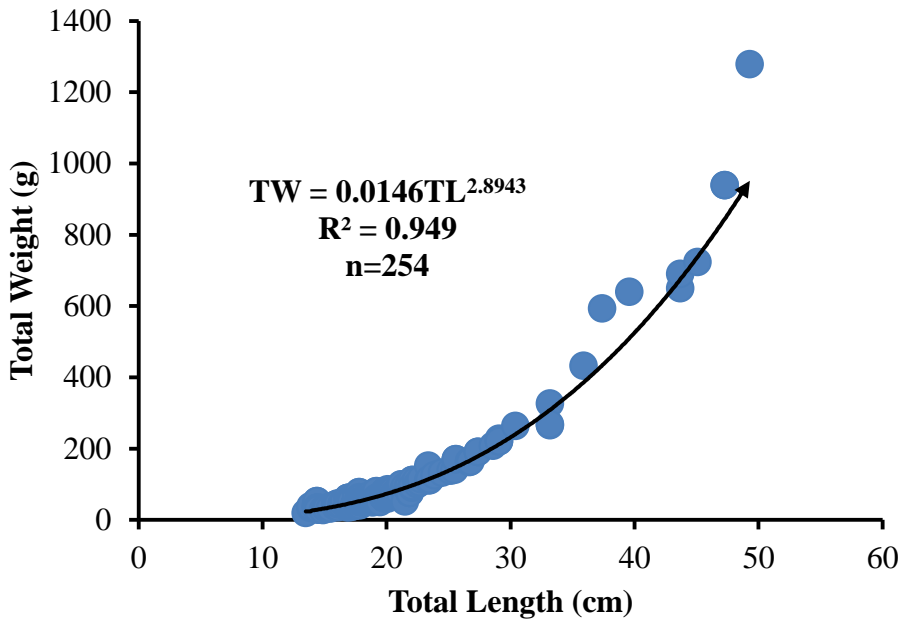


Figure 11. Length weight relationship of female *L. intermedius* in Beles River

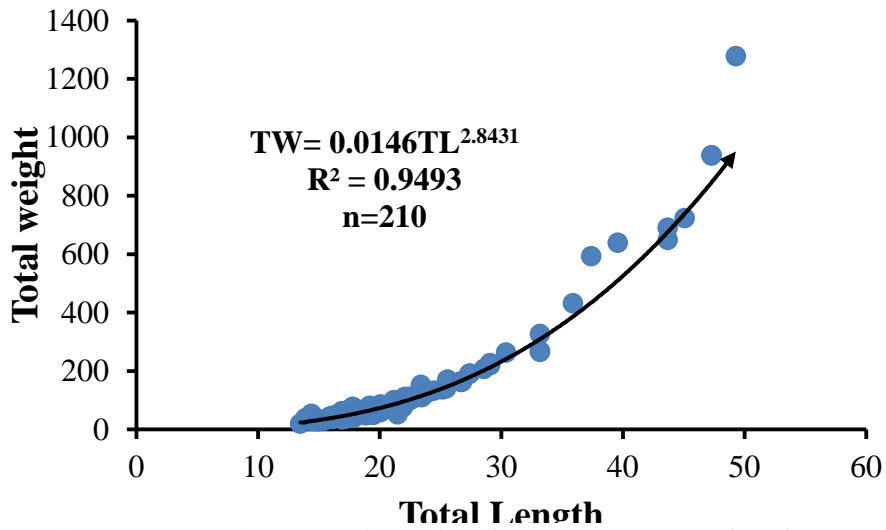


Figure 12. Length weight relationship of male *L. intermedius* from Beles River

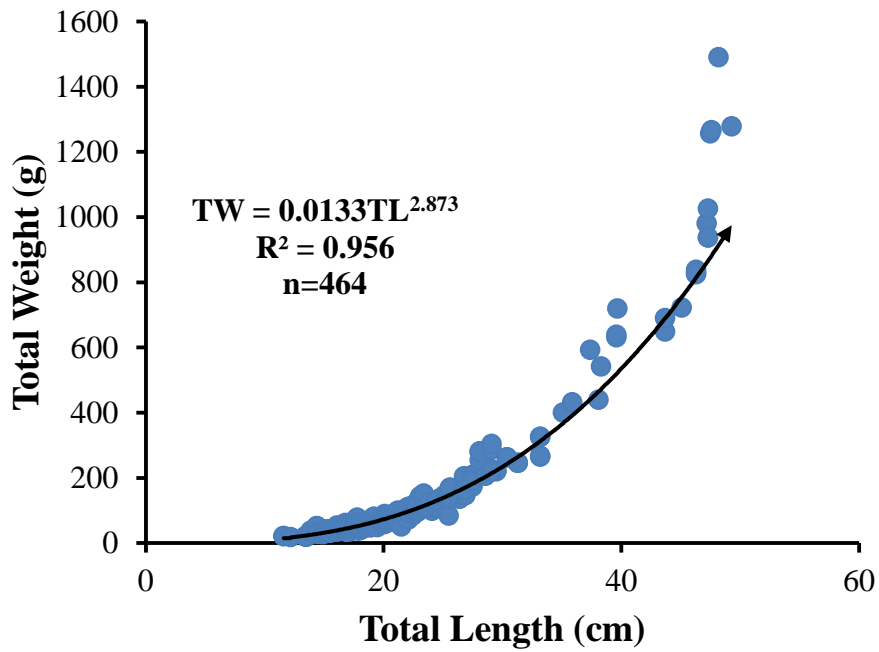


Figure 13. Length weight relationship of both sexes of *L. intermedius* in Beles River

### Length-length relationships

The total length (TL) with both fork length (FL) and standard length (SL) relationships was highly significant, with correlation shows that as strongly correlated, the value of  $R^2$  was very high. Also, there was no significant variation between sexes and months (ANOVA  $p > 0.05$ ); therefore, an equation combined for both sexes was fitted and shown in Figures 14 and 15.

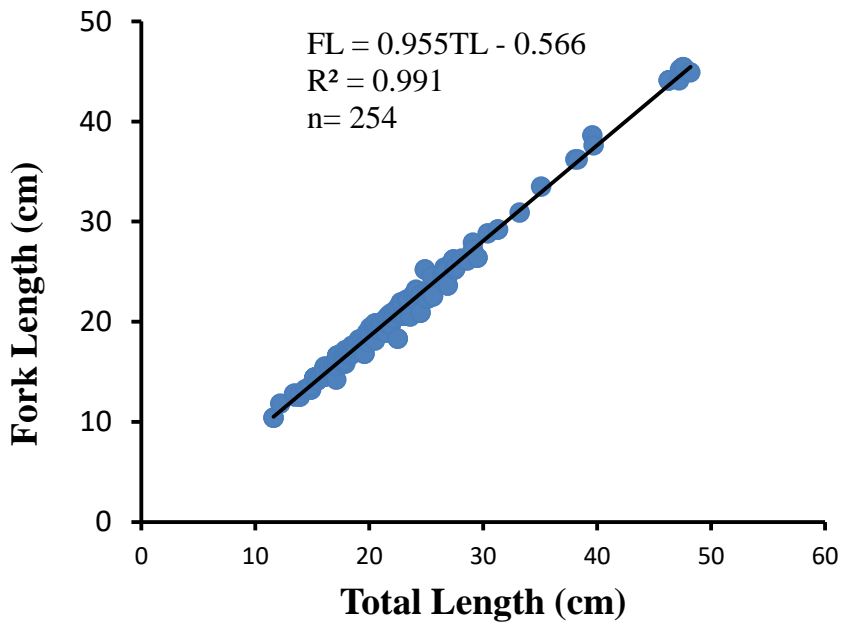


Figure 14. Total length and Fork length relationship of *L. intermedius* in Beles River

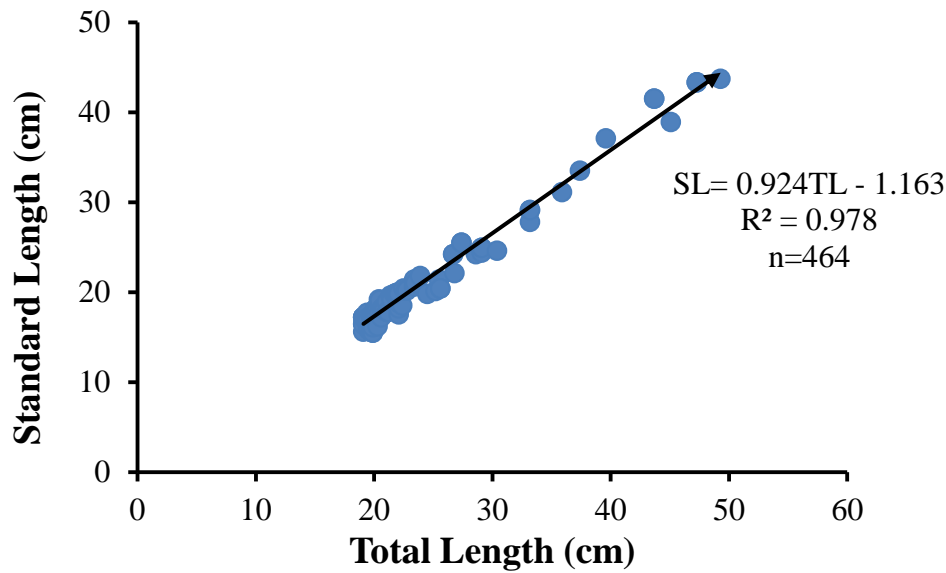


Figure 15. Relationship between TL and SL of *L. intermedius* in Beles River

## 5. DISCUSSION

### 5.1. Reproductive biology

The study conducted in Beles River found that there were more females than males in the population, which was statistically significant ( $\chi^2$  4.2\*  $p < 0.01$ ). This means that there is a difference in mortality rates between the two sexes in the same population. In line with the present study, various authors reported that there were mostly numerous females over males in studies like Shewit Gebremedhin *et al.* (2012) in the Arno-Garno River and Genanaw Tesfaye (2006) in the Angereb and Sanja Rivers. Moreover, sex ratio deference, especially the preponderance of male over female, was also reported by Gizachew Teshome *et al.* (2015) in some tributary rivers of Lake Tana. Agumassie Tesfahun (2018), also reported male preponderance over females in Lake Koka. This study also attempted to examine if there was a difference in sex ratio based on size class and different months, but no significant differences were observed between months and also between sizes except for two size classes of 20 to 24.9 cm and 25 to 29.9 cm TL.

On the other hand, in contrary to present study; for instance, Tadlo Awoke *et al.* (2015) in some tributary rivers of Lake Tana reported that the sex ratio was not significantly deference to the ideal (1:1) sex ratio. Furthermore, various authors have also reported that the variation was not statistically significant in the sex ratio of the species from different water bodies, including Shewit Gebremedhin *et al.* (2014) and Simagne Melaku *et al.* (2017).

This difference might be obtained by different biotic and abiotic factors, especially those related to the biology of the fish and due to the vulnerability of the fishing gears between males and females (Shewit Gebremedhin *et al.*, 2012). Overall, this study suggests that preference for different environments and recruitment success for different sexes may play a role in the observed differences in sex ratio.

The findings of this study indicated that the length at which 50% of individuals reach sexual maturity ( $L_{m50}$ ) in Beles River was 28.8 cm TL for males and 26.4 cm TL for females. On average, females reached sexual maturity at a smaller size than males in the Beles River, suggesting that they expend more energy for egg development at early age. These findings contradicted with the report of Agumassie Tesfahun (2018), which stated that males reach sexual maturity at a smaller size and younger age than females. This discrepancy may be attributed to the higher energy requirements for egg development in females compared to sperm production in males (Shewit Gebremedhin, 2011).

In agreement with the present study, various authors reported the size at first maturity of *L. intermedius* in different water bodies and reported that  $L_{m50}$  for both sexes ranged from 21.4 cm to 34.4 cm TL, with females attaining sexual maturity at a smaller size than males. For instance, Dereje Tewabe (2014), Agumassie Tesfahun and Mathewos Temesgen (2017), Mathewos Temesgen *et al.* (2018), and Feven Zerihun (2020) are all reported  $L_m 50$  of the spp. within a the above given range .

The length at first maturity for female's fish in this study was higher than that reported in Lake Tana (22.6 cm) by Wassie Anteneh *et al.* (2007). Similarly, the length at first maturity for male *L. intermedius* in this study (28.8 cm TL) was higher than the reported length (25.4 cm) by Shewit Gebremedhin *et al.* (2012). This variation may be attributed to differences in environmental conditions and the recruitment success of the fish in addition to the genetics of the stock.

Unlike other studies, *L. intemedius* in Beles River breeds in both dry and wet months of the sampling period, with higher intensive breeding in the dry month of February and less intensive and declining breeding from May towards the wet month of the sampling period. The result of the present study was in agreement with the report of Feven Zerihun (2020), where the intensive breeding season of *L. intermedius* in Lake Hawassa occurred during the dry months of October for

males and January for females. In contrast to the present study, other authors reported that *L. intermedius* breeds intensively in wet months (Shewit Gebremedhin *et al.*, 2012, Dagne Mequanent *et al.*, 2014, Dereje Tewabe, 2014, , Gizachew Teshome *et al.*, 2015, Agumassie Tesfahun and Mathewos Temesgen, 2017, Mathewos Temesgen *et al.*, 2018).

The peak spawning month of *L. intermedius* in Beles River was during the dry months of February and March. There was no breeding activity during the month of April, but less intensive breeding activity occurred in the months of May and July. This might be due to the availability of high-quality insects, zooplanktons, detritus, and phytoplankton in the dry months around the river. The gonad development and rate of fish growth were also affected by both biotic and abiotic factors. Factors like fishing rate, grazing, temperature, chemicals, oxygen concentration, availability and quality of food, and may affect the periodicity of the breeding of the fish in a water body (Zdanowski *et al.*, 2001; Shewit Gebremedhin *et al.*, 2012).

High GSI values coincided with the peak breeding time (February 2023 and May to July 2023) of *L. intermedius* in Beles River. The smallest GSI value was recorded in the month of April, which was a non-breeding month for the fish in Beles River and high GSI was recorded in the month of May which was the time of wet and non-intensive breeding period. In agreement with the present study most of the studies conducted in various water bodies, reported that wet months were the time were of high GSI values were recorded (Shewit Gebremedhin *et al.*, 2012; Dagne Mequanent *et al.*, 2014; Dereje Tewabe, 2014; Agumassie Tesfahun and Mathewos Temesgen, 2017; Agumassie Tesfahun ,2018; Mathewos Temesgen *et al.*, 2018;). Additionally, Shewit Gebremedhin *et al.* (2014) in the Arno-Garno tributary river of Lake Tana, where 86.4% of the total catch had ripe gonads and consequently high GSI values from August to October were recorded. In addition Shewit Gebremedhin *et al.* (2013) found out that 64% of the total catch had ripe gonads from August to November (rainy months) in Infuranza River of lake Tana.

Unlike the above studies Feven Zerihun (2020) stated that a high GSI value for *L. intermedius* was recorded in the dry month in Lake Hawassa. This difference in high breeding activity and higher values of GSI could probably be due to variation in environmental and other biological factors that affect the breeding periodicity of the species in different water bodies. Due to the short period of sampling months it was difficult to generalize the pattern of GSI.

The result of the fecundity obtained from the present study for *L. intermedius* ranged from 1,392 to 207,477 eggs per fish, with a mean fecundity of 76,359 eggs per fish. This finding was incomparable with the results reported for the same species in different lakes and rivers like in Gelda and Gumara Rivers (1,265 to 13,289 eggs Per fish) (Alekseyev *et al.*, 1996), (Genanaw Tesfaye, 2006) in Angereb and Sanja Rivers (27,094 to 120,314); Gilg Beles and Beles River (1,535 to 13,864 eggs.per fish) (Zelege Berie, 2007), Shewit Gebremedhin *et al.* (2013) from Infranz River (1,122 to 24,506); Dagneu Mequanent *et al.* (2014) from Gilgel Abay River and its Tributaries (12,57 to 15,579) Tadlo Awoke *et al.* (2015) in the Blue Nile (1,345 to 7,235 eggs Per fish,).

In contrast to, reports of other studies findings of this study indicated that fecundity of *L. intermedius* in Beles River was very high. This is due to the difference in the environment, vulnerability to mortality, or the genetic difference of the same species of different stock from different water bodies. According to Lake Fisheries Development Project (LFDP) (1997) fishing mortality increases, the reproduction rate in order to compensate for the loss of the stock. Moreover Paterna *et al.* (2002) reported that fast growth, early maturity, and high fecundity are characteristics of an unstable environment. So, as the present study's finding the environment might be unstable or the stock has good genetic makeup.

Based on the findings of this study, the fecundity of *L. intermedius* from the Beles River was strongly and positively correlated with its ovary weight (OW), total length (TL), fork length (FL), standard length (SL), and body weight. In agreement with the present study, the other authors

reported that the relationship between Fecundity with OW, GW, TL, TW, FL, and SL has a strong relationship, as reported in Gelda and Gumara Rivers (Alekseyev *et al.*, 1996); in Beles and Gilgel Beles Rivers (Zelege Berie, 2007); at the head waters of the Blue Nile River (Mohammed Omer, 2010); Borkena and Mille Rivers (Assefa Tessema *et al.*, 2012); in Arno-Garno River Shewit (Gebremedhin *et al.*, 2014), and Gilgel Abay River and its Tributaries (Dagne Mequanent *et al.*, 2014). This finding indicates high reproductive potential of the species in Beles River.

## **5.2. Food and feeding habits**

Detritus, phytoplankton, macrophytes, insects, gastropods, and zooplankton were significant food items based on the gut content of the current study, with an order of importance ranging from higher to less important. In line with the present study, Elias Dadebo *et al.* (2013) reported that *L. intermedius* feeds mainly on detritus, phytoplankton, macrophytes, and insects, which are highly important food items in Lake Koka. Moreover, other authors reported, comparable to the present study, that the main food items of *L. intermedius* constituted macrophytes, detritus, and aquatic insects in Lake Koka (Kassahun Assaminew, 2005).

Similarly, in Lake Tana, the diet of *L. intermedius* was dominated by benthic prey organisms, especially insect larvae and detritus (Sibbing, 1998; De Graaf, 2003). Moreover, Filipos Engdaw (2014) reported balanced ingestion of both plant and animal origins of food. The documentation of Kassahun Assaminew (2005) and Elias Dadebo *et al.* (2013) showed nearly similar findings to the present study, however the present study revealed fewer food categories in contrast to the above two authors. This difference could be due to the difference in the size classes of fish sampled in the two studies and the short period of sampling in the present study.

However, in contrary to the present investigation, the findings of Demeke Admassu and Elias Dadebo (1997); and Feven Zerihun (2020) showed that the primary dietary sources of *L.*

*intermedius* were animal origins and detritus, with less importance given to macrophytes, phytoplankton, zooplankton, and ostracods. These findings also indicated that the fish tended to be piscivorous above 30 cm TL. Furthermore, Nagelkerke (1997); Zerihun Desta *et al.* (2006), and Mulugeta Wakijira (2013), showed that the fish had piscivorey feeding habits and extensively feed on ostracods, zooplankton, mollusks, aquatic insects, fish, and algae, which indicated comparatively different food items from the present studies. Nagelkerke (1997) noted that in Lake Tana, Ethiopia, five out of eight big barbs were found to be specialized on fish, and the nature of piscivory is due to the abundance of *Barbus humilis* in the littoral region and *Barbus tanapelagius* in the pelagic area. Moreover, Zerihun Desta *et al.* (2006) reported in Lake Hawassa that the *L. intermedius* was piscivore and mainly depended on the small barb *Barbus paludinosus* due to their abundance in the littoral zone and the absence of other fish specialized in piscivorous feeding habit.

The high occurrence and volumetric contribution of detritus in the guts of *L. intermedius* in the present study showed the significant contribution of this food item to their nutrition. Detritus was considered low in nutritional value (Bagenal and Braum, 1978; Bowen, 1979). Several studies in lotic and lentic water systems have considered that increased consumption of detritus is a prime response to a decline of higher-value primary food resources (Bowen, 1979; King *et al.*, 2003). So, the present study showed a decline in the availability of food in Beles River because detritus was the main food item of the fish sampled.

In this study we attempted to determine the difference in the diet of the fish examined between the dry and the wet sampling months. There was no noTable difference between the type of food items and their volumetric contribution between the dry and wet months difference. On the other hand Demeke Admassu and Elias Dadebo (1997) reported a defined seasonal variation where the contributions of insects, macrophytes, fish, and gastropods were found to be high during the dry season and insects contributed the bulk of the diet during the wet season.

Elias Dadebo *et al.* (2013) also showed a highly significant difference in the diet of *L. intermedius* in Lake Koka between wet and dry months. The above author showed that the volumetric contributions of detritus (34.0%) and insects (32.5%) were high during the dry period, whereas during the wet month, macrophytes (66.1%) and detritus (24.0%) constituted the bulk of the diet. In Gilgel Gibe Reservoir, Mulugeta Wakijira (2013) reported that, the contributions of aquatic insects, detritus, and zooplankton to be high during the dry season, whereas the contributions of macrophytes were high during the wet season in the diet of *L. intermedius*.

There was a noTable ontogenetic dietary shift in the diet of *L. intermedius* in Beles River. The change observed was that, length groups of less than 25 cm TL showed that insects (28.5%), gastropods (26.8%), and zooplankton (19.9%), were highly important food items identified in their total diet, whereas for the length range of 25–34.9 cm, insects (16.1%), gastropods (13.7%), zooplankton (15.1%) phytoplankton (18.2%), macrophytes (16.25%) and detritus (20.65%) contributed more or less equal volume of the fish diet. For the length group greater than 35 cm, detritus (23.1%), phytoplankton (23.5%), macrophytes (30.1%) were highly important food items the species. As the finding of this study the species preferred food items in relation to their size of mouth and ability of the fish to digest food items.

In contrast to the present study, Zerihun Desta *et al.* (2006) reported slight variation, which was not significantly visible, in diets of different length classes of the same species within all habitats of Lake Hawassa. The slight variation observed by Zerihun Desta *et al.* (2006) was that the importance of insects, fish eggs, and ostracods was higher in smaller length classes (<15 cm TL), while the importance of gastropods, fish, and detritus increased with the size of fish (>25 cm TL). Moreover, Feven Zerihun (2020) reported a slight variation in food items in relation to the size of the fish in Lake Hawassa. According to Feven Zerihun (2020), a higher portion of insects were consumed by length groups <25 cm TL and a higher proportion of gastropods and macrophytes were consumed by length classes >25 cm TL.

In agreement with the present study, Demeke Admassu and Elias Dadebo (1997) reported defined ontogenetic variation in the diet of *L. intermedius* from Lake Hawassa. According to these authors, smaller fish (<25 cm TL) fed mainly on insects and gastropods, while intermediate fish (25–32 cm TL) fed on insects, fish, gastropods, and macrophytes more or less in equal proportions. Larger fish (>32 cm TL) were exclusively piscivores, mainly feeding on *O. niloticus*. Moreover, Elias Dadebo *et al.* (2013) reported a visible ontogenetic dietary shift in Lake Koka where in fish less than 20 cm TL, feed on detritus and insects constituted more than 75% of the total bulk of food, whereas fish greater than 20 cm TL tended to feed more on macrophytes and detritus, and the contribution of these two food categories comprised more than 75% of the total volume of food. The main contributing factor was that the importance of insects declined with size while the importance of macrophytes increased with the size of fish (Elias Dadebo *et al.*, 2013).

### **5.3. Fulton's condition factor**

The Fulton condition factor (FCF) recorded in the present study ranged from 0.38 to 1.004 with a mean value of 0.83 for combined sex and a 95 percent confidence interval. The FCF of the present studies has no significant variation between sexes and has a significant difference between sampling months, also suggesting a similar seasonal fluctuation pattern in the condition factor (growth pattern) of both male and females and a different growth pattern for each sampling month. The mean FCF was nearly the same as the condition factor reported by Demeke Admassu and Elias Dadebo (1997) in Lake Hawassa, which was found to be 0.89 and 0.98 with a 99 percent confidence interval.

The mean result of Fulton's condition factor obtained in this study was less than the findings reported in Angereb River (1.14), Genanaw Tesfaye (2006); in Beles and Gelgel Beles (1.1, 1.05), Zeleke Berie (2007); in Aveya River (1.22), Shewit Gebremedhin *et al.* (2012); in Arno-Garno River (1.3), Shewit Gebremedhin *et al.* (2014); in Aveya River (1.18), Shewit Gebremedhin and

Minwyelet Mengist, (2014); in Lake Ziway (1.73), Lemma Abera (2016); in Geba and Sor Rivers (1.21) Simagne Melaku *et al.* (2017) and in Lake Langano (1.33), Mathewos Temesgen *et al.* (2018); This indicates that *L. intermedius* from the Beles River has poor body condition as compared to the above authors from different water bodies.

On the other hand, the mean FCF of this study was better compared to the reports of Shewit Gebremedhin *et al.* (2013) (0.13) and Filipos Engdaw (2014) (0.14) in contributory rivers of Lake Tana. The differences in body condition obtained might be due to differences in environmental conditions, availability and quality of food, feeding rate, and the water level fluctuation. Since both biological and environmental factors affect the FCF of the fish (Nehemia *et al.*, 2012), the body condition becomes low in unfavorable environmental conditions. So the species in Beles River is assumed to be in unfavorable environmental condition like alkalinity, acidity, lack of quality food because of its lower FCF.

The FCF of the species from the Beles River showed a difference between dry and wet sampling months. The mean Fulton's condition factor of *L. intermedius* was higher in wet months than dry months. In line with this study, previous studies reported the same pattern in the Angereb and Sanja Rivers (Genanaw Tesfaye, 2006); the Gelgel Gibe reservoir (Mulugeta Wakjira, 2013); the Aveya River (Shewit Gebremedhin and Minwyelet Mengist, 2014). Additionally FCF in Beles River has significant variation between months which is in agreement with other studies in other water bodies ( Zeleke Berie, 2007; Shewit Gebremedhin *et al.*, 2013, 2014; Gizachew Teshome *et al.*, 2015;).

Unlike the present study, the mean Fulton condition factor of this species was greater in dry season (1.1) than wet season (0.9) in Lake Koka (Elias Dadebo *et al.*, 2013). Similar seasonality of condition factor was observed in Arno-Garno River (Shewit Gebremedhin *et al.*, 2012). The values were higher in dry season (1.39) than wet season (1.28) in Arno-Garno River. Since environmental

conditions affect FCF, the present finding suggests that there was a difference in environmental conditions between the sampling months *i.e.* there might be variation in food quality, feeding rate, and level of water fluctuation.

Also, the FCF recorded for *L. intermedius* in this study did not indicate a significant variation among the sexes, which was in agreement with the finding of Agumassie Tesfahun. (2018) in Lake Koka, Tadlo Awoke *et al.* (2015) in Nile River, and Zeleke Berie (2007) in Gilgel Beles and Beles Rivers. As the finding this study there was no body condition difference between sex, this could be due to the small number of mature females in the sampling month.

#### **5.4. Length weight relationship**

Various studies were conducted on length-weight relationships to predict average weight of fish for a given length and reported cubic growth pattern (Gulland, 1983; Pauly, 1987; Wotton, 1995). The length-weight regression coefficients for males ( $b = 2.84$ ) and females ( $b = 2.89$ ) in this study indicated nearly curve-linear relationship with slight negative allometric growth pattern. In agreement with the present study, *L. intermedius* caught from Gelgel Gibe reservoir and Geba and Sor River showed negative allometric growth ( $b=2.87$ ), as reported by Mulugeta Wakjira (2013), and Simagnew Melaku *et al.*, 2017, respectively. Additionally, positive allometric growth was found in Gelgel Beles and Beles Rivers, Koka reservoir populations, and some tributaries of the White Nile, as indicated by Zeleke Berie (2007), and Mathewos Temesgen *et al.* (2018), respectively.

However, there were also studies that reported different growth patterns in relation to the present study such as as Dereje Tewabe, 2008 (in Gendewuha, Guang, and Shinfa); Assefa Tessema *et al.*, 2012 (in Borkena and Mille River) Shewit Gebremedhin *et al.*, 2014 (Arnogarno River), Tadlo

Awoke *et al.*, 2015 (in Blue Nile River), Gizachew Teshome *et al.*, 2015 (in some tributaries rivers of Lake Tana); all these studies reported isometric growth patterns.

These contrasting findings suggest that the growth patterns of *L. intermedius* may vary depending on the specific location and environmental factors. Specially, variation in biological factors, such as, quality and quantity of food, feeding rate, and spawning period of fish, affect the “*b*” value of fish (Demeke Admassu and Elias Dadebo, 1997). In addition, as Wotton (1995) and Agumassie Tesfahun (2018) reported, the coefficient of LWRs value “*b*” is used as an indicator of food availability and growth pattern, where feeding availability is influenced by spatial and temporal variations of food. Moreover, the variation between habitats and physiological and biological (gonad development) factors of the fish affect fish growth patterns (Zdanowski *et al.*, 2001).

## 6. CONCLUSIONS AND RECOMMENDATIONS

### 6.1. Conclusion

- ❖ Six food items were identified during the period of investigation: phytoplankton, macrophytes, detritus, insects, zooplankton, and gastropods, all of which were important in the diet of *L. intermedius*. But the dominant food items in all size classes were detritus, phytoplankton, and insects, while the remaining food items were low in their contribution.
- ❖ Insects, gastropods, and zooplankton were the dominant food items of juveniles, while detritus, phytoplankton, and macrophytes were the dominant food sources of adults. Foods of plant origin become more important in the diet of the fish as they grew older.
- ❖ During both wet and dry periods, the same food items were used, except for their contribution in frequency and volumetric. Generally, *L. intermedius* was found to be an omnivorous and polyphagous fish by searching for available food in its feeding habits.
- ❖ In general, this study showed that male-to-female sex ratio (1:0.83 and  $\chi^2=4.2^*$ ) of *L. intermedius* in Beles River was significantly different from the ideal (1:1) sex ratio.
- ❖ Size at first maturity of *L. intermedius* was in the same range as other water bodies like Arnogarno River, Megech and Dirma Rivers, Gendewuha, Guang, and Shinfa River, and in Blue Nile River, which was 28.6 and 26.4 for males and females, respectively. In general females matured at a smaller size than males.
- ❖ The breeding months of *L. intermedius* were throughout the sampling period, in both dry and wet months of the sampling time, with intensive breeding in the dry month of February. The patterns of monthly fluctuations in the frequency of the ripe fish and the GSI values were significantly different from one month to the next, and high GSI values were recorded in the wet month of May, but there was no significant variation regarding sex.

- ❖ Fecundity of *L. intermedius* in the Beles River was considerably higher than all other Ethiopian and African water bodies reported.
- ❖ Moreover, this study has shown that the length-weight relationships of *L. intermedius* of in Beles River were curvilinear and has a slight negative allometric growth pattern .

## **6.2. Recommendations**

- ❖ Based on the findings of this study, the following recommendations were forwarded:
- ❖ Since the size variation was narrow and there was a very short period of sampling months in the current study, to obtain better and more accurate result on the reproductive biology and feeding habits, it is recommended to increase the size variation and increase the period of sampling to 12 or more months.
- ❖ *L. intermedius* under 28.6 cm total length should be protected to save the breeding fish from the unwise and traditional fishing gears used by local peoples.
- ❖ There was an overlap between the intensive fishing season and high breeding period (February to March). There should be protection during these months. If the fish are exploited during this time the stock could be negatively affected in the long run.
- ❖ Compared to other studies from Ethiopian and African water bodies, *L. intermedius* in Beles River showed relatively high fecundity rate.
- ❖ The ecological role and life history characteristics of *L. intermedius* from the Beles River ecosystem, could ultimately contribute to the understanding and conservation of this fish in the study area.

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## 8. LIST OF APPENDICES

. oneway GS Sex

Source	Analysis of Variance			F	Prob > F
	SS	df	MS		
Between groups	.937134582	1	.937134582	0.69	0.4056
Within groups	624.924934	462	1.35265137		
Total	625.862069	463	1.35175393		

Bartlett's test for equal variances:  $\chi^2(1) = 0.1394$  Prob> $\chi^2 = 0.709$

. oneway FCF Sex

Source	Analysis of Variance			F	Prob > F
	SS	df	MS		
Between groups	.011403718	1	.011403718	0.47	0.4918
Within groups	11.1320365	462	.024095317		
Total	11.1434403	463	.024067906		

Bartlett's test for equal variances:  $\chi^2(1) = 0.3701$  Prob> $\chi^2 = 0.543$

### Appendix 1 ANOVA value of male and female in relation with GSI and FCF

. oneway FCF Month

Source	Analysis of Variance			F	Prob > F
	SS	df	MS		
Between groups	1.79374277	4	.448435693	6.91	0.0000
Within groups	29.7933441	459	.064909246		
Total	31.5870869	463	.06822265		

Bartlett's test for equal variances:  $\chi^2(4) = 190.1464$  Prob> $\chi^2 = 0.000$

. oneway GSI Month

Source	Analysis of Variance			F	Prob > F
	SS	df	MS		
Between groups	709.168591	4	177.292148	4.15	0.0026
Within groups	19618.5014	459	42.7418331		
Total	20327.67	463	43.9042549		

Bartlett's test for equal variances:  $\chi^2(4) = 435.1967$  Prob> $\chi^2 = 0.000$

### Appendix 2 ANOVA in month with both FCF and GSI

. oneway F TWg

Source	Analysis of Variance			F	Prob > F
	SS	df	MS		
Between groups	1.6417e+11	23	7.1378e+09	1206.86	0.0000
Within groups	29571689.7	5	5914337.93		
Total	1.6420e+11	28	5.8642e+09		

Bartlett's test for equal variances: chi2(3) = 1.5304 Prob>chi2 = 0.675

note: Bartlett's test performed on cells with positive variance:  
20 single-observation cells not used

. oneway F TLcm

Source	Analysis of Variance			F	Prob > F
	SS	df	MS		
Between groups	1.3393e+11	17	7.8785e+09	2.86	0.0403
Within groups	3.0263e+10	11	2.7512e+09		
Total	1.6420e+11	28	5.8642e+09		

Bartlett's test for equal variances: chi2(6) = 23.8144 Prob>chi2 = 0.001

note: Bartlett's test performed on cells with positive variance:  
11 single-observation cells not used

. oneway F GW

Source	Analysis of Variance			F	Prob > F
	SS	df	MS		
Between groups	1.6419e+11	25	6.5678e+09	5509.47	0.0000
Within groups	3576266	3	1192088.67		
Total	1.6420e+11	28	5.8642e+09		

Bartlett's test for equal variances: chi2(1) = 0.3976 Prob>chi2 = 0.528

note: Bartlett's test performed on cells with positive variance:  
23 single-observation cells not used  
1 multiple-observation cells not used

. oneway F OW

Source	Analysis of Variance			F	Prob > F
	SS	df	MS		
Between groups	1.6420e+11	26	6.3153e+09	25362.48	0.0000
Within groups	498002	2	249001		
Total	1.6420e+11	28	5.8642e+09		

Appendix 3 P value using ANOVA for fecundity with TW, TL, GW and OW



**appendix 4 Microscopic view of gut content of *L. intermedius* in Beles River**



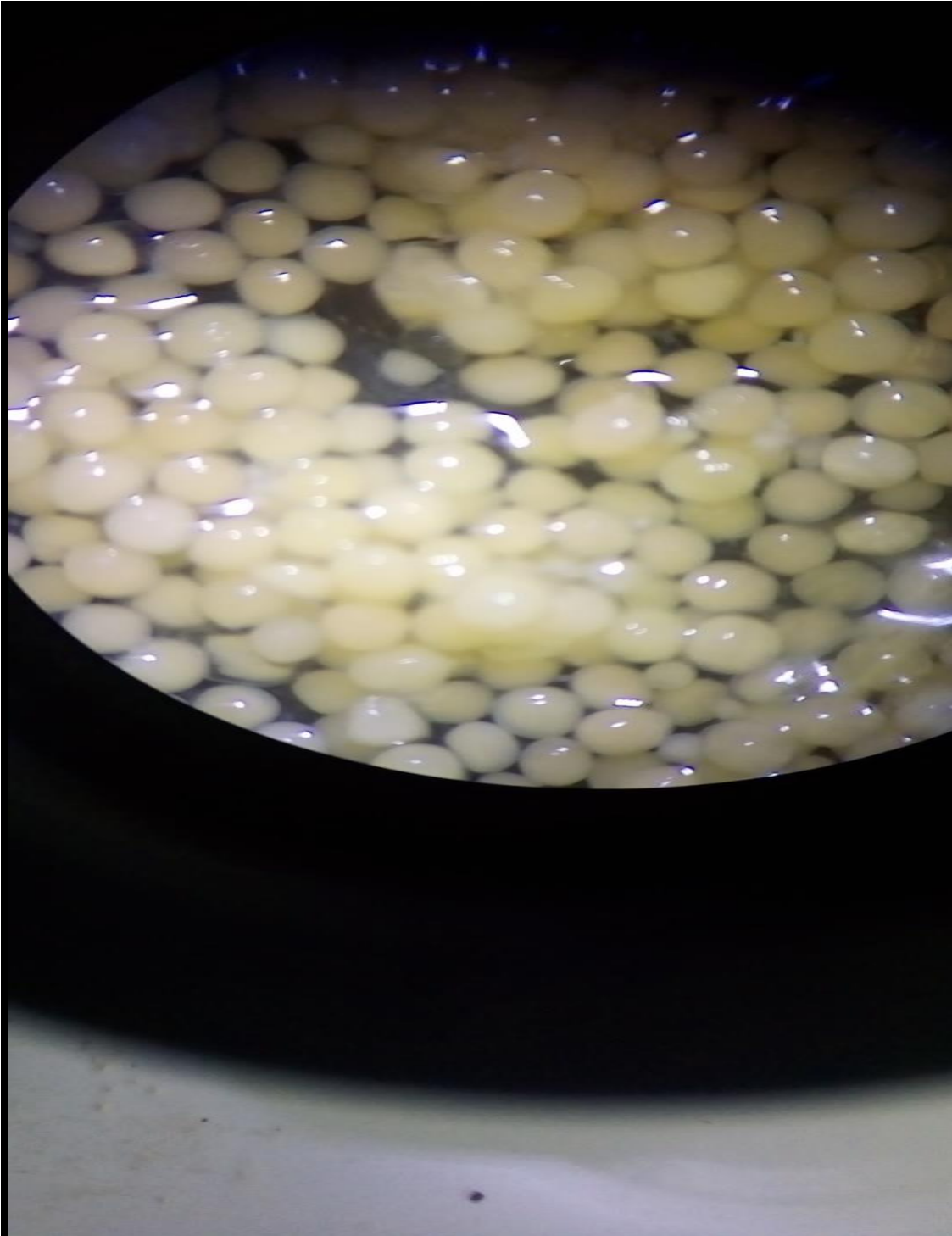
**Appendix 5 View of ripe (IV) ovary of *L. intermedius* in Beles River**



**Appendix 6 View of ripe (IV) male gonad of *L. intermedius* in Beles River**



**Appendix 7 Counting of eggs of *L. intermedius* in Beles River using microscope from Hawassa university laboratory**



**Appendix 8 Microscopic view of eggs of *L. intermedius* in Beles River**