REPRODUCTIVE BIOLOGY AND FEEDINDG HABITS OF THE NILE TILAPIA *OREOCHROMIS NILOTICUS* (L. 1758) (PISCES: CICHLIDAE) IN DAMTE DAM, WOLAITA ZONE SOUTHERN ETHIOPIA

OREOCHROMIS NILOTICUS

MASTERS OF SCIENCE (MSc.) THESIS

BY ERMIAS SHIRKO BIRBIRE

HAWASSA UNIVERSITY, HAWASSA, ETHIOPIA

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THESIS SUBMITTED TO THE DEPARTMENT OF AQUATIC SCIENCES, FISHERIES AND AQUACULTURE (ASFA) HAWASSA UNIVERSITY, COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES, SCHOOL OF GRADUATE STUDIES,

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SPECIALIZATION: AQUACULTURE AND FISHERY MANAGEMENT

ADVISOR: PROFESSOR ELIAS DADEBO

HAWASSA, ETHIOPIA

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DEPARTMENT OF AQUATIC SCIENCES, FISHERIES AND AQUACULTURE (ASFA)

ADVISORS APRPROVAL SHEET

This is to certify that the thesis entitled "**Reproductive biology and feeding habits of the Nile tilapia *Oreochromis niloticus* (L. 1758) (Pisces: Cichlidae) in Damte Dam, Wolaita Zone Southern Ethiopia",** submitted in partial fulfillment of the requirements for the degree of Masters of Science with specialization in **Aquaculture and Fishery Management in the Department of Aquatic Sciences, Fisheries and Aquaculture (ASFA),** was carried out by **Ermias Shirko Birbire ID No.: GpAqR/0003/15**, under my supervision. Therefore, I declare 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).

Advisor

Professor Elias Dadebo	Signature	Date
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We, the undersigned, members of the Board of Examiners of the thesis open defense by **Ermias Shirko Birbire** have read and evaluated his thesis entitled "**Reproductive biology and feeding habits of the Nile tilapia *Oreochromis niloticus* (L. 1758) (Pisces: Cichlidae) in Damte** Dam**, Wolaita Zone Southern 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 Masters of Science in **Aquaculture and Fishery Management** (AFM).

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BIOGRAPHICAL SKETCH

I was born in Shakisho Shone Kebele, Damot Gale District, and Wolaita Zone of Southern Ethiopia Regional State on June 4, 1999. I attended my primary education at Wolaita Zone Damot Gale District Buge Kebele Primary and Hadiya Zone Shone Town Number 2 Elementary School. I also attended my secondary education at Shone Lech-Gogo and Shone General and Preparatory School. After completing my preparatory education, I joined Werabe University, Ethiopia, College of Natural and Computational Sciences, Department of Biology, since January 2018 and graduated in January, 2021. After my graduation, I was employed in Wolaita Sodo University in September, 2021 and served as graduate assistance for one year. Then, I joined the School of Graduate Studies of Hawassa University since October 2022 to pursue my MSc. Degree in Aquatic Sciences, Fisheries and Aquaculture Department in the field of Aquaculture and Fishery Management in a regular program, using the opportunity given by the Ministry of Education. Then, after I completed my research work in October 2024, I am now ready to defend my work.

DECLARATION

This declaration attests to the fact that this research work is entirely original with me adhering to all technical and ethical scholarly guidelines throughout the selection, data collection, and analysis phases. The thesis was written and submitted to Hawassa University as a partial fulfillment of the requirements for a MSc. in Aquaculture and Fisheries Management. The relevant acknowledgements and references have been used to properly credit all academic sources that were used in this thesis. In accordance with the policies and procedures of the University Library, copies of this thesis will be placed in Hawassa University Library and made accessible to end users and borrowers. I additionally declare that I have not submitted this thesis anywhere else to any other university.

Name **Ermias Shirko Birbire**

Signature…………………………………………………………….

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ACRONYMS/ABBREVIATIONS

GSI	Gonado Somatic Index
GW	Gonad weight
Ka	Allometric Condition Factor
LFDP	Lake Fisheries Development Project
L_{m50}	Length at First Maturity
LWR	Length Weight Relationship
MATHLAB	Mathematical Laboratory
ACF	Allometric Condition Factor
SL	Standard Length
TL	Total Length
TW	Total Weight
SRS	Southern Regional State
OW	Ovary Weight

ABSTRACT

Reproduction, feeding and condition factor of *O. niloticus* were investigated in Damte Dam based on the samples collected from February, 2024 to September, 2024. A total of 584 fish samples were caught ranging from 10 cm to 33.9 cm TL and 32 g to 750 g TW for males and 9.7 cm to 33.9 cm TL and 32.1 g to 421 g TW for females. The aim of this study was to investigate reproduction and feeding habits of *O. niloticus* in Damte Dam, Ethiopia. The overall male to female sex ratio was significantly different from 1:1 (χ^2=4.281, $p<0.05$). L_{m50} for males and females were 14.7 cm TL and 13.9 TL cm, respectively. GSI values ranged from 0.26 to 1.59 for males and 0.25 to 1.8 for females. The fish bred throughout the sampling period with intensive breeding months in May, June and July. The length weight relationship was found to be curvilinear ($TW = 0.0105TL^{3.1988}$). ACF value of male was minimum values of 0.40 to maximum value of 2.99 with a mean of 0.933 ± 0.013 and females *O. niloticus* ACF was ranged from 0.75 to 2.77 with mean value of 1.39 ± 0.016. Detritus (94.61%, 34.53%), macrophytes (88.41%, 29.59%), phytoplankton (85.18%, 31.36%), insects (18.33%, 2.61%) and zooplankton (11.59%, 1.90%) were using frequency of occurrence and volumetric analyses respectively. In general, ACF and ripe gonad were inversely proportional, and compared to other studies. The fecundity of *O. niloticus* in Damte Dam was relatively low. There was no observable variation in the food items between dry and wet months, but notable ontogenetic variation was seen in the diet. *O. niloticus* under 15 cm TL should be protected to save the breeding fish from the risky fishing of locals. The study emphasizes the importance of raising public awareness about the value of using fisheries resources to improve local communities' living standards and research on Damte Dam conservation.

Key words: Damte Dam, Feeding habits, *O. niloticus*, Reproductive biology

1. INTRODUCTION

1.1 Background of the Study

Inland fisheries contribute significantly to the world wide fisheries, being a means of livelihoods for millions of people, predominantly in less-developed countries with limited income alternatives (Million Tesfaye *et al.*, 2021). Ethiopia is endowed with a number of lakes and rivers, which are believed to be promising potentials of different fish stocks. It has numerous water bodies including ponds, lakes, rivers, reservoirs and wetlands. The inland water bodies of Ethiopia are estimated to encompass about 13,637 km^2 of lake area which is about 1.2% of total land surface and total river length of about 8,065 km. These water bodies harbor more than 200 fish species (Gashaw Tesfaye and Wolf, 2014). The Nile tilapia (*Oreochromis niloticus* (Linnaeus 1758) is the widespread commercially preferable fish species in Ethiopia (Agumassie Tesfahun and Sale Alebachew, 2023). It covers about 50% of the total catch in Ethiopian water bodies (Gashaw Tesfaye & Wolff, 2014). Fishery resources definitely can offer one of the solutions to the problem of food shortage in a country like Ethiopia. Moreover, *O. niloticus* is the most preferred fish species in Ethiopia for human consumption and the demand has increased rapidly over the last decade (Lemma Abera, 2013).

Descriptions of reproductive strategies and the assessment of fecundity of *O. niloticus* are fundamental topics in the study of the biology and population dynamics and also for evaluation of the reproductive potential of the fish species. This will increase our knowledge about the state of a stock and improves standard assessments of many commercially valuable fish species (Tsegaye Teame, *et al.*, 2018). According to Mathewos Temegen *et al.* (2018), life history parameters, such as length at sexual maturity (L_{m50}), sex ratio, fecundity and spawning time considerably vary between fish species.

Fish require nutrients for growth, reproduction and other normal physiological functions. In a natural aquatic environment, phytoplankton, zooplankton, plant materials, insects, insects' larvae, worms and other food items are the major food types of fish. Moreover fish tend to show a preference for particular food items within their environment (Mathewos Temesgen *et al.*, 2022). The availability of food in any aquatic environment determines the well-being and reproductive potential of fish. The weight and size of fish are a reflection of food availability in the aquatic ecosystem. Many environmental factors such as water temperature, food availability, stocking density and environmental conditions influence the food selection behavior of fish. Fish's size, age, and food items can also affect how they choose what to eat (Mathiwos Temesgen *et al.,* 2022). Fish feeds on food items that fit in their mouth relative to the size of their stomachs. As fish gain weight or length, their stomachs also grow larger and their digestive systems become more developed (Agumassie Tesfahun and Sale Alebachew., 2023). In natural water bodies, however, the absolute rate of food consumed rises while the feeding rate in relation to body weight falls. The main food sources for *O. niloticus* are plankton (including phytoplankton and zooplankton), macrophytes, aquatic insects and their larvae and pupae, nematodes (round and flatworms), and sediment (Mathewos Temesgen *et al.,* 2022). *O. niloticus's* food and eating habits have been examined by a number of authors in relation to seasonal variations and size variations in Ethiopian water bodies (Workiye Worie and Abebe Getahun, 2015; Abebe Tesfaye *et al*., 2020; Genanaw Tesfaye *et al.*, 2021; Solomon Wagaw *et al.*, 2022; Agumassaie Tesfahun and Sale Alebachew, 2023).

Even though various authors have studied the reproductive biology, feeding habits and morphometric relation of fish species in inland water bodies of Ethiopia, no scientific study has been conducted in Damte Dam, which was built for the purpose of providing irrigation water and also for fish production. The local fishermen in this area employ ineffective fishing practices, utilizing traditional fishing gear that selectively captures young and reproductively immature fish. This indicates lack of awareness and appropriate technology use within the community. Therefore, this area-specific study is essential to understand the biology of the fish stock for future management and sustainable utilization.

1.2 Objectives of the study

1.2.1 General objective

- To assess the reproductive biology and feeding habits of *O. niloticus* in Damte Dam

1.2.3 Specific objectives

- To determine the sex ratio and size at first maturity of *O. niloticus*
- To describe the breeding season and gonado somatic index of *O. niloticus*
- To determine morphometric relationships of *O. niloticus*, such as the length- weight relationships, length- length relationships and Allometric Condition Factor.

- To investigate diet composition, ontogenetic dietary shifts and seasonal feeding behavior.

1.3 Research questions

The following questions were addressed by this study:

- Do the (*O. niloticus*) at Damte Dam have a different sex ratio than 1:1? At what size does 50% of male and female *O. niloticus* begin to breed?
- At which months of the season do *O. niloticus* possess higher proportion of ripe gonads in Damte Dam? Does the Gonado Somatic Index (GSI) correlate with the breeding season? How much fertility does a female's ripe gonad hold, too?
- Do *O. niloticus* in Damte Dam have a relationship between their length- weight, as well as their length- length? Which sexes of *O. niloticus* has better condition factor in Damte Dam?
- What food items do *O. niloticus* eat in Damte Dam? Does *O. niloticus* exhibit dietary variation among its size classes at Damte Dam? Does the *O. niloticus* at Damte Dam have seasonal feeding variation?

1.4 Statement of the problem

According to Goraw Goshu *et al.* (2010), Ethiopia adopted a sustainable fish resource utilization policy in 2004 and since that time the illegal fishing pressure has decreased but still there are destructive fishing activities and a general lack of awareness on the policy. Fish production is faced with different challenges, including depletion of production among wild fish and in aquaculture due to lack of available food and water quality, and some illegal fishermen's employment in the rainy season. Although Damte Dam was constructed for the purpose of irrigation and fishery activities, the Dam was exposed to different challenges. In Damte Dam, the majority of the fish caught were below their expected maturity size due to illegal fishing gear by illegal fishermen. This problem is the major and urgent problem that should be solved. Other problems include introducing of pollutants such as waste materials and sewage from the nearby town of Shone, as well as the accumulation of fertilizers in Damte Dam from sloppy agricultural land.

The reservoir was threatened by a number of factors, including catchment degradation, encroachment, siltation, and the local gear used by the fishermen to selectively capture young fish that are not reproductively mature (Zuriash Seid, 2016). Information on the reproductive biology and feeding habitats of *O. niloticus* in Damte reservoir was absent. As the stock in the reservoir was virgin for study, there is a need to study the reproductive biology and feeding habit of *O. niloticus*. Therefore, the present study is believed to contribute to filling this research gap.

1.5. Significance of the study

The results of the current study contribute to the understanding of *O. niloticus's* reproductive biology and feeding habits in Damte Dam. By identifying the fish's breeding period; it is possible to protect the fish from faulty fishing. The size at maturity can be used to calculate the mesh size needed for fishing.

Scientific studies on fish food and feeding habits have made possible the trophic relationships found in aquatic ecosystems, the structure, composition, and stability of food webs, as well as the effective management of capture fisheries and aquaculture (Agumassie Tesfahun and Sale Alebachew, 2023). According to Mohammed and Uraguchi (2013) *O. niloticus* is the most important fish species in tropical and subtropical freshwaters. It is often the basis for commercial fisheries in a number of African countries. Its exceptional resistance to environmental stressors and ability to consume both prepared and natural feeds make it economically viable (Adeyemi, 2009).

The study's conclusions would provide essential information that the management and exploitation of the *O. niloticus* fishery can utilize to properly manage the stock in Damte Dam . The study was produced the needed data that could be utilized in later research because it provides the baseline information for future studies.

1.6 Scope of the study

O. niloticus that was gathered from Damte reservoir between February 2024 and September 2024 was the subject of this study. The reproductive biology and feeding habits of *O. niloticus* as well as morphometric relationships from Damte Dam was covered in this study. Reproductive biology includes: sex-ratio, Gonado Somatic Index, length at first maturity, breeding months, fecundity. Feeding habits includes: diet composition, ontogenetic dietary shift and monthly variation and morphometric relationships includes length- weight relation and length- length relation of *O. niloticus* in addition to condition factor of the species in Damte Dam with in eight sampling months.

1.7 Limitation of the study

- Due to the limited study period of eight months, the findings regarding reproductive seasonality and feeding habits may not fully capture the seasonal variations, which could vary significantly across a full year.
- The non-random nature of fish sampling, relying on local fishermen's catches, could introduce biases in terms of fish size and species composition, limiting the generalizability of the findings. An important aspect of fish biology such as age and growth, stock density, the fish mortality rate was not studied.
- The absence of detailed Limnological data on the physico-chemical parameters of the Damte Dam water could limit the understanding of how water quality and environmental factors influence reproductive cycles and feeding behaviors. Perfect Dam's surface area, mean depth, max depth and related studies were not studied.

2 LITERATURE REVIEW

2.1 Reproductive biology

2.1.1 Sex ratio

O. niloticus can be easily identified by their secondary sexual characteristics. The anal fin a male has two openings right in front of it. The urogenital pore is the smaller opening at the tip, and the large opening is the anus. The genital pore, the anus, and the urinary pore are the three openings on the female. According to Tsegay Teame *et al.* (2018), study from the total of 1,826 *O. niloticus* examined in Tekeze Reservoir; 845 (46.28%) of them were males and 981 (53.72%) were females. According to chi-square analysis, the overall sex ratio was 1:1.16 (males to females), with significant deviations from one ($\chi2 = 10.13$; $p<0.05$). According to Lemma Abera (2013) the number of male and female *O. niloticus* captured during each sampling event was recorded in Lake Baseka. The monthly sex-ratio (male: female) was then computed, yielding a total sample of 793: 273 (1:0.34).

According to Abarike and Ampofo (2016) 155 fish were sampled from the Golinga reservoir in Ghana, out of which 42 were males and 73 were females (1:1.7) with a significant variation from the hypothetical 1:1 ratio. Matsuyama *et al.* (1988) discovered that the female-to-male ratio imbalance in red sea bream is most likely caused by a variety of biological mechanisms, such as distinct rates of migration, mortality, and maturity for the male and female sexes. As reported by Buchale Shishitu *et al.* (2021), from Lake Chamo, a total of 1,245 *O. niloticus* fish samples were collected, 277 (22.25%) were males while 968 (77.75%) were females, over the year, there were more females. The theoretical 1:1 sex ratio is significantly different from the actual 1:3.49 (male: female) sex ratio ($\chi2= 393.0$; $p < 0.05$).

2.1.2 Size at first maturity

Length at first maturity is often defined as the average length at which 50% of the fish became mature. It is also referred to as L_{m50} (Willoughby and Tweddle, 1978). Mehanna (2007) verified in Egypt and the Southeastern Mediterranean; determining the ideal mesh size heavily depends on the length at first maturity (L_{m50}). According to Lemma Abera (2013) in Lake Baseka, the smallest sexually mature fish that was caught a female fish of 6 cm TL and a male fish of 7 cm TL. The (L_{m50}) was calculated using the information from the maturity stages. It was estimated that the 50% maturity length (L_{m50}) for females was 14 cm TL and for males it was 17 cm TL. It seemed that females reached sexual maturity at a smaller size on average than males. The smallest sexually mature male in Tekeze Reservoir, northern Ethiopia, measured 14 cm TL, while the smallest female measured was 12.5 cm TL. Tsegay Teame *et al*. (2018), also found that male *O. niloticus* reached 50% sexual maturity (L_{m50}) at 15 cm TL, while females reached at 14 cm TL.

2.1.3 Breeding season

Fish breeding is the act of producing young ones from parent brood fish. This ensures species continuity and survival. *O. niloticus* bred throughout the year, but its intensity of breading season is varying. According to Tsegay Teame *et al*. (2018) *O. niloticus* individuals with ripe gonads were caught all year long in the Tekeze Reservoir in northern Ethiopia. Nonetheless, there were significant monthly variations in the frequency of both ripe male and female. The main breeding season of *O. niloticus* in Tekeze Reservoir, however, was brought about by the main rainy season, which increases the availability of food (plankton), and the minor breeding period of the fish in the reservoir may be linked to the high temperature and solar radiation. The main breeding season, of took place between July and September, followed by a minor one between January and March. Demeke Admassu (1996) found that while fish were caught in Lake Hawassa almost every month at different stages of gonad development and spawning, breeding fish were more common twice a year, with a main peak occurring from January to March and a secondary one occurring from July to September. Tessema Assefa *et al.* (2020), found that in Lake Hayq when the water temperature is high and there is rainfall, both male and female *O. niloticus* reached full maturity between February and April. In April, mature fish accounted for over half of all fish caught. Only three months (February to April) were recorded for fully matured *O. niloticus.*

2.1.4 Fecundity

Fecundity, along with fertility, is a related concept that is fundamental to both theoretical and applied population biology. Fecundity is the physiological maximum potential reproductive output of an individual (usually female) over its lifetime. As stated by Bradshaw and Mahon (2008) it is the individual's current (actual) reproductive performance. As such, a measure of fertility is fecundity. Many researches on the fecundity of *O. niloticus* fish have been conducted in Ethiopia and around the world. These include (Bradshaw and Mahon, 2008; Lemma Abera, 2013; Tessema Assefa *et al.,* 2020; Tadlo Awoke *et al*., 2015; Mathewos Temesgen *et al.,* 2018 Tsegaye Teame *et al.,* 2018; Tamirat Handago *et al.*, 2024).

2.1.5 Gonado Somatic Index (GSI)

The gonad weight expressed as a percentage of a somatic body weight is called the Gonado Somatic Index (GSI), also called the maturity coefficient. It is employed to evaluate gonad maturation and determine the state of reproduction at that moment. According to Bargenal and Braum (1978) suggestion, it is used to identify the stocks' spawning season. One crucial measure of an organism's overall health is the GSI. Reproductive capacity is estimated or measured using it. The most crucial phase of a species' life cycle, reproduction decides whether the species will survive and thrive. Fish nutritional and energy condition changes can be accurately detected by the GSI. For every fish, the GSI was also calculated. The GSI was calculated as:

$$GSI = GW/TW \times 100 \quad (1)$$

Where, GSI = Gonado somatic index

GW = Gonad weight in g

TW = Total weight in g, where mass of the gonad is the mass of the fresh gonad, blotted on absorbing paper. Several studies were conducted on *O. niloticus* fish regarding the GSI. Some of them are: Mathewos Temesgen *et al*., 2018; Tsegay Teame *et al.*, 2018).

2.2 Food and feeding habits

Fish primarily consume food that fits in their mouths and that their stomachs can process, as stated by Otieno *et al*. (2014), Fish need nutrients for normal physiological processes like growth and reproduction. Fish primarily eat phytoplankton, zooplankton, plant materials, insects, fish larvae, worms and smaller fish in their natural aquatic habitats (Wakil *et al*., 2014). Shalloof and Khalifa (2009) state that research on the diets and feeding behaviors of freshwater fish species is ongoing. This is due to the fact that it provides the framework for the creation of an effective fish capture and culture management program. Additionally, research on fish feeding behavior naturally allows for the identification of trophic relationships found in aquatic ecosystems, as well as the composition, structure, and stability of food webs within the ecosystem (Otieno *et al*., 2014). For this reason, knowledge of food and feeding habits is essential to successful culture of fish in a controlled setting (Shalloof and Khalifa, 2009). *O. niloticus* is known for its adaptable feeding habits, which are defined by their opportunistic and generalist omnivorous feeding styles (Canonico *et al*., 2005). The diet composition of this species can fluctuate depending on the seasonal and spatial conditions of its surroundings (Houlihan *et al.*, 2001). The food composition can also change based on the fish's size, maturity, habitat type, and environmental conditions (Kamal *et al.* 2010).

Numerous authors have reported the seasonal variation of food types and their proportion in the diet of *O. niloticus*, as demonstrated in the study conducted in Ethiopian water bodies. In every study, phytoplankton were the most significant food consumed during the dry season in most inland water bodies of Ethiopia (Agumassie Tesfahun and Mathewos Temesgen, 2018; Mathiwos Temesgen, 2017; Mulgeta Wakjira, 2016).

Water turbidity affects phytoplankton growth and abundance by reducing sunlight penetration. The high levels of flooding from the catchment area were linked to the low proportion of phytoplankton during the wet season. This can lead to fluctuations in water levels and an increase in turbidity (Paaijmans *et al.*, 2008). According to reports from the dry season in most of the rift valley lakes, including (Lake Langeno, Mathiwos Temesgen, 2017; Lake Chamo, Teferi Yirgaw *et al.,* 2000; Lake Hayq, Workiye Worie and Abebe Getahun, 2015) of the Ethiopian high land, microcystis and diatoms were the most prevalent phytoplankton that *O. niloticus* consumed. Some of the authors that were examined the diet and feeding patterns of *O. niloticus* in Ethiopian water bodies (Mathewos Temesgen, 2017; Mulgeta Wakjira, 2016; Tsegaye Teame *et al.,* 2018). They have all noted that the food that *O. niloticus* eats varies according to the type of environment that they inhabit.

2.2.1 Seasonal variation in diet composition

Low water levels have poor resources in trophic dynamics, whereas high water levels are considered resource rich (Balcombe *et al.*, 2014). Due to the seasonal variations food availability is dynamic throughout the year in the tropics, and fish feeding habits also vary according to the season (Ballesteros *et al.*, 2009). Seasonal variations in the diet composition of *O. niloticus* in Ethiopian water bodies have been documented by various authors. In Lake Langeno, Mathewos Temesgen *et al.* (2022), found that during the dry season (January to May); ***O.*** *niloticus* stomachs phytoplankton contributed the bulk of the diet.

In the wet season of heavy flooding from the catchment area, which can alter the water level and increase turbidity, the proportion of phytoplankton in the water was comparatively low. Turbidity affects the growth and abundance of phytoplankton by reducing the amount of sunlight that reaches the water. The outcome demonstrates how the diet composition of *O. niloticus* in Lake Shala varied with the seasons (Solomon Wagaw *et al.*, 2022). The most significant food source in both the wet and dry seasons was phytoplankton. Yet, during the dry months, phytoplankton demonstrated a significant variation in *O. niloticus's* dietary contribution in Lake Langeno (Mathewos Temesgen *et al.,* 2022).

The findings of Mathewos Temesgen *et al. (*2022), from Lake Langeno, Phytoplankton was found in 94.7% of the stomachs during the dry season, accounting for 84.9% of the total volume of food. But in the rainy season, its share of the total volume dropped to 60.3%. This was due to low level of solar radiation penetrating in the water and high turbidity of the water in the wet season. Additionally, zooplankton revealed a seasonal variation in *O. niloticus's* diet composition, which was particularly noticeable during the rainy season in Lake Langeno. During the wet season, zooplankton were found in 21.4% of the food's total volume and 54.3% of the stomach contents (Mathewos Temesgen *et al.,* 2022). However, during the dry season, their volume decreased to 27.3%, making up 10.3% of the total volume of food items. Fish scales, detritus, nematodes, and insects (chironomids) all showed notable seasonal variations in *O. niloticus's* diet (Mathewos Temesgen *et al.,* 2022).

Additionally, Workiyie Worie and Abebe Getahun (2015) demonstrated that, Daphnia was consumed extensively during both the dry and wet seasons. On other hand, Merismopedia, Melosira, and Keratella were consumed in greater quantities during the dry season (January-February) but less so during the wet season (August-October) in Lake Hayq. Phytoplankton was the predominant food source, and during the dry season the significance of diatoms as a group increased (workiyie Worie and Abebe Getahun, 2015).

2.2.2 Ontogenetic dietary shifts

The majority of fish species alter the make-up of their diets as they mature. This is due to change of fish's size. Animals frequently experience ontogenetic dietary shift, which is defined as changes in diet utilization that take place over the course of an individual consumer's lifetime (Sanchez-Hernandez *et al*., 2018). Therefore, comprehending this dietary shift is crucial to studying important ideas in trophic theory and modeling as well as to improving our understanding of the biological and ecological processes that operate at the individual, population, and community levels (Genanaw Tesfaye *et al.,* 2021).

Fish size and weight indicate the availability of food in the aquatic ecosystem (Bolarinwa and Popoola, 2015). According to Wakil *et al.* (2014) fish primarily eat things that fit in their mouths and can be digested by their stomachs. Fish's digestive systems develop and their stomachs get longer as they get bigger. Nonetheless, the absolute rate of food consumed rises while the feeding rate in relation to body weight falls. According to Mathewos Temesgen *et al*. (2022) of the 512 fish that were assessed in Lake Langeno, 5.8% (n = 30) had TL less than 10 cm, 25.7% (n = 131) had TL between 10 and 15 cm, 22.2% (n = 114) had TL between 15 and 20 cm, 30.1% (n = 154) had TL between 20 and 25 cm, and 16.1% (n = 82) had TL greater than 25 cm. The largest contributions were made by phytoplankton (32.1%), zooplankton (26.2%), and insects (14.3%) for the length group less than 10 cm. However, as the total length rose to 30.5 cm, the contribution of these prey items decreased by 23%, 17%, and 9.4%. The composition of detritus (31.1%), macrophytes (13.2%), and fish parts (3.4%) was extremely high in the stomachs under study for the length group of 20–25 cm TL and above. This implies that as the size of the fish change, its feeding volume also change significantly.

2.3. Allometric Condition Factor (ACF)

Condition factor, conversely, is a measurement of different biological and ecological factors concerning their feeding condition. According to Nehemia *et al*. (2012), the coefficient of body condition expresses the degree of well-being of fish in their habitat. The availability of food in water bodies is affected by changes in water chemistry caused by variations in the surrounding environments and atmosphere (Pothoven *et al*., 2001). There were differences in *O. niloticus* condition factor between the populations in the lakes, rivers, and reservoirs. High energy content, sufficient food availability, the ability to reproduce, and ideal environmental conditions were all associated with higher body condition (Pauker and Rogers, 2004). Some of the values of Fulton's Condition Factors (FCF) are: (Mulgeta Wakjira, 2013 (1.67); Zenebe Tadesse, 1998 (1.94); Mathiwos Temesgen, 2017 (1.77)). Relatively high condition factors were recorded in (Lake Chamo (2.35) Teferi Yirgaw and Demeke Admasu, 2002; River Baro (2.05), Melak Tesfaye, 2009). However, recently in Lake Chamo the water quality has drastically altered due to improper land use practices such as fertilizer use, nutrient loading, agricultural activities that causes poor water quality, it is in turn stress on the fishes' body condition. In the same way, the Ethiopian rift valley lakes such as Ziway, Langeno, Hawassa, Koka and Beseka are under high human pressure like Lake shore farming, destruction of buffer zone, effluent discharges from textile, ceramic and tannery industries drained into water bodies (Gebretsadik Teklu and Kassahun Mereke, 2017).

2.4. Morphometric relationships

2.4.1 Length Weight Relationship (LWR)

According to Lawsen *et al*. (2013), one of the most crucial biological factors in fishery management is the length-weight relationship. The average weight at which a fish can reach a specific length is estimated using this method. The two's relationship also suggests how well the fish are doing (Hamid *et al.*, 2015). According to the study by Tessema Assefa *et al.* (2020), the relationship between *O. niloticus's* total length and weight was curvilinear, and as a result, the regression equation described the line fitted to the data; the *b* values of both males and females differed significantly from 3; the allometric growth of both sexes had a highly correlated length-weight relationship, as evidenced by the R^2 values being very close to one. According to Costa Novaes and Carvalho (2012) the regression coefficient values (b) frequently fluctuate between 2.5 and 3.5.

2.4.2. Length- length relationship

A very little information is available about the length- length relationships of *O. niloticus*. However, Tamirat Handago *et al.* (2024), from Lake Boyo found that the relation between total length and standard length was linear and highly correlated.

3 MATERIALS AND METHODS

3.1 Description of the study area

Damte Dam is located in Damot Gale District which is one of the Zonal administrations in Wolaita Zone, Southern Ethiopia in which the study was conducted with geographical information such as longitude and Latitude (7°7′0″ N and 37°5730″ E) respectively with an elevation of 2,050 meters above sea level. The study area is located South of the capital city of Addis Abeba, which is 346 km as well as North of Boditi town administration, which is 24 km far and South of Shone town administration located at 4.5 km. The Dam was constructed by the Southern Regional State(SRS) Water Irrigation and Mines Development Bureau in collaboration with Federal Government of Ethiopia in 2008 and completed in 2012. Initially the Dam was constructed for the purpose of irrigation and fishing activities; but it serves for the other additional socio- economic purpose like rearing of animals, washing, and house hold utility and for other purpose. The majority of the source of water for the Dam drains from the surrounds of Shone town and nearby kebeles. Total surface area of the Dam was estimated to be about 0.8 km^2. The dry season includes the months from December to May and the wet season includes June to November. In the mid of May, gradually the rain fall increases and the peak rainy season was August (203.1 mm) and, the next peak rainy months were July and September. In the November, the patterns of the rain fall were slightly decreased and show the upcoming of dry season. The highest minimum temperature was observed in the March (14.9 °C) and, the lowest minimum temperature was observed in the August (12.3 °C).

Aquatic biota includes fish species such as *C. garipinius* and *O. niloticus* were as bird like duck and other bird species were available. A portion of farmland and many tiny trees that border the Dam's shoreline become submerged as a result of the wet season, which occurs in July, August, and September. The wetland as a whole floods and the water level rises. In addition, the wetland's west, south, and north farming sections flood. A sizable portion of the marsh dries out and transforms into a sizable expanse of grassland during the peak dry season, which is then utilized by the nearby kebeles of local residents for grazing. The hills and mountains that encircle the dam are known locally known as the "ye ingida terara," or Shone Mountains.

According to Dagnachew Legesse and Tenalem Ayenew (2006) excessive land degradation, deforestation, and irrigation led to significant sedimentation and an increase in soil salinity. Since material from the nearby hills is being carried into the wetland during the rainy season, the issues of soil erosion and siltation have a significant effect on the wetland's continuity.

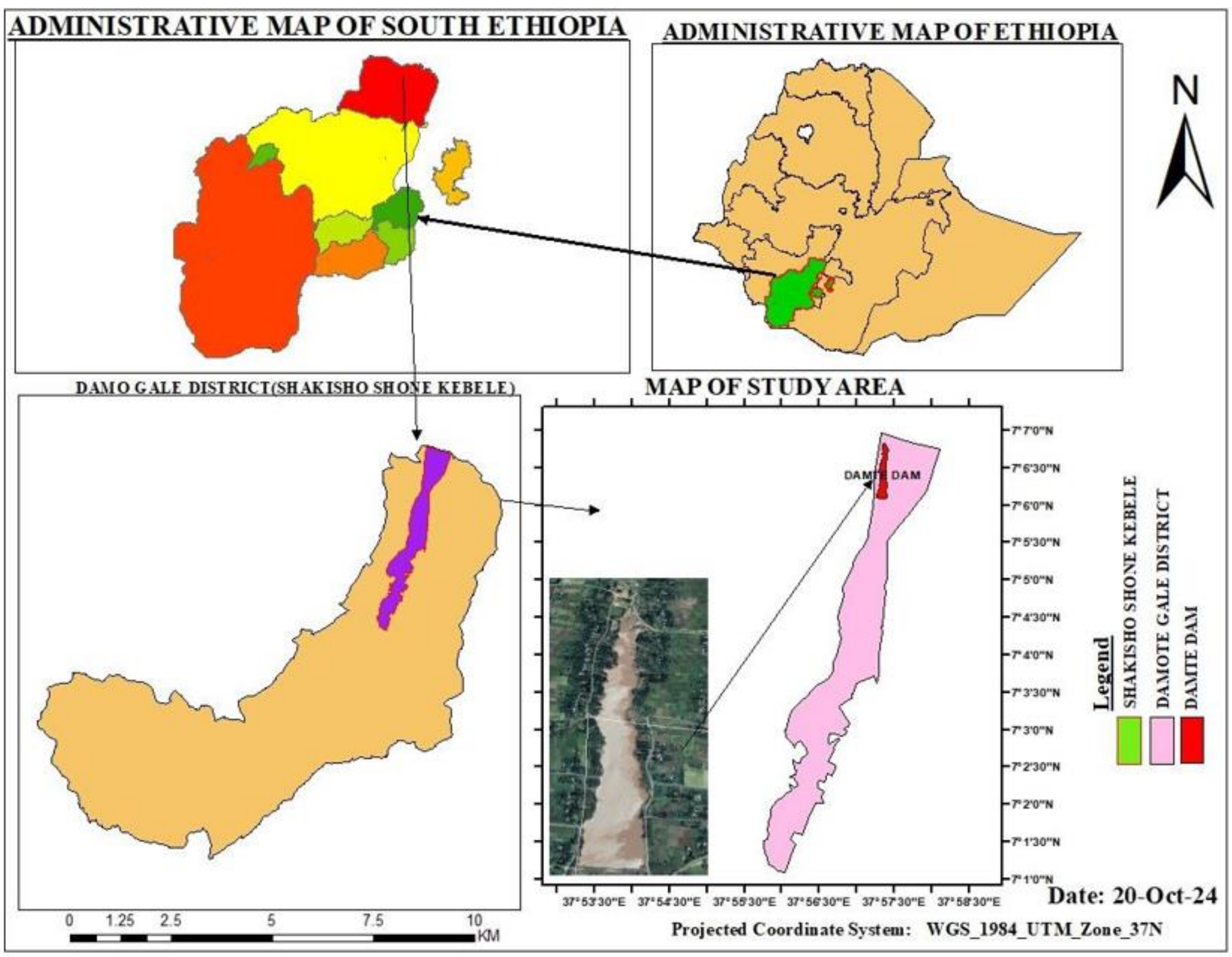


Figure 1: Map of the study area

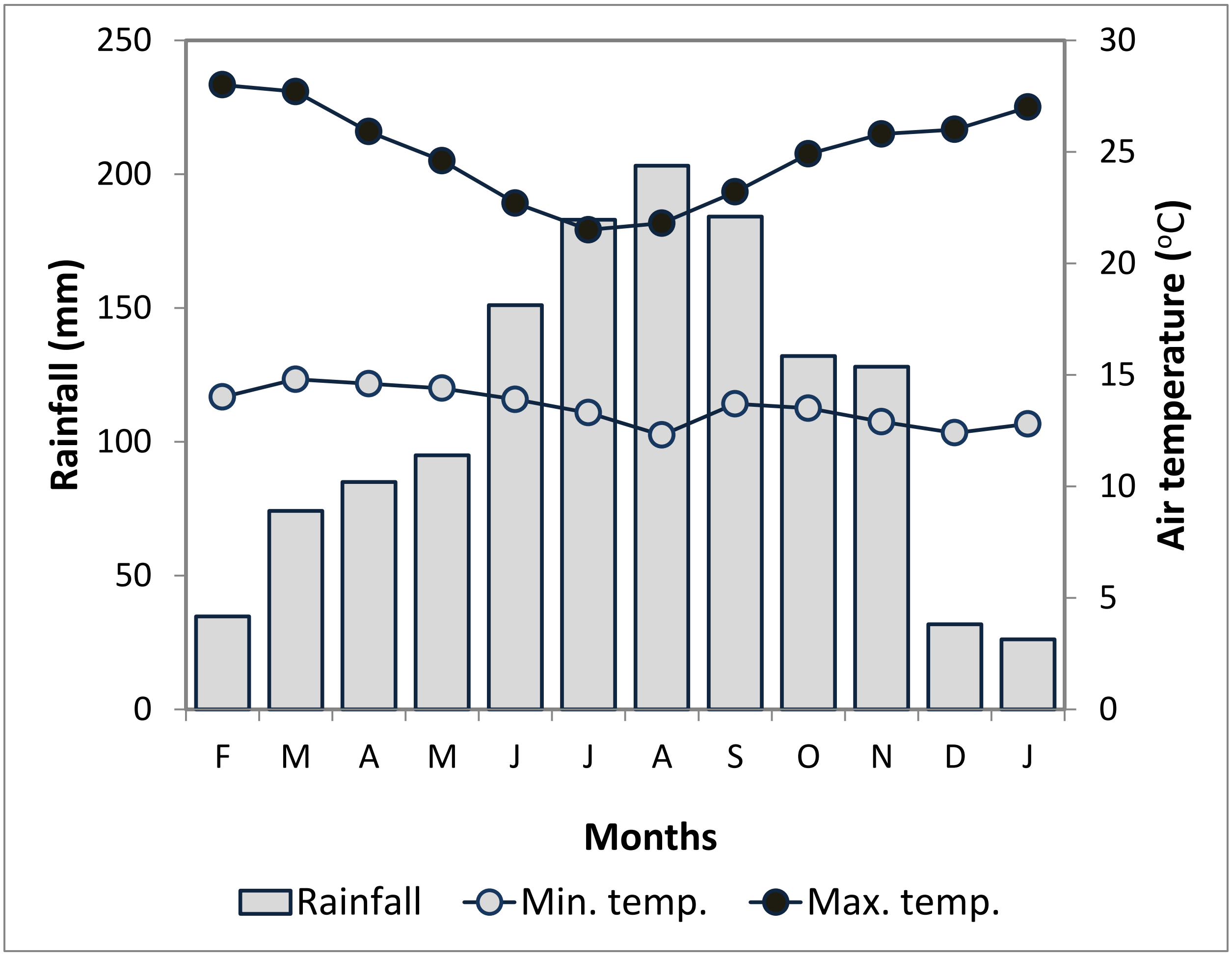


Figure 2: Average rainfall pattern and temperature of the study area

(a)

(b)

Figure 3: Damte Dam (a) Spill way of the Dam (b) (used when the water level rises in the rainy season, water flows over the top of the Dam).

3.2 Data collection and sampling

Fish samples were purchased from the landings of the fishermen using simple random sampling for eight months including four months during the dry season and four months during the rainy season by using beach siene net. For the purpose of fish sampling from the Dam two sites were selected; the upper margin of the water which extends to the Lalo Garbe Kebele and the lower part of the Dam which is base area at the shore. The collected samples were transported to Hawassa University Main Campus Fishery Laboratory. Total length (TL) was measured to the nearest millimeter for both sexes and total weight (TW) was taken to the nearest 1 g. Stomach contents were preserved in 5% formalin solution. Food items were identified using a compound microscope (Leica DME, magnification-100x), a dissecting microscope (Leica, MS5, magnification-10x) and using the identification key as described in the phytoplankton identification manual (Verlencar, 2004).

After dissecting the samples, sex and gonadal maturation were seen with the naked eye to determine maturation stage and the data were recorded. Gonads of each fish were removed and weighed to the nearest 0.01g and their maturity stages were also visually determined and recorded. Then the gonads were persevered in 5% formalin before counting the eggs and estimation of fecundity was carried out.

3.3 Reproductive biology

3.3.1 Sex ratio

The actual number of fish whose sexes were successfully determined was considered for sex ratio. The sex ratio was expressed as the ratio of number of males to females. Sex ratio of the fish species was determined by calculating male to female ratio at different months of the year and at different sizes of the fish dividing the number of female fish by that of male fish (Vazzoler, 1996). The significant deviations from the hypothetical 1:1 ratio were determined using Chi-square test at 5% significance level.

3.3.2 Length at first maturity

The length at first maturity was estimated as the total length classes at which 50% of all the individuals were sexually mature following Njiru, *et al.* (2006), procedures. The fish samples in the maturity stage I and II were considered as non-breeding (immature) and those in stages III, IV and V were considered breeding (mature) for the purpose of calculating L_{m50} (Njiru, *et al.*, 2006). The (L_{m50}) was determined by grouping the ripe stage III, IV and V males and females separately in to 2 cm length class interval. The resulting cumulative frequency was subjected to logistic curve function (the S- shape curve) and the length at which 50% of the individuals fall was determined for both males and females. The (L_{m50}) of both sexes was determined from the percentages of mature fish as described by logistic function (Echeveria, 1987).

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

Where P = estimated proportion of mature fish, L= total length in centimeters, and α and β are coefficients. Equation (1) can be transformed into logarithmic form as indicated below:

$$\mathrm{Ln}\,(1\text{-}P/P) = \alpha - \beta L \qquad (3)$$

From the above linear regression relation, the size at first maturity L_{m50} of both sexes was estimated as $L_{m50} = -\alpha/\beta$.

3.3.3 Breeding season and Gonado-Somatic Index (GSI)

Table 1 Gonad maturity stages of fishes and their descriptions (Adapted from Holden and Raitt, 1974; Nagelkerke, 1997).

Gonad stage	Testes	Ovaries
I	Immature, impossible to distinguish females from males. Gonads are a pair of transparent strings running along the body cavity.	Immature, impossible to distinguish females from males. Gonads are a pair of transparent strings running along the body cavity.
II	Unambiguously male, very small testes, white-reddish, not lobed, tube-shaped strings.	Unambiguously female, very small ovaries, tube-shaped and reddish, eggs not visible (recovery spent or developing virgin).
III	Larger testes, white-reddish, somewhat lobed starting to flatten sideways (Ripening).	Ovary somewhat larger and starting to flatten sideways, eggs visible, but very small (Ripening).

IV	Large testes, white-reddish, lobed, flattened sideways(Ripe).	Large ovary flattened sideways and almost covering body cavity wall, eggs yellowish (Ripe).
V	This stage is marked as spent for *O. niloticus*	*This stage is marked as spent for the other fish species

The breeding season of *O. niloticus* was determined from monthly frequency of fish with ripe gonads. The breeding season was determined by looking at the seasonal variation of the ripe (stage IV) gonads. The sampling was conducted for eight months including four months of the dry season and four months of the wet season. Sampling months of February, March, April and May represent dry season, and June, July August and September were represent the rainy season.

The GSI for each fish was computed as the weight of the gonads as the percentage of total body weight as of Peña-Mendoza *et al.* (2005), :

GSI= GW×100/TW____(4)

Where, GSI = gonado-somatic index, GW = gonad weight (g), TW = total body weight (g), where the weight of the gonad is the weight of the fresh gonad blotted on absorbing paper. GSI was calculated for monthly sampled fish specimens to govern the breeding season of fishes in the lake (Peña-Mendoza *et al.*, 2005). Descriptive statistical procedures (percentages and mean) were used to describe and summarize the data obtained from sex ratio, size at first maturity and fecundity of *O. niloticus* from Damte Dam.

3.3.4 Fecundity

The actual number of mature eggs in the ovaries was counted to determine the fecundity of *O. niloticus* from Damte Dam. Fecundity was estimated from total counts of eggs in the ovaries of fish in the most advanced state of development (Njiru *et al.*, 2006). Ripe ovaries of stage IV were used for the fecundity estimation. Accordingly, total fecundity of *O. niloticus* was determined by counting all the eggs in the ovaries by using the total count method. The relationships between fecundity and some morphometric measurements were determined by relating fecundity to total length (TL) and total weight (TW) and ovary weight (OW), using the following formulae as of

(Crim and Glebe, 1990):

$$F = a \times OW^b \quad (5)$$

$$F = a \times TL^b \quad (6)$$

$$F = a \times TW^b \quad (7)$$

Where *a* and *b* are parameters of the fitted line.

3.4 Food and feeding habits

3.4.1 Stomach content analysis

Stomach content analysis was conducted in the Fishery Laboratory of the Hawassa University, Ethiopia. The contents of the entire guts were taken by dissecting the fish stomach and preserving them in 5% formalin immediately after morphometric measurements were taken. The stomach contents were emptied into petri dish to identify each prey (food) item. Food items were identified using a compound microscope (Leica DME, magnification-100X) and dissecting microscope Lieca, MS5, (magnification 10X). The relative importance of each food item was determined using frequency of occurrence and volumetric analysis methods (Hyslop, 1980; Bowen, 1983).

3.4.2 Frequency of occurrence

In the frequency of occurrence the number of stomach samples containing one or more of a given food item was expressed as a percentage of all non-empty stomachs examined. The proportion of the population that fed on certain food items was estimated by this method. Frequency of occurrence of the different food categories during the dry and wet season were compared using a Chi-square test.

3.4.3 Volumetric analysis

Volume of food items were measured by using by displacing a known volume of liquid graduated cylinders. After measuring the total volume of samples, the samples were continuously shaken to homogenize and transferred to the Petri dish. Three drops of sub-sample were set with a slide. The percent contribution for each prey was identified using a compound microscope (LEICA DME) with a magnification power of 100X. For similarly identified taxa, their averages were considered. Finally, the volumetric contributions of each food item per total volume of the non-empty stomach sample were expressed as percentages (Bowen, 1996).

3.4.4 Ontogenetic dietary shift

Ontogenetic dietary shift of *O. niloticus* from Damte Dam was studied based on the volumetric contribution of each food item within each length group. For studying ontogenetic dietary shift, fish was classified into five size classes: 10-14.9 cm TL, 15-19.9 cm TL, 20-24.9 cm TL, 25-29.9 cm TL and 30-34.9 cm TL. The relative importance of each food item in each size class was estimated by taking the mean percentage volume of each category of food items to the total volume in that size class (Flipos Engdaw, 2014).

3.5. Allometric Condition Factor (Ka)

The wellbeing of *O. niloticus* was determined using Allometric Condition Factor (ACF) from the data of morphometric measurements such as total length and total weight (Bagenal and Tesch, 1978). Allometric Condition Factor (Ka) was calculated as follows:-

$Ka = W/L^b \times 100$, ____ (8)

Where, "W" is the total body weight and "L" is the total length, '*b'* the slop of log transformed line of the length- weight relationship.

3.6 Morphometric relationships

3.6.1 Length- weight relationship

TL and TW were used to calculate length- weight relationship using the following formula:

$TW = aTL^b$ ____ (9)

Where TW is the total weight in g and TL is the total length in cm; *a* and *b* are parameters

3.6.2 length- length relationship

For the seek of comparing the present study with future study and for other biological comparison, length - length relationship of *O. niloticus* from Damte Dam was employed. The relationship between total length (TL), and standard length (SL) was calculated using the following formula:

$TL = a + bSL$ ____ (10)

Where a= intercept and b= slope.

3.7 Statistical analysis and interpretation

The collected data were analyzed, interpreted and were presented in descriptive statistics by using statistically developed software known SPSS software version 27 to know the relation between this quantitative and qualitative data of the sampled fish species as well as another software known as MATLAB (mathematical laboratory software) was employed to show *O. niloticus's* size at first maturity. Also Micro Soft Word Excel 2010 software was employed to save raw data and analyzation of data. ANOVA was employed to the significant level of the data.

When Data analysis was done with the use of SPSS software version 27, Microsoft statistical application package was used to save the data. (Zar,1999). Length- weight relation was done using morphometric relationship analysis. Chi-square test was used to determine male to female sex ratio and to compare frequency of occurrence and t- test for percentage volume of the different food categories during the dry and wet months (Sokal and Rohlf, 1995). The results were presented through tables and graphs with present frequency value of the data. Regression analysis was applied to determine the R^2 in length- weight and length- length relationships.

4. RESULTS

4.1. Reproductive biology

4.1.1. Sex ratio

Out of the 584 fish samples, 317(54.2%) were males whereas the remaining 267 (45.7%) were females. The total male to female sex ratio (1:0.84) was significantly different from the theoretical value of 1:1 (χ^2=4.281, p<0.05) as indicated in Table 4.1. Except February, where males were more numerous than females (χ^2 =18.75, p<0.01), the remaining sampling months were showed slight sex ratio variation. Males were more numerous than females. Furthermore, male to female sex ratios were also given for different size classes of *O. niloticus* in Damte Dam (Table 2). There were no significant variations in the sex ratios of the different size classes except the size class between 12-13.9 TL, 14-15.9 and ≥30.0 cm TL where chi-square values of 8.52, 8.56 and 4.50, respectively were calculated.

Table 1: Sex ratio of *O. niloticus* at different months of the year from Damte Dam

Months	Males	Females	Sex ratio (M: F)	χ^2
F	55	18	1: 0.327	18.753**
M	43	30	1: 0.698	2.315
A	37	36	1: 0.973	0.014
M	31	42	1: 1.355	1.658
J	39	34	1: 0.872	0.342
J	35	38	1: 1.860	0.123
A	37	36	1: 0.973	0.014
S	40	33	1: 0.825	0.671
Total	317	267	1: 0.842	4.281*

* indicates significant difference (p<0.05)

Table 2: Male to female sex ratio of *O. niloticus* at different size classes in Damte Dam

Size class	Males	Females	Sex ratio (M:F)	Chi-square (χ^2)
10.0- 11.9	15	13	1: 0.867	0.143
12.0- 13.9	60	32	1: 0.533	8.521*
14.0- 15.9	67	37	1: 0.552	8.564*
16.0- 17.9	46	56	1: 1.217	0.980
18.0- 19.9	55	64	1: 1.164	0.681
20.0- 21.9	39	32	1: 0.821	0.690
22.0- 23.9	21	26	1: 1.238	0.532
24.0- 25.9	4	4	1: 1.000	0
26.0- 27.9	2	1	1: 0.500	0.333
28.0- 29.9	1	1	1: 1.000	0
≥30.0	7	1	1: 0.143	4.5*
Total	317	267	1: 0.842	4.281*

* indicates significant difference ($p<0.05$)

4.1.2. Length at first maturity

The length at first maturity (L_{m50}) of *O. niloticus* was 14.7 cm TL for males and 13.9 cm TL for females (Fig. 2). The smallest male with ripe gonads was 11.7 cm TL with TW of 24.5 g whereas the smallest female caught with ripe gonads was found to be 10.2 cm TL and 17. 2 g TW.

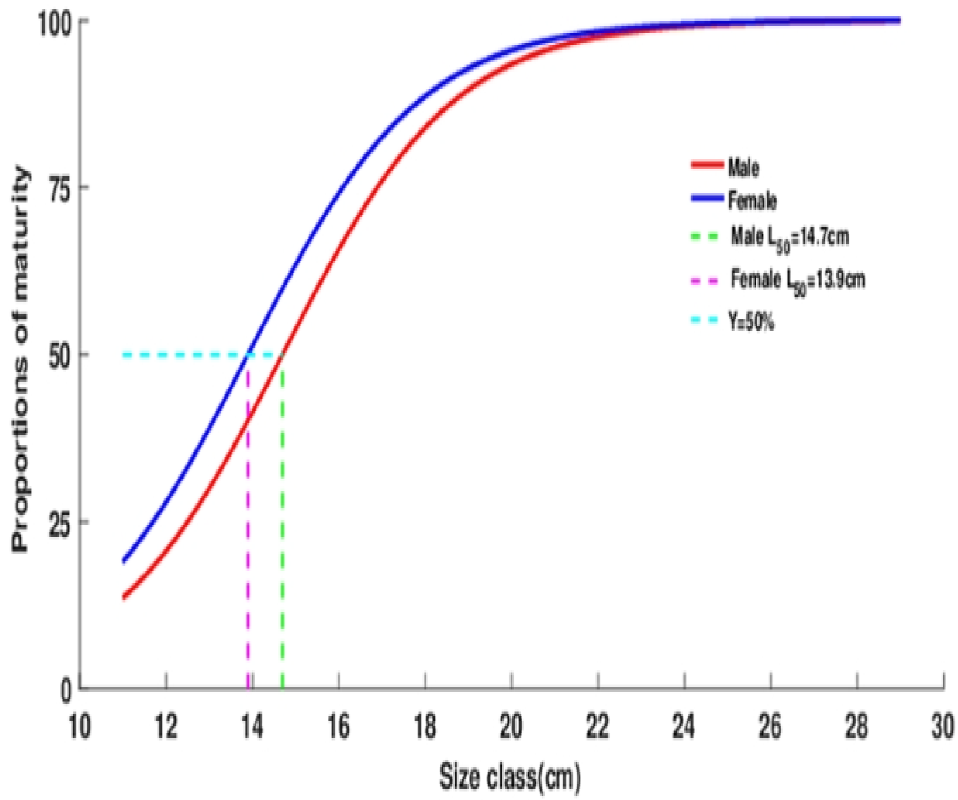


Figure 4: Length at first maturity of *O. niloticus* in Damte Dam

4.1.3. Breeding season

O. niloticus from Damte Dam reproduced throughout the whole sampling months from February to September. The high intensity of breeding months for both sexes was May, June and July. But the peak breeding month for male fish was May. The proportion of males with ripe gonads ranged from 5.45 % to 56.25% and females with ripe gonads ranged from 10.34 % to 38.24 % (Fig. 3.). The lowest breeding months for males and females were February and March where the fish had 5.45% and 10.34% ripe gonads, respectively. The peak breeding month for males was May (56.25%) and June (38.24 %) for females. The next intensive breeding month for both sexes was July, 45.71 % and 36.84 %, respectively.

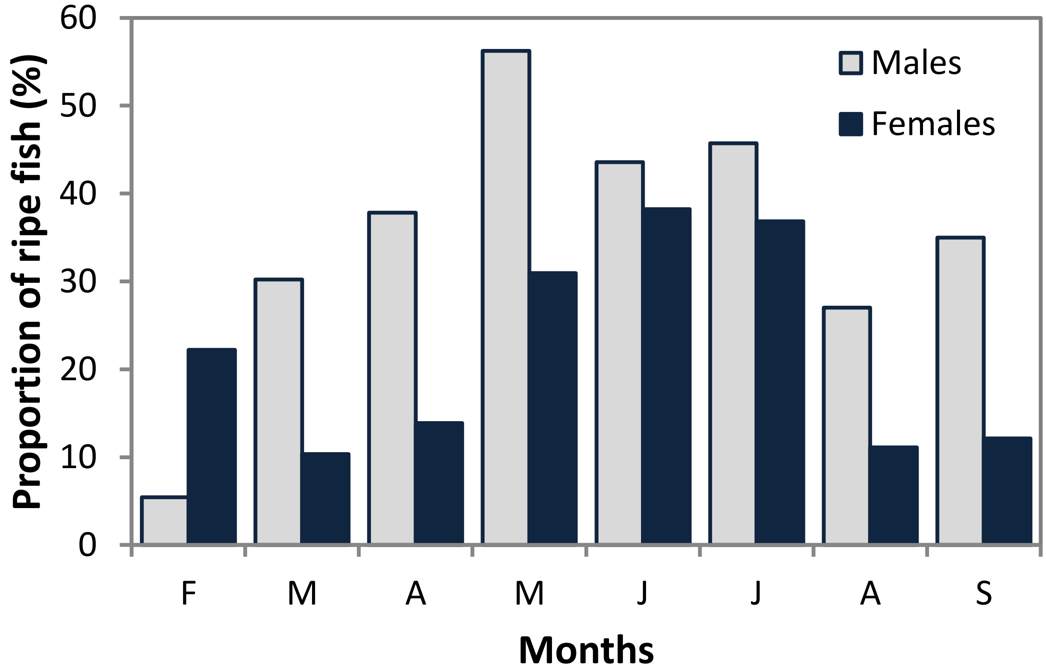


Figure 5: Breeding season of *O. niloticus* from Damte Dam

4.1.4. Gonado Somatic Index (GSI)

The GSI values of male *O. niloticus* ranged from 0.26 to 1.59 with a mean value of 0.76 ± 0.015 while the GSI value for females ranged from 0.25 to 1.8 with a mean value of 0.77 ±0.017. There was a significant variation between the GSI values throughout the sampling months, (ANOVA = < 0.001, $p<0.05$,) while sex by month interaction didn't show significant variation (ANOVA 0.831 $p > 0.05$) at a 95% CI. The total mean comparison showed a significant variation in a both sexes (ANOVA=0.009, $p<0.05$).

High values of GSI were obtained from March to July for male and female fishes. The peak GSI for male *O. niloticus* was obtained in May and for females in February. Nearly the same GSI value for both sexes of *O. niloticus* was obtained in August. The pattern of fluctuations of the frequencies of ripe fish and GSI values were more or less similar (Figs. 5 and 6).

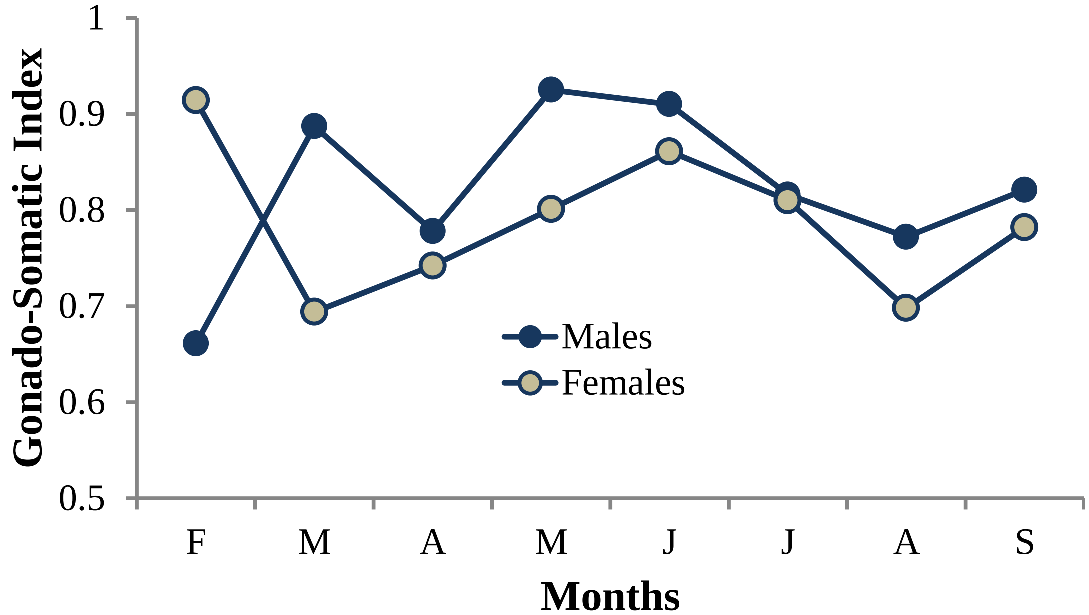


Figure 6: Gonado Somatic Index (GSI) of *O. niloticus* from Damte Dam

4.1.5. Fecundity

From the total of 267 sampled female fish, 84 fish contained ripe ovaries. The number of eggs in these ripe ovaries ranged from 62 to 860, and the mean was 347.The fish containing the lowest fecundity of 62 was 13.2 cm TL and weighed 55.4 g TW. The ovaries of this fish weighed 0.2 g (0.32 % of the body weight). The highest fecundity of 860 eggs was recorded in a fish measuring 33.9 cm TL and 421g TW, with the ovaries weighing 3.5 g (0.4% of the body weight). The relationships between fecundity and TL (b=2.94, R^2 = 0.836) and fecundity and TW (*b*=1.190, R^2 = 0.889) were curvilinear, while the relationship between fecundity and OW (F = 215.94OW + 41.301, R^2 = 0.947, $p<0.05$) was linear and highly significant,

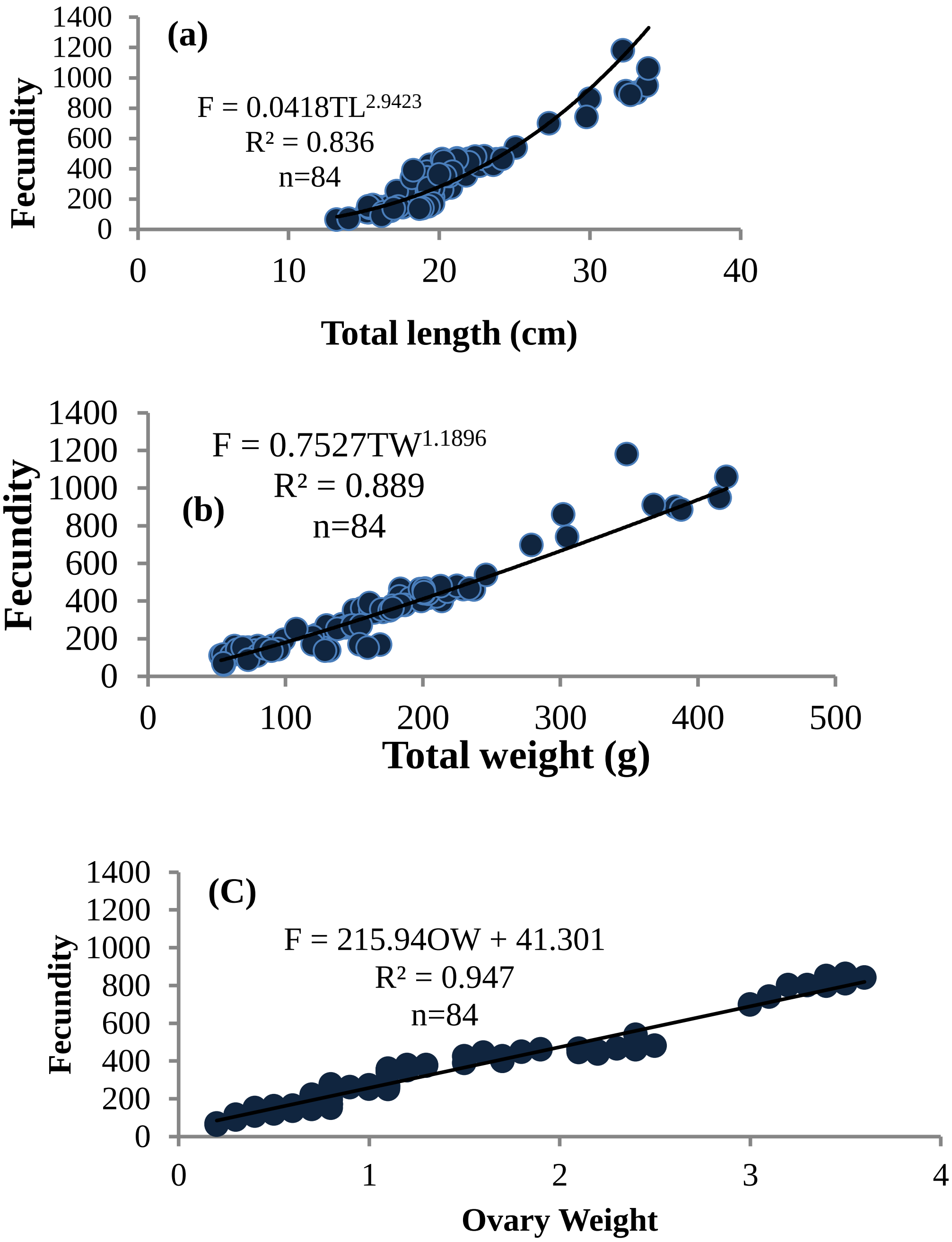


Figure 7: The relationship between total length and fecundity (a), total weight and fecundity (b) and ovary weight and fecundity (c) of O. niloticus from Damte Dam

4.2. Feeding habits

4.2.1. Diet composition

A total of 584 stomach samples were collected during the present study. Of these, 213 stomachs (36.47%) were empty. The remaining 371 (63.52%) stomach samples contained a wide variety of food items of plant and animal origins. Food items of plant origin were macrophytes, phytoplankton and detritus, whereas food types of animal origin were insects and zooplankton. Phytoplankton were most varied, as they included diatoms, green algae, blue green algae, euglenoids and dinoflagelletes. The quantitative analyses of the diet composition were conducted using the following methods:

4.2.2 Frequency of occurrence

Based on the frequency of occurrence method detritus, macrophytes and phytoplankton were most frequent food categories in the stomachs of the fish occurring in 94.61%, 88.41% and 85.18%, respectively (Table 3). The high frequency of the occurrence of the phytoplankton was mainly due to diatoms (34.47%), blue green algae (32.35%) and green algae (32.1%). The occurrences of other food categories such as zooplankton, and insects were relatively low (Table 3).

4.2.3. Volumetric analysis

The volumetric analysis indicated that detritus, phytoplankton and phytoplankton were the most important food categories constituting 34.53%, 31.36% and 29.59%, respectively of the total volume of the food consumed (Table 3). The contributions of zooplankton and insects were low compared to the above food categories (Table. 3).

Table 3: Summary of food categories of *O. niloticus* from Damte Dam (n= 371).

Food categories	Frequency of occurrence		Volumetric analysis	
	Frequency	**Percent**	**Volume (ml)**	**Percent**
Detritus	**351**	**94.61**	**165.92**	**34.53**
Macrophytes	**328**	**88.41**	**142.17**	**29.59**
Phytoplankton	**316**	**85.18**	**150.67**	**31.36**
Diatoms	139	37.47	35.80	7.45
Green algae	119	32.1	35.73	7.44
Blue green algae	120	32.35	33.67	7.01
Euglenoids	83	22.37	25.51	5.31
Dinoflagelletes	59	15.90	19.04	3.96
Zooplankton	**43**	**11.59**	**9.13**	**1.91**
Cladocerans	12	3.23	2.41	5.02
Copepods	18	4.85	2.97	0.62
Rotifers	20	5.39	3.11	0.65
Insects	**68**	**18.33**	**12.52**	**2.61**
Chironomidae larvae	30	8.09	4.36	0.91
Ephemeroptera	13	3.50	2.20	0.46
Tricoptera	19	5.12	3.66	0.76
Anisoptera	15	4.07	1.77	0.37

4.2.4. Ontogenetic dietary shift

The size of *O. niloticus* with food in their stomachs ranged from 10 cm to 34.9 cm TL, and to get clear image, the fish were grouped into five classes with the interval, 10-14.9 cm TL, 15-19.9 cm TL, 20-24.9 cm TL, 25-29.9 cm TL and 30- 34.9 cm TL. There was a difference in the volumetric contribution of the different food categories with in the size class compared. The notable change was observed in the contributions of detritus, macrophytes and phytoplankton, as their volumetric contribution increased as the fish size increased. In the food categories of zooplankton and insects, as the fish size increased, the volumetric contribution of the food items decreased. More than 30% of zooplankton were consumed in the fish size class below 15 cm TL, and the next highest volumetric contribution of the fish size class was observed in size class of 15 -19.9 cm TL (18.6%). In the length class of 30-34.9 cm TL no zooplankton were observed. Insects were somewhat important food categories in the smallest size class, but their importance declined progressively as the size fish increased (Fig. 8)

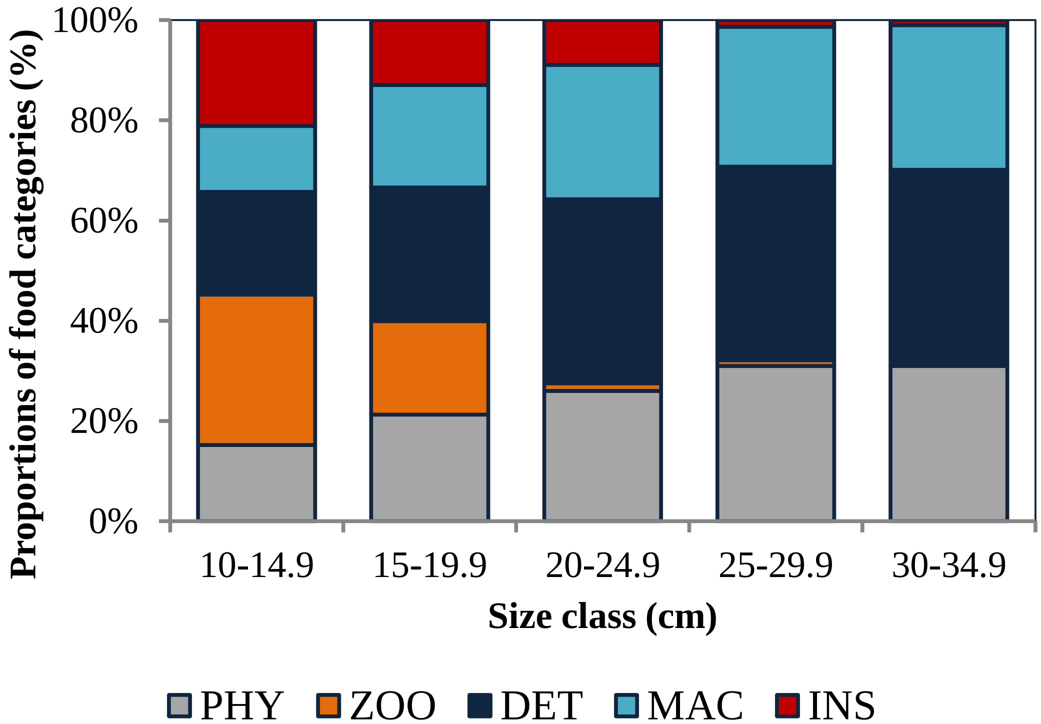


Figure 8: Ontogenetic dietary shift of *O. niloticus* from Damte Dam (PHY- Phytoplankton,Zoo- Zooplankton, DET- Detritus, MAC- Macrophytes, INS- Insects)

4.2.5. Variation of seasonal diet composition

There was no notable variation in the type of diet and some variation in the proportion of diet consumed by the *O. niloticus* in Damte Dam during dry and wet months. Except for the phytoplankton and detritus which were slightly higher in dry months, volumetric contribution of macrophytes, zooplankton and insects were slightly higher in the wet months than in dry months. Furthermore, except for zooplankton, which is higher in wet months than in dry months; the frequency of occurrence of detritus, macrophytes, insects and phytoplankton were higher in dry months than wet months. Thus, there was slight variation in the seasonal diet of *O. niloticus*, but statistically insignificant variation (t- test, $p>0.05$) (Tables 4 and 5).

Table 4: **Summary of food categories of *O. niloticus* from Damte Dam during the dry months (n= 199)**

Food categories	**Frequency of occurrence**		**Volumetric analysis**	
	Frequency	**Percent**	**Volume (ml)**	**Percent**
Detritus	**194**	**97.49**	**86.78**	**34.98**
Macrophytes	**189**	**94.97**	**70.56**	**28.44**
Phytoplankton	**181**	**90.95**	**82.12**	**33.10**
Diatoms	99	49.75	23.72	9.56
Green algae	76	38.19	18.25	7.36
Blue green algae	70	35.18	18.75	7.56
Euglenoids	39	19.60	10.56	4.26
Dinoflagelletes	33	16.58	10.19	4.11

Zooplankton	**20**	**10.05**	**2.87**	**1.16**
Cladocerans	6	3.02	0.87	0.35
Copepods	10	5.03	1.44	0.58
Rotifers	7	3.52	0.73	0.29
Insects	**37**	**18.59**	**5.77**	**2.33**
Chironomidae larvae	19	9.55	2.64	1.06
Ephemeroptera	2	1.01	0.31	0.12
Tricoptera	10	5.03	1.75	0.71
Anisoptera	8	4.02	0.76	0.31

Table 5: Summary of food categories of *O. niloticus* from Damte Dam during the wet months (n= 172)

Food categories	Frequency of occurrence		Volumetric analysis	
	Frequency	**Percent**	**Volume (ml)**	**Percent**
Detritus	**157**	**91.28**	**79.15**	**34.07**
Macrophytes	**139**	**80.81**	**71.60**	**30.82**
Phytoplankton	**135**	**78.49**	**68.59**	**29.53**
Diatoms	42	24.42	12.07	5.20
Green algae	43	25.00	17.48	7.52
Blue green algae	50	29.07	14.89	6.41
Euglenoids	44	25.58	14.94	6.43
Dinoflagelletes	26	15.12	8.84	3.81
Zooplankton	**23**	**13.37**	**6.25**	**2.69**
Cladocerans	6	3.49	1.53	0.66
Copepods	8	4.65	1.52	0.65
Rotifers	13	7.56	2.38	1.02
Insects	**32**	**18.60**	**6.74**	**2.90**
Chironomidae larvae	11	6.40	1.71	0.74
Ephemeroptera	11	6.40	1.88	0.81
Tricoptera	9	5.23	1.91	0.82

Anisoptera	7	4.07	1.01	0.43

4.3. Allometric condition factor (ACF)

The mean ACF of male *O. niloticus* considered for the present study was ranged from a minimum value of 0.40 to maximum value of 2.99 with a mean of 0.933 ± 0.013 respectively. While females *O. niloticus* ACF was ranged from 0.75 to 2.77 with mean value of 1.39 ± 0.016. The minimum average allometric condition factor for both male and female *O.niloticus* was observed by February which recorded 0.75 and 1.17, respectively, while the maximum mean values ACF for male *O. niloticus* in this study was during September (0.97) and during July (1.55) for females respectively. The mean combined condition factor for both sexes was 1.14. Throughout the sampling month, ACF value was significant variation (ANOVA = < 0.001, $P < 0.05$).

The values did not vary significantly (ANOVA= 0.068, $p>0.05$)) between sexes. The interaction between month was significantly different from each other (ANOVA = <0.001, $p<0.05$), that there was ACF different between month, also suggesting that similar seasonal fluctuation pattern in condition factor (growth pattern) of both males and females and different growth pattern of each sampling months (Fig. 9).

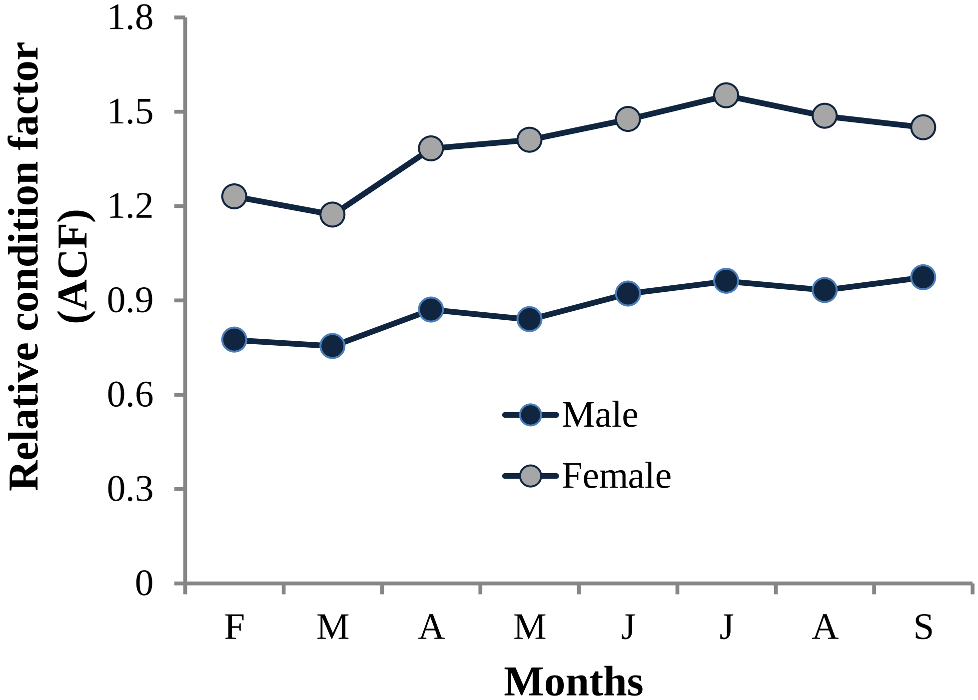


Figure 9: Allometric condition factor (ACF) at different months of the year of *O. niloticus* from Damte Dam

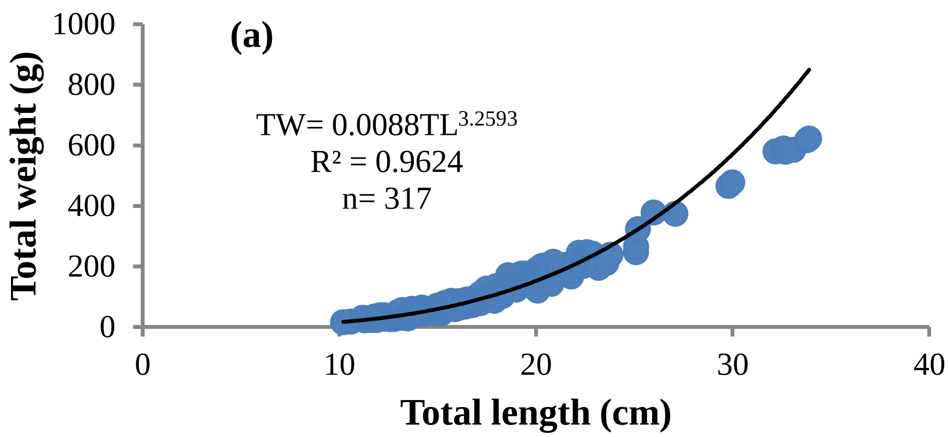
4.4. Morphometric relationships

4.4.1. Length- weight relationship

Length- weight relationship showed highly significant, and the growth pattern was slightly positive allometric for combined sexes (3.198). The '*b*' value of the males was 3.259 (positive allometric and 3.104 for females (nearly isometric growth pattern). There was significant variation between sexes or between months, and they are correlated with each other. ($p<0.05$) with 95% confidence interval; hence an equation combined for sexes was fitted and shown in Figs. (10 a, b, c)).

4.4.2. Length- length relationship

The relationship between total length and standard length was linear and highly significant, and the analysis of variance with correlation shows that as strongly correlated, as the value of R^2 was nearly one. Also there was no significant variation between sexes ($p>0.05$; therefore an equation for both sexes was fitted and shown in figs. (11a, b, c).



(a)
TW= 0.0088TL3.2593
R² = 0.9624
n= 317
Total weight (g)
1000
800
600
400
200
0
0
10
20
30
40
Total length (cm)

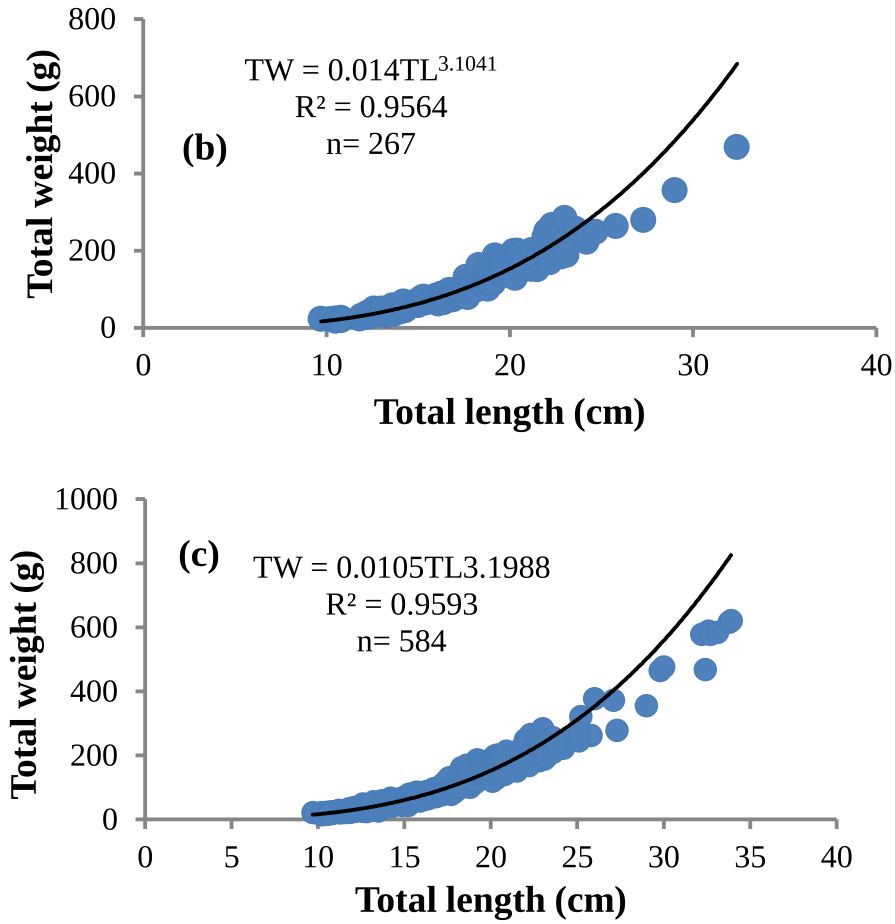
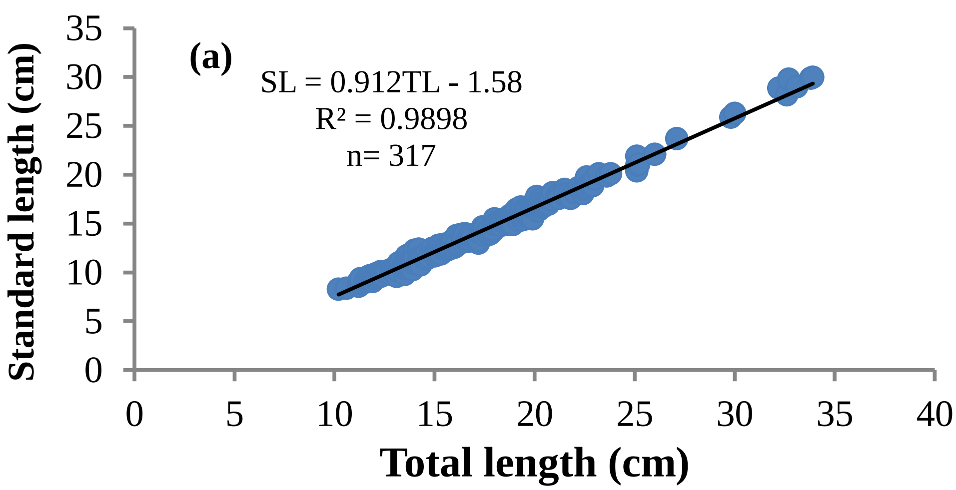
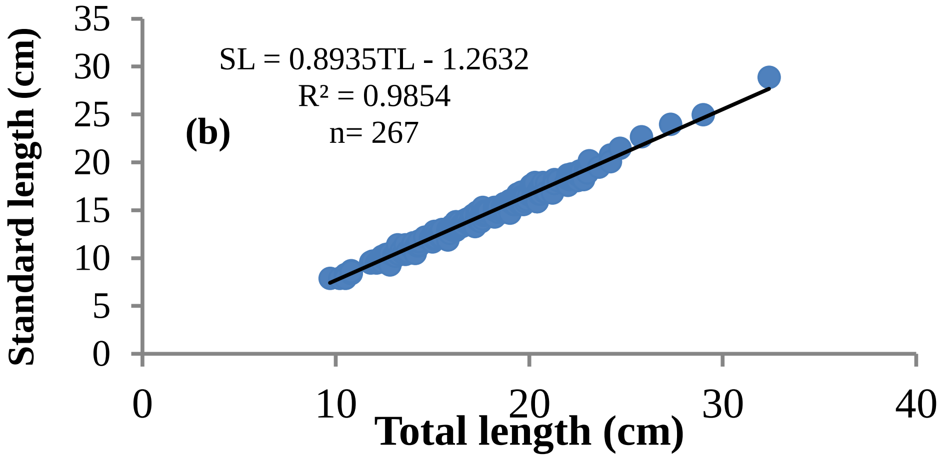


Figure 10: Length- weight relationship of males (a), females (b) and combined sexes (c) *O. niloticus* from Damte Dam





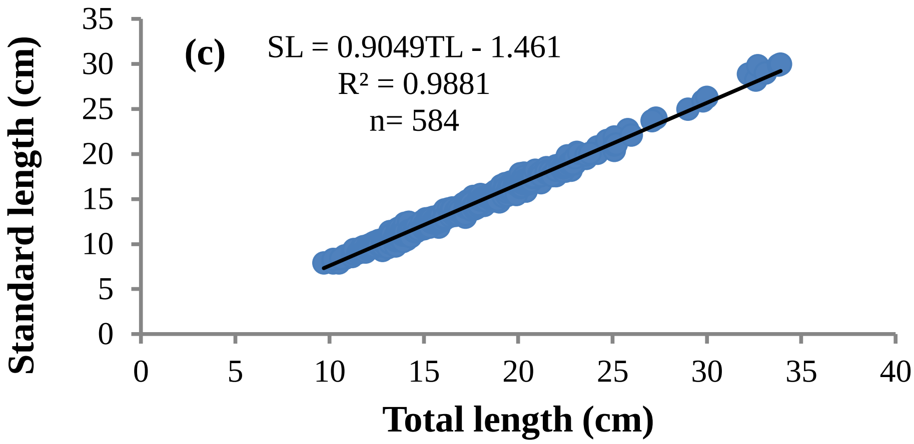


Figure 11: Relationships of length- length relationship of males (a), females (b) and combined sexes (c) of *O. niloticus* from Damte Dam

5. DISCUSSION

5.1. Reproductive biology

Five hundred and eighty four samples of *O. niloticus* were examined in the study conducted in Damte Dam. There were more males in the population, 317 (54.28%) than females 267 (45.71%. The overall sex ratio which was 1:0.84 was significantly different from hypothetical 1:1 sex ratio (χ^2= 4.8* $p<0.05$). Thus, it is probable that there is a difference in mortality rates between the two sexes in the same population. The results of the present study agrees well with the finding of Zenebe Tadesse (1997) where the number of males (383) that was caught from Lake Tana was numerous than females (297) (1:0.78), and statistically significant ((χ^2= 10.88, $p<0.01$). The similar result was found in (Lake Victoria, Njiru *et al.*, 2006; Lake Babogoya, Lemma Abera, 2012). Also similar results were reported for *O. niloticus* in Emiliano Zapata Dam in Mexico (Peña-Mendoza *et al.,* 2005).

Unlike the present study, Tamirat Handago *et al.* (2024), from Lake Boyo reported insignificant variation in male to female sex ratio of 1:0.92 ($p > 0.05$). The results of the above authors also showed that there were more males than females in the sampling month of December, while females dominated in the months of July and September. For the rest of the months (January-April), male and female *O. niloticus* were represented with almost equal proportions. Additionally, contrary to the findings of the present study, other authors have reported that female fish predominated over males in a number of Ethiopian lakes and reservoirs, including (Lake Hawassa, Demeke Admasu, 1996; Lake Beseka, Lemma Abera, 2013; Lake Hayq ,Workiye Worie and Abebe Getahun, 2014; Tekeze Reservoir, Tsegaye Teame *et al.,* 2018).

The predominance of one sex over the other can be caused by sexual segregation during the spawning period, habitat preference differences, behavioral variations and susceptibility to different types of fishing gear and fishing sites (Tsegay Teame *et al.,* 2018). According to Demeke Admasu (1994) there are two main possible causes of the unequal ratio of males to females: behavioral differences between the sexes that render one sex more susceptible to fishing gear than the other, or differences in refuge preference brought about by deviations in sexual maturity stages during the spawning season.

Additionally, it's possible that males' aggressive movements in pursuit of mates and the construction of nests for courtship could contribute to their dominance in the capture and made make them more susceptible to gill nets. Additionally, consistent with the current discovery, past research on the same species in Lake Tana also revealed the dominance of males over females, a finding that has been linked to the fish's reproductive habits (Zenebe Tadesse, 1997).

Fish size at first maturity is regarded as the lowest size at which a particular species of fish can be harvested (Tesfaye Muluye *et al.,* 2016). Many fish species have different maturation times based on demographic factors, which are influenced by both genetics and the environment (Senait Girma, 2015; Gashaw Tesfaye *et al.,* 2016). Fish in bad condition typically reach maturity at a lesser size than fish in good condition (Senait Girma, 2015). According to the current study's findings, the lengths in Damte Dam at which 50% of individuals reach sexual maturity (L_{m50}) were 13.9 cm TL for females and 14.7 cm TL for males. In Damte Dam, females typically attained sexual maturity at smaller size than males; the probable explanation could be that females use more energy for physiological processes like egg development.

The current results corroborated those of Bwanika *et al.* (2004), who found that female fish reach sexual maturity at a smaller size than male fish in two Ugandan crater lakes, Lake Nyamusingiri and Lake Kyasanduka. The results of Tamirat Handago *et al.* (2024), from Lake Boyo, showed that female fish reached sexual maturity at a smaller size than male fish, were similarly in agreement with the current findings. In contrary to the present results Otieno *et al.,* 2014, reported that the smallest mature male and female fish in the sample were 20 cm TL and 22 cm TL, respectively. This indicates that male fish reach sexual maturity at a smaller size than female fish.

Additionally, the results of Njiru *et al.* (2006), who determined the sexual maturity of male and female fish in Lake Victoria at 21 cm TL and 22.7 cm TL, respectively, are in contrast to the results of the current study. The early maturity may be a survival strategy to deal with pressures such as heavy fishing pressure and difficulties from other bottom feeding fish such as the *C.*

garipinius, which destroys *O. niloticus* breeding nests while feeding at the lake bottom (Njiru *et al.*, 2006).

O. niloticus bred continuously throughout the sampling months of both the dry and wet months in Damte Dam; however, the male *O. niloticus* peaked in breeding during the dry month of May. The season's intensive breeding months occur nearly exclusively in the wet month. There was a downward trend observed in both sexes from August through September. From February to July, the proportions of ripe fish increased in both sexes. The findings of Tamirat Handago *et al.* (2024), in Lake Boyo, also showed that the wet months were the time of intense breeding for both sexes.

According to Tessema Assefa *et al.* (2019), the peak breeding season for both male and female *O niloticus* in Lake Hayq was between February and April, a time when there was an abundant rainfall and high water temperature. Over half of the fish harvested in April were fully grown. Additionally, the current findings contradicted those of Lemma Abera (2013), in Lake Baseka, who found that the frequency of ripe fish was highest during the dry months of March and April and decreased during the next few months of June, July, and August for both sexes.

The intensive spawning months of the fish in Damte Dam was related with the intensive rainy months. Therefore, in the rainy month of June, female fish showed the peak breeding intensity. But for the male fish the peak breading month was in the dry month of May. This might be due to the availability of high quality insects, zooplanktons, detritus, and phytoplankton in the dry month around the Dam. Therefore, precipitation and related elements like temperature may serve as cues for fish to spawn so that the progeny are born when conditions are better for growth and survival. Rainfall's influence on fish spawning has a long history. Increased nutrient concentrations from runoff, for example, leads to better food quality and quantity (Lowe-Mc Connell, 1982).

The peak breading months for *O. niloticus* from Damte Dam corresponded with the maximum GSI value. As a result, the breeding season and GSI value patterns were somewhat similar. February was a non-intense breeding month, with the smallest GSI value recorded for both sexes. In July, the next highest GSI value was noted for both sexes. The increasing availability of food and greater metabolism that occur with rising temperatures could be the causes of the increase in

GSI (Abarike and Ampofo-Yeboah, 2016). The current study was similar with the finding of Njiru *et al.* (2006), who reported that the peak GSI value was in the month of June which was the wet season. In contrast, Tessema Assefa *et al.* (2019), from Lake Hayq found that the peak value of GSI was in the month of March for both sexes of *O. niloticus*, which is the dry season.

Additionally, the current study contradicted the findings of Abarike and Ampofo-Yeboah (2016) from Ghana's Golinga reservoir, which showed that the month of April which is the dry season had the highest GSI value. Owing to the brief duration, generalizing about the pattern of GSI of *O. niloticus* may be challenging without a year round investigation. Fish reproduction intensity is determined by the average number of eggs laid by each fish as well as the frequency of egg laying (Alekseev and Vinogradova, 2019). Only a few hundred offspring are produced by a female *O. niloticus* during a single spawn, although under ideal circumstances, they spawn regularly every four to six weeks (Pullin, 1991). *O. niloticus* have very low fecundity because they are mouth brooding (keeping the young in the mouth cavity for several weeks until they can live independently) and have a restricted amount of space for doing so (Welcomme, 2006). Even though *O. niloticus* produces few progeny at a time, the risk of predation is quite low for their offspring (Fryer and Iles, 1972). Due to differences in environmental factors like food and temperature that impact fish body size, fecundity within the same species of fish can vary from one body of water to another. Fish fecundity and body size are directly correlated (Alekseev and Vinogradova, 2019).

In the present study fecundity of *O. niloticus* ranged from 62 to 860 eggs per fish, with a mean fecundity of 347 eggs per fish. Based on the present study, fecundity of *O. niloticus* from Damte Dam was positively and curvilinearly correlated with body length (R^2=0.91853), weight (R^2=0.961377) and ovary weight (R^2= 0.945876), $p<0.05$)). Fecundity of *O. niloticus* linearly correlated with ovary weight (Fig. 7). The present finding indicates that the reproductive potential of *O. niloticus* in Damte Dam was low compared to some other studies carried out in Ethiopian water bodies.

This finding was comparable with the findings of other authors from different water bodies of Ethiopia such as Lake Hawassa (304 to 967 eggs per fish) (Demeke Admasu, 1994; Lake Tana (495 to 1,243 eggs per fish) (Zenebe Tadesse, 1997); Lake Hayk (324 to 745 eggs per fish) (Tessema Assefa *et al.*, 2019); Lake Boyo (216 to 1,157 eggs per fish) (Tamirat Handago *et al.*, 2024). In line with the present study Wang and Muir (2018) reported fecundity *O. niloticus* from Lake Victoria to be 378 to 998 with a mean fecundity of 358. Teferi Yirgaw *et al*. (2001) reported the range of fecundity from 1,047 to 4,590 eggs per fish which is the highest so far reported for the species.

The current study's value was high in comparison to other research findings from Ghana's Golinga Reservoir (173 eggs per fish on average) (Abarike and Ampofo-Yeboah, 2016). Because of genetic variances between stocks from different water sources, fluctuations in the habitat and mortality vulnerability the mean fecundity may vary from one water body to another. In order to make up for the loss of the stock, the reproduction rate rises, according to the report of (Lake Fisheries Development Project (LFDP) (1997).

Fecundity is usually lower in young fish than older ones and it increases directly with body weight and length (Njiru *et al*., 2006). Most species of *O.niloticus* breed continuously throughout the year during favorable environmental conditions of higher temperature and rainfall (Gomez-Márquez *et al.*, 2003). The peak breeding season of most tilapia species is usually associated with higher water temperature, rainfall, phytoplankton and rising water level in lakes (Babiker and Ibrham, 1979). The difference in fecundity of *O. niloticus* is associated with environmental factors such as temperature, altitude and these factors vary from one location to the other.

5.2. Food and feeding habits

The dominant food items for *O. niloticus* in Damte Dam were detritus, macrophytes, and phytoplankton, with zooplankton and insects being less important. The results of the current study are in line with the findings of Tamirat Handago *et a.,* 2024; Filipos Engdaw *et al.,* 2013; Mathewos Temesgen, 2017). In the current finding, detritus occurred in highest frequency of occurrence in addition to macrophytes and phytoplankton. The occurrences of macrophytes were also found slightly higher in the diet of *O. niloticus* than other food items, and it is in agreement with some of the Rift Valley lakes (Alemayehu Negasa and Prabhu, 2008; Filipos Engdaw *et al.*, 2013; Mathewos Temesgen, 2017). Also in line of the present study, phytoplankton are the most important food items consumed in Lake Koka in the dry season. For instance, the study made in Lake Koka showed that about 66.1% of the total volumes of food items identified in the diet of *O. niloticus* were phytoplankton (Filipos Engedaw *et al.,* 2013).

Similar findings were also reported in Lake Langeno (Mathewos Temesgen, 2017; Lake Hayq, Workiye Worie and Abebe Getahun, 2015; Lake Ziway, Alemayehu Negassa and Prabu, 2008; Lake Chamo, Teferi Yirgaw *et al.,* 2000; Omo River, Mulugeta Wakjira, 2016). The low proportion of phytoplankton during the wet season is associated with the high flooding from the catchment area, which can cause fluctuation in water level and increase turbidity (Njiru *et al.,* 2004). Turbidity of water decreases the penetration of sunlight and affects the growth and abundance of phytoplankton (Paaijmans *et al.,* 2008).

The less occurrence of zooplankton and high occurrence of detritus in this study was in agreement with the findings of Tamirat Handago *et al.* (2024), but the less occurrence of zooplankton in the diet of *O. niloticus* in the present study was not in line with the findings from (Lake Ziway, Alemayehu Negasa and Prabhu, 2008; Lake Hayq, Workiye Worie and Abebe Getahun, 2015); Lake Langano, Mathewos Temesgen, 2017). Furthermore, contrary to the present study, the contribution of insects was highest in some southern rift valley Lakes like (Gilgel Gibe Reservoir, Mulugeta Wakjira, 2013); Lake Chamo, Teferi Yirgaw *et al.,* 2000); Lake Hashange among the high altitude lakes, Tsegaye Teame *et al.,* 2016).

Generally, slight differences were observed among volumetric contributions and frequency of occurrences in dry and wet months, but statistically there were no significant differences ($p>0.05$). For instance in present study there was no notable difference between the types of food categories in the dry and wet months. Detritus and macrophytes were the main food items during the wet season. Nearly similar results of high contribution of foods of plant origin (macrophytes and detritus) were reported in most of the water bodies (Alemayehu Negasa and Prabhu, 2008; Filipos Engdaw *et al.,* 2013; Workiye Worie and Abebe Getahun, 2015). The rainy season is linked to the high macrophytes abundance in *O. niloticus*'s wet season diet. According to Workiye Worie and Abebe Getahun, 2015, the rise in ingested macrophytes during the rainy season may be explained by fish migrating to shallow areas of the lake for reproduction.

In the present study, detritus, macrophytes and phytoplankton were the dominant food categories in both dry and wet seasons. The significant contribution of foods of plant origin is in agreement with the studies made in different water bodies; for instance, (in Lake Ziway, Alemayehu Negasa and Prabhu, 2008; in Lake Koka, Filipos Engdaw *et al.,* 2013; in Lake Hayq, Workiye Worie and Abebe Getahun, 2015; in Omo River, Mulugeta Wakjira, 2016). Numerous research findings have shown that the availability of resources in the environment influences the eating habits of tropical fish, which in turn influences the choices and preferences of the fish based on their trophic niches or foraging areas (Ahrens *et al.,* 2012). There was a notable ontogenetic dietary shift in the diet of *O. niloticus* in Damte Dam.

The general trend was that the importance of zooplankton and insects declined with the size of fish while detritus, phytoplankton and macrophytes increased with fish size; this showed that the fish tended to be more herbivorous in its mode of feeding. The majority of the studies indicated that juvenile of *O. niloticus* were generally omnivorous, mainly feeding on zooplankton and insect larvae and some phytoplankton, of which diatoms are the major dietary components (Flipos Engdaw *et al.,* 2013; Mathewos Temesgen, 2017; Workiye Worie and Abebe Getahun, 2015). This is because juvenile fish need high protein intake to support high growth rate and metabolism (Benavides *et al.,* 1994). Also in line with the present study, having a small stomach volume that cannot support big macrophytes, and detritus loads can be another reason for juveniles to feed on larval insects and zooplankton (Flipos Engdaw *et al.,* 2013). For the larger fish groups (>15 TL), however, the plant origin food types (phytoplankton, detritus and macrophytes) were highly preferred food types. *O. niloticus* shifts its dietary habits from mostly being omnivorous to being herbivorous due to their high energy requirements as they become bigger, as reported (Benavides *et al.,* 1994).

In contrast to the present finding, Agumassie Tesfahun and Sale Alebachew (2023), showed that zooplankton were abundant food items in the size class between 30- 34 cm TL. It is not possible to meet the increasing demand for energy by consuming only benthic and zooplanktonic organisms. This makes it possible for them to change from being zooplankton and benthic invertebrate feeders to becoming generalist feeders. In addition, the bigger fish are more capable of digesting cell wall material, and therefore can be less selective in their feeding pattern (Benavides *et al.,* 1994).The present study showed the change of diet with size. A low level of intraspecific competition for a specific food among various length groups was indicated by the shift in eating behavior (Ayoade *et al.,* 2008).

5.3. Allometric Condition Factor

Allometric Condition Factor (ACF) recorded in the present study ranged from 0.42 to 2.77 with a mean value of 1.14 for combined sexes with 95 percent confidence interval. The values did not vary significantly ($p= 0.068$, $p>0.05$) between sexes. The interaction between month was significantly different from each other (ANOVA $p<0.05$), that there was ACF differences between months, also suggesting that similar seasonal fluctuation pattern in condition factor (growth pattern) of both males and females and different growth pattern of each sampling months. The present study of mean ACF was higher than the findings of Senait Girma (2015) from Lake Beseka, (0.05), but the value was lower than for the same fish species in relatively high condition factor recorded (in Lake Chamo, (2.35) Teferi Yirgaw and Demeke Admassu, 2002; in Gilgel Gibe Reservoir, (1.87) Mulugeta Wakjira, 2013; in Lake Langano (1.67) Zenebe Tadesse, 1998; in Lake Langano, (1.77) Mathewos Temesgen, 2017). Higher body condition is correlated with high energy content, adequate food availability, reproductive potential and favorable environmental conditions (Pauker and Rogers, 2004).

In the present study the average ACF of male *O. niloticus* was 0.93 while the average female ACF was 1.39. The present finding of average ACF of female *O. niloticus* fish was lower than the values of (Tamirat Handago *et al*., 2024, from Lake Boyo, (1.77); Eyualem Abebe and Getachew Teferra (1992) from Lake Hawassa (2.03); Teferi Yirgaw *et al.* (2001), from Lake Chamo (2.35)). The variation in ACF value could be due to changes in the environmental conditions of the lake and thereby changes in the nutritional status of the fish. For instance, there are different agricultural activities taking place around the Dam and these activities might disturb and break the available food chain for the fish. Variations in the condition factor of many fishes is believed to be related to their reproductive cycle, feeding rhythms, physiochemical factors of lake environment, age, physiological state of fish or some other unknown factors (Njaya, 2002).

In Damte Dam condition factor value of *O. niloticus* was low compared to the majority of the findings from other water bodies in Ethiopia and elsewhere. Generally speaking, during some of the studied period, females' the Allometric Condition Factor (ACF) values were higher than those of males. This could be because females have heavier gonads than males, which leads to a higher total body weight, and because males may lose weight due to the energy they expend building and guarding their nests.

5.4. Morphometric relationships

According to Lawsen *et al.* (2013), one of the most crucial biological factors in fishery management is the length-weight relationship. The average weight at which a fish can reach a specific length is estimated using this method. The relationship also suggests how well the fish are doing (Hamid *et al.*, 2015). Various studies were conducted on length weight relationships to predict average weight of fish for a given length (Tamirat Handago *et al.*, 2024; Tessema Assefa *et al.* 2020; Novaes, J.L and Carvalho, 2012; Otieno *et al.*, 2014).

In the present study, the length weight regression coefficient for males (b=3.25) was curve-linear relationship with positive allometric growth pattern while length weight regression coefficient for females (b=3.104) was curve-linear relationship with nearly isometric growth pattern. The combined length weight regression coefficient value of *O. niloticus* from Damte Dam was (b=3.19) which was curve-linear relationship with slight positive allometric growth pattern. In agreement with present finding, Otieno *et al.* (2014), found from Lake Naivasha Kenya, the length weight relationship of positive allometric growth pattern (b<3). Also the report of Tamirat Handago *et al.*, 2024, was in agreement with the present study, In contrast to the findings of the present study, some authors reported negative allometric growth pattern in some stocks of *O. niloticus* in African water bodies (Offem *et al.*, 2007; Lemma Abera, 2013).

The negative allometric growth pattern in fish is an indication that the population has heterogeneous groups with body weights varying differently with the cube of total length (Olurin and Aderibigbe, 2006). Isometric growth pattern for the combined sexes of *O. niloticus* was reported in different water bodies of Ethiopia e.g. (in Lake Beseka, Senait Girma, 2015; Gilgel Gibe Reservoir, Mulugeta Wakjira, 2013; Lake Hawassa, Demeke Admassu, 1990; Lake Ziway, Zenebe Tadesse, 1998; Lake Chamo, Teferi Yirgaw and Demeke Admasu, 2002; Baro River, Simegnew Melaku *et al.*, 2009; Lake Hawassa, Bjorkil, 2004), Lake Koka, Filipos Engdaw *et al.*, 2013; Lake Langano, Mathewos Temesgen, 2017).

The nearly isometric growth pattern is common for this fish species in both running and standing water bodies. However, several authors documented that the allometric growth pattern is the most appropriate for describing morphometric growth of fishes (Karpouzi and Stergiou, 2003). But, it should be rare in nature and the estimation is not optimally applicable to all measurement comparisons, because the relationship tells the effect of different factors, such as habitat type and feeding habits on the growth of fish. The growth performance of fish could vary in different habitats and at certain period of the year(Karpouzi and Stergiou, 2003). Mostly, differences in biological factors, such as availability of food items, quality and quantity of food items, feeding rate and spawning period of fish affects the '*b*' value of fishes in the environment where they live (Suquet *et al.,* 2005). Moreover, the regression coefficient of length weight relationship value (*b*) is used as an indicator of food availability, water quality and growth pattern, where the feeding availability is influenced by spatial and temporal variations of food items (Wottoon, 1995).

6. CONCLUSION AND RECOMMENDATION

6.1. CONCLUSION

Overall, this investigation demonstrated that male-to-female sex ratio was 1:0.84, which differed significantly from the theoretical 1:1 sex ratio and was statistically significant (χ^2= 4.281* $p<0.05$). In line with studies from two Ugandan crater lakes, Lake Nyamusingiri and Lake Kyasanduka, and Lake Boyo, Ethiopia, where female fish reach sexual maturity at a smaller size than male fish, the size at initial maturity demonstrated that female fish matured earlier than male fish. Females typically reached adulthood at a smaller size than males. *O. niloticus* from Damte Dam reproduced over the entire February–September sampling period. May, June, and July were its peak breeding months for both sexes.

For male fish, however, May was the best month to reproduce. The frequency of ripe fish and the GSI levels fluctuated monthly in a pattern that varied dramatically from month to month. The peak breading months for *O. niloticus* from Damte Dam corresponded with the maximum GSI value. The GSI value showed a significant fluctuation in both sexes through the sampling month (ANOVA, $p<0.05$, <0.001), while the sex by month interaction did not reveal a significant variation (ANOVA, $p>0.05$, 0.831) at a 95% confidence interval. May was the driest month of the year when the GSI value peaked. Compared to other analyzed water bodies, *O. niloticus* in the Damte Dam had a lower fecundity.

During the course of the study, three food categories were found to be significant to *O. niloticus's* diet: detritus, macrophytes and phytoplankton. Other food categories, namely zooplankton and insects were relatively unimportant to the nourishment of the species Juveniles' primary food sources were insects and zooplankton, while adults' primary sources were phytoplankton, detritus and macrophytes. As fish size increase, the demands of plant source increased. The same foods were employed by *O. niloticus* in Damte Dam, with the exception of their frequency of occurrence and volumetric contribution during both dry and wet times. *O. niloticus* was often an omnivore in Damte. This study also demonstrated that *O. niloticus* from Damte Dam had positive allometric growth pattern and curvilinear length-weight relations.

6.2 Recommendation

Based on the findings of this study, the following recommendations were forwarded:

- *O. niloticus* under 15 cm TL should be protected to save the breeding fish from the risky fishing of locals.
- As the fish is omnivore feeding on locally available food, it could be the best candidate for aquaculture production.
- As the average value of ACF of *O. niloticus* from Damte Dam was low compared to other water bodies of the same species, it should need conserving the Dams and conducting further research on the Dam to identify concerned problems.

- As the intensive breeding months for both males and females *O. niloticus* in Damte Dam was wet months of June and July, should be protect the Dam from intensive fishing.
- It might be beneficial to extend investigation of morphometric relationships by examining additional indices of fish health and condition, such as the Gonado Somatic Index (GSI) or the condition factor in Damte Dam.
- Since the sampling months for the present study were narrow and short period it is recommended to widen the size variation and increase the period of sampling to 12 and more months.

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LIST OF APPENDICES

	Minimum	.4242	.2551
	Maximum	2.1992	1.5900
Total	Mean	1.144060	.763878
	N	584	584
	Std. Deviation	.3469780	.2709262
	Std. Error of Mean	.0143581	.0112110
	Minimum	.4242	.2525
	Maximum	2.7763	1.8779

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
Relative condition * sexofON	Between Groups	(Combined)	30.843	1	30.843	456.206	<.001
	Within Groups		39.347	582	.068		
	Total		70.190	583			
gonadosomatic * sexofON	Between Groups	(Combined)	.003	1	.003	.045	.831
	Within Groups		42.789	582	.074		
	Total		42.793	583			

Measures of Association

	Eta	Eta Squared
Relative condition * sexofON	.663	.439
gonadosomatic * sexofON	.009	.000

Appendix 1: ANOVA value of male and female in relation with GSI and ACFACF

	Maximum	1.7200	1.0390
Total	Mean	1.144060	.763878
	N	584	584
	Std. Deviation	.3469780	.2709262
	Std. Error of Mean	.0143581	.0112110
	Minimum	.4242	.2525
	Maximum	2.7763	1.8779

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
Relative condition * sampling month	Between Groups	(Combined)	14.346	7	2.049	21.138	<.001
	Within Groups		55.844	576	.097		
	Total		70.190	583			
gonadosomatic * sampling month	Between Groups	(Combined)	2.874	7	.411	5.925	<.001
	Within Groups		39.919	576	.069		
	Total		42.793	583			

Measures of Association

	Eta	Eta Squared
Relative condition * sampling month	.452	.204
gonadosomatic * sampling month	.259	.067

Appendix 2: ANOVA in month with both ACF and GSI

Fecundity with TL								
SUMMARY OUTPUT								
Regression Statistics								
Multiple F	0.914488							
R Square	0.836289							
Adjusted I	0.834292							
Standard E	0.115319							
Observati	84							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regressio	1	5.570478	5.570478	418.8818	5.74E-34			
Residual	82	1.090473	0.013298					
Total	83	6.660951						
	Coefficient	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-1.37844	0.1881	-7.32823	1.47E-10	-1.75263	-1.00425	-1.75263	-1.00425
X Variable	2.942315	0.143762	20.4666	5.74E-34	2.656327	3.228303	2.656327	3.228303

Appendix 3: p value using regression analysis for fecundity estimation with TW, TL and OW


Appendix 4: Sample collection

Appendix 5: Measuring Length and weight of *O. niloticus* from Damte Dam

Appendix 6: Stomach content analysis and inspection of stage of matured *O. niloticus* fish

Appendix 7: Fecundity estimation