International Journal of Engineering Research & Management Technology
ISSN: 2348-4039
January-February-2023 Volume 10, Issue-1
Email: editor@ijermt.org
www.ijermt.org

STUDY THE REPRODUCTIVE BIOLOGY AND POPULATION CHARACTERISTICS OF FISH

Dr. Dhankesh Meena

Assistant professor, scrs government college

Sawai Madhopur (Rajasthan)

ABSTRACT.

During the period of March 2015 to February 2016, the research project that investigated the reproductive biology of commercially important fish species in Lake Langeno, Ethiopia, was carried out. Gillnets with varying mesh sizes and long lines were used to capture fish samples from a variety of sampling locations where fish were collected. The total number of fish specimens that were gathered was 4207. According to the observations, the peak breeding season for Oreochromis niloticus, Clarias gariepinus, Labeobarbus intermedius and Cyprinus carpio Linnaeus 1758 was seen to be between the months of April and June, May and July, June and July, and March and May, respectively. Their respective L50 measurements were as follows: 16.4 cm and 15.8 cm TL for females, 28.5 cm and 29.5 cm TL for males, 30.5 cm and 29.5 cm FL for females, and 28.2 cm and 27.6 cm FL for males at the same time. Among the fish species, the mean fecundities were found to be 463.83 ± 114 eggs per fish, 141466 ± 40982 eggs per fish, 3055 ± 2234 eggs per fish, and 105631 ± 46680 eggs per fish, respectively. It was shown that the link between fecundity and total or/fork length was curved for all fish species. On the other hand, the association between fecundity and total weight was linear for O. niloticus, L. intermedius, and C. carpio, but curvilinear for C. gariepinus (r2 > 90). The analysis of variance (ANOVA) revealed that there was a noteworthy temporal fluctuation in the GSI for every species of fish (P < 0.05). As a result of the short L50 of the majority of fishes, it also demonstrated the dominance of fishes of smaller sizes. It is therefore necessary to implement efficient management in order to enhance the situation of fishes in the lake.

Keywords: *reproductive biology, population characteristics of fish.*

INTRODUCTION

When it comes to the evaluation and management of fish stocks, the features of fish populations, particularly those that pertain to the reproduction of fish, are extremely essential inputs. in order to conduct stock evaluations that are credible, it is necessary to make certain that the underlying parameters have been estimated in a manner that is accurate and precise, based on unbiased sample collections and robust estimation procedures. There are a number of management measures that are entirely dependent on the reproductive characteristics of stocks. These measures include the minimum landing size (MLS), closed fishing seasons, closed areas, and the mandatory release of egg-bearing females of certain species of decapod crustaceans (for example, European Regulation 1967/2006; Moroccan Royal Decree 1-73-255 of 1973).

The number of publications that have been published in the primary literature that are concerned with the reproductive biology of fishes has gradually increased over the course of time (for the Mediterranean Sea, Tsikliras and Stergiou unpublished**). Since 2002, the number of such articles has averaged more than 1100 pieces per year around the world. On the other hand, this information is available in a broad variety of formats, making it challenging to assemble and analyze.

We provide recommendations on various aspects of the reproductive biology of fishes (such as sampling, reporting, and statistics) in this editorial note, just as we did with the one on weight–length relations of fishes. These recommendations may be useful in the planning of research, the analysis of data, the presentation of findings, and the preparation of manuscripts.

OBJECTIVES

1. To study reproductive biology.
2. To study population characteristics of fish.

Reproductive biology

Over the course of human history, fishing has been one of the activities that has allowed people to survive. Economic revenue and job opportunities can be found through fishing. Through the provision of halieutic protein, it has the potential to significantly improve nutritional health. The majority of Côte d'Ivoire's fishing grounds are created by humans in the form of lakes. There are fishing activities that take place in the man-made lakes of Taabo, Kossou, and Faé throughout the entire year, throughout each and every month. As a result of this extended fishing time, several bodies of water have been overfished. Particularly, this overexploitation is reflected in the fact that the average size of the fish species has decreased in comparison to the size of the same species found in the other pools, that large individuals have vanished, and that the daily catches have sharply decreased despite the fact that the fishing gear that is being used has become more effective. The authors Gourène et al. state that the overexploitation of aquatic fauna, notably fishes, in continental African aquatic settings, which is caused by fishing and pollution from a variety of sources, puts the sustainability of fishing in jeopardy. Côte d'Ivoire's primary continental fishing activities take place in reservoirs, which are located throughout the country.

These lake habitats are being exploited in an abusive manner, which constitutes a severe hurdle that has the potential to have a profound effect on the regular biological activities of species, such as growth and reproduction. Certain fish populations adopt adaptation methods in response to pressures brought on by overexploitation. These tactics include the management of growth and reproduction, both of which are particularly important. For a species of fish to be able to successfully reproduce, it is necessary for that species to exhibit a particular collection of features that constitute its reproductive strategy. An overall model of species-specific reproduction, reproductive strategy encompasses a wide range of life cycle features, including as age, size at first sexual maturity, gonadal development, fecundity, oocyte size, reproductive period, and oviposition period. Reproductive strategy is also an overall model of speciesspecific reproduction. The amount of food available, the degree of pressure in fishing, and the conditions of the habitat can all have an effect on some life cycle traits. Therefore, having an understanding of these life cycle characteristics of fish species is a vital tool that can provide pertinent information for the establishment of regulations governing fisheries management. These regulations are intended to enable sustainable exploitation of fisheries as well as the conservation and preservation of fish and biological stocks. After several years of exploitation, it would therefore be important, both ecologically and managerially, to control the reproduction period of the fish species targeted by fishing. This would be done in order to improve the management of the fishery resources of these lakes and ensure that they are exploited in a sustainable manner (Taabo, Kossou, and Faé). In light of this, the purpose of this study is to investigate the reproductive features of the primary fish species that are caught in the lakes of Taabo, Kossou, and Faé. To be more explicit, the objective is to ascertain (1) the sizes of the initial sexual maturity and the first capture, and (2) the duration of the reproductive cycle. In the second place, these preliminary findings will make it possible for us to suggest a management strategy for the three lakes that will allow for sustainable fishing.

Research Methodology

Study area

Lake Langeno is one of the lakes that are found in the Ethiopian rift valley. It is situated in the state of Oromiya, between the Western Arsi zone and the East Shoa zonal Administration, and it is situated around 200 kilometers south of the capital city of Addis Ababa. In the north, the Arsi Negelle District is surrounded by the Adami Tullu Giddo Kombolcha District, which is located between 7°36'N and 38°43'E at an elevation of 1585 meters above sea level. The district is surrounded by the south, west, and east. The lake has a maximum depth of 48 meters and an average depth of 17 meters, making it a significantly deep body of water. It covers an area of around 240 square kilometers. The eastern portion of the lake is surrounding by the Munisa Forest, which is part of the Eastern Langeno Nature Reserve. In addition to runoff and hot springs, the lake receives water from a number of tiny perennial rivers that originate in the highlands of the Arsi Mountains. These rivers include the Lepis, Gedemso, Garabula, Metti, Tufa, and Sedesedi rivers. the River Hora-Kelo drains Lake Langeno and then joins Lake Abijata on the western side of the lake. It is estimated that the volume of water that is brought in by these rivers and hot springs is approximately 533.4 million m3, whereas the volume of water that is discharged is around 527.9 million m3 annually.

As is the case with other lakes in the Ethiopian rift valley, the water chemistry of this lake is comparable to that of other lakes in the region, where the predominant cations and anions are Na+ and CO3 2-, respectively. According to the lake's mean conductivity, it is approximately 1632 µS cm-1. The lake has a salinity that is likewise quite high, coming in at approximately 9.4 mg L-1. The lake is home to a wide variety of plant and animal species, making it a vital habitat. There are dense blooms of phytoplankton, primarily Cyanophytes, that are characteristic of the lake. In spite of this, the lake has a very low phytoplankton biomass, which is measured at 1.6 mg L-1, and a very low productivity, which is measured at 2 µg L-1, according to Belay and Wood 1984. The assemblage of zooplankton is primarily composed of species belonging to the Cladocera and Copepoda families.

Study design and sample site selection

Between the months of March 2015 and February 2016, this study was carried out. Six sample sites were chosen for the collection of data. One of the sites was chosen from the middle of the catchment area, and the other five were chosen from shore areas. The selection of these sampling sites was based on the number of fisherman in the region, the distance from the coast, the depth of the lake, the distance from the road, and the human activities that occurred in the catchment area. A labeled rope that was tied with weight at each sampling location was used to assess morphometric variables of the lake, such as the average and maximum depth. These measurements were taken during both the wet and dry seasons of the lake's life cycle. For the purpose of delineating the positions of the sampling sites, the Global Positioning System (GPS) was utilized (Fig. 1).

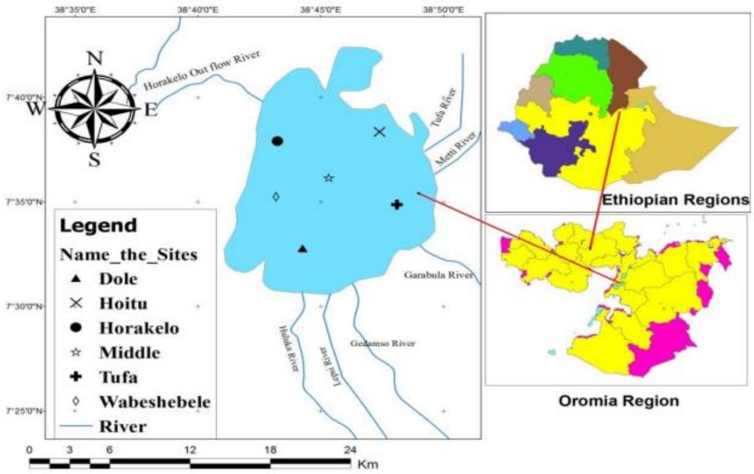


Fig. 1. Selected sites for collection of fish samples from Lake Langeno, Ethiopia.

Fish sampling method

During the period of one year, beginning in March 2015 and ending in February 2016, fish samples were collected from the six sites that were chosen. Several different mesh sizes of gillnet, including six centimeters, eight centimeters, ten centimeters, and twelve centimeters, were utilized at each sample station. The length of the panel was twenty-five meters, and the depth was one and a half meters. In addition, extended lines with hook sizes of 9 and 11 were utilized in order to successfully capture the species of fish that were of a large size.

At depths more than ten meters, two nets were utilized: one net was placed at the top, and the other net was placed at the bottom. The setting for the bottom net was between 10 and 15 meters. The captures were gathered the following morning two hours after sunrise (Imam et al. 2010). The nets were set up roughly two hours before dusk, and they were left hanging overnight. At each and every sample occasion, the total number of fish that were caught was recorded. In order to make an immediate comparison between the length of the fishes and their reproductive characteristics, the total length of the fishes was measured to the nearest 0.1 centimeters using a measuring board, and the weight was measured using a scale with a sensitivity of 0.1 grams. After dissecting all of the fishes that were collected, the sexes of the individual fish specimens were visually separated from one another. According to the maturity indices of fish, the size, look, form, texture, and color of the gonads were used to determine the maturity stages of various fish species. A variety of fish species were evaluated. As soon as the fish reached maturity, the gonads were extracted and stored in formalin at a concentration of ten percent. Following the placement of the fish samples and the preserved gonads in plastic jars containing 10% formalin, the jars were labelled and then transported to the Zeway Fishery Resources Research Center (ZFRRC) for additional analysis.

Identification of fish species

A solution of tap water was used to soak the specimens in order to remove the formalin. Following a period of several days, the specimens were then moved to a solution containing 75% ethanol prior to the identification of the species. the fishes that were taken were identified to the species and genus level at the ZFRRC laboratory.

Estimation of sex-ratio, breeding season and gonadosomatic index

in each station, the proportion of fishes that represented the five-point maturity scales was estimated based on the gender of the fish. The sex ratio, which is the ratio of females to males, was determined for each species of fish as well as for the total samples. According to the breeding season of all fishes that were sampled was established by calculating the percentage of fishes that had ripe gonads that were sampled in each month. This percentage was computed as follows: MSi% = MSi ∑ MSi 5 i=1 1004

Where: MSi% = the percent fish with maturity stage 1

MSi = number of fish in maturity stage 1

∑ MSi = total number of fish of all maturity stages (1 to 5)

The gonado somatic index (GSI) was also computed for each fish species to determine their breeding season (Armstrong et al. 2004; Wudneh 1998). The GSI was calculated as:

$$GSI = (GW/TW - GW) \times 100$$

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

Estimation of length at sexual maturity (L50)

Based on the length of fishes that had matured gonads, a research was carried out to determine the length at which fish are fifty percent sexually mature (L50).

Estimation of fecundity

In order to determine the fertility of fish, an estimation was performed on female fishes that had matured gonads (the stage of maturation of V ovaries). The gonads of mature female fishes were removed and stored in Gilson's fluid after they had reached their full maturity. A delicate balance was used in the laboratory to weigh the gonads (eggs) of each ripening female fish. This was done after vigorous shaking of the fish. The weight was determined to the nearest 0.01 g. Following the removal of the ovarian membranes using mechanical means, the preserved ovaries were rinsed with tap water again. The total number of eggs was counted in order to determine the fecundity of O. niloticus using this method. On the other hand, for C. gariepinus, L. intermedius, and C. carpio, three sub-samples of one gram of eggs per ovary were counted, and the total number of eggs per ovary was determined by extrapolation. For the purpose of calculating the total number of eggs, the following formula was utilized:

$N/n = W/w$, from which $N = (nW)/w$

Where, N - Total number of eggs, n - Number of eggs in sub sample (=1000), W - Weight of all eggs (g) and w - Mean weight of the sub sample (g)

In the end, the mean fecundity of each species of fish was calculated by taking their entire length, also known as their fork length, and their total weight.

Data analysis

The statistical software SPSS version 21.0 was used to perform the analysis on the data, and the results were presented using a variety of descriptive statistics. For the purpose of determining the monthly variation of the sex ratio, a Chi-square test was made. In addition, a one-way analysis of variance was utilized in order to examine the monthly fluctuation in fish fecundity and GSI. The final step was to conduct a regression analysis in order to determine the nature of the connection that exists between fecundity and the total/fork length as well as the total weight of the fish.

Result and Discussion

Fish species composition

In all, 4207 fish specimens were gathered from the lake. These specimens included 50 males and 2257 females, and they belonged to seven different species that were classified into three families: Cyprinidae, Cichlidae, and Clariidae categories.

The Cyprinidae family, which included five different species and accounted for 55% of the total catch, became the dominant family in the fish communities, followed by the Cichlidae family. The most abundant species was Enteromius paludinosus with a percentage of 40.69 percent, followed by Oreochromis niloticus with a percentage of 39.41 percent. On the other hand, the species with the lowest abundance were Carassius carassius and Garra dembecha Getahun & Stiassny, 2007 (Table 1).

Table 1. The commercially important fish species composition collected from Lake Langeno, Ethiopia.

Family	Fish species	No. individuals			Percentage (%)
		Male	Female	Total	
Cyprinidae	Enteromius paludinosus (Peters 1852)	765	947	1712	40.69

	Labeobarbus intermedius (Rüppell 1835)	127	129	256	6.09
	Cyprinus carpio Linnaeus 1758	138	156	294	6.99
	Garra dembecha Getahun & Stiassny 2007	13	15	28	0.67
	Carassius carassius (Linnaeus 1758)	17	10	27	0.64
Cichlidae	Oreochromis niloticus (Linnaeus 1758)	778	880	1658	39.41
Clariidae	Clarias gariepinus (Burchell 1822)	112	120	232	5.51
Total		1950	2257	4207	100

Sex ratio of the collected fish species

Due to the limited number of specimens obtained for C. carassius and G. dembecha, the sex ratio was evaluated for a total of 4152 fish specimens that were classified under five different fish species. These fish species were O. niloticus, E. paludinosus, C. gariepinus, L. intermedius, and C. carpio. Among these, 46.24 percent (n = 1920) corresponded to males, while 53.76 percent (n = 2232) were females. However, with the exception of L. intermedius, the sex ratio of all fish species was found to be significantly different from the supposed ratio of 1:1, as shown by a Chi-square value greater than one ($P < 0.05$). This was observed in Table 2.

Table 2. Number and the corresponding sex ratios of commercially important fish species collected from Lake Langeno, Ethiopia from March 2015 through February 2016.

Fish species	No. of individuals				
	Total	Female	Male	Sex ratio	Chi square
Oreochromis niloticus (Linnaeus 1758)	1658	880	778	1.13:1	2.72
Enteromius paludinosus (Peters 1852)	1712	947	765	1.24:1	6.35
Clarias gariepinus (Burchell 1822)	232	120	112	1.02:1	1.29

Labeobarbus intermedius (Rüppell 1835)	256	129	127	1.02:1	0.82
Cyprinus carpio Linnaeus 1758	294	156	138	1.13:1	1.84
Total	4152	2257	1950	1:16:1	2.14

Chi-square test is significant at $P < 0.05$

Maturity and breeding season of fish species in the lake

Due to the fact that the study of reproductive biology was mainly focused on economically important fish species (O. niloticus, C. gariepinus, L. intermedius, and C. carpio), a total of 2440 fish specimens were investigated for this study. Of these, 47.34 percent (n = 1155) were males, and 52.67 percent (n = 1285) were females. According to the findings, fish that had reached the maturity stage two (II) position were the most prevalent in both sexes of every species of fish. There were 8.9 percent of males and 10.3 percent of females with sexually mature gonads (IV) in O. niloticus, 28.3 percent and 19.4 percent in C. gariepinus, 17.7 percent and 18.5% in L. intermedius, and 11% and 23.1% in C. carpio, respectively, as shown in Figure 2. Across all fish species, there was no statistically significant difference in the proportions of maturity stages between the sexes ($\chi 2$; $P > 0.05$).

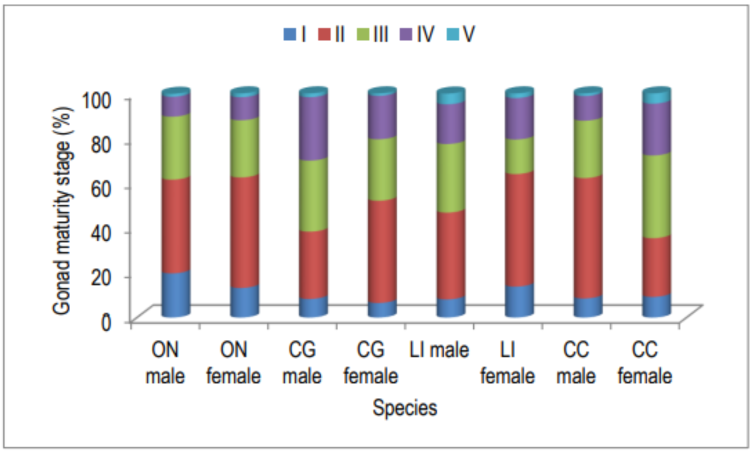


Fig. 2. The proportion of gonad maturity stages of commercially important fish species (%) in Lake Langeno, Ethiopia (ON = Oreochromis niloticus, CG = Clarias gariepinus, LI = Labeobarbus intermedius and CC = Cyprinus carpio).

It is worth noting that the fraction of fishes that possess fully formed gonads exhibited a noteworthy temporal variation across all species, as indicated by the statistical analysis ($\chi 2$; $P < 0.05$). For example, between the months of April and June, May and July, June and July, and March and May, a significant number of fishes with completely grown gonads (IV) were observed. This was the case for O. niloticus,

C. gariepinus, L. intermedius, and C. carpio, respectively. The months of October to November, October to December, October to December, and September to November resulted in the collection of the fewest number of fishes that had fully grown gonads, as shown in Figure 3.

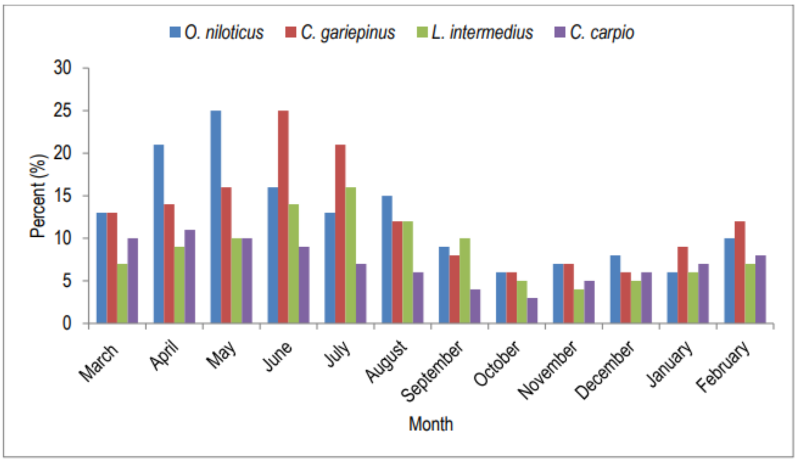
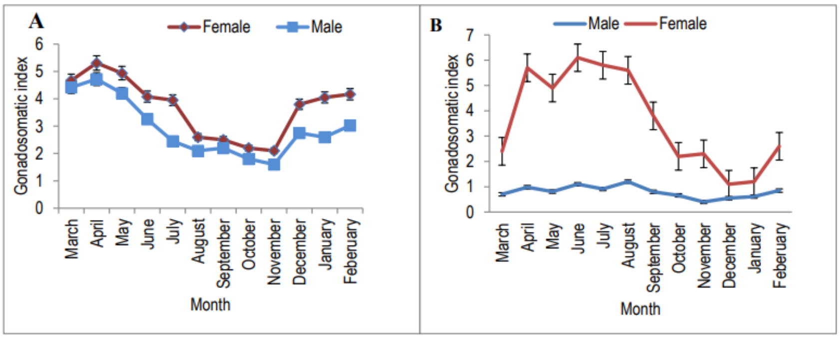


Fig. 3. Monthly distribution of commercially important fishes with ripe gonads collected from Lake Langeno, Ethiopia.

Gonadosomatic index (GSI) of fishes

From 2.1 to 5.31 (mean 3.75 ± 1.13) for females, the monthly variation of GSI for O. niloticus ranged from 1.6 to 4.72 (mean 2.93 ± 1.04) for males. This range was observed for both genders. (Fig. 4A) The GSI was found to be at its maximum in the month of April, while it was at its lowest in the month of November. Similarly, the GSI value of C. gariepinus varied from 1.1 to 6.1 (mean 3.64 ± 1.89) for females and from 0.4 to 1.2 (mean 0.79 ± 0.23) for males. The maximum GSI value was recorded in June, while the lowest GSI value was found in December (Fig. 4B). For females, the GSI values of Labeobarbus intermedius varied from 2.31 to 5.98 (mean 3.44 ± 1.09), while for males, the GSI values ranged from 1.89 to 5.18 (mean 3.69 ± 1.07), with the highest and lowest GSI values being scored in July and December, respectively (Fig. 4C). The GSI values of C. carpio ranged from a minimum of 7.3 and a high of 12.2 (mean 9.72 ± 1.39), respectively, for females. Furthermore, the GSI values for males were 2.1 and 4.8 (mean 3.63 ± 0.85). The month of May, which had the highest GSI value, was followed by the month of November, which had the lowest value (Fig. 4D). There was a noteworthy temporal fluctuation in GSI found across all fish species, as indicated by the analysis of variance (ANOVA) ($P < 0.05$). However, there was no significant difference observed between the sexes (ANOVA, $P > 0.05$).



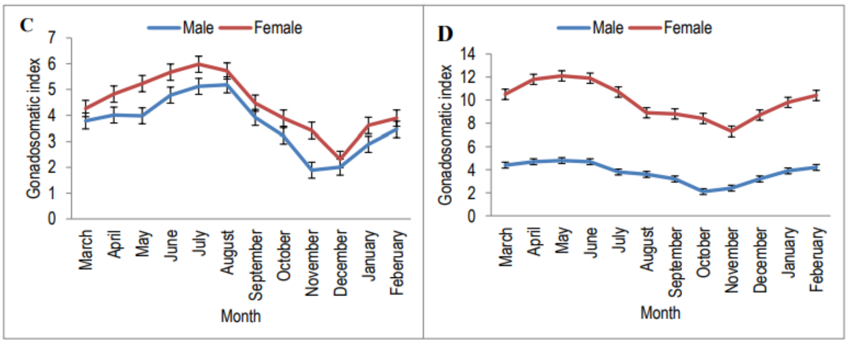


Fig. 4. Mean monthly variation of gonadosomatic index of commercially important fish species (A. Oreochromis niloticus, B. Clarias gariepinus, C. Labeobarbus intermedius, D. Cyprinus carpio) in Lake Langeno, Ethiopia.

Length at sexual maturity (L50)

In this study, the smallest sexually matured female and male that were captured were 12.8 cm and 13.5 cm TL for O. niloticus, 24.5 cm and 25.5 cm TL for C. gariepinus, 17.5 cm and 18.3 FL for L. intermedius, and 19.3 cm and 20.5 cm FL for C. carpio. These measurements were taken from the tail length of the fish. The total weights of the two individuals were as follows: 52 g and 63.2 g, 318 g and 271 g, 149.6 g and 162 g, and 147.2 g and 165 g, respectively. For both female and male O. niloticus, C. gariepinus, L. intermedius, and C. carpio, the length at 50% sexual maturity (L50) was determined to be 16.4 cm and 15.8 cm TL, 28.5 cm and 29.5 cm TL, 29.5 cm and 30.5 cm FL, and 28.2 cm and 27.6 cm FL, respectively (Figs. 5–8). These measurements were obtained according to the length at 50% of the sexual maturity.

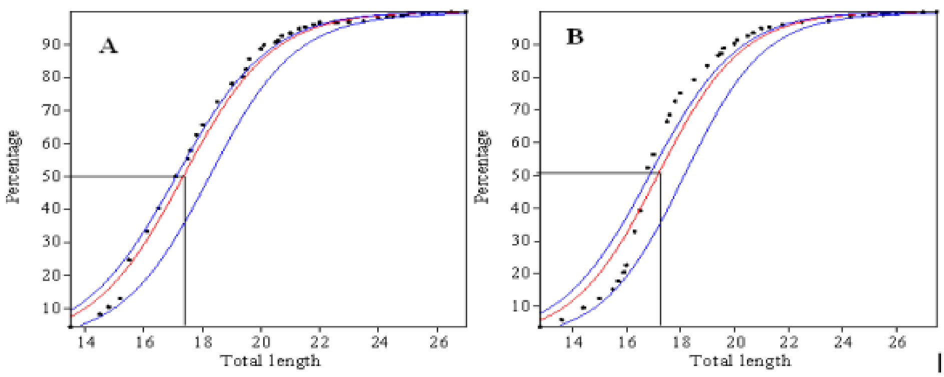


Fig. 5. Length at sexual maturity (L50) of Oreochromis niloticus (A = male and B = female) in Lake Langeno, Ethiopia. The dotted line represents the observed value, the red line represents the logistic curve and the blue line represents the 95 % CL.

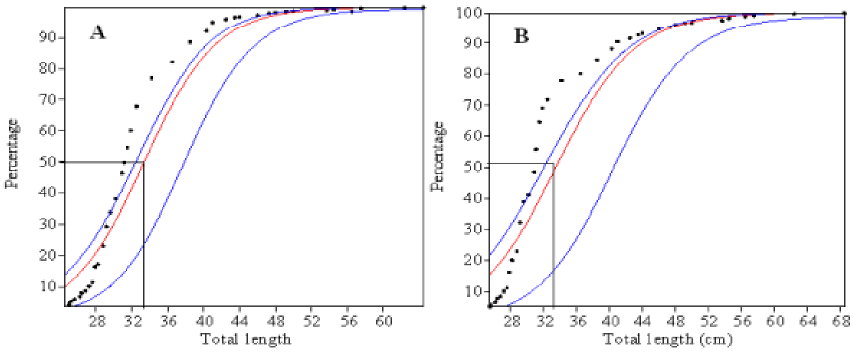


Fig. 6. Length at sexual maturity (L50) of Clarias gariepinus (A = male and B = female) in Lake Langeno, Ethiopia. The dotted line represents the observed value, the red line represents the logistic curve, and the blue line represents the 95 % CL.

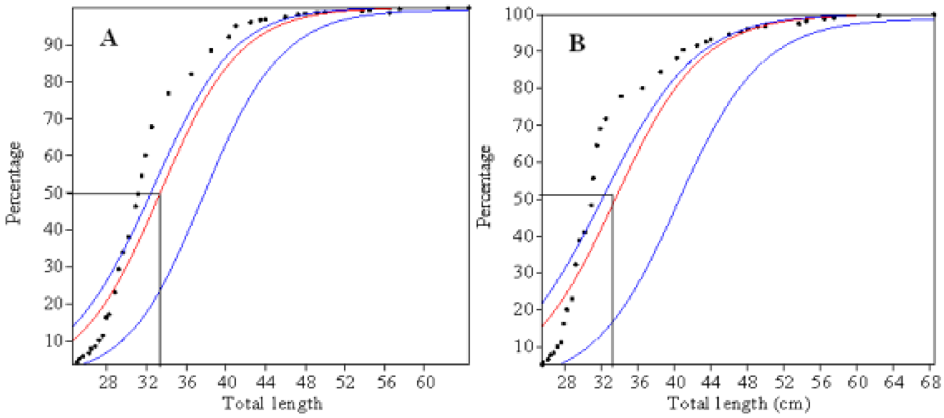


Fig. 7. Length at sexual maturity (L50) of Labeobarbus intermedius (A = male and B = female) in Lake Langeno, Ethiopia. The dotted line represents the observed value, the red line represents the logistic curve, and the blue line represents the 95 % CL.

Fecundity

There were 126 ripe females of O. niloticus, 32 females of C. gariepinus, 33 females of L. intermedius, and 36 ripe females of C. carpio that were evaluated for fecundity. O. niloticus, C. gariepinus, L. intermedius, and C. carpio each had a total or fork length that ranged from 12.8 cm to 27.5 cm TL, 24.5 cm to 68.5 cm TL, 17.5 cm to 51.5 cm FL, and 19.3 cm to 51.5 cm FL, respectively. The length of the forks of the fish species that were considered for this study was also measured. In addition, the total weights of these individuals were discovered to fall within the ranges of 52.4 to 347 g, 318 to 2189 g, 162.5 to 1156 g, and 147.2 to 1604.3 g, respectively. For O. niloticus, their total fecundity ranged from 427 to 1132 eggs, while for O. niloticus, it was between 187 and 978 eggs.g-1 with an absolute fecundity ranging from 82600 to 211442 eggs for C. gariepinus, 1078 to 6532 eggs for L. intermedius, and 681 to 1922 eggs for L. intermedius species.for C. carpio, with an absolute fecundity ranging from 32749 to 392487 eggs per population. Among the fish species under consideration, the average fecundity was found to be 463.83 ± 114 eggs, 141466 ± 40982 eggs, 3055 ± 2234 eggs, and 105631 ± 46680 eggs, respectively. From the analysis of variance (ANOVA), it was observed that there was a noteworthy disparity in fecundity between the various lengths and species ($P < 0.05$).

Conclusion

The current investigation came to the conclusion that the mating season for the many species of fish that live in Lake Langeno is throughout the entire year. Their precise peak breeding time, on the other hand, was very varied from one another. This is primarily due to the seasonal fluctuations and the availability of meals in the area that researchers were studying. The majority of fish species had their most productive reproductive periods around the beginning of the rainy season and throughout the rainy season itself. This means that the majority of the fish species found in this lake had a very short length at the time of sexual maturity in comparison to the lengths of the fish species found in other bodies of water that are comparable. Furthermore, the fertility of the majority of the species was lower than that of those dwelling in other lakes that were comparable. This revealed that the fish species that live in this lake are residing in an environment that is difficult for them to survive, which may be the result of either natural or human forces. In order to guarantee the long-term viability of the resources, the findings of this study suggest that there should be a greater emphasis placed on the establishment of efficient management systems, in addition to the implementation of additional monitoring programs.

References

1. Abera, L. 2016. Current status and trends of fishes and fishery of a shallow rift valley Lake, Lake Zeway, Ethiopia. PhD dissertation submitted to Department of Zoological Sciences, Addis Ababa University, Ethiopia. 206 pp.

2. Jennings S., Dulvy N.K. 2018. Beverton and Holt's insights into life history theory: influence, application and future use. Pp. 434–450. In: Payne A.I., Cotter A.J.R., Potter E.C.E. (eds.) Advances in fisheries Science: 50 years on from Beverton and Holt. Blackwell Publishing, Oxford, UK. DOI: 10.1002/9781444302653.ch18

3. Morgan M.J. 2018. Integrating reproductive biology into scientific advice for fisheries management. Journal of the Northwest Atlantic Fisheries Science 41: 37–51. DOI: 10.2960/J.v41.m615

4. Tsikliras A.C., Antonopoulou E., Stergiou K.I. 2020. Spawning period of Mediterranean marine fishes. Reviews in Fish Biology and Fisheries 20 (4): 499–538. DOI: 10.1007/s11160-010-9158-6

5. Tsikliras A.C., Antonopoulou E. 2016. Reproductive biology of round sardinella (Sardinella aurita) in the north-eastern Mediterranean. Scientia Marina 70 (2): 281–290.

6. Sadovy de Mitcheson Y., Liu M. 2018. Functional hermaphroditism in teleosts. Fish and Fisheries 9 (1): 1–43. DOI: 10.1111/j.1467-2979.2007.00266.x

7. Núñez J., Duponchelle F. 2019. Towards a universal scale to assess sexual maturation and related life history traits in oviparous teleost fishes. Fish Physiology and Biochemistry 35 (1): 167–180. DOI: 10.1007/s10695-008-9241-2

8. Diarra A. Kossou: Un pôle de production halieutique en décadence. Revue Espace, Territoires, Sociétés et Santé. 2020;3(5):79-91.

9. Ouattara M, Diomandé D, Boussou KC, Gourène G. Stratégies de reproduction de Marcusenius ussheri (Pisces, Mormyridae) en fonction des conditions hydrologiques créées par la construction du barrage hydroélectrique d'Ayamé I sur le cours principal de la rivière Bia (Côte d'Ivoire). Belgian Journal of Zoology. 2020;140(1):11-19.

10. Tah L, Da Costa KS, Kouassi JN, Moreau J. Effort de pêche et production piscicole au lac d'Ayamé I (Bassin de la Bia; Côte d'Ivoire) après le départ des pêcheurs « bozos ». Agronomie Africaine. 2019;21(1):103-115.

11. Ouattara M, Diomandé D, Boussou KC, Gourène G. Stratégies de reproduction de Marcusenius ussheri (Pisces, Mormyridae) en fonction des conditions hydrologiques créées par la construction du barrage hydroélectrique d'Ayamé I sur le cours principal de la rivière Bia (Côte d'Ivoire). Belgian Journal of Zoology. 2020;140(1):11-19.

12. Pathak BC, Ali R, Serajuddin M. Comparative Analysis of Reproductive Traits in Barred Spiny Eel, Macrognathus pancalus (Hamilton, 1822) from Lotic and Lentic Ecosystems of Gangatic Basin, India. World Journal of Fish and Marine Sciences. 2021;4(5):470-479.

13. Aliko NG, Da Costa KS, Konan KF, Ouattara A, Gourène G. Fish diversity along the longitudinal gradient in a man-made lake of West Africa, Taabo hydroelectric reservoir, Ivory Coast. Ribarstvo. 2019;68(2):47-60.

14. Kouassi KL, Goné DL, Meledje NH, Wognin AV, Aka K. Hydrologie et évolution spatio-temporelle des charges solides en suspension dans le lac du barrage hydroélectrique de Taabo (Côte D'Ivoire). European Journal of Scientific Research. 2017;18(3):464-478.

15. Niyonkuru C. Etude comparée de l'exploitation et de la démographie des poissons Cichlidés dans les lacs Nokoué et Ahémé au Bénin. Thèse de Doctorat, Université d'Abomey-Calavi, Bénin. 2017, 199.

16. Atse BC, Konan KJ, Kouassi NJ. Biologie de la reproduction du Cichlidae Tylochromis jentinki dans la lagune Ebrié (Cote d'Ivoire). Cymbium. 2019;33(1):11- 19.

17. Ouattara M, Doumbia L, Yao K, Gourène G. Reproduction du poisson-chat africain Schilbe mandibularis (Günther 1867) (Siluroidei ; Schilbeidae) en mileix lacustre et fluviatile (Côte d'Ivoire). Livestock Research for Rural Development. 2018;20(1).

18. Berté S, Kouamélan EP, Ouattara NI, Koné T, Goore BG, N'Douba V, et al. Cycle de reproduction et fécondité de Distichodus rostratus (Characiformes, Distichodontidae) dans un bassin ouest africain (fleuve Bandama, Côte d'Ivoire). Tropicultura. 2018;26(2):104-107.