



Some Biological Observations on Rearing Juveniles of Nile Tilapia (*Oreochromis niloticus* (Linnaeus, 1758)) in Fixed Cages at Gezira Irrigation Canals, Sudan

Sana Yagoub Abdallah Tahir^{1*}, Abdalla Gadain Alnaiem² and Egbal Osman Ahmed³

¹Department of Fish Sciences, Al-Neelain University, Khartoum, Sudan.

²Fisheries Research Center, Khartoum, Sudan.

³Department of Fish Sciences, Al-Neelain University, Khartoum, Sudan.

Authors' contributions

This work was carried out in collaboration between all authors. Author SYAT designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors AGA and EOA managed the analyses of the study. Author EOA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study was conducted at Gezira Irrigation canal to evaluate the growth performance and the effect of water temperature to the culture ability of Nile tilapia juveniles for 120 days. Monosex *Oreochromis niloticus* sized 8.17 ± 0.33 g were carried out from Mabroka fish farm and stocked in 400 m³ fixed cages at a density of 50 fish/m³. Fish were fed daily with a commercial pellet diet with 33% protein concentration at a feeding rate of 3% of their body weight per day. Feed was given twice a day (09:00 morning and 16:00 evening). Fish growth parameters, water quality analysis have measured every two weeks. The final body weight of fish was 40.23 ± 1.04 grams and the mean daily gained weight was 0.29 g/day, while the survival rate of fish was $99.7\% \pm 6.7$ and the Food Conversion Ratio (FCR) was 3.8. The average value of temperature, pH and transparency were 23°C, 7.5, 31.5 cm respectively. The results of the study revealed that there is a possibility to

*Corresponding author: Email: sana.agoub.at@gmail.com;

culture tilapia juvenile at stocking density of 50/m³ in fixed cages in Irrigation Canals, for the effect of water temperature on fish growth performance the results obtained that no more effect on fish growth during study period.

Keywords: Cage culture; growth performance; irrigation water; tilapia juveniles.

1. INTRODUCTION

Fish and fishery products represent a very valuable source of protein and essential micronutrients for balanced nutrition and good health. With sustained growth in fish production, world fish food supply has grown dramatically in the last five decades [1]. Cage culture, the practice of rearing fish in cages, can be applied in existing bodies of water include lakes, large reservoirs, farm ponds, rivers, cooling water discharge canals, estuaries and coastal embayments [2]. The idea of fish farming in cages is searching for producing fish of less cost, high degree of efficiency, and to achieve a good return at the same time [3]. Cage aquaculture has grown rapidly during the past decades and is presently undergoing swift changes in response to pressures from globalization and an escalating worldwide global demand for aquatic products in both developing and developed countries [4]. Cage culture offers several important advantages including; the mixed-sex of tilapia populations can be reared in cages without the problems of recruitment and stunting growth, close observation of fish feeding response and health, ease and economical treatment of parasites and diseases, ensure protection against fish predators (birds, frogs, and reptiles), the possibility of changing cages locations, relatively low capital investment, selling fish fresh to the consumers and may get better prices [2,3,5,6]. The most important species of fish that have successfully cultivated in cages are tilapia, carp, catfish (in freshwater) and mullet, sea bass, trout, salmon, and croaker in salt and brackish water [3]. Among these cultured fishes, tilapia ranks third in terms of production, only after carps and Salmonids [4]. Tilapia is the generic name of a group of Cichlids endemic to Africa. The group consists of three aquaculturally important genera *Oreochromis*, *Sarotherodon* and *Tilapia* [7]. The choice of a species for culture depends mainly on availability, legal status, growth rate, and cold tolerance [2]. Tilapia is one of the most popular aquaculture species, farmed in more than 120 countries and territories [8]. The intensive culture of tilapia has been globally expanding,

experimentally, and commercially, in ponds, tanks, raceways, cages, recirculating and aquaponic systems [9]. The positive aquacultural characteristics of tilapia are their tolerance to poor water quality and the fact that they eat a wide range of natural food organisms [7]. Mixed-sex culture of tilapia has been a common practice in many countries for decades. However, extensive attention has been given to monosex culture of tilapia during the past two decades. Monosex tilapia may have many attributes that make them an excellent candidate for aquaculture. Among these are: high growth rates and feed utilization efficiency, high tolerance to severe environmental conditions including temperature, salinity, low dissolved oxygen, etc, higher energy conservation, reduced aggressiveness, greater uniformity of size at harvest, better flesh quality and appearance, high resistance to stress and diseases and role in controlling over-reproduction [9]. Many authors [10,11] have reported that male tilapia grows faster than females, this may be caused either by a sex specific physiological growth capacity, female mouth breeding or the more aggressive feeding behavior on males [12].

Tilapia cage culture has been practised experimentally and commercially since the early 1970s. Currently, commercial tilapia culture in cages is expanding at a very fast rate, especially in tropical and subtropical developing countries in Asia, Africa and Latin America [9]. The success of tilapia cage culture depends on a number of factors, including water quality, water level, tilapia species and strains, stocking density, stocking size, cage size and shape, feed quality and feeding frequency.

In Africa, the contribution of tilapia production from cages is low and varies between countries. Small cages constructed from locally available materials are generally used in various parts of Africa [9]. Sudan has a large number of water bodies diverse in the River Nile and its branches and tributaries, private lakes, reservoirs, wetlands, dams and flood plains, valleys and creeks (permanent and seasonal) and thousands of kilometers of agriculture irrigation

canals [13]. All of these water resources can be used for fish farming for increasing fish production in different culture systems in particular floating and fixed cages. Recently, the cage culture activity in Sudan is new, in a few years ago has gained special importance and many floating fish farms were erected by the private sector in lakes and rivers, but and has not sufficient scientific results.

The aim of this study is to determine the growth performance of Nile tilapia juveniles, the ability of rearing them in fixed cages and to test the effect of water temperature on fish growth.

2. MATERIALS AND METHODS

2.1 Study Site

This study was conducted in large fish ponds size 10500 m² (210×50 m²) irrigated by gravity from the main Gezira Irrigation canal at Mabroka fish farm, situated in Gezira state, about 150 km south to Khartoum. For the period of 120 day from 1 December 2012 to 1 April 2013.

2.2 Cages Construction and Management

Fixed cages of size 400 m³ (20×10×2 m³) were used in three replicates. The different types of materials used in cage construction, were wood for frames and bamboo to fix the standing cages in a pond, while the cage bag was fabricated by using nylon netting material with 1 cm mesh size. The plan of monitoring cages by checking cages setting and stability, feed preparation, removal of fouling organisms, replacement of damaged or torn nets, the feed intake, removing and recording of the dead fish, and checking cage conditions were carried out immediately throughout the experiment period. Cleaning of the cages was done by brushing bio-fouling organisms such as freshwater algae, sponges, and debris that set on nylon net as soon as they detected.

2.3 Fish Stocking and Feeding

Monosex *O. niloticus* juveniles of mean weight 8.17±0.33 g were collected from Mabroka hatchery ponds and stocked in net cages at 20,000 fish/cage, with three replicates. The fish were manually fed twice daily (9:00 am and 04:00 pm) with commercially pelleted feed made of wheat bran, corn flour, bean cake, fish meal, mineral and vitamin premixes, containing 33%

crude protein. The fish were fed with their experimented diets at (3%) body weight twice daily. Fish weights were measured every two weeks and the quantity of feed adjusted based on the changes in body weight of fish.

2.4 Fish Sampling and Growth Performance Measurement

Sampling was carried out every two weeks for 120 days to determine the growth parameters of fish. Every sampling taken randomly 50 fish from each cage using a scoop net. Then the individual live body weights, the total length were measured using a measuring board, and an electronic weighing scale (QE-400-capacity 5000 gx1 gx177oz x0.1 oz). The fish growth parameters were calculated according to the following formulae [14,15,16]:

$$\text{Survival rate (SR)\%} = \frac{\text{Final fish number}}{\text{Initial fish number}} \times 100$$

$$\text{Weight gain (WG) \%} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}} \times 100$$

$$\text{Specific growth rate (\% day)} = \frac{\ln(\text{final weight}) - \ln(\text{initial weight})}{\text{Days of feeding}} \times 100$$

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Feed intake}}{\text{Body weight gain}}$$

$$\text{Mean Daily weight gain (g/day)} =$$

$$\frac{\text{The final weight at harvest} - \text{The initial weight at stocking}}{\text{The duration of culture}}$$

2.5 Water Quality Analysis

Water quality parameters such as temperature, pH, and water transparency were recorded during study period by using an Ordinary Thermometer, an electric pH meter, (Digital-HANNA instruments), and Secchi disk.

2.6 Statistical Analysis

The Statistical analysis of the data was performed with a statistical package (SPSS 15.0, SPSS Inc., Richmond, CA, USA). Values were presented as means ± standard error of the mean. Data for the growth parameters were tested for variances, and then possible differences were tested using one-way ANOVA and T. Test. with the significant level at ($P < 0.05$) (df = 49).

3. RESULTS AND DISCUSSION

The results obtained in this study showed that, net weight gain, daily growth and the weight gain percentage of *Oreochromis niloticus* were significantly ($P < 0.05$) increased Table 1, 2. From the second week up to twelfth week the growth was very slow not more than 2 grams in every two weeks period of cultivation. Then, the fish growth increased to more than 5 grams (two times) in average every two weeks during the second two months. This is because of the water getting cold (21 °C) in the winter and then became warmed later in the last two months (March and April 25 °C), see Fig. 1.

The data for water parameters (water temperature, pH, and transparency) of the study site were measured throughout the experimental period, were ranged between (20 – 26 °C, 6.9 – 9 and 27 - 38 cm) respectively, shown in Fig. 2.

The following Fig. 2 presents the means of the measured criteria of Nile tilapia rearing water quality parameters. The water temperature was relatively cold during winter months December to January (the first 8 weeks), where the pH and transparency values were in a good range during farming period.

The fish growth data collected for 18 weeks showed an increase in fish weights with time.

The daily growth rate of Nile tilapia fish is not much different from the findings of [17] that given for the same species (males) and with the same stocking density (50 fish/m³) cultivated in cages in earthen ponds. But this paper results for daily growth rate (0.29 g) disagree with results that obtained from cages cultivated in open waters (4.59 g) with the same stocking density of this animal. Also our result is different from the findings of [18] in breeding Nile tilapia (46, 63±0, 79 g) in cage culture system at different stocking densities (50, 100, 150, 200 fish/m³) in Lake Kuriftu, was ranged from (0.68 – 1.15).

The survival rate of fish in this experiment was (99.7%) which was in agreement with the results obtained by [19] in breeding mixed-sex Nile tilapia juveniles (35.99 ± 0.23 g) in cage culture system at a density of 50 fish/m³ in Lake Hora-Arsedi, (98%-100%). But it was higher than results obtained by [17] in rearing tilapia in cages in ponds and in open water which was about (90%). Also it is different from the results of [20] in rearing monosex tilapia (*Oreochromis niloticus*) 10.7±2.48 – 11.8±2.15 g in floating cages under different stocking densities (35,40,45 fish/m³) at Dekar haor in Sunamganj, the values ranged between 91.4% - 95.4% and from the results of [21] in farming Nile tilapia juveniles (23.54 ± 0.57 g) in cages at different stocking densities.

Table 1. Growth performance, feed utilization and fish production during the growth period

Parameters	Value
Initial mean body weight (g)	8.17±0.33
Final mean body weight (g)	40.23±1.04
Mean weight gain (g)	32.03±1.20
Mean gained weight (g/day)	0.29±0.07
Specific growth rate (%/day)	1.33±0.09
Food conversion ratio (FCR)	3.8±0.23
The survival rate in percentages	99.7%±6.70
Production (kg/m ³) per season	2.0

* Values are expressed as the mean ± Standard error (SE)

Table 2. Weight gain %, daily growth rate (g) of experimental fish during farming period

Farming dates	Weight gain %	Mean gained weight (g/day)
Week, 2	90.45	0.53
Week, 4	97.43	0.04
Week, 6	137.33	0.23
Week, 8	159.49	0.13
Week, 10	190.94	0.18
Week, 12	276.62	0.50
Week, 14	313.34	0.19
Week, 16	392.41	0.48

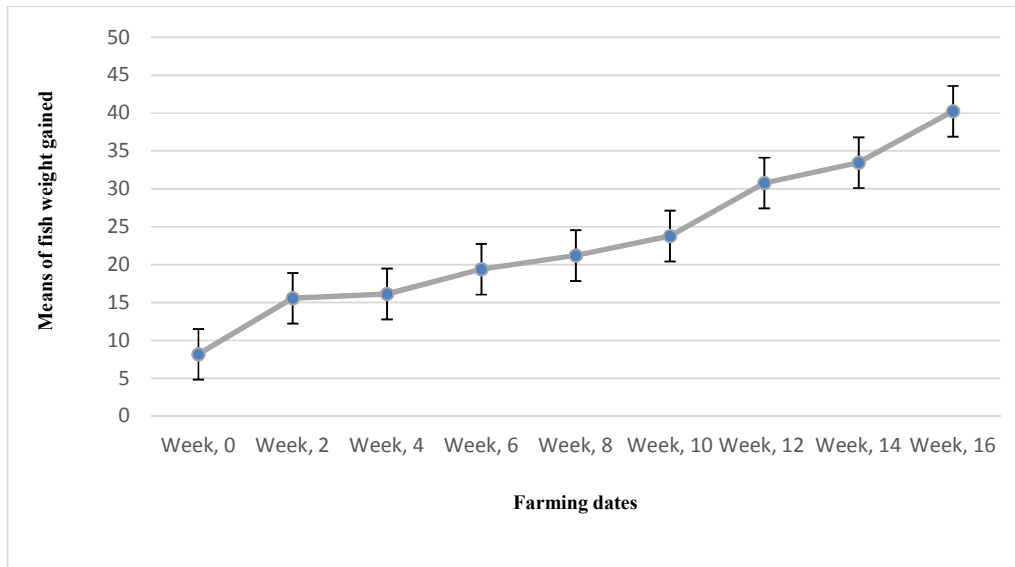


Fig. 1. The means of fish weight gained in grams during the growth period

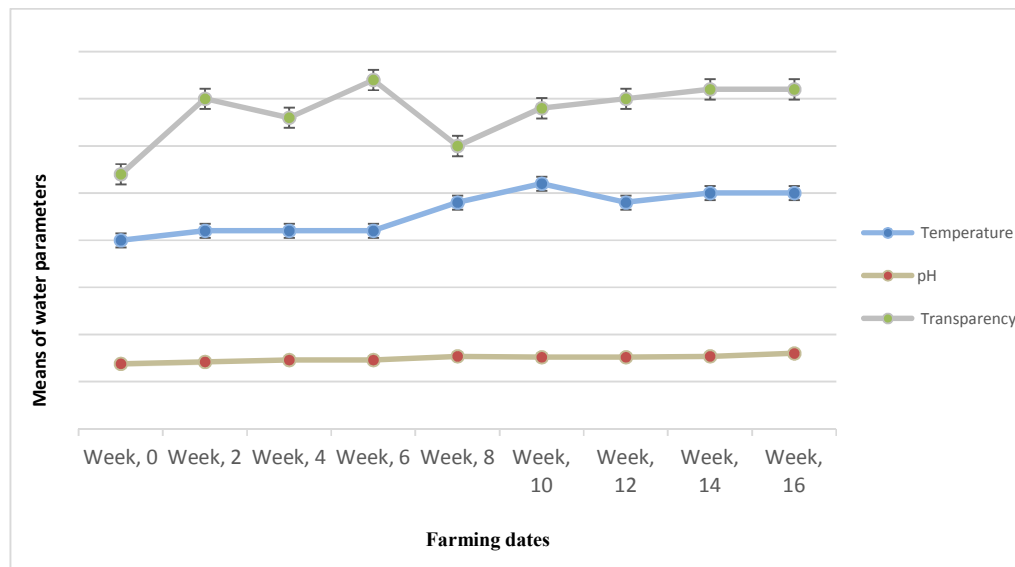


Fig. 2. Means of water temperature, transparency, and the ph value of the canal waters

Thus, the food conversion ratio observed in this study was (3.8), these results are not much different from [19] findings in breeding mixed-sex Nile tilapia juveniles sized (35.99 ± 0.23 g) in cage culture system at a density of 50 fish/m³ in Lake Hora-Arsedi of FCR values 3.73 - 4.79, but our results are not agree with the results of [21] in farming Nile tilapia juveniles (1.76). Also our value is different from the results obtained by [20] in different densities which ranged between (1.50 – 1.65). The same can be said with results of [15] in

breeding Nile tilapia in a cage culture system at different stocking densities in Lake Kuriftu, which was about (2.5) at a density of (50 fish/m³).

Where the specific growth rate %/day of this study (1.3) is not much different from the results of [16] which was 1.1 and the results of [18] which was about (1.0) at a density of 50 fish/m³, but higher densities are used (100, 150, 200 fish/m³) was ranged between (0.79 - 0.97), also it is higher than [19] results which was ranged

between (0.74 – 0.98). But our SGR is lower than the findings of [21] which reached 2.23 at the same stocking density and the results of [20] was between (2.25, 2.27, 2.16) at a density of 35,40,45 fish/m³ respectively.

Where the average fish gross yield in this study was about 2 kg/m³ which less than published data by [20] for monosex Nile tilapia at different stocking densities, values ranged between 5.60 – 6.60 kg/m³. Also the study results less than the result of [19], the values ranged between 9.94 and 17.25 kg/m³ per year. The paper's gross yield also was not in agreement with the findings of [21] which valued 6.25, 8.13, and 9.75 kg/m³ in a density of 50, 100, 150 fish/m³ respectively,

The water quality parameters affect fish growth and health and determine the failure or success of overall culture [9]. In this study the average values of water temperature are of the range 20 °C - 26 °C, are in agreement with the results of [19] in Lake Hora-Arsedi which between (22.6 °C - 25.8 °C), also our irrigation canal waters temperature are not much different than the result obtained by [15] in Lake Kuriftu (20.6 °C - 27.7 °C).

The average value of the canal waters pH (7.7) is higher than the results of [16] which was about (7.2). Where, the water transparency value of this study (36) is much different from the results obtained by [18,19] which ranged between 35 - 60 cm and 91 - 111.5 cm respectively. The water quality parameters of the irrigation canal, the pH and transparency were in a good range recommended for tilapia culture [9] and maybe had not affected on the growth of *Oreochromis niloticus* juvenile during the farming period where the water temperature was at low range 20 – 26 °C and this range maybe had no more effect on fish growth as the ideal range for tilapia is between 25 °C - 30 °C. The materials used in the study cage construction (nylon nets, wood and bamboo) showed a good durability in canal waters, the nylon nets had a good resistance to the sun light, winds and water currents during the study period, this result is agree with the results obtained by [22] to evaluate the benefits and performance of locally available materials for fish cages construction in the water body of El-Rahad Lake.

4. CONCLUSION

Considering the growth performance of this fish and the canal water characteristics during the

farming period, the results revealed that there is an ability for farming Nile tilapia juveniles in fixed cages in the irrigation canals.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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