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Assessment of fish species composition, some biology and fishing gear selectivity in Lake Harkiso

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Keywords

Lake Harkiso,
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Gill nets

Abstract

This study was conducted Quarterly for one year in 2021 using different mesh size gillnets (6cm, 8cm. 10cm, and 12cm) in Lake Harkiso to assess the fishery potential of the lake, fish diversity, fish growth parameters , gear selectivity and the general fishery status of the lake. The result indicates that, the lake consists of only two commercially important fish species, *C.gariepinus* (the dominant species) and *O.niloticus*. The length and weight of *O.niloticus* ranged from 10.5 – 33 cm and 40 – 475 g respectively and majority of the catch were sexually matured (74%). In similar way, the length and weight of *C. gariepinus* was ranged from 18 – 64 cm and 119.8 - 1423.5 g respectively and 70% of the catches were sexually matured. However, both fish species in the lake showed negative allometric growth due to limited fish feed available in the lake. Fishermen group can use multifilament gillnet of 6 cm and 8 cm mesh size if they target *O. niloticus* without impacting immature fish. In the same way, fishermen can use multifilament and monofilament gillnet of 12 cm mesh sizes if they target *C. gariepinus* without impacting immature fish. The fish production potential of the lake was calculated as 6tonnes/year. So, it can accommodate about 6 fishermen without overharvesting the resource assuming one fisherman harvesting only 3 kg/day.

Introduction

Ethiopians depend on the fish found in the inland lakes as a cheap source of animal protein. It can also indirectly assist by producing revenue to purchase food for underprivileged areas. Only a small percentage of Ethiopia's numerous freshwater bodies have undergone adequate fisheries research, despite the country's rich fish fauna and significant production potential of the Oromia region in particular. Using artisanal techniques, the majority of fish consumed in Ethiopia is harvested from the wild. The country's present actual fish production is estimated to 75,000 tons yearly (FAMP, 2024). Brook Lemma (2012) states that while fishing is conducted in some capacity in most of Ethiopia's freshwater bodies, commercial fishing is mostly focused on Lakes Tana, Chamo, Ziway, Abaya, Koka, Langano, Hawassa, and Turkana. According to Tesfaye Wudneh (1998), the majority of the fish supplied to Ethiopia's largest cities and towns comes from the lakes in the Rift Valley (40%) and Lake Tana (50.2%) in the north, with the remainder coming from riverine fisheries.

Even though Ethiopia's fish species is diverse and has a great potential for production, only a small number of its many freshwater bodies have under gone thorough fishing research.

According to Golubtsov *et al*. (1995), Ethiopia's territory appears to be one of the parts of the African continent that is least investigated for ichthyofauna.

The Ethiopian ichthyofauna's composition, population structure, distribution, and population, as well as the biology and production of the fish species, are not fully understood, and a sizable number of small, medium, and even some large rivers have not been thoroughly investigated and studied (Abebe Getahun, 2005).This is especially true of Ethiopia's inland water fish population, both generally and specifically in the Bishoftu Creater lakes.

This was also a case of Harkiso Lake. This study was aimed to assess the composition, diversity and abundance of the fish, its biology, and determine appropriate fishing gear to be used in Lake Harkiso.

Materials and Methods

Description of the study area

The study was conducted at Lake Harkiso. The Lake is located at about 42 km south of Batu town and 5km from Lake Langano to the North (Fig 1). It has an area of about 0.7 km^2 (70 hectares).The lake is found in the rift valley system at adjacent to Lake Langeno in Rift valley area with an average elevation of 1,645 m.a.s.l.

Fig 1: Location (Sat. image) of Lake Harkiso

Sampling procedures for fish and water quality

First, a survey was conducted at the start of the project to choose the best sampling sites that were used to collect all of the desired parameters. Accordingly, the data were collected once quarterly (Q1 = July - September, Q2 = October - December, Q3 = January – March and Q4 = April – May) for one year in 2021.

Field sampling and measurements

Fish parameters

Fish sample was collected quarterly at selected sites using variety of fishing gears, which includes gill nets of various mesh sizes (6, 8, 10 and 12 cm stretched mesh size), monofilament nets of 12cm. The gears were set in the afternoon at 4:00 pm and collected in the following day at 7:00 am.

Fish specimens were dissected and the sexes determined by inspecting the gonads for some biological parameter analysis. A five-point maturity scale was used to describe stages of gonads (Holden and Raitt, 1974).

Length-weight relationship of the fish

The relationship between total/fork length and total weight of the fishes was calculated using least squares regression analysis (Bagenal and Tesch, 1978) as follows:

$$TW = aTL^b$$

Where: TW - Total weight in gram
a - Intercept of the regression line
TL - Total length in centimeters
b - Slope of the regression line

Estimation of sex-ratio

The number of female and male individuals was recorded for each sampling occasion. Sex-ratio (female: male) was then calculated for each species of the total sample. Chi-square test was employed to test if sex ratio varied from one-to-one in the total samples for each species as in DemekeAdmassu (1994).

Estimation of length of fish maturity (L_{50}): After classifying data by length class, the percentages of male and female fishes with mature gonads was plotted against length to estimate L_{50} graphically (Tweddle and Turner, 1977).

Catch and effort

Estimation of relative abundance of fishes in the lakes was made by taking the contribution in number and weight of each species in the total catch in each sampling effort. An Index of Relative Importance and Shannon diversity index was used to evaluate relative abundance and species diversity of fishes, respectively.

Fish production potential of Lake Harkiso

The potential fish production of Lake Harkiso was calculated by using empirical models, Crul (1992) which is a suitable model and based on relationship between catch ($t.y^{-1}$) and area (km^2) for 71 African lakes and reservoirs

$$Catch = 8.32*(Area)^{0.92}$$
$$R^2 = 0.93$$

Data analysis

The fishery data, gear selectivity, diversity and fishery status of the lake was analyzed by using Statics like SPSS, chi-square test, Shannon diversity Index, and the results were interpreted using pie chart, graph, chi-square test, table and descriptive statics.

Results and Discussion

Fish production potential of Lake Harkiso

Based on the empirical model provided in methodology (Crul, 1992 model), the fish production potential of Lake Harkiso is calculated as;

Catch = 8.32*(Area) $^{0.92}$
R^2 = 0.93

Area of Lake Harkiso = 0.7km^2.

So, production potential of Lake Harkiso = 8.32*(0.7 km^2) $^{0.92}$

Catch production potential of Lake Harkiso =8.32*0.72

Catch production potential of Lake Harkiso =5.99 t.y^{-1} ~ 6t.y-^{1}

Hence, the fish production potential of the lake is estimated at 6 tons per year.

Fish species composition of Lake Harkiso

From the current study result, Lake Harkiso comprises of two commercially important fish species; *O.niloticus* and C. *gariepinus*(Fig 2). Majority of the catch 74 % by number was *C.gariepinus* while the remaining (26 %) was *O.niloticus.*

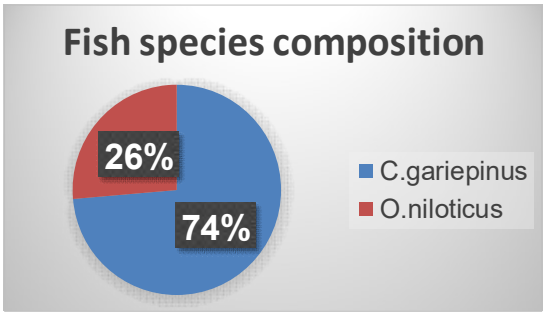

Fig 2: Fish catch percentage composition of Lake Harkiso

Fish growth parameters of Lake Harkiso

The mixed sex of *O.niloticus* and *C.gariepinus* growth parameters were listed in the Table1 below.

Table 1: Growth parameters of *O.niloticus* and *C.gariepinus* in Lake Harkiso.

Fish species	Length range (cm)	Average Length (cm)	Weight range (g)	Average weight (g)
O.niloticus	10.5-33	19.05 ± 5.71	40-475	158.26 ± 125.34
C.gariepinus	18-64	39.71 ± 11.84	119.8-1423.5	584.57 ±390.12

Estimation of sex-ratio

Sex ratio of the two fish species in Lake Harkiso was tested using chi-square test. The result indicated that female to male ratio in the lake was almost similar. There is no statistically significant deviation (p-value 0.48) from the 1:1 sex ratios in both of the fish species (Table 2). The current result agree with the findings of Tamirat *et al*., (2024).

Table 2: Sex ratio of *O.niloticus* and *C.gariepinus* in Lake Harkiso

Fish species	sex		Female: Male ratio	χ2	Sign.
	Female	Male			
O.niloticus	9	10	0.9: 1	0.39	0.48
C.gariepinus	29	25	1.2: 1	0.11	
Total	38	35	1.05: 1	0.5	

Index of Relative Importance (IRI)

The Index of Relative Importance (IRI) is a metric used in ecological and fisheries studies to quantify the significance of different prey items in the diet of a predator species. It provides a comprehensive measure of the dietary importance of various prey types based on their frequency of occurrence, abundance, and biomass in the diet.

The current analysis of the fish caught from Lake Harkiso, comprising 19 Tilapia and 54 Catfish, yields key insights into the ecological importance and diversity of the species present as follow.

IRI=Relative Abundance + Relative Frequency + Biomass (Curtis & McIntosh, 1951).

Relative Frequency represents their presence in the catch. Accordingly, if the frequency is the same for both (1 for *O.niloticus*) in the catch and (1 for *C.gariepinus*). Accordingly, IRI for *O.niloticus* is calculated to be 3033.04, while for Catfish, it is 43332.92. This indicates that *C.gariepinus* have a significantly higher IRI compared to *O.niloticus* (Table 3), reflecting their greater combined measure of abundance and biomass in the sampled population.

Table 3: The IRI of *O.niloticus* and *C.gariepinus* in Lake Harkiso

Fish species	No.	Frequency	Relative Abundance	Biomass (g)	IRI
O.niloticus	19	1	19/73 =0.2603	3013.78	19+ 1 * 3013.78 = 3033.04
C.gariepinus	54	1	54/73 =0.2603	43258.18	54+1*43258.18= 43332.92
Total	73	-	-	-	-

Shannon Diversity Index (H')

The Shannon Diversity Index, also known as the Shannon-Wiener Index, is a widely used metric in ecology to quantify the diversity of a community. It takes into account both the number of species (richness) and their relative abundance (evenness) within a given area or sample.

$$H' = -\sum(p_i \cdot \ln(p_i))$$

The **Shannon Diversity Index (H')** of the current fish species in Lake Harkiso was calculated as the following.

Proportions: *pO.niloticus*= 19/73 = 0.2603
PC.gariepinus= 54/73 = 0.7397

Shannon Index (H′) = − ((0.2603*ln (0.2603)) + - (0.7397*ln (0.7397))

(H′) = − ((0.2603*−1.3533) +- (0.7397* −0.3057))

H′= − (−0.3525) + −(-0.2267)
H′ = 0.5792

The Shannon Index (H′) of the current study is calculated to be 0.579. The interpretation of Shannon **Index** (H′) suggests that if (H′) value is less than one (<1) that specific ecology has Low diversity in a community with few species or where one or a few species dominate significantly over others. If it is one to two (1 to 2), it has Moderate diversity and the community has a more balanced species distribution and a greater number of species compared to a low diversity scenario. If **Shannon Index** (H′) is beyond two (>2), there are high diversity suggesting a community with a high number of species and a relatively even distribution of individuals among those species.

Based on these interpretations, the current value (0.5792) reflects a low diversity within the fish community, suggesting a reasonable balance

between the two species but with a dominant presence of *C.gariepinus* relative to *O.niloticus*.

Length-weight relationship of fish in Lake Harkiso

Studying the length-weight relationship in fish is vital for effective fisheries management, conservation efforts, and understanding ecological dynamics and used to ensure that fish populations are healthy, sustainable, and able to thrive in their environments. The formula for isometric growth in fish is typically written as:

$W=a \cdot L^b$
W = weight of the fish (usually in grams or kilograms)
L = length of the fish (usually in centimeters or meters)
a = a constant (specific to the species or population)
b = the scaling exponent.

Fish weight length relationship and its growth pattern can be one of the following based on environmental/ecological/ condition where fish exists.

Isometric Growth (b =3): If b is approximately 3, it suggests isometric growth, meaning that the weight of the fish increases proportionally with the cube of its length. This is typical in many fish species.

Positive Allometric Growth (b>3): If b is greater than 3, it indicates positive allometric growth. The fish grows faster in weight compared to its length. This might suggest that the fish is becoming bulkier as it grows.

Negative Allometric Growth (b<3): If b is less than 3, it indicates negative allometric growth. The fish grows more slowly in weight compared to its length, which might suggest a more streamlined body shape or slower weight gain relative to length.

From the current result, both *C.gariepinus*(Fig 3) and *O.niloticus*(Fig 4) showed negative allometric growth (b<3) in Lake Harkiso. According to different authors, this type of growth occurs due to lower abundance (lower quality and quantity) of fish food in water bodies. For instance, LuelTeka (2001) observed a lower growth of *C.gariepinus* in Lake Langano as compared to Lake Hawassa due to difference in fish food in the two Lakes to result difference in condition between the two *C. gariepinus* populations. In similar way, the current water body is found in adjacent to Lake Langano to the north part. Even though a diversity of zooplanktons and phytoplankton's availability in Harkiso Lake reported by Lemma Abera (2021), abundance may be lower which enable to support fish growth in the Lake.

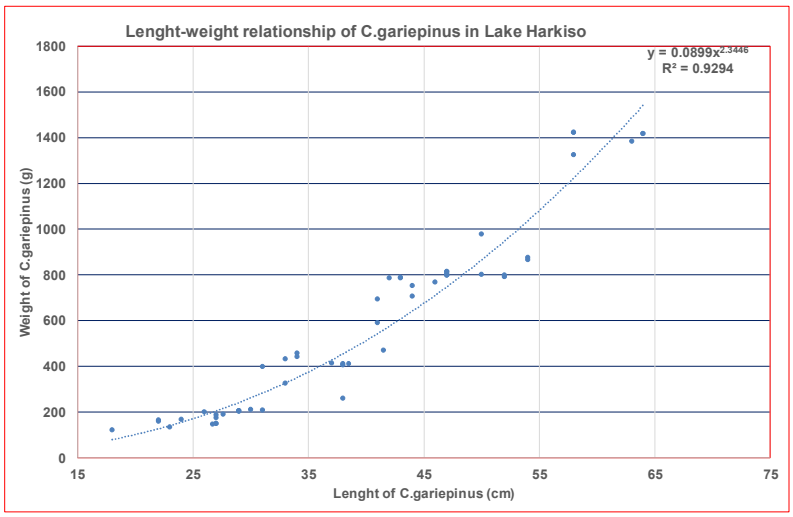

Fig 3: Length-weight relationship of *C.gariepinus in* Lake Harkiso.

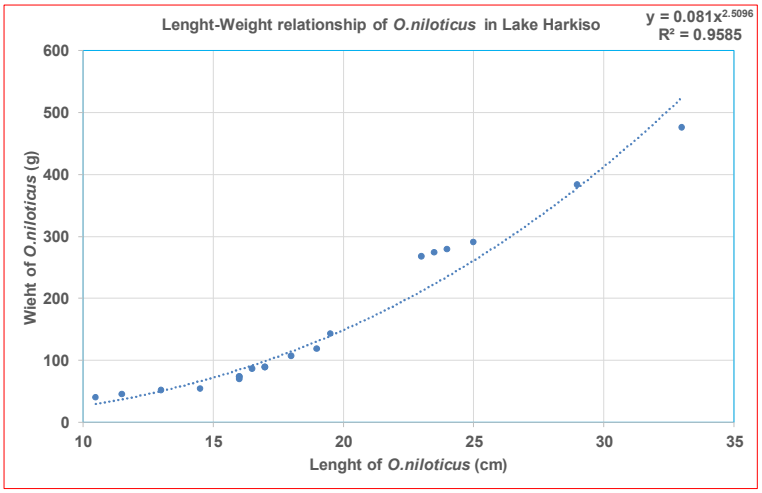

Fig 4: Length- weight relationship of *O.niloticus*in Lake Harkiso

Estimation of *O.niloticus* and *C.gariepinus* fish maturity (L_{50}) from Lake Harkiso

Out of total sampled *O.niloticus* fish (19), matured male ranged from 17 - 33 cm with average length of 19.35 ± 5.97 while mature female *O.niloticus* ranged from 10 - 29 cm with average total length of 16.68 ± 4.24. On the other hand, matured male *C.gariepinus* ranged from 27 - 64 cm with average length of 47.56 ± 11.20 while matured female *C.gariepinus* ranged from 24 - 63 cm with average total length of 39.17 ± 10.11 (Table 4).

Table 4: Length (cm) categories of matured *O.niloticus* and *C.gariepinus* fish in Lake Harkiso

Fish length (cm) categories	*O. niloticus*	*C. gariepinus*
Male length ranges (cm)	17 - 33	27 - 64
Male average length class (cm)	19.35 ± 5.97	47.56 ± 11.20
Female length ranges (cm)	10-29	24-63
Female average length class (cm)	16.68 ± 4.24	39.17 ± 10.11

Percent of mature and immature *O.niloticus* and *C.gariepinus* from Lake Harkiso

From all *O.niloticus* fish captured with the experimental nets in this study, about 74% were matured and the remaining (26%) were sexually immature. In similar way, 70% of the total catches of *C.gariepinus* were sexually matured and the remaining 30% were immature (Fig 5).

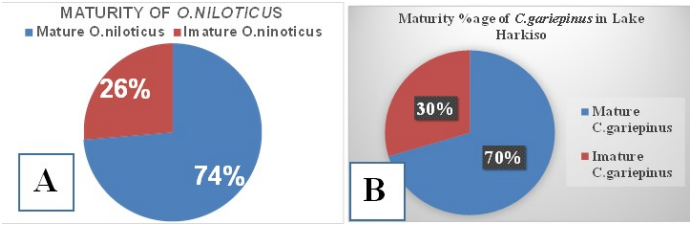

Fig 5: Maturity % of *O.niloticus* (A) and *C.gariepinus*(B) captured with experimental nets in Lake Harkiso

Gear selectivity

Gear selectivity refers to a fishing gear's ability to target and capture certain species, sizes, or sexes of fish while allowing incidental by catch to escape unharmed.

In the present study, among the different mesh-sized fishing nets used (6 cm, 8 cm, 10 cm, and 12 cm stretched mesh sizes), only two categories of multifilament fishing nets (6 cm and 8 cm) caught *O. niloticus*, with the majority (84%) of the fish being caught by the 6 cm mesh (Fig. 6A). Unlike *O. niloticus*, *C. gariepinus* were caught using a wider range of gill nets (8 cm, 10 cm, and 12 cm) (Fig. 6B). The majority of the *C. gariepinus* catch (39%) was obtained using a 12 cm monofilament mesh.

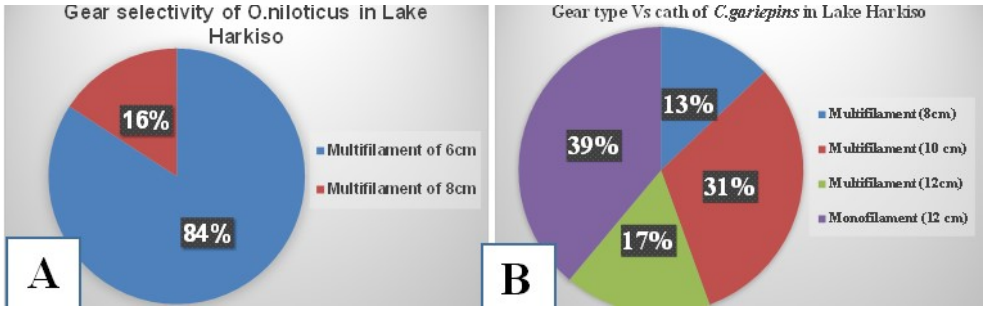

Fig 6: Gear selectivity of *O.niloticus* (A) and *C.gariepinus*(B) in Lake Harkiso

Conclusion and recommendations

From the current findings it possible to conclude that, the fish production potential of the Lake Harkiso is 6 tons/year. The lake consists of only two commercially fish species (*O.niloticus* and *C.gariepinus*) catch dominated by *C.gariepinus*. Sex ratio of the two fish species are not deviated from 1:1. the fish growth because length weight relationship of the two fish species showed negative isometric growth perhaps due to the inadequate natural feed in the lake to support proper fish growth. Both fish species caught by using different sized gillnets are at their maximum size (majority of the catch were matured) and L_{50} of both fish species were in a good range.

As a recommendation, fishermen group can use multifilament gill net of 6 cm and 8 cm mesh size if they target *O.niloticus* without impacting immature fish. In the same way, fishermen can use multifilament and monofilament of 12 cm mesh size, if they target *C.gariepinus* without impacting immature fish. The Lake can accommodate about 6 fishermen without overharvesting the resource assuming one fisherman harvesting only 3kg/day.

This work is a preliminary, only conducted for one year. All important fishing parameters were not deployed in this study due to security issues in the area. So, other fishing gears like different size long line, smaller mesh size mono and multifilament (<6cm) parameters were not evaluated. So, if security problem is resolved, it is important to include all fishery biology and gear selectivity studies to have clear image of the fishery of Lake Harkiso.

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