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Yield and Condition Factor of *Oreochromis niloticus* L. In Tropical Small Dams, Tigray, Northern Ethiopia

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Abstract: Fishes are good sources of proteins. In some of the reservoirs of Tigray, fishes have been introduced for fish production. The objective of this study was to understand the productivity and condition factor of the fish in Tigray dams. Most relevant information associated with fish population dynamics were collected and fish morphological measurements such as total length, weight, maturity were registered. Fish samples were collected four times for the collected four months, December 2012, March, April and May 2013. Fishes were sampled by deploying 40 meter monofilament commercial net with 12cm mesh size for 1 hour. Fifteen species of phytoplankton, eight taxa of rotifer and seven taxa of other zooplankton were recorded. A total of 286 *Oreochromis niloticus* were collected from five dams and no significant difference was observed in fish catch among the studied dams during the sampled seasons ($\chi 2 = 7.77$, $p > 0.05$). Schlesinger and Regier [15] fish yield estimation model depicts 5.5 in Mai Sesela, 4.5 in Mai Nigus, 4.9 in Mai Seye, 4.5 in Lailay Wukro and 4.4 quintals in Korir. L50 maturity of *O. niloticus* in the dams is 24.5cm. The fishes mature while they are very small ($\chi 2 = 81.32$, d.f.= 2, p= 0.000). Almost half (49.65%) of the *O. niloticus* caught were weighing less than 300gm ($\chi 2 = 23.22$, d.f= 6, $p < 0.001$). The condition factor of *O. niloticus* in the reservoirs remains high, more than 60% of the fishes caught were having k-factor greater than 1.75 ($\chi 2 = 17.88$, d.f.= 6, $p < 0.007$). In general, if the dams are better managed, the Tigray dams have high potential for fish culture, thus they can be used as promising sites of pisciculture by the unemployed youth who want to be engaged in fish production in the region.

Key words: Condition Factor · Dams · Ethiopia · Fish Yield · *Oreochromis niloticus*

INTRODUCTION

Rainwater practiced in Ethiopia for the purpose of hydroelectric power and irrigation. In Tigray, northern Ethiopia, more than 70 reservoirs have been constructed [1] for irrigation purpose. Since all dams have dead storage, in some of the dams fishes have been introduced for fish production. Very recently fingerlings of *Oreochromis niloticus* were added to Gerebawso, Gereb Beati and Mai Gassa dams.

Oreochromis niloticus is the common native fish species of Ethiopia [2]. It is also the most important the fisheries of tropical African inland waters because of the extended breeding season, which in most cases extends throughout the year [3, 4].

In Ethiopia, studies on ecology, reproduction, breeding seasonality of *O. niloticus* in the lakes including the Rift Valley Lakes and Lake Tana have been intensively studied [5-7]. Lakes and rivers have been the focus of numerous investigations but less attention has been paid to reservoirs.

The yield of fish, season change in fish density and the factors which influence them are important for the sustainable management of fisheries in the reservoirs. Thus, this research was initiated to obtain detailed information on the current status of fish yield and condition factor of *O. niloticus* in Mai Nigus, Mai Seye, Mai Sessela, Laelay Wukro and Korir dams. It is expected that the outcome of the study would help the potential entrepreneurs of fish production in these areas.

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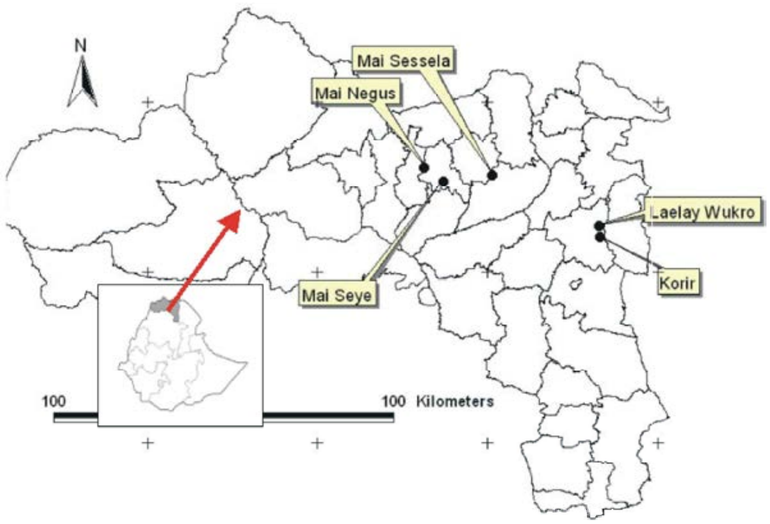

Fig. 1: Map of the study area

MATERIALS AND METHODS

Description of the study area: Mai Nigus, Mai Sessea and Mai Seye dams are located in the Central Zone of Tigray while the other two study dams (Lelay Wukro and Korir) are located in the eastern and central zone of the Regional State of Tigray (Fig. 1). In Tigray, we surveyed these 5 reservoirs that have received *O. niloticus.*

The most relevant information associated with fish population dynamics such as biotic components, abiotic variables and merphometric data were collected for months, December 2012, March, April and May 2013. Morphological measurements include total length, weight, maturity were registered. The Total Length (TL) of the fish was measured from the tip of the anterior part of the mouth to the caudal fin using meter rule calibrated in centimeters and total weight (In grams), respectively.

Methods: Fish samples were collected four times in December 2012, March, April and May 2013 from. Fishes were collected by deploying 40 meter monofilament commercial net of 12cm mesh size for 1 hour. Captured fish were dissected to determine sex and maturity. The gonads which are two parallel tubules located on the dorsal wall of the abdominal cavity were examined with the naked eye in the case of sexually mature and gonads [8]. Sex determination of each adult specimen was done through examination of the gonad and the maturity level of the gonad was determined through visual examination following five-point maturity scales for *O. niloticus* [9, 10]. A generalized classification was used to group the fishes as immature or mature assigned using modified Nikolski [11] scheme which has been described by Ojuok *et al.* [12]. The degree of association between the length and weight was computed from linear regression analysis [8, 13]. Length (L) and weight (W) of fish was expressed by regression equation [14].

The condition factor (k) of the experimental fish was estimated from the relationship [14]: $K = \frac{100 * W}{L^b}$ The log transformed data gave a regression equation Log w=log a + b log

By using the equation: W=aLb

where K= Condition factor. W=Weight of fish in (g), L=Total Length (TL) of fish in (cm. a= Exponent describing the rate of change of weight with length t (intercept of the regression line on the Y axis) Constant b= the slope of regression line also referred to the allometric and isometric coefficient. The "a" and "b" values were obtained from a linear regression of the length and weight of fish. The correlation (r^2) that is the degree of association between the length and weight was computed from the linear regression analysis: $R = r^2$.

Predicted fish yield (kg/hectar/year) was calculated for reservoirs from the global yield model developed by Schlesinger and Regier [15] (Yield: Log 10 Yield = 0.044 T°C +0.482 Log MEI + 0.021.

Crustacean zooplankton were sampled with a Schindler-Patalas trap (12 L content, 64 μm mesh size) at three depths and pooled. Cladocerans were identified using Flössner [16] and Smirnov [17]; copepods were only classified as either calanoids or cyclopoids. Subsamples were taken and specimens were identified and counted until at least 300 individual cladocerans per sample were counted to determine densities and the resulting density values were converted to dry-weight biomasses using equations proposed by Bottrell *et al*. [18].

Chlorophyll a was estimated through fluorometer readings (Turner Aquafluor; average of three measurements) on the pooled water sample. Phytoplankton was identified using inverted microscope following identification keys by John *et al*. [19] and Komarek and Anagnostidis [20]. Biomass of phytoplankton was estimated from counts: first bio-volume was estimated by combining count data with data on cell size measurements, then biomass was calculated using published conversion factors [21, 22].

From each reservoir spatial, morphometrical, physical, chemical and biotic variables were assessed. Spatial variables include geographical coordinates (Latitude and longitude) and altitude. Morphometrical variables were maximum depth and surface area. Temperature, dissolved oxygen and pH of the water were measured in situ at three different depths (Surface, middle and near-bottom) with electrodes at a haphazardly chosen location in the middle of the reservoir. Water transparency was measured using a cylindrical Snell's tube (Length: 0.6 m; diameter: 60 mm; disc diameter: 55 mm) as well as a Secchi-disc (Diameter: 0.3 m). Water samples were taken with a Heart valve sampler (3 liters content) from three depths (Surface, middle and near-bottom) and pooled.

Data Analysis: Chi square tests were used to test for a difference in the mean fish catches between the dams. A Chi-square goodness of fit test was also used to test the difference in the maturity stage and difference in total length and weight of the species. All variables except pH were log-transformed to stabilize the variance. Multiple regression analysis was used to explain the variation in fish catches in the five dams. From general limnological point of view, only variables that were expected to bring potential effect on the dependent variable were considered during inclusion of the explanatory variables. Univariate and multivariate analyses were performed with the statistical program SPSS 16.

RESULTS

Limnological Characteristics of the Reservoirs: The value of average (Mean), minimum and maximum temperature, pH, dissolved oxygen, secchi disc (Relative measure of transparency), turbidity and total dissolved solid measurements of four months are presented in Table 1. Temperature ranges 17.8 to 25°C, Dissolved oxygen ranges from 4.58 – 11.4mg/l, pH was almost alkaline ranging from 7.88 - 8.58, while that of water transparency ranges from relatively transparent state 85 cm to a turbid state (16cm). Total dissolved solid (TDS) ranges from 45 to 240 mg/l.

Phytoplankton, Rotifer and Zooplankton Species Composition: During field observation, 15 phytoplankton species were identified: *Aulacoseira, Fragilaria, Closterium, Cosmarium, Pediastrum, Euglena, Scenedesmus, Oocystis, Cryptomonas, Anabaena, Phacus, Anphanozomenon, Microcystis, Peridinum and Trachelomonas* (Table 2). *Peridinum* and *Trachelomonas* were found in all dams whereas *Scenedesmus* and *Microcystis* were unique to Korir (Table 2).

Eight taxa of rotifer species were identified from the studied dams: *Brachionus calyciflorus, Brachionus quadridentatus, Brachionus rubens, Cephallodella* sp., *Filinia* sp., *Hexarthra* sp., *Keratella quadrata* and *Polyarthra* sp.

Table 1: The morphometric measurements and physicochemical parameters of Korir, Lailay Wukro, Mai Nigus, Mai Sesela and Mai Seye dams

Variable	Mean ± St.dev	Minimum	Maximum
Altitude and morphometrics			
Area (m^2)	10.8±1.76	8	13
Average depth (m)	3.3± 1.8	0.70	8.00
Altitude (m)	20032±28.8	2006	2087
Physicochemical variables			
Dissolved oxygen (mg/l)	7.03±1.54	4.58	11.40
pH	8.2 ±0.18	7.88	8.58
Conductivity(iS /cm)	201.56 ±92	90.00	480.00
TDS(mg/l)	101.28±46	45.00	240.00
Secchi disc (cm)	39.75±20	16.00	85.00
Temperature (^{0}C)	22.2±2.4	17.80	25.00
Turbidity	60.4±82	9.31	334.00

Table 2: Phytoplankton Biomass (pgC/ml)

Genus	Korir	L. Wukro	Mai Nigus	Mai Sesela	Mai Seye
Aulacoseira	0	0	670.91	0	718.83
Fragilaria	132.52	2650.5	378.64	0	5553.43
Closterium	995.276	1935.26	0	0	1290.18
Cosmarium	0	17471.84	0	0	0
Oocystis	113.439	0	47.27	14.17996	0
Pediastrum	249.51	3118.89	0	0	0
Scenedesmus	67.66	0	0	0	0
Cryptomonas	809.51	0	0	0	20648.52
Anabaena	0	791.03	5435.77	0	0
Aphanizomenon	1482.83	41788.76	0	0	0
Microcystis	2986.82	0	0	0	0
Peridinum	2672.79	1155981	343007.8	11359.35	142548.7
Euglena	283.783	0	0	0	3783.77
Phacus	3924.95	0	0	0	26166.31
Trachelomonas	4119.02	49912.78	24552.57	25101.77	65258.14

Table 3: Zooplankton taxa (µgm/L) identified in the Korir, Lailay Wukro, Mai Nigus, Mai Sesela and Mai Seye dams during December 2012 to May 2013

Taxa name	Mean & Stand- dev	Minimum	Maximum
Daphnia barata	1.0±2.24	0	5.14
D. pulex	0.34±0.7	0	1.59
Diaphanosoma	0.48±0.45	0.12	1.26
Cerodaphnia	15.65±32.1	0.12	72.98
Calanoid	5.03±3.82	0.17	9.49
Cyclopoid	4.75±1.95	2.45	6.87

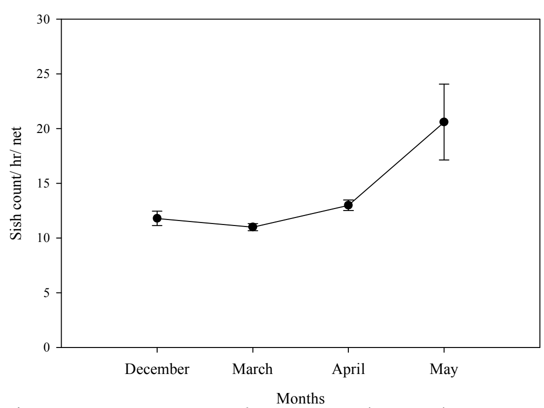

Fig. 2: Average *O. niloticus* catch per hr per netwith monofilament commercial fish net in the five studied reservoirs in Tigray (2012/2013)

Six taxa of zooplanktons were recorded: *Daphnia barbata, Daphnia pulex*, *Diaphanosoma*, *Moina micrura*, *Cerodaphnia,* calanoid and cyclopoid (Table 3). *D. pulex* was only found in Korir and Lailay Wukro, while, *D. barbata* was only found in Korir and Mai Sessela.

Fish Catch: A total of 286 *Oreochromis niloticus* were collected from five dams (Korir, Lailay Wukro, Mai Nigus, Mai Sesela and Mai Seye, see Fig. 2). No significant difference was observed in fish catch among dams and sampled seasons (χ^2 = 7.77, p> 0.05). The highest fishes were caught in Mai Sesela especially in May 2013.

According to multiple regression analysis, turbidity (t=3.48, p<0.003) and total dissolved solid (TDS) (t=3.415; p<0.046) were more important in explaining the variation in the catch of *O. niloticus* in the five studied dams in Tigray (Table 4). Both turbidity and total dissolved solid positively influence the amount of fish caught in the studied dams.

Fish Yield Estimation: The average yield per kg/ha in the studied dams was 44.78 kg/ha (range 43.56 to 56.68) while the total average fish yield estimate per year is 4.74 quintal (Range 4.36 to 5.47 quintal) (Table 5).

Fish Weight and Size

Fish Weight: Fish weight is significantly variable among the five studied Tigray dams (χ^2 = 23.22, d. p< 0.001) (Fig. 3). In these dams L_{50} weight of *O. niloticus* is 300g (Fig. 4).

Fish Size: Total length (TL) measurement results are presented in Figs. 5 and 6. L_{50} maturity of *O. niloticus* in the dams is 24.5cm. The fishes mature while they are very small (χ^2 = 81.32, p< 0.000). Besides, the highest mature

Table 4: Results of multiple regressions on *O. niloticus* fish catch per hr per 40 meter using monofilament commercial fish net in the five studied dams

Fish catch

Model: $R^2 = 0.62$; Adjusted $R^2 = 0.57$; $F (2, 17) = 13.98$; $p<0.000$

	Beta	Std. Err.	t(17)	p-level
Intercept			22.17	0.000
Turbidity	0.57	0.00	3.48	0.003
TDS	0.35	0.00	3.15	0.046

Table 5: Fish yield estimation per dam

Log 10 Yield = 0.044 T°C +0.482 Log MEI + 0.021	Mai Sessela	Mai Seye	Mai Nigus	Lailay Wukro	Korir
Formula	0.044	0.044	0.044	0.044	0.044
Formula	22.4	22.4	22.4	22.4	22.4
Formula	0.482	0.482	0.482	0.482	0.482
LOG MEI	1.35299	1.24806	1.178	1.5495	1.3124
Formula	0.021	0.021	0.021	0.021	0.021
LOG 10 Yield	1.6587	1.6082	1.5744	1.7535	1.6392
Antilog Yield Kg/ha	45.5765	40.5663	37.5315	56.6838	43.5689
Area of the dam in ha	12	11	13	8	10
Yield in the dam Kg/Year	546.9183	446.2288	487.9096	453.4704	435.6892
Yield in Dam in quintal/Year	5.4692	4.4623	4.8791	4.5347	4.3569
If 60% used in sustainable way	3.2815	2.6774	2.9275	2.7208	2.6141
Price of MSY (60%) (4500 Birr/Quintal	14766.79	12048.18	13173.56	12243.70	11763.61

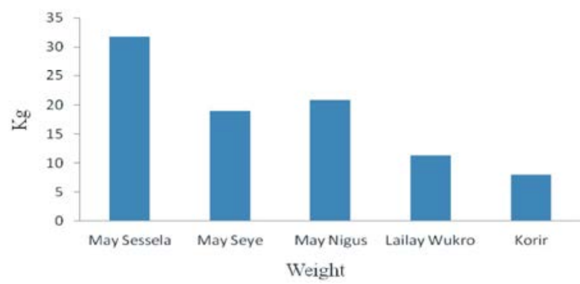

Fig. 3: Total weight of *O. niloticus* collected in 4hrs with 40 m monofilament commercial fishnet in the five surveyed dams

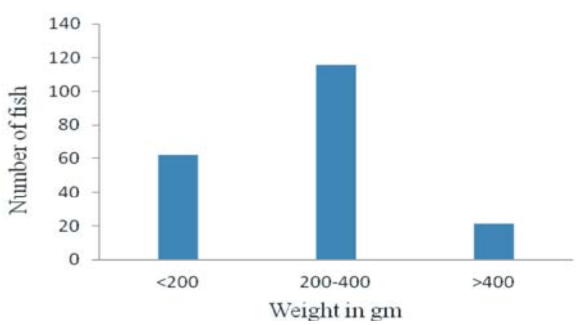

Fig. 4: The weight of *O. niloticus* collected in 4hrs with 40 m monofilament commercial fishnet in the five surveyed dams

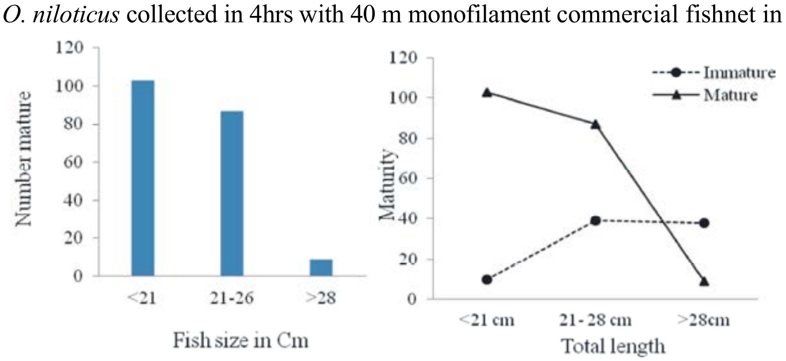

Fig. 5: TL and maturity of *O. niloticus* with respect to the total length in the studied reservoirs in Tigray, (2012-2013).

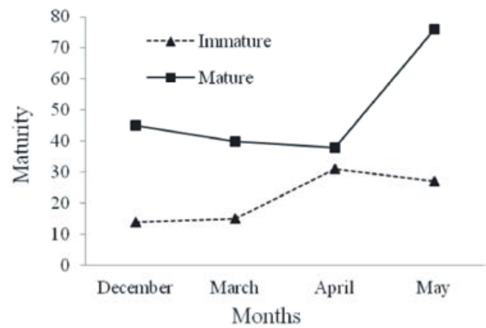

Fig. 6: Maturity of *O. niloticus* with respect to sampling seasons in the studied reservoirs in Tigray, (2012-2013).

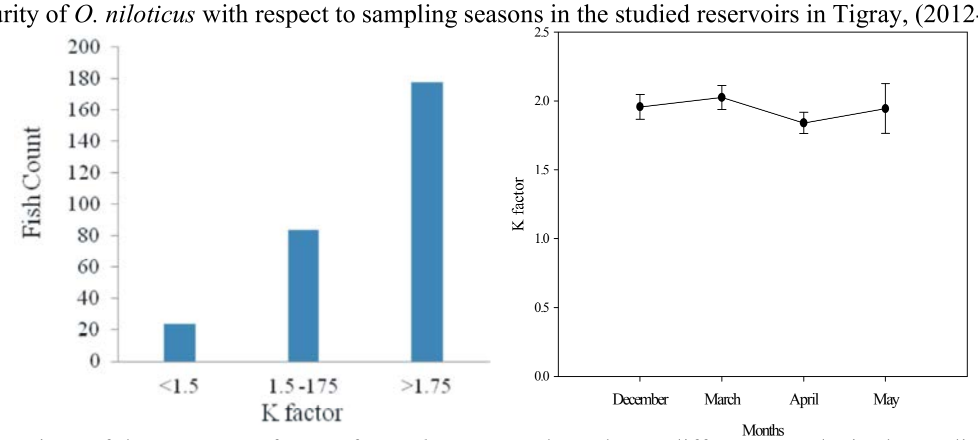

Fig. 7: Comparison of the average K factor of *O. niloticus* caught and K at different months in the studied 5 reservoirs in Tigray (2012-2013).

Table 6: Results of multiple regressions on *O. niloticus* fish condition factor in the five studied dams

Fish Condition factor				
Model: R^2 = 0.27.2; Adjusted R^2 = 0.30; F (2, 17) = 5.04; p<0.019				
	Beta	Std. Err.	t(17)	p-level
Intercept			11.19	0.000
Turbidity	-0.614	0.001	-2.89	0.01
STDS	0.510	0.001	2.41	0.028

fishes were caught during May (χ^2 = 9.22, p< 0.026). Such results may indirectly indicate the seasonal variation in the maturity of *O. niloticus*.

Fish Condition factor: The condition factor (K) of *O. niloticus* in the studied Tigray dams was found to be variable; the least was in April (χ^2 = 22.5, p< 0.001). (Fig. 7). More than 60% have K factor greater than 1.75 (χ^2 = 17.88, p< 0.007).

According to multiple regression analysis, turbidity (t=-2.89, p< 0.01) and TDS (t=2.41; p<0.028) were more important in explaining the variation in the catch of *O. niloticus* in the five studied dams in Tigray (Table 6). Turbidity being influenced negatively while TDS positively in the number of fish caught in the studied dams.

DISCUSSION

The five studied dams, Mai Nigus, Mai Seye, Mai Sessela, Korir and Lailay Wukro dams are generally shallow. Among the several factors that can contribute to the growth of *O. niloticus*, water temperature was found to be generally low. The minimum temperature recorded in this study was found to be similar to the survey reported by Scordella *et al*. [23].The water temperature recorded in the dams was lower than the temperature reported to be optimum for *O. niloticus* growth and reproduction [23, 24]. This low temperature reported in the current study area might be due to the regular monthly sampling time, which was measured from 8.30-10.00 AM. The established optimal growing temperature for *O. niloticus* is between 22-29°C and temperature requirement of spawning greater than 22°C [24, 25].

Unlike temperature, dissolved oxygen of the dams was in the range of optimum growth requirement, that is, greater than 3mg/l [26-29]. The pH of the water bodies was also in the fish's best growth requirement range, which is pH 7-9 [29]. The water was generally turbid, but this might be to some extent explained due to the clay nature of the dam construction, since there is no buffering zone. Besides, the high abundance of phytoplankton could also explain the turbid status of the dams. The findings of this study are similar to the observation of Scordella *et al*. [23] and also to the previous reports by Tadesse *et al*. [1] and Atakilt Berihun and Tadesse Dejenie [30].

The presence of high abundance of phytoplankton and zooplankton in the dams was an indication of potential food source for fish culture in the artificial reservoirs. The dams have contained varieties of phytoplankton and zooplankton taxa. Different studies indicated that *O. niloticus* feed on algae, diatom, green algae, as food for all groups and zooplankton and macro-invertebrates by the young of the year (YOY) groups [31, 32].

As we were using monofilament net, the nets were not deployed for 12 hrs to calculate the Catch per unit effort (CPUE), but the quarter CPUE (Only 4 hr catch with 40m size) catch. The average calculated CPUE for *O. niloticus* was 572. This high CPUE may be related to smaller fish catch effort in the three dams; Mai Seye, Mai Sessela and Mai Nigus, The highest fish catch was from May Sesela May 2013. Our results are similar to that of Tesfaye [33], which reported the peak of *O. niloticus* from June to October in 1992 and July and August 1993 in Lake Tana. The highest fish Catches are associated with the increase in the food availability brought from catchment area after floods. Fish catches in our study were related with nutrient load of the dams, TDS and turbidity, which can be indirect measurements of nutrient load.

Mai Sesla with higher density of fish (71) was characterized by a higher relative abundance of *O. niloticus* than the other studied dams, which might be attributed to the fact that Mai Sesesela is very far from town with no human interference.

The average *O. niloticus* yield per annum is estimated to be about five quintals, which is very small. Food security in Tigray is not dependent on fish production in dams. Therefore, steps are necessary to increase fish production in the dams.

The average maturity size of *O. niloticus* in the dams was 20 -25cm total length. The mean average maturity size for both male and female was found to be 24.5cm (L_{50}). These findings are in agreement with the findings Morales [34] that reported *O. niloticus* reproduce when they are only a few centimeters below market weight (Early sexual maturity). This early maturity has a negative influence on their growth rate and market value. On the other hand, maturing while their size is small may represent a strategy to maximize reproduction such dams with intensive fishing.

Mature *O. niloticus* with eggs and sperms were found all during the sampling months in our survey in Korir Laelay Wukro, Mai Nigus, Mai Sesela and Mai Seye reservoirs. Similar findings were reported by Peterson *et al*. [35] and Peña-Mendoza *et al*. [36]. Besides, the extended breeding season of *O. niloticus* was also reported elsewhere [2].

In this study, we found high K factor of *O. niloticus* in the Tigray dams. The average K factor for the studied dams was greater than 1.75. When we compare the K value of our findings with the food value prepared by Ighwela et al, [37] for different concentration of maltose level feeds for *O. niloticus*, the fishes in the Tigray dams are with good amount of feed. The obtained K value also indicates an isometric growth, which is the desirable for fish farm. The condition factor of most fishes in the Tigray dams was found to be much better than the 30% maltose feed [37]. The fishes are in a good condition and health, which shows the dams have high potential to support high fish production.

CONCLUSION

Fish yield in the study dams was generally low. Besides, the fishes mature while they are small in size. The condition factor of *O. niloticus* in the dams was found to be greater than the artificially prepared fish feed. The fishes in the dams were in a good condition and health which shows the reservoirs have high potential to support high fish production. Such findings indicate the potential of the dam for the production of protein rich fish and the subsequent steps to be taken for enhancing its production.

On the basis of the findings and observations, the researchers would like to suggest the following points to the concerned bodies of the fish managers in the country.

Proper management of the dams, especially avoiding use of illegal fish net, fishing during pick breeding season, the disturbance of the littoral side of the dams by livestock, etc might contribute to high fish production. Higher fish production would provide more protein and income to people living around the dams and contribute to the food security programs of Tigray Region.

Further study on GSI (Gonado somatic index) is recommended to determine the seasons for fishing and the time for banning of fishing in the reservoirs.

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