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A Comparison of the Reproductive Patterns of *Oreochromis niloticus* from Two Distinct Locations: Wadi Halfa, Sudan, and Aswan, Egypt

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ABSTRACT

Reproduction is among the most vital biological processes in the life cycle of any organism, such as fish. The biology of *Oreochromis niloticus* reproduction in Lake Nasser and Lake Nubia was studied using different mesh sizes of gill nets. A total of 480 *Oreochromis niloticus* were caught from Lake Nasser, Egypt, and 369 from Lake Nubia, Sudan, from January through December 2021. Sex ratio size at first maturity and maturity stages of *O. niloticus* were examined. In Nasser's Lake, the sex ratio of male to female was 1:1.02, whereas in Lake Nubia, it was 1:0.89. The first maturity length in Lake Nasser was 27.5cm for males and 27cm for females, while in Lake Nubia, it was 32cm for males and 26cm for females. The gonado somatic index indicated that the species breeds in Lake Nasser and Nubia during summer and spring, respectively.

INTRODUCTION

Description of reproductive strategies is a topic in studying fish species' biology, population dynamics and evaluating the capacity of individual fish to reproduce. This will enhance conventional evaluations of numerous economically valuable fish species and broaden the understanding of the stock state **(Murua *et al.*, 2003)**. Fishery management relies heavily on fish reproductive biology **(Jakobsen *et al.*, 2009)**. The biological process through which a live organism acquires the traits of its parent for the purpose of maintaining the survival of the relevant species is known as reproduction **(Muchlisin, 2014)**.

The species' reproductive strategy is one of the most crucial biological characteristics that needs to be studied to manage fisheries resources. By maintaining a stable future for the recruitment and production of fish, the current population is proliferated **(Dinh, 2018)**. In recent decades, research on reproductive biology has gained popularity. Information on reproductive biology is useful not only for conservation but also for choosing fish targets in the wild to diversify fish species for the aquaculture

sector **(Muchlisin, 2013)**. Natural challenges encourage the fish to maximize their lifetime production of progeny and, more crucially, their offspring's survival until adulthood **(Murua & Sabodiro-Rey, 2003)**. Lake Nasser and the River Nile's interior fisheries are two water bodies of Egypt's critical suppliers of fish **(AbouelFadl & Farrag, 2020)**.

A few number of species are essential to Lake Nasser's fishery. According to research, only six species— *Sarothrodon galilaeus*, *Coptodon zillii*, *Oreochromis niloticus* **(Shalloof *et al*., 2020)**, *Alestes dentex, Lates niloticusand Hydrocyanic forskalii*—have an economic significance **(Mehanna *et al*., 2021)**. At least 80% of the overall catches in Lake Nubia's commercial fish landings are from the most common fish families: Bagridae (*Bagrus bayad* and *Bagrus docmac*), Centropomidae (*Lates niloticus*), Cyprinidae (*Labeo* sp.), and Cichlidae (*Tilapia* sp.) **(El-Shabrawy, 2009)**. Fish production of the lake is represented mainly by tilapia (67%), followed by pebbly fish "*Alestes* sp." (18%), then the Nile perch "*Lates nilotcus*" (8%) and tiger fish "*Hydrocynus* sp." (6%) **(Shalloof *et al*., 2020)**. In tropical and subtropical climates, including Egypt, thevital fish for the ecology is the Nile tilapia, *Oreochromis niloticus* (Pisces: Cichlidae). According to **Offem *et al*. (2007)**, it is the most recognized bony fish species in Africa and is credited with numerous advantageous traits. These traits include the ability to withstand low water quality, a large variety of foods, flexible delicious flavor, growth and firm flesh **(Fryer & Iles, 1972)**, long breeding seasons, and short generation times due to their reproductive nature **(Coward & Little, 2001; Peterson *et al.* 2004)**. Many documented studies on *Oreochromis niloticus's* reproductive biology have been conducted in various locations. These include the study by **Bakhoum (2002)** in Lake Edku, Egypt; **Shalloof and Salama (2008)** in Abu Zabal Lake, Egypt; **Hipro (2013)** in Lake Beseka, Ethiopia; and **Khallaf *et al.* (2020)** in Egypt's Bahr Shebeen Canal Delta. There has been little research on Lake Nasser, and features such as fish body weight, filleting yield, and flesh quality—especially in Lake Nubia—have not received much attention in Sudan. However, no study has combined both lakes, as the research has been fragmented, with a few Sudanese researchers in Lake Nubia, particularly **Ali (1993)** and **Hassan (1996)**. Therefore, examining *Oreochromis niloticus's* reproductive biology was the aim of the current investigation, which inhabits Lake Nasser and Lake Nubia. Specific focus was placed on the gonado-somatic index (GSI), sex ratio, size at initial maturity, and maturity stage.

MATERIALS AND METHODS

Study area

Along the Nile River, the 6,000km^2 Aswan High Dam Reservoir extends 500km, with two thirds of that area in Lake Nasser, Egypt, and a one third in Lake Nubia, Sudan. After Lake Volta in Ghana, Lake Nubia and Lake Nasser comprised the world's second-

largest man-made dam **(El Shahat, 2000)**. It reaches Aswan, Egypt, from Cataract at Dal in the Sudan. Wadi-Halfa is a city in the northern state of Sudan, close to the Egyptian border, on the banks of Lake Nubia.

Collected samples

Between January 2021 and December 2021, a total of 480 specimens of *Oreochromis niloticus* were obtained from Aswan, Gerf-Hussein, and Abo-Simple Port, and 369 were collected from Wadi-Halfa (Fig. 1). The samples were placed on crushed ice and immediately sent to the lab for additional examination. Every fresh specimen's weight (TW) and total length (TL) were estimated to the nearest centimeter and gram, respectively. The gonads of the dissected fish were removed and weighed to the nearest 0.00lg.

Ratio of sexes

The specimens were sexed by visual inspection; specimens without sex were kept apart, and the sex ratio (M: F) was calculated. The ratio of gonad weight to fish weight was used to calculate the maturity coefficient, commonly known as the gonado-somatic index (GSI), for each specimen **(Khallaf & Authman, 2010)** as follows:

GSI equals GW/TW x 100.

Where, TW is the total body weight (g), and GW is the gonadal weight (g) x 100

Assessment of sexual maturation

In addition to thread or immature stage, there are six maturity stages **(Mair *et al*. 2004)**. The stage of sexual development of the gonads was recorded based on the criteria developed by **Hörstgen-Schwark and Langhölz (1998)**.

Length (L50 or Lm) at initial sexual maturity

For each sex, distinct length classes of three centimeters were used to assess the length (L50), at which 50% of fish reached sexual maturity. An excel plot was made to display the frequency percentage of mature male and female *Oreochromis niloticus* compared to the mid-length during the spawning season (stages III, IV, or V) (Sendecor, 1956).

Analytical statistics

The excel's features in Office 2016 were used for statistical analysis, mathematical computations, and form drawing.

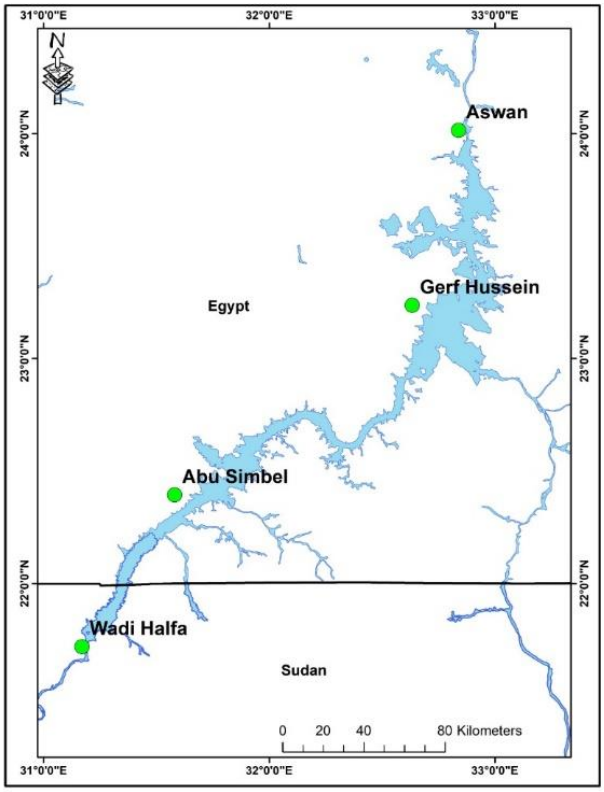


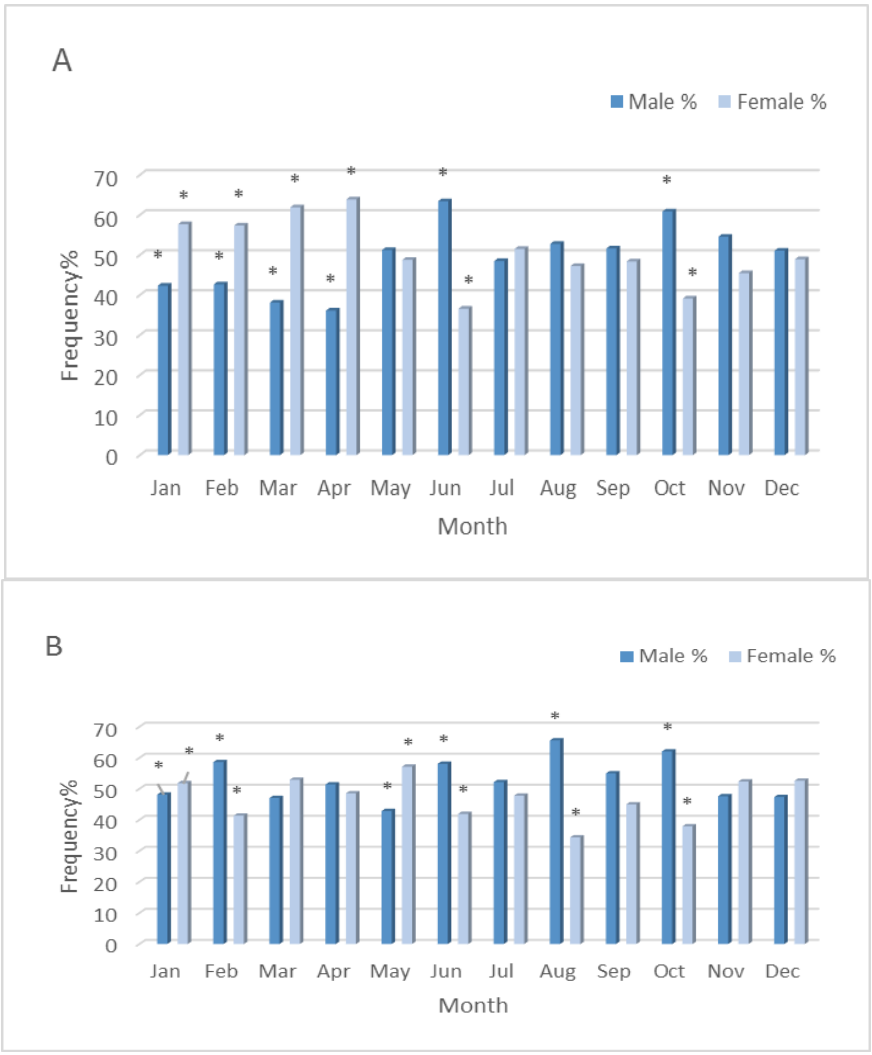
Fig. 1. Map showing the location of study in Egypt (Aswan, Gerf -Hussein, Abu Simbel) and in Sudan (Wadi- Halfa)

RESULTS

Sex ratio

Following the unsexed specimens' removal from the chosen locations, a total of 849 specimens were obtained from Lake Nasser (Egypt): 237 (49.37%) were males; 243 (50.62%) were females, and from Lake Nubia (Sudan): 187 (52.82%) were males, and 167 (47.17%) were females. Overall, *Oreochromis niloticus* had a male to female ratio of 1:1.02. (Lake Nasser) and 1:0.89 for *Oreochromis niloticus* (Lake Nubia).

In *Oreochromis niloticus* from Lake Nasser, the sex ratio fluctuated around 1:1 and deviated significantly at $P \leq 0.05$ during January at 1:1.36, February at 1:1.34, March at 1:1.62, April at 1:1.76, June at 1:0.57, and October at 1:0.64. In all the remaining months, there was no discernible deviation in the sex ratio from the expected 1:1 ratio. In Lake Nubia's *Oreochromis niloticus*, the sex ratio fluctuated around 1:1 and deviated significantly at $P \leq 0.05$ during January at 1:1.07; February at 1:0.70; May at 1:1.33; June at 1:0.72; August at 1:0.52; and October at 1:0.61. In all the remaining months, the sex ratio did not differ appreciably from the predicted 1:1 ratio. The male to female sex ratio for Lake Nasser and Lake Nubia through the months is shown in Fig. (2).



*Significant $P< 0.05$

Fig. 2. Monthly sex ratio of *Oreochromis niloticus* from **(A)** Lake Nasser in Egypt, and **(B)** Lake Nubia in Sudan

Gonado -somatic index (GSI)

The gonado-somatic index grew as both male and female gonads matured. Until they were fully developed, the index drastically declined in spawning and spent fish. *Oreochromis niloticus* from Lake Nasser recorded its maximum value in April at 2.597 for males and 2.666 for females, whereas *Oreochromis niloticus* in Lake Nubia peaked in April at 1.494 for males, and for females, it peaked in May at 2.418. However, the GSI's lowest value was recorded in December at 0.304 for males and 0.289 for females of *Oreochromis niloticus* from Lake Nasser, while it was in February at 0.409 for males and in July at 0.391 for females of *Oreochromis niloticus* from Lake Nubia. The GSI for both

male and female for *Oreochromis niloticus* from Lake Nasser and Lake Nubia in different months are represented in Fig. (3).

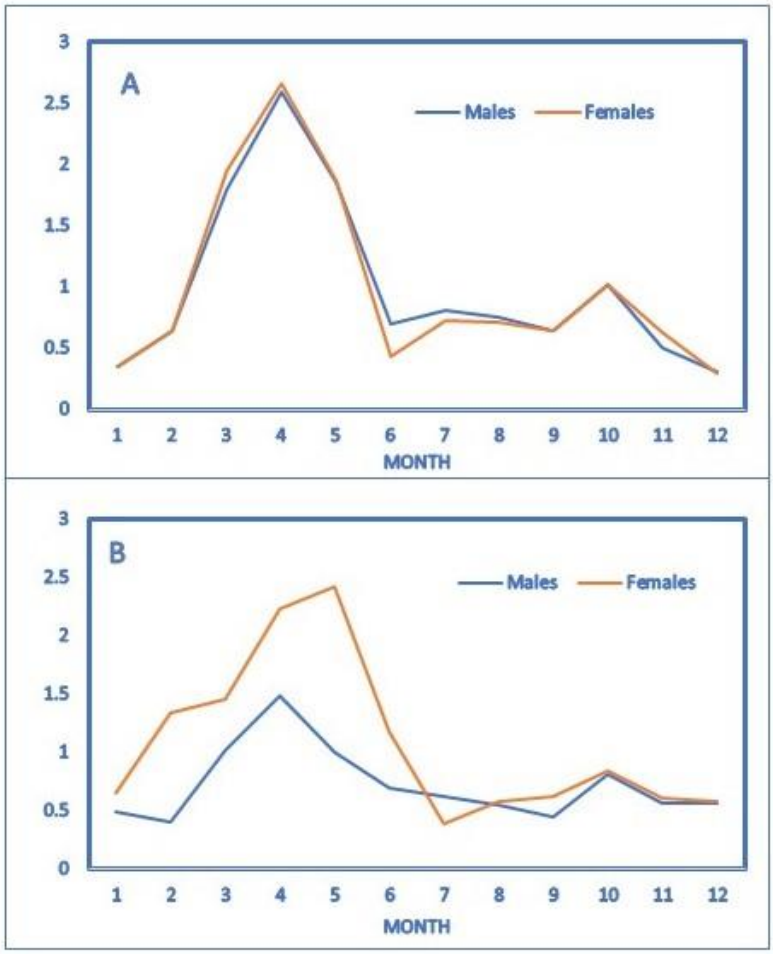


Fig. 3. *O. niloticus* gonado-somatic index (GSI) from Lake Nasser, Egypt, and Lake Nubia, Sudan

Stages of maturity

The phases of gonad maturity varied between males and females of *Oreochromis niloticus* from Lake Nasser and Lake Nubia. The percentage of overall samples from Lake Nasser accounted for 59.9% immature males, 40.08% mature males, 56.79% immature females, and 43.20% mature females. While, the males from Lake Nubia accounted for 58.28% immature, 41.71% mature, and the females accounted for 50.89% immature inactive and 40.1% mature. Fig. (4) shows the progression from the immature state to the ripe condition through distinct intermediate stages of maturation and ripening, together with the percentage of each gonadal developmental stage. The males gonadic stages for fish from Lake Nasser were: 37.55% stag I, 22.36% stage II, 18.14% mature (III), 4.64% ripe (IV), 7.17% spawning (V), and 10.12% spent stage (VI). For females

gonadic stages were: 28.8% stage I, 27.98% stage II, 20.16% mature (III), 7.81 ripe (IV), 6.17% spawning (V), and 9.05% spent sage (VI). The males gonadic stages for *Oreochromis niloticus* from Lake Nubia were: 32.62% stage I, 25.66% stage II, 20.32% mature (III), 5.88 ripe (IV), 5.88% spawning (V), and 9.62% spent stage (VI). The female gonadic stages for fish from Lake Nubia were: 21.55% stage I, 29.34% stage II, 22.75% mature (III), 8.38% ripe (IV), 6.58% spawning (V), and 11.37% spent stage (VI).

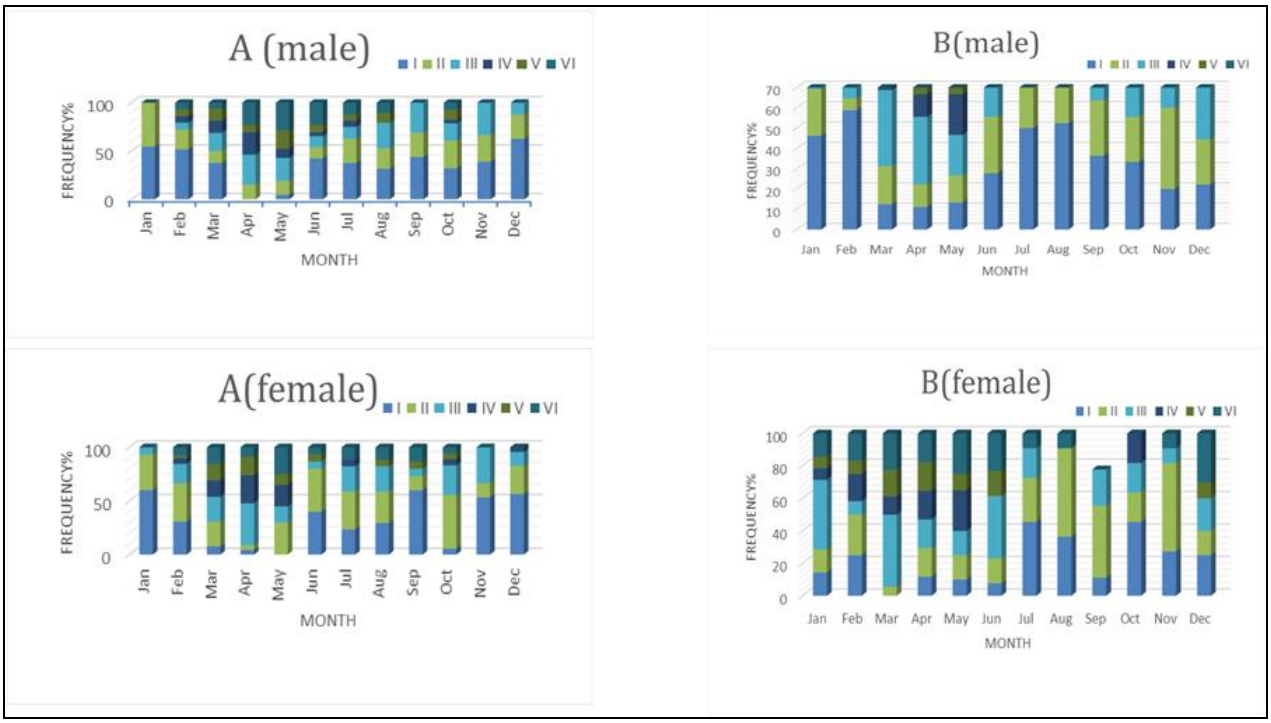


Fig. 4. Monthly variation in maturity stages of *Oreochromis niloticus* from **(A)** Lake Nasser, Egypt, and **(B)** Lake Nubia, Sudan, distributed monthly

Length at first sexual maturity

The percentage of maturity increased with length although the patterns varied depending on the research area. The length at first maturity for the mature individuals of both sexes in each size group was estimated using the total length at which 50% of the fish are mature. When fish reached first sexual maturity, the males in Lake Nasser measured 27.5cm and the females measured 27cm (TL), whereas the males in Lake Nubia measured 32cm and the females measured 26cm (Fig. 5)

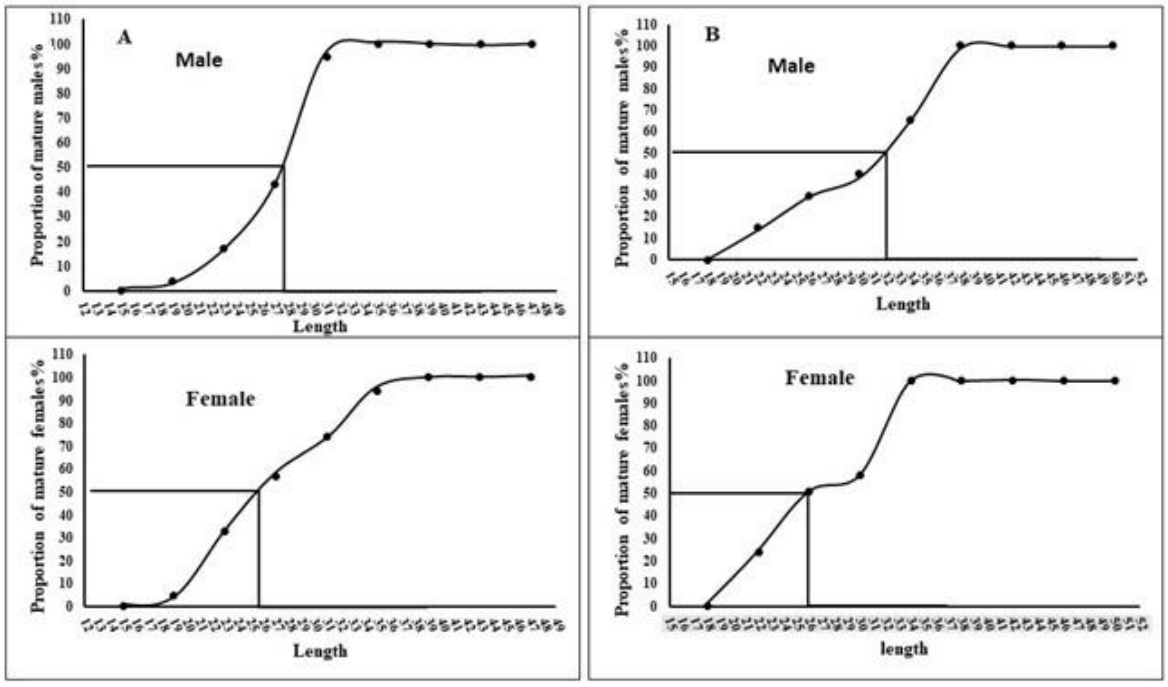


Fig. 5. The logistic curve to estimate the length at first maturity of *Oreochromis niloticus* from **(A)** Lake Nasser, Egypt, and **(B)** Lake Nubbin, Sudan

DISCUSSION

One of the most important topics covered in fish biology is the study of reproduction. Most fish species have a sex ratio of 1:1, though this can vary, and seasonal fluctuations are common ***(*Helfman *et al*., 2009)**. The present study detected an increase in the number of female *Oreochromis niloticus* from Lake Nasser compared to males; however, the fish from Lake Nubia did not match the predicted ratio (1:1), recording a higher number of males than females. **Fryer and Iles (1972)** noted that, males frequently dominate cichlid populations in African water bodies since they typically grow larger than females. Additionally, the fact that the females hide under vegetation to incubate the eggs and protect the young may help to explain this observation. Males become more susceptible to being caught in the feeding zones after migrating there due to this activity **(Offem *et al*. 2007; Shalloof & Salama, 2008)**. Furthermore, different environmental factors are predicted to have distinct effects on sex differentiation. The present study of *Oreochromis niloticus* from Lake Nasser agrees with that of **Issa (1997)** in Kigera reservoir, New Bussa; **Bakhoum (2002)** in Lake Edku, Egypt; **Gómez *et al.* (2003)** in

Emiliano Zapata Dam, Morelos, Mexico; **Shalloof and Salama (2008)** in Abu-Zabl Lake, Egypt; and **El-Kasheif *et al.* (2015)** in El-Bahr El-Faraouny canal, Egypt's Alminufiya Province. In contrast, our results concerning fish from Lake Nubia disagree with the findings of those authors. In addition, the sex ratio of *Oreochromis niloticus* from Lake Nasser disagrees with the results of **El-Kasheif *et al.* (2013)** from Damietta branch, the River Nile, Egypt. These differences in the sex ratio of the Nile tilapia from different localities may be traced back to to the state of the fish stock, sampling season, and fishing efficiency **(Shalloof & Salama, 2008)**.

The gonad development was monitored using the gonado- somatic index (GSI) **(Komolafe & Arawomo, 2007)**. One basic indicator of spawning is the fluctuation in GSI. The highest values of the GSI related to the two lakes under study coincide with those of **Bakhoum (2002)** who conducted his study in Lake Edku, Egypt, and the values recorded in the study of **Tessema *et al*. (2019)** in Lake Hayq, Ethiopia. However, the lowest GSI values observed in the current study did not correspond with the findings of other authors, such as those reported by **El-Kasheif *et al.* (2013)** in Egypt's Damietta branch of the Nile. The variables that affect the brewing season are salinity fluctuations, temperature fluctuations, and water quality, including pollution, which also affects the maturation of gonads. The peak reproductive season of most tilapia species is typically correlated with the increased levels of lake water, rainfall, phytoplankton, and water temperatures **(Babiker & Ibrahim, 1979)**. In the present work it was noticed that, females reached their sexual maturity before males, maturing at the end of stage II and the start of stage III, and stage IV. Whereas, the studies of **Shalloof and Salama (2008)** in Abu Zabal Lake, Egypt, **Hipro (2013)** in Lake Beseka, Ethiopia, and **Tessema *et al*. (2019**) in Lake Hayq, Ethiopia, reported different ages at first maturity. On the other hand, the investigations of **Bakhoum (2002)** in Lake Edku, Egypt, and **Gómez-Marquez *et al*. (2003)** in the Mexican Lake Coatetelco, elucidated that males reached their sexual maturity before females. It is worthy to mention that, the length at first maturity (L) is essential in determining the optimum mesh size **(Mehanna, 2007)**. In this respect, **Waithaka (2020)** reported that both males and females reached maturity at the same length. The variations in the length and age at first sexual maturity of the studied species

are ascribed to the difference in the abundance of food, seasonal food availability, predation, temperature, and photoperiods **(Gómez-Marquez *et al.*, 2003)**.

CONCLUSION

The current study found variations between *Oreochromis niloticus* populations from Lake Nasser and Lake Nubia in terms of their reproductive cycles. Additionally, compared to other studies conducted in different parts of the world, the results of this study showed variations in *Oreochromis niloticus*' reproductive cycle and pattern. According to the present results, the reproduction of the Nile tilapia can be improved by providing suitable environmental condition. Additionally, reproduction can also be improved by using techniques that enhance productivity, such as improving the fish feeding system or providing natural fertilizers to the water.

REFERENCES

Abouel Fadl, Kh. Y. and Farrag, M. M. S. (2020). Biology and population dynamics of the freshwater puffer fish, Tetraodon lineatus (Linnaeus, 1758), from the River Nile, Aswan, Egypt. Egypt. J. Aquat. Res. 47: 75-80 and Reservoir Management 35: 415–434.

Ali, M.T. (1993). Lake Nubia commercial landings for two decades (1970-1990). FRC Wadi Halfa.

Babiker, M. and Ibrahim, H. (1979). Studies on the Biology of Reproduction in the Cichlid Tilapia nilotica (Linneo): Gonadal Maturation and Fecundity. Journal of Fish Biology, 14: 437-448

Bakhoum, S.A. (2002). comparative reproductive biology of the Nile Tilapia *Oreochromis niloticus* (L.), Blue Tilapi A, *Oreochromis aureus* (Steind.) and their hybrids in lake edku, Egypt.

Coward, K. and Little, D. (2001). Culture of aquatic chicken. Present concerns and prospects. Biologist, 48: 12-16.

Dinh, Q. (2018). Aspects of reproductive biology of the red goby Trypauchen vagina (Gobiidae) from the Mekong Delta. Journal of Applied Ichthyology, 34(1): 103-110.

El Shahat, M.M. (2000). Lake Nasser overview, p.3-6. In: J. F. Craig (ed). Sustainable fish production in Lake Nasser; Ecological basis and management policy. ICLARM Conf. Proc., 61: 184p.

El-Kasheif, M.A.; Authman, M.M.N.; Al-Ghamdi, A.F.; Ibrahim, A.S. and El-far A.M. (2015). Biological Aspects and Fisheries Management of Tilapia Fish *Oreochromis niloticus* (Linnaeus, 1758) in El-Bahr El-Faraouny Canal, Al-Minufiya Province, Egypt.

El-Kasheif, M.A.; Shalloof, K.A. and Authman, M.M.N. (2013). Studies on Some Reproductive Characters of Tilapia Species in Damietta Branch of the River Nile, Egypt. Journal of Fisheries and Aquatic Science 8(2):323-339.

El-shabrawy, G.M. (2009). Lake Nasser- Nubia, Monographiae Biologicae, in book: The Nile (pp.125-155)

Fryer, G., and Iles, T.D. (1972). The cichlid fishes of the great lakes of Africa: their biology and evolution. Oliver and Boyd Publications, Edinburgh, Scotland, pp: 641.

Gómez-Márquez, J.L.; Peña-Mendoza, B.; Salgado-Ugarte, I.H. and Guzmán-Arroyo, M. (2003). Reproductive aspects of *Oreochromis niloticus* (Perciformes: Cichlidae) at Coatetelco lake, Morelos, Mexico. Rev Biol Trop 51(1): 221–228.

Gunderson, D. R. (1993). Surveys of fisheries resources, John Wiley & Sons.

Hassan, A.M. (1996). Body Weight Characteristics and Physical Composition of Some Fish Species from Lake Nubia. M.Sc. Thesis Khartoum University, Faculty of Animal Production, Sudan

Helfman, G.S.; Collette, B.B.; Facey, D.E. and Bowen, B.W. (2009). The diversity of fishes: biology, evolution, and ecology. 2nd ed. Wiley-Blackwell, Oxford, England, 720 p.

Hirpo, L.A. (2013). Reproductive biology of *Oreochromis niloticus* in Lake Beseka, Ethiopia.

Hörstgen-Schwark, G. and Langhölz, H.-J. (1998). Prospects of selecting for late maturity in tilapia (Oreochromis niloticus): III. A selection experiment under laboratory conditions. Aquaculture, 167: 123-133.

Issa, E.A. (1997). The reproduction of Oreochromis niloticus (Cichlidae) in Kigera Reservoir, New Bussa, Fisheries Society of Nigeria.

Jakobsen, T.; Fogarty, M.J.; Megrey, B.A. and Moksness, E. (2009). Fish Reproductive Biology: Implications for Assessment and Management. Oxford: Blackwell.

Khallaf, E.A.; Alne-na-ei, A.A.; El-messady, F.A. and Esraa Hanafy (2020). Effect of climate change on growth and reproduction of Nile tilapia (Oreochromis niloticus, L.) from Bahr Shebeen Canal, Delta of Egypt.

Khallaf, E.A.H. and Authman, M.M.N. (2010). Some biological aspects of the Nile Mormyrid Fish, (*Mormyrus kannume*, Forsskål, 1775), from Bahr Shebeen Nilotic

Komolafe, O.O. and Arawomo, G.A.O (2007). Reproductive strategy of Oreochromis niloticus (Pisces: Cichlidae) in Opa reservoir, Ile-Ife, Nigeria. Rev. Biol.Trop.,55: 595-602.

Mair, G.C.; Lakapunrat, S.; Jere, W. L. and Bart, A. (2004). Comparison of Reproductive parameters among improved strains of Nile tilapia Oreochromis niloticus L.

Mehanna, S.F. (2007). Stock assessment andmanagement of the Egyptian Sole *Solea aegyptiaca*Chabanaud, 1927 (Osteichthyes: Soleidae), in the Southeastern Mediterranean, Egypt. Turkish J. Zool., 31: 379-388.

Mehanna, S.F.; Osman, Y.A.; El-Mahdy, S. M.; Mohammad, A. S. and Makkey, A.F. (2021). Maximum Sustainable Yield Estimates from Lake Nasser Fisheries, Egypt with Special Reference to Nile Tilapia Oreochromis niloticus using ASPIC SoftwareAsian Journal of Fisheries and Aquatic Research.

Muchlisin, Z.A. (2013). Study on potency of freshwater fishes in Aceh waters as a basis for aquaculture and conservation development programs. Jurnal Iktiologi Indonesia, 13(1): 91-96.

Muchlisin, Z.A. (2014). A General Overview on Some Aspects of Fish Reproduction, Aceh International Journal of Science and Technology.

Murua, H. and Saborido-Rey, F. (2003). Female reproductive strategies of marine fish species of the north Atlantic. Journal of Northwest Atlantic Fisheries Society, 33: 23-31.

Offem, B.O.Y.; Akegbejo-Samsons. and Omoniyi, I.T. (2007). Biological assessment of Oreochromis niloticus (Pisces: Cichlidae; Linne ;1958) in a tropical floodplain river, Afr,J. Biotechnol.,6:1966-1971.

Peterson, M.S.; Slack, W.T.; Brown-Peterson N.; McDonaldv, J.L. and Taylor, C.M. (2004). Reproduction in NonnativeEnvironments: Establishment of Nile Tilapia, *Oreochromis niloticus*, in Coastal MissippiWatersheds. Copeia, 4: 842-849.

Sendecor, G.W. (1956). Statistical methods applied to experiments in agriculture and biology. Iowa State University Press, 5: 534.

Shalloof, K.A.S.; Elfar, A.M. and Aly, W. (2020). Feeding habits and trophic levels of cichlid species in tropical reservoir, Lake Nasser, Egypt. The Egyptian Journal of Aquatic Research, 46(2): 159-165

Shalloof, K.A.S.h. and Salama, H.M.M. (2008). Investigations on Some Aspects of Reproductive Biology in Oreochromis niloticus (Linnaeus, 1757) Inhabited Abu-zabal Lake, Egypt.

Tessema, A.; Getahun, A.; Mengistou, S.; Fetahi, T. and Dejen, E. (2019). Length - weight relationship, condition factor and some reproductive aspects of Nile tilapia (*Oreochromis niloticus*) in Lake Hayq, Ethiopia.

Waithaka, E.; Yongo, E.; Outa, N. and Mutethya, E. (2020). Population Biology of Nile tilapia (*Oreochromis niloticus*) in Lake Naivasha, Kenya.