Effect of Water Velocity on Tilapia Oreochromis Niloticus Fingerlings Growth Parameters and Body Composition

Ibrahim E. H. Belal
Department of Arid Land Agriculture, United Arab Emirates University, Al Ain, United Arab Emirates
Email: Ibelal@yahoo.com

***Abstract*—Groups of ten *Oreochromis niloticus* fingerlings (average weight in grams 8 ± 0.07, were randomly stocked in plastic circular tanks (water volume 70 L). Each group (tank) of fish was randomly assigned a water velocity level. Six water velocity levels includes 5, 15, 25, 35, 45, 55 cm/sec. were used in triplicate. Tanks were part of a semi-closed water recirculation system. Fish were fed a commercial tilapia feed for eight weeks. At the conclusion of the trial, final weight gain, feed intake, feed conversion ration and the fillet percentages were gradually improved with increasing water velocity levels up to 35 cm/sec. followed by gradual decrease of the growth parameters. Tilapia body composition was affected by water velocity levels. Body fat was gradually reduced and body moisture and proteins was gradually increased with increasing the level of water velocity. Under the reported conditions Exposing tilapia to forced exercise al a level 35 cm/sec of water current improves growth parameters.**

***Index Terms*—water velocity, tilapia, growth, body composition**

I. Introduction

Genetic, environmental and nutritional factors affects animal growth [1]. The environmental factors are of particular importance for poikilothermic aquatic vertebrates [1]. Environmental factors influencing fish growth can be classified into determining factors such as temperature, salinity and photoperiod and limiting factors such as oxygen and ammonia levels [2].

Forced exercise contrary to what one expect, seems to result in reduced oxygen consumption. This is attributed to physiological adaptations such as increase in white muscle activity [1], improvement in cardiac output, and enhanced oxygen carrying capacity of the blood [2]. This can also be saving in ‘breathing” cost as [3] explained that fish who can maintain their position in fast flowing water need only to open their mouths to ventilate the gills. They called it ram ventilation. Ram ventilation can contribute to saving energy in two ways, by not having to pump water over their gills which in turn, results in less turbulence, i. e. a more streamlined flow of water is maintained over the body. This hydrodynamic advantage results in small, but measurable, reduction in oxygen consumption [5]. Additionally, forced exercise help in removing carbon di-oxide and other wastes. The cost of breathing in a dense medium, such as water, can be substantial. Reports are from 10% [6], to 30% or more [7] and according to [8], the cost may be as much as 30 % of the total oxygen uptake. Other researchers [9] offered another explanation. They indicated that the elevated surface velocity in the fish cross flow rearing tank along with a homogeneous dissolved oxygen concentration may accelerate the diffusion at their air-water interface, thus make oxygen available more than the net decrease shows. A more efficient food conversion ratios and growth rates were indicated [9]. Researchers [10] related that for several salmonidae, the speed of water can increase the growth of animals and moderate their aggressive behavior. Study on turbot [11] showed that increasing the flow rate promotes the growth of turbot up to a flow rate of 4.7 tank volumes/h. in eel (*Anguilla anguilla*) commercial intensive culture in The Netherlands producers successfully increased their production by increasing flow rates beyond 1 to 2 tank volumes/h [12]. On the other hand A negative effect on growth of decreased flow rate has been demonstrated for seabass (*Dicentrarchus labrax*) [13] and Atlantic salmon (Salmo salar) smolts (13). It has been indicated low water flow influences the growth rate of Atlantic salmon fry negatively [10].

To the best of my knowledge after reviewing the literature, there is no similar work done on a worm water fish species as tilapia. All the previous studies were done on only cold water fishes.

Tilapia is now the second most important farmed fish in the world. They are the most widely grown of any farmed fish and are adaptable to a wide variety of water conditions. Its production has reached more than 2 million metric tons [14]. Tilapia culture has been moving towards intensive system which depends on artificial feed. Therefore, great challenge for searching for new techniques to increase tilapia productivity in economically feasible system. Nile tilapia was selected for this study as it is a potential species for the UAE aquaculture development and it is widely cultured in many countries around the world. The objective of this

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study was to evaluate the effect of six levels of water velocity on growth, feed conversion, muscle mass, and body composition of *O. niloticus* fingerlings.

II. Materials and Methods

A. Experimental System

Groups of ten *Oreochromis niloticus* fingerlings (average weight in grams 8 ± 0.07, were randomly stocked in plastic circular tanks (water volume 70 L). Dead fish were replaced within the following two days of stocking. Each group (tank) of fish was randomly assigned one water velocity level. Six water velocity levels (5, 15, 25, 35, 45, 55 cm/sec) were used in triplicate. Water rotational velocities were measured by timing the distance traveled by a submerged object carried unobstructed by the rotating flow near the tank wall. Tanks were part of a semi-closed water recirculation system [15]consisting of a four settling tanks to remove solids, small pieces of plastic tubes for nitrification, UV tube, Aquafine U V disinfection made in the USA (Aquafine corporation), for disinfection and an elevated head tank to provide water to each tank. De-chlorinated tab water was used for filling tanks and replace make-up water that was lost due to evaporation and system maintenance. Water was heated using a High Watts Liquid heater unit made in England (E.Braud Limited). Fish were fed to adlib level twice a day seven days a week for eight weeks. Water quality parameters (DO, temperature, total ammonia, and pH) were measured twice a week using Dissolved Oxygen Meter, YSI Model 52 (YSI Instrument Co. Inc., Yellow spring, Ohio, USA), Digital pH ,Jenway ion meter, Jenway Limited cat no. 3205, England, total ammonia ORION Photometer, Orion Research; INC. Aquafast, USA. The system was equally exposed to 12 h illumination using fluorescent lighting.

TABLE I. Analysis of the Commercial Tilapia Feed[1] on Dry Weight Basis

Type of analysis	Content percentage
Moisture	12
Crude protein	30
Crude fat	3
Calcium	0.04
Total phosphorus	2.2

1 The commercial tilapia feed from Emirates Flour and Animal Feed Factory. It contains fish meal, wheat flour, soybean meal, animal fat, and poultry by product, and vitamins and minerals premix.

B. Feed Efficiency Parameters

Feed efficiency parameters including fish weight gain (WG), and feed conversion ratio (FCR), were calculated from the following equations:

a) WG = $w_2 - w_1$
b) Where w2 = mean final weight (g) / fish, w1 = mean initial weight (g) / fish
c) FCR = feed (dry) intake (g) / wet weight gain (g)

C. Analysis

Each fish sample and the commercial diet were analyzed in triplicate for moisture using a forced air oven, crude protein by macro-Kjeldahl, crude fat by ether extraction method, and total ash by muffle furnace (550 C) for 24 h. The methods of analysis were performed as described in [16]

All other data were subjected to one way ANOVA to determine significant ($P \leq 0.05$) differences among the treatment means. Least Significant Differences (SD) multiple range tests [17] were used to distinguish significant differences among treatment means. All statistical analyses were conducted using a system SPSS for windows, (version 12).

TABLE II. Growth, Feed Utilization and Feed Conversion Values for *O. Niloticus* Treated with Different Forced Exercise Levels Values in the Same Column with Different Superscripts Are Significantly Different (P = 0.05)

Water velocity cm / sec	W_0[1] (g fish^{-1})	W_1[2] (g fish^{-1})	W_1-W_0[3] (g fish^{-1})	FI[4] (g fish^{-1})	FCR[5]	PER[6]	% of fish fillet
5	8.17	20.4	12.23[a]	25.23[a]	2.06[b]	1.51[b]	39.98[b]
15	7.9	23.7	15.8[b]	29.81[b]	1.89[ab]	1.66[c]	43.53[c]
25	8.0	24.5	16.5[b]	31.57[b]	1.80[b]	1.63[c]	46.81[d]
35	8.3	26.6	18.3[c]	32.85[c]	2.07[b]	1.74[d]	47.47[d]
45	7.8	22.39	14.59[b]	30.26[b]	2.19[c]	1.51[b]	40.55[b]
55	7.87	21.86	13.99[ab]	30.61[b]	2.19[c]	1.42[a]	35..8[a]

[1] Mean initial wt. (g fish^{-1}), [2] Mean final wt. (g fish^{-1}), [3] Weight gain (g fish^{-1}), [4] Feed intake (g fish^{-1}), [5] Feed conversion rate, [6]Protein efficiency ratio.

III. Results

Although no mortality appeared to occur due to treatments, instances of mortality due to escape (jumping out of experimental tanks) did occur. Water quality parameters were similar and were within the acceptable limits for fish growth throughout the duration of both experiments [18] The average water quality parameters (± SD) were as follows: water temperature, 26 ± 2 C; dissolved oxygen 6.3 ± 1.0 mg/L; total ammonia 1.3 ± 0.1 mg/L and pH 7.3 ± 0.1. Only pH was lower in the lowest water velocity level 6.1.

Proximate composition values (Table II) of the commercial feed agreed well with the estimated values recommended for *O. niloticus* fingerlings [18].

Growth and feed efficiency parameters of *O. niloticus* fed the commercial tilapia feed are shown in Table II. There was no significant difference among the initial weights of fish; however, some of the final weights of fish treated with the six water velocity levels (5, 15, 25, 35, 45, 55 cm/sec) were significantly different from the control. Growth rates of *O. niloticus* increased with increasing the level of forced exercise from 5 to 35 cm /sec. Then, as the water velocity level increases above that (45, 55 cm / sec) growth rates was reduced. Feed intake, on the other hand, was increased as the level of water velocity increased. Feed conversion rates (FCR) was reduced as the water velocity level increases (improved) with increasing the level of forced exercise from 5 to 35 cm /sec while it was increased as the water velocity level increases (low efficiency) above that (45, 55 cm / sec).

Proximate composition of whole fish is shown in Table III. Crude fat of *O. niloticus* body was significantly reduced with increasing water velocity level. Body moisture was, as expected, increased gradually with increasing velocity level. Crude protein, on the other hand was increased with increasing the level of water velocity from 5 to 35 cm / sec flowed by gradual reduction as the level increases. The fillet percentages were gradually improved with increasing water velocity levels up to 35 cm/sec. followed by a gradual decrease

TABLE III. WHOLE BODY COMPOSITION[1] OF *O. NILOTICUS* EXPOSED TO THE EXPERIMENTAL VELOCITIES. VALUES IN THE SAME ROW WITH DIFFERENT SUPERSCRIPTS ARE SIGNIFICANTLY DIFFERENT ($P < 0.05$).

Analysis	5 cm / sec.	15 cm / sec.	25 cm / sec.	35 cm / sec.	45 cm / sec.	55 cm / sec.
Moisture	70.3 [a]	71.6 [a]	72..6 [a]	72.5 [a]	74.2[b]	74.9[b]
Crude protein	16.2 [a]	16.7 [a]	17.2 [a]	17.2 [a]	15.9 [b]	15.1 [b]
Crude fat	7.9 [a]	6.1 [b]	5.0 [c]	4.9 [c]	3.1 [d]	2.8 [d]
Total ash	4.4[a]	4.5 [a b]	4.1[a]	5.1 [b]	5.5 [b]	5.2 [b]

[1] Expressed as a percentage of fish wet weight

IV. DISCUSSION

Growth parameters (weight gain, feed conversion rates, and the percentages of white muscles) were improved by about 50 % when the fish were exposed to water velocity level of 35 cm / sec. This was probably due to the gradual increase in feed intake and increase in muscle mass. On the other hand, increasing the water velocity level from 35 to 55 cm / sec caused gradual reduction in growth parameters. These probably, because of combinations of the following 1) fish were loosing some energy from the higher water velocity (exhausting the fish) than the optimum level, 2) fish were getting some benefits of the forced exercise, and 3) the increase in feed intake levels. Similar results were shown [13] with cold water fish species (rainbow trout) and eel (*Anguilla anguilla*) he indicated that fish weight gain was increased by 40% at the optimum water velocity rate. On the other hand, at lower water velocity 55 cm / sec, fish growth parameters were probably affected negatively due to lower feed intake and increased CO_2 concentration which causes lower pH of 6.1. Similar results were indicated in a study on eel [12]. It has been shown [8] that higher carbon dioxide concentrations combined with low pH may have resulted in a slightly lower growth rate for the low water flow.

Body compositions of O. *niloticus* fingerlings exposed to the optimum water velocity level had several (35 cm/sec) advantages over those exposed to the other levels as followed: 1) tilapia had more moisture and less fat, this would have an economical advantage as it increases fish shelf life of fish, 2) fish had more body protein and muscle mass, fish became more efficient in feed utilization (FCR). These results agreed well with previous work [19].

In conclusion, optimum water velocity level improves *O. nilotoicus* growth performance and body composition parameters. 35 cm / sec is recommended to be used as an optimum water velocity level.

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Ibrahim E H Belal was born in City of Al Mahahlla Al Kobra, Egypt. Got his BSc in animal science from Ain Shams University, Cairo, Egypt in 1975, MSc in aquacuture from Auburn University, Alabma, USA in 1982 and PhD in fish nutrition from Michigan State University East Lansing Michigan USA in 1987

He served obligatory military service the Egyptian in 1976 for one year, worked in Poultry Company for two years in feed mill as an Agriculture Engineer then Joined National Aquaculture Center. I was sent to USA to study MS, PhD in aquaculture. I worked as an Assistant Professor in King Faisal University in the College of Food and Agriculture, Department of Aquatic resourse Development, Al Hassa, Saudi Arabia from 1988 to 2004 and work as an Associate Professor in the College of Food and Agriculture, Department of Aridland Agriculture, Al Ain, United Arab Emirates from 2004 to date where I served as Department Chairman from 2008 to 2012.

Dr. Belal is a member of World Aquaculture Society Aquaculture.

