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Effects of varying stocking densities and temperature on growth performance of Nile tilapia *(Oreochromis niloticus)* fingerlings cultured in semi closed system

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Abstract
An experiment was conducted to determine the impact of stocking densities (SDs) on growth rates, specific growth rates (SGR), daily weight gain (DWG), feed conversion ratio (FCR), feed conversion efficiency (FCE) and survival rate (SR) for Nile tilapia (Oreochromis niloticus) fingerlings in the fish hatchery of Sudan University of Science and Technology. Fingerlings (1.32±0.28g) were stocked in triplicate at stocking densities; 10 (T1), 15 (T2) and 20 (T3) fish/tank, in indoor plastic tanks 40×46×64cm for seventy days. Fish which were fed a commercial floating diet containing 35% crude protein has been added two times per day five days a week in 9% of the stock biomass. Growth measurement of fingerlings and water physiochemical parameters were recorded every 10 days. Result show that Daily weight gain (DWG) is higher ($p>0.05$) in SD (T2) (0.28±0.06g day^{-1}) compared with (T3) (0.21±0.03g day^{-1}) and and) (T1) (0.19±0.03g day^{-1}). Concerning feed conversion ratio (FCR) which is in general very low, specific growth rate (SGR) and feed conversion efficiency (FCE) there is no significant different due to stocking densities ($p> 0.05$), but it is in all show more bust in SD (T2) compare to SD (T1) and SD (T3). The results showed that, there is no effect on survival rate according to different stockings densities ($p> 0.05$). Fish meat analysis indicated that, there is no significant differences according to stocking densities ($p> 0.05$) except for crude protein concentrate which record higher value in (T1) (31.15±0.21) and (T3) (31.05±0.21). Except some temperature fluctuations observed, all water quality parameters tested throughout the experimental period revealed that all parameters were within the permissible levels for optimum growth of O. niloticus. The pH gives no significant differences between the three stocking densities, but with more effects by temperature. In summary, the results showed that the medium stocking density (T2) (15 fingerlings/tank) give favored growth comparing with 10 (T1) and 20 (T3) fingerlings/tank.

Keywords: stocking densities, growth performance, Nile Tilapia

1. Introduction
Nile tilapia *Oreochromis niloticus* provides one of the major sources of protein and income throughout the world. Farmed tilapia production throughout the world increased dramatically in recent year. Among the wide variety of tilapia, Nile tilapia *O. niloticus* is the most common in aquaculture (is the most culture freshwater species among the farmed tilapia and contributes about 71% of the world total tilapia production [1]. For Nile tilapia, a need for systematic effort to secure and to further improves the genetic quality of farmed stock is widely recognized [2].

The effect of stocking density on growth, survival and yield on aquaculture are well known for different species, and seemed to impact production differently [3]. Consequently, identifying the optimum stocking density for a species is a critical factor not only to enable efficient management and to maximize production profitability, but also for optimum husbandry practices [4].

Evaluation of the performance of Nile tilapia fingerlings *Oreochromis niloticus* raised at hyper intensive stocking density in a recirculating culture system which fish (2.07 ± 0.04 g) were stocked in triplicate at 400 ("T1"), 500 ("T2") and 600 ("T3") fish m^2. Stocking density did not affect significantly the survival (89.5 to 93.6%). The growth rate of "T1" (0.96 g day^{-1}; 5.01% day^{-1}) and "T2" (0.92g day^{-1}; 4.95 % day^{-1}) was significantly higher than "T3" (0.83 g day^{-1}; 4.80% day^{-1}). For "T2" and "T3" the SGR were influenced by the variation of dissolved oxygen [5]. The SGR from "T3" was also affected by the concentration of ammonia nitrogen (31%). Further studies investigated the growth response of Nile tilapia; *O. niloticus* (1.8-2.5 g/fish) at two stocking densities (15 and 30 fish/100L. in tank) and the results showed that final body weight, percent weight gain, and specific growth rate (SGR) were inversely affected by stocking density [6]. Condition factor and survival rate was not significantly affected by stocking density. The maximum growth was obtained at low density, whereas the lowest growth was obtained at high density [6]. Feed conversion ratio (FCR), protein efficiency ratio (PER) were significantly affected by stocking density ($P<0.01$). The best FCR was obtained at low density, while crude protein, total lipids and ash were significantly affected by stocking density. The highest protein content in fish body was obtained with low and high densities. The highest content of body lipids was observed at low and high densities [6].

Tilapia culture in concrete and fiberglass are the most popular materials although plastic, metal, and poly-board are also used [7]. Intensification of tilapia culture is a good solution for increasing fish production, and to optimize fish intensification, both feed quality and stocking density should be considered. Reports on the optimal growing temperatures of tilapia fishes in general are revealed and typically was

ranged between 22°C and 29°C, and growth is poor below 20°C [8].

The objectives of this study therefore, was to determine the impact of different stocking densities of Nile tilapia *O. niloticus* fingerlings on growth performance and some physiochemical parameters under semi control culture system.

Materials and Methods

The experiment was performed at the fish hatchery of the collage of Animal Production Science and Technology at Sudan University of Science and Technology (Sudan) for a period of seventy days from 13 Nov, 2015 to 21 Jan, 2016. Nile tilapia *O. niloticus* fingerlings average weight 1.32±0.28g obtained from said facilities hatchery. Prior to start of the experiment fish fingerlings were acclimatized for two days in plastic containers (tanks) (40×46×64cm, W×H×L) containing 50 liter of tap water.

The experiment design base on a three stocking densities (SD); 10 (T1), 15 (T2) and 20 (T3) fingerlings/tank with three replicated per treatment [7]. Commercial floating pellets (35% protein) were handily fed during two feeding period 10:00 and 16:00 at 9% body weight [9] for five days a week (each daily ration divided into two portion [8]) 30% of the water volume from each tank replaced twice daily by siphoning out residual feed and fecal matter [10]. Supplemental aeration were provide to maintain dissolved oxygen in every tanks. Fish mass increase was estimated every 10 days by weighting all number in each tank and the feed rations adjusted accordingly [9]. During the study period, dead fish (mortality) were recorded and removed quickly. Seventy days post-stoking, all fish harvested, each stocking density were weight and counted.

Growth Performance Analysis

Fish growth performance for each treatment was evaluated basing on Specific Growth Rate (SGR), Daily Weight Gain (DWG), Food Conversion Ratio (FCR), Feed Conversion Efficiency (FCE), and Survival Rate (SR) using the formulae below:

$$SGR\ (\%\ day^{-1}) = [(\ln \text{final weight} - \ln \text{initial weight}) / \text{time (days)}] \times 100$$ [10]

$$\text{Weight gain (WG)} = \text{Final weight} - \text{Initial weight}$$ [11]

$$\text{Daily Weight Gain (DWG)}\ (g day^{-1}) = \frac{\text{Mean final weight (g)} - \text{Mean initial weight (g)}}{\text{Duration of nursing (days)}}$$

$$FCR = \frac{\text{Amount of dry food intake (g)}}{\text{Fresh weight gain in fish (g)}}$$ [12]

$$\text{Feed conversion efficiency (FCE)} = \frac{\text{Weight gain (g)}}{\text{Total feed given (g)}} \times 100$$ [12]

Survival rate (%) (SR) = (Final number of fish/Initial number of fish) ×100, was estimated based on feed inputs.

Physico-chemical parameters of the water such as temperature (°C), pH, dissolved oxygen (DO) (mg/L) were monitored every ten days at 10:00am during the whole culture period. Concerning water temperature, three temperature ranges were recorded during the study period e.g. 18-20°C, 16-18°C and 20-22°C, respectively. Monitoring was done by recording temperature with a glass Celsius thermometer. In the other hand, pH and dissolved oxygen (DO) were measured using a digital pocket pH meter (Eco Testr pH1 Waterproof Pocket Tester, Singapore) and (DO) meter (DO-5509, Lutron Electronic Enterprise Co. Ltd., Taipei, Taiwan), respectively. Other chemical parameters such as ammonia (NH_3), phosphorus (P), nitrite (NO_2) and nitrate (NO_3) were measured using API* Freshwater Master Test Kit (model RM000741-00-0310, USA).

Biochemical Analysis

To find any significant different in fish meat; chemical composition due to different stocking densities, kjeldahl method were used [13].

Statistical Analysis

Growth performance and fish meat chemical parameters were statistically compared using a one-way ANOVA ($P< 0.05$), and differences among means were identified using the Duncan Multiple Range Test. Analyses were carried out with the STATISCA ver. 21 computer software.

Results

Growth performance parameter

The effects of different levels of stocking densities on growth, and some other biological indices of Nile tilapia *O. niloticus* fingerlings rearing for seventy days are shown in (Fig. I). (Table I) showed the Growth, survival and production of fingerlings in terms of final weight. The highest increase in weight was obtained in treatment SD (T2) (15 fish/tank) with followed by treatment with SD (T3) (20 fish/tank) and SD (T10 (10 fish/tank) respectively.

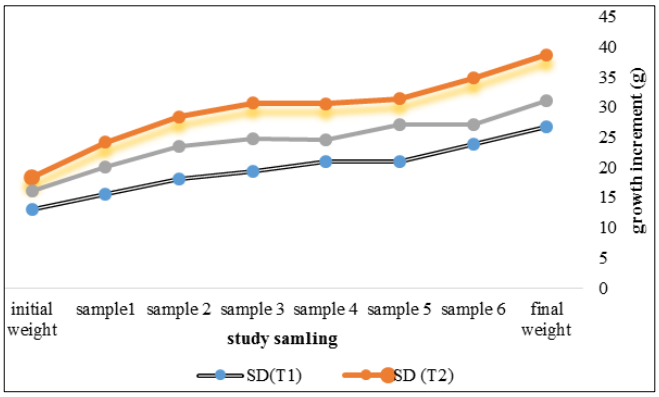

Fig 1: Growth increment (g) of *O. niloticus* fingerlings reared at three stocking densities; 10 (T1), 15 (T2) and 20 (T3) fish/tank for 70 days.

Final body weights, specific growth rates, food conversion ratios, and survival rates are presented in (Table 1; Figure 1). The final weights of the fish stocked at a density of 10, 15 and 20 fish/tank reached mean weights of 26.7±3.2, 38.7±7.1 and 31±6.8g, respectively. Growth increased up to stocking density of 15 fish/tank and dropped at the density of 10 fish/tank. There were no significant differences in weight between experimental groups and no significant differences were found between replicates of the groups over the course of the experiment. Hence data from replicates were pooled

for each treatment prior to analysis. Statistically no significant differences were found between the groups (10, 15 and 20 fish/tank) in terms of final body weights yet better response were detected in medium stocking density group i.e. 15 fish/tank.

Table 1: Rearing indexes of *(Oreochromis niloticus)* fingerlings at different stocking densities

Performance parameters	Stoking density (fish/tank)		
	10 (T1)	15 (T2)	20 (T3)
Final weight harvested (g)	26.67±3.23[b]	38.67±7.15[a]	31.03±3.48[ab]
Weight gain (g)	13.70±2.07[b]	20.23±4.84[a]	14.97±2.15 [ab]
Daily weight gain (g)	*0.19±0.03[b]	0.28±0.06[a]	0.21±0.03[ab]
Feed conversion ratio (FCR)	1.28±0.17	1.28±0.70	1.30±0.01 n
Specific growth rate	1.02±0.17	1.07±0.31	0.93±0.13 n
Survival rate %	100.00±0.00	100.00±0.00	96.67±2.89 n

*Mean ± standard deviation a, b superscript letters within the same row means significant difference according to Duncan's multiple range test; n = not significant difference

The growth indices, survival and production parameters of fingerlings under different treatments over the ten weeks experiment are summarized in (Table 1). Statistically no significant difference was observed in the initial weight of hatchlings stocked in all the experimental tanks. The mean final weight of fingerlings was higher in treatment group with 15 fingerlings/tank than in treatment group with 10, 20 fingerlings/tank. Highest weight gain was also observed in treatment group with 15 fingerlings/tank followed treatment group that have 20 fingerlings/tank, respectively.

Specific growth rate (SGR) was higher in treatment group that has 15 fingerlings/tank in comparison to those in treatment group that has 10, 20 fingerlings/tank. The best food conversion ratio (FCR) was observed in treatment group with 15 (5.87) fingerlings/tank compared to the other treatment. Further, the highest survival rate was also observed in treatment group with 10, 15 fingerlings/tank followed by treatment group with 20 fingerlings/tank ($P < 0.05$). The effect of temperature degree (16-22°C) on growth rate during the study period is seen clear in the daily weight gain of all stocking densities; SD "T1", SD "T2" and SD "T3", on the three temperature ranges; 18-20°C (first thirty days of the treatment), 16-17°C, and 17-22°C with recorded growth rate of 0.31g, 0.08g and 0.28g day^{-1} respectively.

Body Proximate Composition

The whole body of *O. niloticus* fingerlings under different stocking density levels was analyzed to determine the moisture, dry meat, ash, crude protein, ether extract (total fats) and nitrogin free extract (NFE) (Table 2). Tarting with the moisture and ash content percentage of tilapia *O. Niloticus* fingerlings body showed no significant differences among different treatments ($p > 0.05$) and the highest in group with 20 fish/tank (T3) and 10 fish/tank (T1) as acheived (68%) and (2g) for moistur and ash content repectevily (Table 2). For dry meat (%) Statistical analysis showed that there is no significant difference present among the treatment means, in which 10 fishtank (T1) scor the hihest value (33.5±2.12%), compare with 20 fish/tank (32%) which score the lowest value (Table 2).

Statisticaly, crude proteins (%) content of Nile tilapia *O. niloticus* fingerlings body indicate a significant difference ($p<0.05$) among the treatment means. The highest value obtaine in group with 10 fish/tank (T1) as acheived (31.15±0.21%), while the lowest value was recorded in group with 15 fish/tank as (30.1±0.1%) (Table 2). For the Crude fat (%) contents of tilapia *O. niloticus* fingerlings body varied fewer under different treatments ($p > 0.05$).

The group with 10 fish/tank (T1) showed the highest fat contents at (6.9± 0.14%) followed with group 15 fish/tank (T2) as (6.65± 0.2%), while group with 20 fish/tank (T3) showed the lowest fat content at (6.4± 0.14%) (Table 2). For nitrogen free extract (NFE) (%) there is no significant difference present among the treatment means, in which 20 fish/tank (T3) scor the hihest value (28.6±0.14%), while 10fish/tank (T1) (26.45±2.19%) score the lowest value (Table 2).

Table 2: Proximate Composition of *O. niloticus* fingerlings in different stocking density Levels

Performance parameters	Stocking density (fish/tank)		
	10	15	20
Moisture (%)	*66.5±2.12	67.5±0.71	68±0.00 n
Dry meat (%)	33.5±2.12	33±1.41	32±0.00 n
Ash, g (kg DM) $^{-1}$	2±0.00	1.9±0.14	1.95±0.07n
Crude protein, g (kg DM) $^{-1}$	31.15±0.21[a]	30.1±0.14[b]	31.05±0.21[a]
Crude fat, g (kg DM) $^{-1}$	6.9±0.14	6.65±0.21	6.4±0.14 n
NFE	26.45±2.19	27±1.41	28.6±0.14 n

*Mean ± standard deviation a, b superscript letters within the same row means significant difference according to Duncan's multiple range test; n = no significant differences

Water Quality Management

Water quality is critical for survival, health and growth of fish especially in control systems and for the production of quality fish seed in the hatchery. To maintain good water quality the physical and chemical properties of water should be kept within certain safe levels as well as biological properties.

Temperature

The average of the water temperature in tanks during culture period range from 18–20ºC, 16 -17°C for the first fifty days towards the twenty days, respectively, with no different in temperature degree within the three stocking densities 10 (T1), 15 (T2) and 20 (T3) fingerlings/tank (Table 3).

pH Concentration

The pH average in tanks during culture period range from 7.1– 8.2. The highest pH observed in fish tank with the group of 10 fingerlings/tank (T1), will the low pH observed in fish tank with the group of 15 fingerlings/tank (T2) (Table 3). The average of the pH observed the score of 8.1 with average score of 7.2 (Table 3).

Dissolved Oxygen (DO) (ppm)

Dissolved oxygen average in tanks during sampling period ranged from 7.4–7.7ppm. The highest DO observed in 15 fingerlings/tank (T2), followed by 10 fingerlings/tank (T1) and 20 fingerlings/tank (T3) where the lowest mean (7.7) was observed (Table 3).

Ammonia-Nitrogen (ppm)
The average level of the ammonia-nitrogen in tanks during culture period range from 0.2-2.3 ppm. The highest value observed in fish group with 20fingerlings/tank (T3), while the lower value recorded with group 10 (T1) fingerlings/tank (0.2ppm) (Table 3).

Phosphorus
The average level of the phosphorus in the tanks during culture period range from 0.0- 0.5 ppm. The highest observed in the 20fingerlings/tank, where the lowest was absorbed in 10 and 15fingerlings/tank (Table 3).

Nitrite and Nitrate concentrations (ppm)
Nitrite (NO_2) and nitrate (NO_3) average in tanks during sampling period showed very low concentrate, which ranged from 0.00–0.1ppm and 0.2-2 ppm for the nitrite (NO_2) and nitrate (NO_3) respectively (Table 3).

Table 3: Water physiochemical parameters at different stocking densities during the study period

Physiochemical parameters	Stoking Density Levels		
	(T1) 10fish/tank	(T2) 15fish/tank	(T3) 20fish/tank
Temperature (°C)	16 - 22°C	16 - 22°C	16 - 22°C
PH	7.2 - 8.2	7.1- 8	7.2 - 8
Dissolved oxygen (ppm)	7.6	7.7	7.4
Ammonia (NH_3-N) (ppm)	0.2 - 2.0	0.5 - 2.0	0.3 - 2.3
Phosphorus (P) (ppm)	0.0 - 0.5	0.0 - 0.5	0.2 - 0.5
Nitrite (NO_2-N) (ppm)	0 - 0.1	0.00	0 - 0.1
Nitrate (NO_3-N) (ppm)	0.2 - 1	0.5 - 2	0.2 - 2

Discussion
Stocking density is one of the most important factors in aquaculture because it directly influences Growth, survival behavior, health, feeding and production of fish under farmed conditions [14]. The results of this study (Table 1) showed that, the medium stocking density (SD) (T2) daily weight gain (DWG) made amounted to (0.28±0.07g/day) moral differences for each of the stocking densities (T1) (0.19±0.03g/day) and (T3) (0.21±0.03g/day) as reported[5], and also corresponds to what stated [6, 13] of the impact of weight gain and SGR inversely with increasing tilapia fingerlings in different stocking densities in semi-closed systems.
Medium stocking density (T2) showed more value preference for DWG than others stocking densities (T1) and (T3), and preference to non-moral values to stocking density (T1) in all SGR and FCR, whereas both stoking density (T2) and SD (T1) obtained the moral advantage of the last three weight measurements received above comparing with stocking density (T3).
As we find that there is no significant affect due to different stocking densities on survival rate (SR) which is supported with [6]. Generally, the study find some significant different among the means of different stocking densities in some growth parameters as final weight and weight gain which is agree with some studies [17], in other side, the study showed that the medium stocked density (T2) (15 fingerlings/tank) may be the ideal compared to higher and lower stock densities.
In most instances, temperature degree formed the most important environment factors affecting daily growth rates and earned daily growth rate [15]. Reports on temperature degree (16-22°C) effects on growth rate during the study period is seen clear in the daily weight gain (DWG) of all three stocking densities, daily weight gain had been affected by the three temperature ranges which taken during the study period [8, 16]. Temperature ranged 18-20°C earned the higher daily weight gain (0.31g/day), while the temperature range 16-17°C score the lowers daily weight gain (0.08g/day), and with the corresponding between every species and its ideal temperature range [7]. In the latest temperature range 17-22°C, although the lower temperature degree is 17°C, but the higher temperature (22°C) is seemed to be the highest temperature scored during study period, resulting in an acquired much better daily weight gain (0.28g/day) comparing to thermal range 16-17°C (0.08g/day).
The effect of the different stoking densities on survival rate of Nile tilapia *O. niloticus* fingerlings showed no significant different ($p > 0.05$) among treatments [18, 5]. revealed that stoking density did affect significantly the survival rate and demonstrate an effect of different stocking densities on survival rate.
Concerning fish proximate analysis of the fish meat that taken from the three stocking densities, the result which show that, there is no affected by stocking density for all parameters taken [15], ash and dry meat content, as well as moisture and crude fat. This result is in conformity with the work done concerning nitrogen free extract [18]. In this study, crude protein is the only parameter that effected by stoking densities according to Duncan's, although the higher values recorded in the lower stock density (T1), respectively.
In this study, all the physiochemical parameters of the water which record are within the acceptable optimal range for *Oreochromis niloticus* fish culture except water temperature. Temperature is a major metabolic modifier in these fish, temperature degree which ranging from 16-22°C plays a main role in growth rate performance.
The effect of temperature degree is clear seen, firstly on the daily weight gain (g/day) which score low amount in general [7] which reported that, optimal growing temperature of tilapia in general are typically between 22°C and 29°C, and growth is poor below 20°C, and secondly on daily weight gain for the three temperature ranges which established.
As conclusion based on findings of our results, further recommendation for future research should be geared towards the effect of variance stocking densities of Nile Tilapia *Oreochromis niloticus* under different culture systems for a better growth performance as profitability to be achieved as well.

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