International Journal of Fisheries and Aquatic Studies 2019; 7(5): 555-561

E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2019; 7(5): 555-561

www.fisheriesjournal.com
Received: 20-07-2019
Accepted: 22-08-2019

Assefa Tessema
Department of Zoological Sciences, Addis Ababa University, Addis Ababa, Ethiopia

Abebe Getahun
Department of Zoological Sciences, Addis Ababa University, Addis Ababa, Ethiopia

Seyoum Mengistou
Department of Zoological Sciences, Addis Ababa University, Addis Ababa, Ethiopia

Tadesse Fetahi
Department of Zoological Sciences, Addis Ababa University, Addis Ababa, Ethiopia

Eshete Dejen
Intergovernmental Authority on Development (IGAD), Senior Fisheries Expert, Ethiopia

Correspondence
Assefa Tessema
Department of Zoological Sciences, Addis Ababa University, Addis Ababa, Ethiopia

Length -weight relationship, condition factor and some reproductive aspects of Nile tilapia (*Oreochromis niloticus*) in Lake Hayq, Ethiopia

Assefa Tessema, Abebe Getahun, Seyoum Mengistou, Tadesse Fetahi and Eshete Dejen

Abstract
The objectives of the study were to assess length-weight relationship, condition factor and reproductive potential of Nile tilapia (*Oreochromis niloticus*). Data (total length (TL), total weight (TW), sex ratio, maturity stages, fecundity and gonadosomatic index) were collected. The collected data were summarized using descriptive (percentage, graphs, tables) and Inferential (Chi-Square, Two Way ANOVA, Regression) statistics through application of SPSS 16 and R 3.31 Softwares. The length-weight relationship of both sexes was allometric. The FCF (Fulton Condition Factor) value was higher (1.85) for females than males (1.80). A total of 892 samples (339 female and 553 males) were collected during sampling period. There was significant deviation in sex ratio (Females: Males) from hypothetical 1:1 ratio (Chi-Square, $P<0.05$). The mean fecundity was 217 eggs/ fish and it was positively correlated with TL, TW and gonad weight. The size at first sexual maturity (L_{50}) was 12.8 and 12.9 cm for females and males respectively. The gonadosomatic index was ranged from 0.3 - 0.7 and 1.3- 2.6 for males and females respectively. Nile tilapia breeding season was observed between February and April. The peak breeding season was observed in April. From the average weight (40 g) and L_{50} (nearly 13 cm for both sexes), we can conclude that Nile tilapia has stunt growth in Lake Hayq. Heavy fishing together with illegal fishing activities (narrow sized mesh size, <8 cm, below the National standard), fishing during breeding season and breeding ground, destruction of breeding and feeding ground are the major problems of Lake Hayq that might contribute for stunt growth of Nile tilapia in the lake. Therefore, appropriate fishery management tools such as closing season and ground, mesh size regulation should be implemented for sustainable fishery utilization in Lake Hayq.

Keywords: Gonadosomatic index, length at first maturity, total length, total weight, sex ratio

Introduction
Fish is used as source of cheap protein source in most of African countries. Small-scale fisheries operating mostly in the developing countries accounts half of the total fish production globally. The contribution of inland catches in Africa covers about 25% of global inland catches [1] However, the production of fish has drastically decreased and catches per unit of effort (CPUE) have become low in natural water bodies [2] [3]. The major factors for reduction in production of fishes in Africa are, postharvest loss, illegal fishing and overfishing [4]. Nile tilapia fish species, one of the most important fish species in tropical and subtropical freshwater bodies in Africa are also faced many challenges, illegal fishing (overfishing, fishing during breeding season and ground, fishing with narrow sized mesh size and destruction habitat) [5].
Ethiopia has many lakes and rivers harboring more than 200 fish species [6]. The fish production potential is estimated to 94,500 tons per year in Ethiopia [7]. However, only 30-38% of this potential is currently used [8]. Though the contribution of fishery for GDP is insignificant, the sector is being used as means of livelihoods for many people involved from production to marketing. Artisanal freshwater fishery is one of the most important economic activities in Ethiopia [9]. Improvements in fishery sector would contribute to poverty alleviation and environmental sustainability in Ethiopia [10]
Nile tilapia (*Oreochromis niloticus*) contributes for more than 50% of the total landings in Ethiopia [7]. *Oreochromis niloticus* is widely found in Rift valley lakes such as Abaya, Chamo etc.

Highland Lakes such as Tana, Hayq, Ardibo etc. and rivers such as Baro, Abay etc. and it is the most preferred fish species in the country [11].

The exploitation of fish in Ethiopia is depending on the socio-economic factors, resource accessibility and religious causes on fish utilization that integrates into human diet [6]. Post-harvest loss, illegal fishing activities (fishing with narrow sized mesh size, fishing during breeding season and at breeding ground, application of poisonous plants), knowledge gap in fishery management, limited institutional, technical and financial capacity and low research and development capacities are the major challenges to fishes and fisheries in Ethiopia [8]

In fisheries, continuous data on length-weight relationship, size at first sexual maturity and condition factor are important for sustainable utilization of fish resources [12]. Information on Length-weight relationship, fish condition and Length at first maturity of fishes is very important to estimate minimum harvestable fish size, suitability of waterbodies for the fish and their trophic status [13].

Length weight relationship, size at first maturity and condition factor of *O. niloticus* have been reported from different water bodies of Ethiopia [14-20]

Oreochromis niloticus is one of the commercially important fish species in Lake Hayq. However, this fish species is experiencing stunt growth since 2010 due to illegal fishing activities (Mesh size <8 cm, fishing during breeding season and breeding ground, fishing beyond the carrying capacity) and destruction of buffer zone of the lake (removal of macrophytes and sedimentation) [21, 18, 22, 23]

Though there are some research studies conducted on Lake Hayq's morphometry, water balance, water quality, plankton structure, current information on growth condition and reproductive biology of Nile tilapia is scarce. Therefore, this study was aimed to determine Length-weight relationship, condition factor and some reproductive potential (sex ratio, fecundity and size at first sexual maturity and breeding season) of Nile tilapia and recommend sustainable Nile tilapia fishery production in Lake Hayq

Materials and Methods

Description of the study Area

The study was conducted in Lake Hayq. Lake Hayq is located in the North Central highlands of Ethiopia. It is a typical example of highland Lake of Ethiopia with volcanic origin. Geographically, it lies between 11^0 3' N to 11^0 18' N latitude and 39 ^{0} 41' E to 39^0 68' E longitude with an average elevation of 1911 meter above sea level. The lake has a closed drainage system and the total watershed area is about 77 km^2 of which 22.8 km^2 is occupied by Lake Hayq. The average depth of the lake is 37 m, and the maximum depth is 81 m. The only stream entering the lake is the Ankerkeha River, which flows into its southeastern corner [24]. Lake Hayq is classified as a small highland fresh water [25].

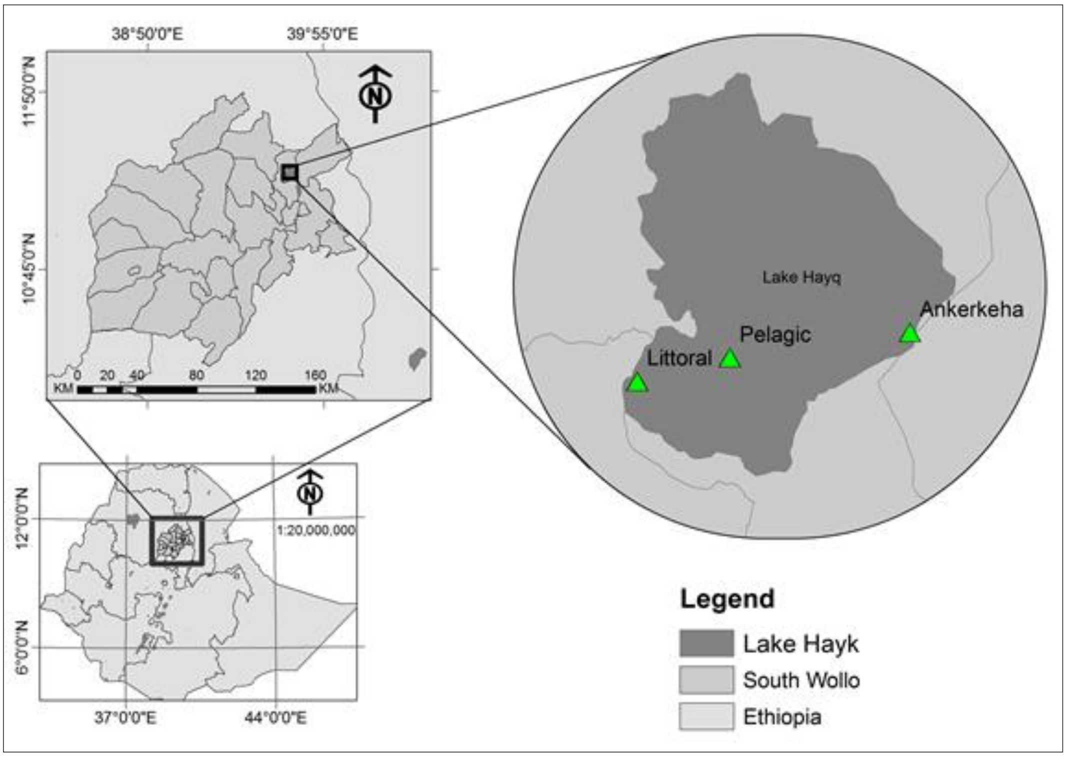


Fig 1: Location map of Lake Hayq with respect to Ethiopia and Amhara Regional State

Data collection and Laboratory analysis

Fish samples were collected monthly between January and December 2018 from January three sampling sites, the shore (Littoral zone), Open water (Pelagic) and River mouth (Ankerkeha) (Fig 1). Fish were captured by gill nets of 4, 6, 8, 10 and 13 cm stretched mesh size through setting the nets overnight in the lake and beach seines of 6 cm mesh size. Data such as length, weight, sex and maturity stages were collected in the field immediately after the fish were caught. Length -weight relationship was determined following [26]. Condition factor was also calculated using the formula indicated in [26]. Sex ratio was calculated using female to male ratio. The absolute fecundity (AF) was of individual female *O. niloticus* was determined gravimetrically [27]. The relationship between absolute fecundity with Total length, Total weight and Gonad weight was determined using least squares regression. The breeding season of *O. niloticus* was determined from the percentages of fish with ripe gonads taken each month and from monthly GSI variations. The spawning periods *O. niloticus* was determined based on monthly variations of the gonadosomatic index (GSI) and calculated using the formula indicated in [28]. Gonad maturity of each specimen was identified using five-point maturity scale [29]. Length at which 50% of both sexes reached maturity (L_{50}) were determined from the percentages of mature fish selected from peak breeding seasons (March -April) and fitted to the logistic equation described in [30].

Data analysis
Descriptive (frequency, percentages, and graphs) and Inferential (Chi-Square, Two Way ANOVA, Linear and Logistic Regressions) statistics were used to summarize the collected data through application of SPSS Software Package Version 16 and R 3.3.1 software

Results
Length-Weight relationship
The relationship between total length and total weight of *O. niloticus was* curvilinear, and as a result the line fitted to the data was described by the regression equation (Table 2). The "b" values of both female and male *O. niloticus* were significantly different from 3, allometric growth (Figure 2 and 3). The length-weight relationship of both male and female Nile tilapia was strongly correlated since the R^2 value of female (0.89) and male (0.85) close to 1 (Table 1)

Table 1: Length –Weight relationship of Male and Female Nile tilapia in Lake Hayq

Sex	Regression equation	R^2	n	Sig.
Female	$TW=0.065TL^{2.50}$	0.888	339	0.001
Male	$TW= 0.099TL^{2.33}$	0.854	553	0.001

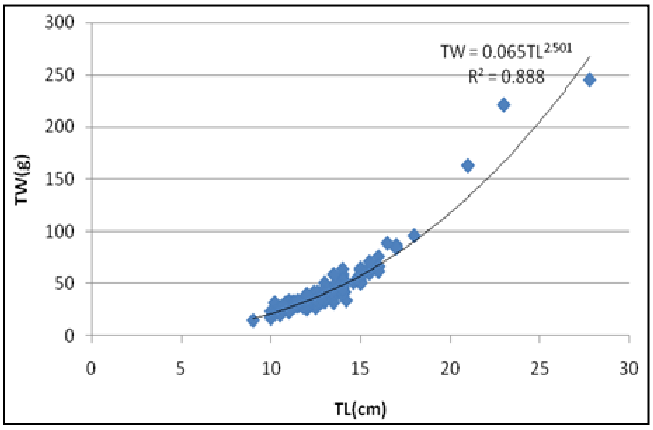


Fig 2: Length-Weight relationshiop of Female *O.niloticus* in Lake Hayq (N=339)

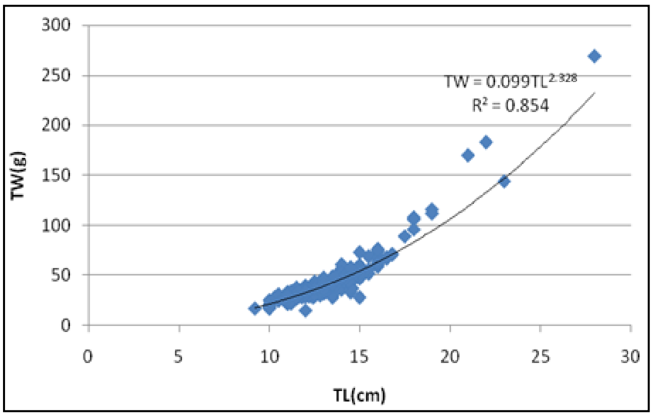


Fig 3: Length-Weight relationship of Male *O. niloticus* in Lake Hayq (N=553

Fulton's Condition Factor (FCF)
There was no significant difference in FCF between sexes in *O.niloticus* of Lake Hayq (ANOVA, P >0.05). However, Fulton's conditions factor of females were slightly higer than males' as shown in Table 2

Table 2: FCF (Fulton's condition Factor) Nile tilapia

Sex	Mean FCF
Female	1.85
Male	1.80

Reproduction Biology of Nile tilapia in Lake Hayq
Sex ratio
From total number of 892 collected *O. niloticus* from Lake Hayq during the study period, 339 (38%) were females and 553(62%) were Males. Males were numerous than females. The Chi-square test showed that there was significant deviation between males and femaless' numbers from 1:1 ratio in *O. niloticus* (χ^2 =79.5, df=11, p<0.05) within sampling months.

Fecundity
Seventy fully mature *O. niloticus* with Total length (10.5-27.8 cm) and Total weight (22-245 g) *were* selected for fecundity study. From this analysis, the average absolute fecundity was 217 eggs per fish (Table 3). The absolute fecundity was positively correlated with total length, total weight and Gonad weight (ANOVA, P< 0.05). It is common to see very small sized Nile tilapia matured at total length (10.5 cm) and total body weight (40g) in Lake Hayq (Figure 4)

Table 3: Absolute fecundity (AF) of *O. niloticus*

Fish species	Range in TL (cm)	Range in TW (g)	Mean AF
O. niloticus	10.5-27.8	22-245	217

Fig 4: *Oreochromis niloticus* of Lake Hayq matured at 40gram body weight and 10.5 cm total length

Breeding Season
In Lake Hayq, both female and male Nile tilapia was fully matured between February and April when the water temperature is high and rainfall is available. More than 50% of the fish caught in April were matured. In the present study, fully matured Nile tilapia was recorded only in three months (February to April). The Gonadosomatic Index values of female and male Nile tilapia were highest in April and lowest in February (Figure 5). The highest Mean GSI value (2.6) was recorded for females in April and highest mean GSI value (0.7) was recorded in the same month, April for males.

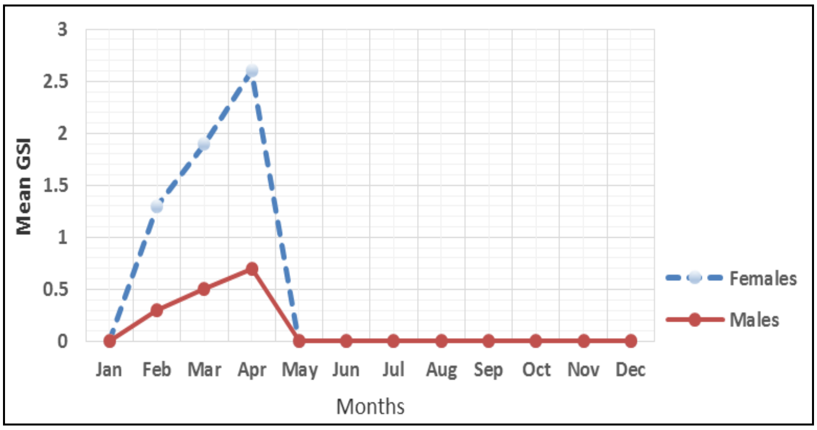
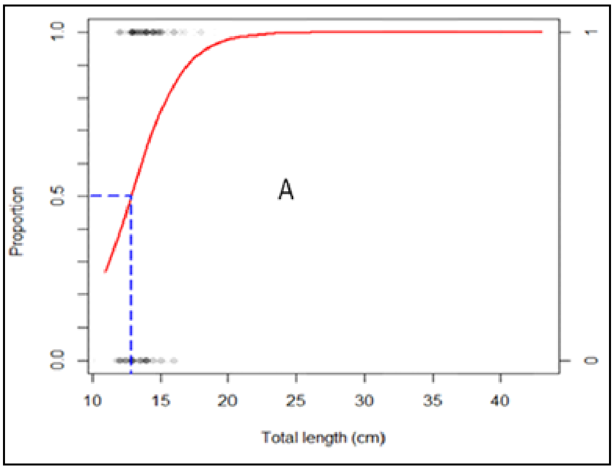


Fig 5: Mean GSI (Mean Gonadosomatic Index) of both female and male *O.niloticus* in Lake Hayq

Size at first maturity

Size at first maturity (L_{50}), is the size at which 50% of the fish get matured for the first time. *Oreochromis niloticus* fish species matured almost at the same size, females (12.8 cm) and males (12.9 cm) in Lake Hayq as shown in Figure 6.



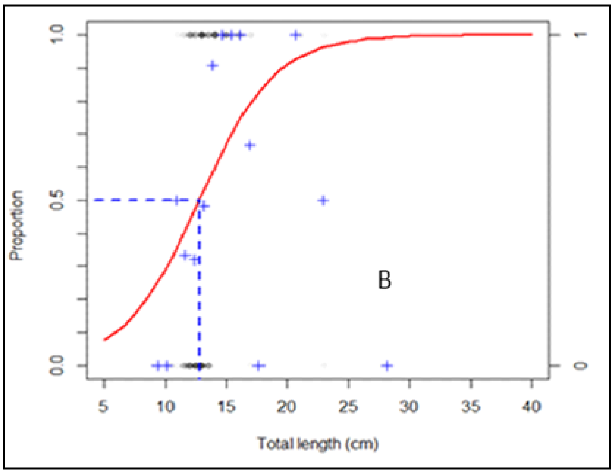


Fig 6(A) **Fig 6(A)**

Fig 6: Length at first sexual maturity (L_{50}) of Male (A) and Female (B) *O. niloticus* in Lake Hayq

Discussion

In the present study, the length-weight relationship of both male and female Nile tilapia was allometric. The result of the present study was similar to Lake Tana [15], Lake Victoria in Kenya [31], Lake Naivasha in Kenya [32], and Peele Reservoir in Burkina Faso [33]. However, it was different from the Lake Hayq [18], Gilgel Gibe Reservoir [34], Lake Hawassa [35], Lake Ziway [36], Baro River [37] and Lake Langano [19]. If length increases in equal proportions with body weight for constant specific gravity, fish are said to exhibit isometric growth. The slope for isometric growth is 3 and values significantly greater or lesser than 3 indicate allometric growth [28]. The slope 'b' is affected by stage of sexual maturity, nutritional adequacy of the diet and toxicology of the environment [27].

In the present study, the mean FCF of female and male were 1.85 and 1.80 respectively. These values were higher than Lake Langano (1.67, combined sexes) [36], Lake Langano (1.77, combined sexes) [19]. However, it was less than Lake Babogaya (1.97, females, 1.86, males) [17] and Lake Chamo (2.35, combined sexes) [38]. The variation in FCF of Nile tilapia in different lakes might be associated with quality of food, time and duration of breeding [39, 35]. Shortage of food during dry season and starvation due to breeding behavior (mouth brooding) in Nile tilapia during breeding season might reduce condition factor [40].

In the present study, males were more numerous than females and there was significant deviation in sex ratio (females: males) from expected 1:1 sex ratio (Chi-square, P<0.05). This result was similar with Lake Tana [15] and Lake Victoria in Kenya [31]. However, it was different from Lake Hayq (Workiye Worie and Abebe Getahun, 2014), Lake Babogaya [17] and Lake Langano [19]. These differences in number of females to males in different water bodies might be associated with fishing efficiency, sampling season and fish stock status [15, 17].

In the present study, the mean absolute fecundity of Nile tilapia in Lake Hayq was 217 eggs per fish. This value was higher than Golinga reservoir in Ghana (173 eggs per fish, mean) [41]. However, it was less than Lake Hayq (290-1287 eggs per fish) [18], Lake Tana (730 eggs per fish, Mean) [15] Lake Langano (464 eggs per fish, mean) [19] and Tekeze Reservoir (399-2129 eggs per fish) [20].

The intensity of reproduction in fish depends on mean number of eggs per fish and how often the eggs are laid by the fishes [42]. Female *O. niloticus* produces only a few hundreds of offspring in a single spawn but under favorable conditions they spawn frequently every 4 to 6 weeks [43]. Fecundity is very low in *O. niloticus* as they are mouth brooding (protect the young in the mouth cavity for several weeks till they are capable of leading independent life) that have limited space available for rearing the young [44, 45]. Though, *O. niloticus* does not produce many progenies at each spawning, their offspring have very less risk of predation [46].

Fecundity of the same fish species may vary from one water bodies to another water bodies due to difference in environmental variables such as temperature and food that affect body size of the fish. Because body size of fishes has direct relation with fecundity [42, 47]. Fecundity, the mean number of eggs per brood is usually higher in young fish than older fishes and it increases directly with body weight and length [47]. Most species of tilapia breed continuously throughout the year during favorable environmental condition, higher temperature and rainfall [48, 49]. The peak breeding season of most tilapia species usually associated with higher water temperature, rainfall, phytoplankton and water rising water level in lakes [50]. The difference in fecundity of Nile tilapia is associated with environmental factors such as temperature, altitude and latitude and these factors vary from one location to the other [41]. The Lower fecundity value in Lake Hayq might be associated with stunt growth caused by fishing pressure. Because, fecundity has direct relation with body weight and total length [47].

The length at first sexual maturity of females and males Nile tilapia was 12.8 and 12.9 cm respectively which mature at almost the same size. This result was lower than the same Lake (14.5 for females and 15.5 cm for males) [18]. Tekeze Reservoir (15 for females and 14 cm for males) [20]. Lake Hawassa (17.8 for males and 14.1 cm for females) [51], Lake Chamo (42 cm, combined sex) [38], Fincha Reservoir (24.5 for males, 21.8 cm for females) [16], Lake Langano (16.4 for female and 15.8 for male) [19] and Lake Hawassa (20.8 for females and 20.3 for males) [52]. Heavy fishing, overfishing can alter population structure, impair growth and earlier maturation depended on selectivity of the fishery [53]. Illegal fishing activities, utilization of a greater number of narrow sized mesh size gillnet can cause lower L_{50} values in Lakes as reported for Lake Victoria in Kenya [34, 31]. Fishing pressure or fishing intensity is one of the major factors for early maturation and stunt growth in *O. niloticus*. Because, they allocate much resource for reproduction than somatic body building in water bodies where there is fishing pressure [54]. The lowest L_{50} values reported in the present study in Lake Hayq might be associated mainly with illegal fishing activities, fishing during breeding season, utilization of narrow mesh sized gillnet (<8 cm, below the standards) and fishing beyond the lake tilapia fish production potential (overfishing) that have been practiced in the lake.

In the present study, The GSI values were ranged from 1.3-2.6 and 0.3-0.7 for females and males Nile tilapia respectively. Both sexes begin maturity in March and more than 50% of the fish get matured in April. The present study result disagrees with the findings of [18] that have reported August to September and January to February as breeding season. However, we couldn’t observe matured Nile tilapia during the aforementioned seasons. The difference in breeding season might be associated with fishing pressure, destruction of habitat and rainfall variability. The breeding seasons of Nile tilapia coincides with higher water temperature, rainfall availability and seasonal flooding that brings nutrients for phytoplankton, higher phytoplankton biomass [46, 14].

Conclusion and Recommendation

Nile tilapia, which was introduced in Lake Hayq in 1970s has being used as commercial fish species. However, the fish species get stunt growth since 2010. The average weight (40 g) and L_{50} (about 13 cm) of Nile tilapia indicate that Nile tilapia has stung growth. As the result, catch per unit effort of this species is very low. Consequently, most of the fishermen of Lake Hayq have changed profession or migrate to Arabian countries. The current stunt growth of Nile tilapia in lake Hayq might be associated mainly with illegal fishing activities, utilization of narrow sized gillnet (< 8 cm), fishing during breeding season and breeding ground, destruction of breeding and feeding ground. In addition to this, there was a heavy fishing activity in the lake for the las ten years. To minimize decline of the population of Nile tilapia and stung growth, fishery management tools such as mesh size regulation, gear restriction and closing season and ground should be properly implemented. Moreover, integrated aquaculture and other livelihoods means should be considered for sustainable utilization of Lake Hayq fishery

Acknowledgment

Authors would like to acknowledge Addis Ababa University, Ministry of Water, Irrigation and Electricity and Jari Agricultural Research Sub-Center for their financial and logistic support. We would also extend our gratitude to fishermen of Lake Hayq, specially Fiseha Woldemariam and Seid Abebe for their unreserved support during fish sample collection.

References

1. FAO (Food and Agricultural Organization). The State of World Fisheries and Aquaculture 2018-Meeting the sustainable development goals. 2018. Rome. Licence: CC BY-NC-SA 3.0 IGO.
2. Adite A, Winemiller KO. Trophic Ecology and Ecomorphology of Fish Assemblages in Coastal Lakes of Benin, West Africa. Ecoscience. 1997; 4:6-23.
3. Houehanou MAG, Gbaguidi A, Adite ET. Ecology and Fish Biodiversity of Man-Made Lakes of Southern Benin (West Africa): Implications for Species Conservation and Fisheries Management. Journal of Environmental Protection. 2016; 7:874-894.
4. FAO (Food and Agricultural Organization). Aquaculture Summary: The State of World Fisheries and Aquaculture Report FAO, 2016, 118.
5. Mohammed EY, Uraguchi ZB. Impacts of climate change on fisheries: implications for food security in Sub-Saharan Africa. In: Hanjra, M. A. (eds.) Global Food Security, Nova Science Publishers, Inc., 2013, 114-135.
6. Temesgen M. Status and trends of fish and fisheries in Lake Langano, Ethiopia. PhD dissertation submitted Department of Zoological Sciences, Addis Ababa University, Ethiopia, 2017, 243.
7. Tesfaye G, Wolff M. The state of inland fisheries in Ethiopia: a synopsis with updated estimates of potential yield. Ecohydrology and Hydrobiol. 2014; 14:200-219.
8. Mitike A. Fish production, consumption and management in Ethiopia. Res. J Agricult. And Environ. Biology. 2014; 3:084-087.
9. FAO. Fishery and Aquaculture Country Profiles – Ethiopia. Fisheries and Aquaculture Department. Available in http://www.fao.org/fishery/en., 2012.
10. Global Fish Alliance. The importance of capture fisheries in food security in Ethiopia. Fact sheets on state of fisheries in African countries, 2010.

11. Golubtsov AS, Mina MV. Fish species diversity in the main drainage systems of Ethiopia: current knowledge and research perspectives. Ethiop. J Natural Resources. 2003; 5:281-318.
12. Shalloof KASh, Khalifa N, Stomach Contents and Feeding Habits of *Oreochromis niloticus* (L.) From Abu-Zabal Lakes, Egypt. World Applied Journal of Science. 2009; 6:01-05.
13. Kumar A, Jitender KJ, Hemendra KV. Length-Weight Relationship and Relative Condition Factor of *Clarius batrachus* (Linnaeus, 1758) from Gaurmati Fish Farm, Kawardha, Chhattisgarh, India. Int. J Curr. Microbiol. App. Sci. 2017; 6:1425-1431.
14. Admassu Maturity D. Fecundity, Brood size and sex ratio of Tilapia (*Oreochromis niloticus* L.) in Lake Awassa. SINET: Ethiop. J Sci. 1994; 17(1):53-96.
15. Tadesse Z. Breeding season, Fecundity, Length-weight relationship and condition factor of *Oreochromis niloticus* L. (Pisces: Cichlidae*)* in Lake Tana, Ethiopia. SINET: Ethiop. J Sci. 1997; 20(1):31-47.
16. Degefu F, Tesfaye G, Tefera F. Study on the adaptability status and reproductive success of *Oreochromis niloticus* L. (Pisces: Cichlidae) and carp (*Cyprinus carpio* L. 1758) in a tropic reservoir (Fincha, Ethiopia). Ethiopia. Hydrobiol. 2012; 416:97-106.
17. Abera L. Breeding Season and Condition Factor of *Oreochromis niloticus* (Pisces: Cichlidae) in Lake Babogaya, Ethiopia. International Journal of Agricultural Sciences. 2012; 2(3):116-120.
18. Worie W, Getahun A. Length-weight relationship, condition factor and some reproductive aspects of Nile Tilapia, *Oreochromis niloticus*, in Lake Hayq, Ethiopia. International Journal of Zoology and Research. 2014; 4(5):47-60.
19. Temesgen M, Getahun A, Lemma B. Reproductive Biology of Commercially Important Fish Species in Lake Langeno, Ethiopia. Asian Fisheries Science. 2018; 31:319-339.
20. Teame T, Zebib H, Meresa T. Observations on the biology of Nile tilapia, *Oreochromis niloticus* L., in Tekeze Reservoir, Northern Ethiopia. 2018; 10(7):86-94.
21. Tessema A, Geleta K. Assessment of Challenges and Opportunities of Fisheries of South Wollo Lakes, Ethiopia. Journal Of fisheries International. 2013; 8:69-73.
22. Tewabe D, Mohamed B, Hailu B. Impacts of anthropogenic activities on fish habitat, breeding ground and macrophytes of Lake Logo. Global Research Journal of Fishery Science and Aquaculture. 2015: 3(1):20-27.
23. Zuriash Seid. Fish Diversity, Abundance, Socioeconomic Importance and the Status of the Fisheries of Lake Logo, South Wollo, Ethiopia. MSc thesis, Department of Zoological Sciences, Addis Ababa University. Addis, 2016, 93.
24. Demlie M, Ayenew T, Stefan, W. Comprehensive hydrological and hydrogeological study of topographically closed Lakes in highland Ethiopia: The case of Hayq and Ardibo Lakes. Journal of Hydrology. 2007; 339(1):145-158.
25. Fetahi T, Michael S, Mengistou S, Simone L. Food web structure and trophic interactions of the tropical highland lake Hayq, Ethiopia. Ecological Modelling. 2011; 222:804-813.
26. Bagenal TB, Tatsch FW. Age and growth. In: Methods for Assessment of Fish Production in Freshwaters (Bagenal. T.B, Ed.). IBP. Hand book No.3, Blackwell, Oxford, England, 1978, 101-136.
27. Bagenal TB, Braum E. Methods for assessment of fish production in freshwaters. Blackwell Scientific Publications, London, 1987, 165-201.
28. Ricker WE. Computational and Interpretation of Biological Statistics of Fish Populations. Bulletin of the Fisheries Research Board of Canada, 1975, 382.
29. Wudneh T. Biology and management of fish stocks in Bahir Dar Gulf, Lake Tana, Ethiopia. PhD thesis. Wageningen Agricultural University, Wageningen, 1998, 150.
30. Echeverria TW. Thirty-four species of California rockfishes: Maturity and seasonality of reproduction. US Fish. Bull. 1987; 85:229-250.
31. Yongo E, Outa N, Kito K, Matsushita Y. Studies on the biology of Nile tilapia (*Oreochromis niloticus*) in Lake Victoria, Kenya: in light of intense fishing pressure, African Journal of Aquatic Science. 2018; 4(2):195-198.
32. Njiru M, Van der Knaap M, Taabu-Munyaho A, Nyamweya CS, Kayanda RJ, Marshall BE. Management of Lake Victoria fishery: Are we looking for easy solutions? Aquatic Ecosystem Health and Management. 2014; 17:70-79.
33. Parfait GS, Adama O, Awa N, Awa G, Wendengoudi G, Papa N, Gustave KB. Some reproductive aspects of *Oreochromis niloticus* (LINNAEUS, 1758) at Peele reservoir, Nakanbé River Basin, Burkina Faso. International Journal of Fisheries and Aquatic Studies. 2018; 6(4):124-130.
34. Wakijira M. Feeding habits and some biological aspects of fish species in Gilgel Gibe Reservoir, Omo-Turkana Basin Ethiopia. Int. J Curr. Res. 2013; 5(12):4124-4132.
35. Admasu D. Some Morphometric relationships and Condition Factor of *Oreochromis niloticus* (Pisces: Cichlidae) in Lake Awassa, Ethiopia. SINET Ethiop. J Sci. 1990; 17:53-69.
36. Tadsse Z. Food and feeding ecology of tilapia, *Oreochromis niloticus* L. and effects of diet on the lipid quality of fish in some lakes in Ethiopia. Ph.D. Thesis, School of graduate studies, Addis Ababa University, Addis Ababa, 1998, 150.
37. Melak T. Diversity, Relative Abundance and Biology of Fishes in some Water bodies of Baro and Tekeze Basins, Ethiopia. MSc Thesis, Addis Ababa University, Ethiopia, 2009.
38. Teferi Y, Admasu D. The length-weight relationship, body condition and sex ratio of tilapia (*Oreochromis niloticus*) in Lake Chamo, Ethiopia. SINET: Ethiop. J Sci. 2002; 25(1):19-26.
39. Weatherly G. Growth of Nile tilapia in rivers. FAO Corporate document repository, Rome, 1987. Available from http://www.scielo.br/pdt/rbo/v60n on 10/07/2006.
40. Medri V, Pereira G, Leoward J. Growth of Nile tilapia in rivers. FAO Corporate document repository-1990: Rome. Available from http://www.scielo.br/pdt/rbo/v60n. Accessed on 14/07/2006.
41. Abarike ED, Ampofo-Yeboah A. Reproductive potential of Nile tilapia (*Oreochromis niloticus* Linnaeus, 1757) in the Golinga reservoir in Ghana. International Journal of Fisheries and Aquatic Studies. 2016; 4(5):279-283.
42. Winberg GG. Methods for estimation of Reproduction of aquatic Animals. Zoological Institute/ Academy of

Science of USA. Academic Press, London & New York, 1991, 143-147.
43. Pullin RSV. Tilapia genetic resources for aquaculture, In: The Biology and Culture of Tilapias, 2nd Ed. University Press Cambridge, 1991, 529-547.
44. Welcomme RL. The fisheries ecology of African flood plain Consultation on the Fisheries problems in the Sahelian zone, Bamako (Mali). FAO Technical paper, (3). 1975: Available from http://www.scielo.br/pdt/rbov60n. Accessed on 10/07/2006.
45. Peterson M, William TS, Naney JB, Jennejer LM. Reproduction in Non- native Environment and Estimation of *Oreochromis niloticus* in Coastal Missisipi watersheds, 2004, 842-849.
46. Fryer G, Iles TD. The Cichlid Fishes of the Great Lakes of Africa. Their Biology and Evolution. Oliver and Boyd, Edinburgh, 1972.
47. Njiru M, Ojuok JE, Okeyo-Owuor JB, Muchiri M, Ntib MJ, Cowx IG. Some biological aspects and life history strategies of Nile tilapia *Oreochromis niloticus* (L.) in Lake Victoria. African Journal of Ecology. 2006; 44:30-37.
48. Ross LG. Environmental physiology and energetics. In: Tilapias: Biology and Exploitation, (Beveridge, M. C. M. and Mc Andrew, B, Eds.) Kluwer Academic Publishers. London, UK, 2000, 89-128.
49. Gomez-Márquez JL, Peña- Mendoza B, Salgado-Ugarte IH, Guzmán- Arroyo M. Reproductive aspects of *Oreochromis niloticus*. (Perciformes: Cichlidae) at Coatetelco lake, Morelos, Mexico. Revista de Biología Tropical. 2003; 51:221-228.
50. Babiker MM, Ibrahim H. Studies on the biology of reproduction in the cichlid Tilapia, *Oreochromis niloticus* (L): Gonadal maturation and fecundity. Journal of Fish Biology. 1979; 14:437-448.
51. Bjørklis G. The fisheries in Lake Hawassa, Ethiopia; estimation of annual yield. M.Sc. Thesis submitted to Department of Plant and Environmental Sciences, Norwegian University Life Sciences, Ås, Norway, 2004.
52. Muluye T, Tekle-Giorgis Y, Tilahun G. The Extent of Immature Fish Harvesting by the Commercial Fishery in Lake Hawassa, Ethiopia. Momona Ethiop. J of Sci. 2016; 8(1):37-49.
53. Jorgensen CK, Enberg ES, Dunlop R, Arlinghaus DS, Boukal K, Brander B *et al*. Managing Evolving Fish Stocks. Science. 2007; 318:1247-1248.
54. Bandara KVSN, Amarasinghe US. Influence of Fishing Pressure and Water Level Fluctuations on the Reproductive Biology Traits of *Oreochromis niloticus* (Linnaeus 1758) in Irrigation Reservoirs of Sri Lanka. Asian Fisheries Science. 2018; 31:127-145.