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Full Length Research Paper

Effect of transportation on storage density and the sustainability and development of Nile tilapia, *Oreochromis niloticus* (Linnaeus)

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The effect of transportation on storage density and the sustainability and development of Nile tilapia, *Oreochromis niloticus* was investigated between May and August, 2006 under controlled conditions. Mortality rate was affected by temperature and weather conditions. The starving of fish before transportation helped to improve the survival of fish which reduced fish metabolic rate and improved the quality of transport water. The percentage mortality was lesser on rainy days (8%) in container with aerator compared to the container without aerator on rainy day (36%). The addition of salt (NaCl) to the transport water stabilized the fish, reduced the stress and eventually reduced fish mortality. The fish stocking density affected the mortality. It was observed that the higher the fish stocking density in the tanks the lower the mortality rate. The condition factor of 1.77 to 2.35 indicated a healthy form; this also displayed considerable changes in average condition which reflected fluctuation in their metabolism balance. In this study the feed consumption rate was found to be affected by the stocking density of fish; the higher the density the higher the conversion rate.

Key words: Growth, *Oreochromis niloticus,* stocking, survival, transportation.

INTRODUCTION

The Nile tilapia previously referred to as *Tilapia nilotica* is now known as *Oreochromis niloticus*, it is widely accepted that *O. niloticus* is one of the species that are acceptable for culture applications (Boulenger, 1965). It is an omnivorous feeder, which can filter feed on plankton as well as accepting larger food particles (Reed et al., 1967). They further reported that *O. niloticus* could be recognised at a glance by characteristic pattern of dark and light bands crossing the caudal fin. The body is rather elongated and usually showed a number of rather narrow bands on the back.

According to Berka (1986), transportation success depends on many factors including the duration of transportation, temperature of the water, water quality, size and density of the fish, physical condition of the fish and duration of the depuration period before fish transportation. Juvenile survival is also directly related to dissolve oxygen availability in the water (Wedemeyer, 1996) and elevated carbon dioxide and ammonia levels can also cause fish mortality during transportation, since they accumulate in the water and may reach toxic concentration (Ross and Ross, 1999). The use of salts and anaesthetics during juvenile fish transportation is widely used to reduce stress (Guest and Prentice, 1982; Ross and Ross, 1999). Among the recommended products are sodium chloride (salt), gypsum and bezocaine, all of which are relatively cheap and easy to use. The salt and gypsum reduce the osmotic gradient between fish and the water (Wedemeyer, 1997), helping

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the fish to maintain their homeostasis. Benzocaine is considered an efficient and safe anaesthetic for juvenile tambaqui (Gomes et al., 2001), but it has not been tested as a transportation additive for this species.

Jensen (1990) noted that experience and research have shown that transportation results can be improved by the addition of certain chemicals and that any chemical used should produce an economical and proven benefit. It was further stated that if food fish are transported, only chemicals and drugs approved by the food and drug administration can be used. Jensen (1990) also implicated that chronic fish losses or weak fish problems are often associated with handling and transporting fish in very soft water (less than 10ppm). It was added that antifoaming agents are used to combats formation of scum or foam on the water surface. Acclimatization is necessary for fish culture in the case of transferred fish. The process of seasonal acclimatization observed in the teleost fish sustains the physiological compensatory mechanisms that the organisms have to survive the natural changes occurring in its habitats (Alvarez et al., 2004). When fish are crowded, stressed and executed, water quality can deteriorate rapidly.

Oxygen is an important limiting factor in fish transport (Jensen, 1990). Temperature is very critical because it influence other water variables. Inadequate acclimation for temperature difference during loading or unloading will stress or kill fish (Jensen, 1990; Boyd, 1998).

Stocking density in any rearing system is very important and is dependent on level of culture system (that is extensive, semi-intensive and intensive) size of fish, species of fish and size of rearing compartment (Ovie et al., 2008). The success of fish culture in water bodies depends on the appropriate water quality, stocking densities and management procedures. Excessive stocking of fish per unit area of rearing compartment may result in stunting of some fishes like the tilapia, *Oreochromis niloticus* (Dambo and Rana, 1992) and Cannibalisus in other like catfishes (Dada et al., 2000). Varion in growth rates and relative sizes attained by fish in a given space is a well known phenomenon (Frenderso and Carpenter, 1971; Amberker and Doyle, 1990; Ovie *et al.,* 2008).

There have been various studies on the effects of stocking densities on growth and survival of some tropical fish species such as channel catfish (Kenneth, 1974); Trouk (Trzebiatowski et al., 1981); *Sarotherodon galilaeus* (Otubusin et al., 1990), *Oreochromis niloticus* (Otubusin, 2000); *Clarias gariepinus* (Inyang and Odo, 1996); *Heterobranchus bidorsalis* (Dada et al., 2000); *Heterobranchus longitilis* (Ovie et al., 2008). Dada et al. (2008) and Ovie et al. (2008) jointly reported that the development of jumpers increased as stocking densities increased.

This study investigates the transportation, acclimatization and the effect of stocking density on the survival and growth of *Oreochromis niloticus* in experimental tanks.

MATERIALS AND METHODS

Transportation and acclimatisation test

The fish were starved a day before transportation. *Oreochromis niloticus* juveniles [Total length 4.08 ± 0.05 cm and weight 1.19 ± 0.05 g (mean ± SE)] were acquired from Agboola farm hatchery, Ayobo Lagos State. The fish were gathered and kept for 2 days in two hapas inside the pond. After this period, Juveniles were transferred from the hapas to depuration tanks (1000-200oL) where they were kept for 12 - 18 h (Gomes et al., 2006). One hundred fish were collected and put into the tank already filled with water. Four tanks were used for the study. Two of the tanks (49 × 35 × 28 cm) were stocked with 25 fish each without aeration and two tanks of the same size as stated above were stocked with 25 fish each with aerator five plan aerator (Atom-2 portable battery pump operating R20 UMI size D 1.5V battery). This was done both on sunny days and rainy days for twice a month for 4 months (May - August 2006). The temperature (with thermometer calibrated in degree Celsius and the fish behaviour were monitored.

After depuration fish were packed in 30 L plastic tanks with 20 L of water without aerator (for 4 plastic tanks) and with aerators (plastic tanks). The tanks were then closed with mosquito net (0.3mm mesh size). Twenty-five fish were stocked in each tank and transported from the farm to University of Lagos. After transportation, the fish survived (FS) was quantified, and the remaining fish from each tank was held in separate 1.2 m^3 fibre tank to evaluate survival after 96 h (Gomes et al., 2006). The tanks were located in the Marine Sciences Department‘s basement, University of Lagos.

Stocking density, fish survival and growth of *O. niloticus*

In the laboratory, the fingerlings were distributed into four glass tanks already disinfected and filled with dechlorinated tap water. The tap water was dechlorinated by exposing it to the sun for three days. The fingerlings were acclimatised for 48 h and the surviving fingerlings were later put into glass tanks (49 × 35 × 28 cm) labelled A, B, C and D. Tank A containing (10 fingerlings), Tank B (20 fingerlings), Tank C (30 fingerlings) and Tank D (40 fingerlings). The fingerlings were supplied with oxygen by the use of two aerators in each tank.

The physico-chemical parameters in this experiment were not measure but suitable conditions were maintained by cleaning the tanks and constantly changing the water which was done twice a week.

Table 1. Composition of NIOMR fish feed.

Ingredients	Weight (%)
Palm kernel cake	37.0
Fish meal	25.5
Wheat bran	37.5
Lipids (total)	6.8

Table 2. Transportation mortality ratio with or without aerator.

Month	No. of fish	With aerator				Without aerator			
		Sunny day	%	Rainy day	%	Sunny day	%	Rainy day	%
May	25	6±0.1	24	2±0.2	8	13.0±0.1	52	9±0.1	36
June	25	5±0.1	20	2±0.1	8	12±0.1	48	10±0.1	40
July	25	6±0.2	24	3±0.2	12	14±0.1	56	8±0.1	32
August	25	6±0.1	24	2±0.2	8	13±0.1	52	9±0.2	36

Table 3. Fish transportation mortality on sunny and rainy days.

Months	With aerator		Without aerator	
	Sunny day	Rainy day	Sunny day	Rainy day
May	7.00±1.41^{B}	2.00±1.41^{A}	13.00±1.41^{C}	9.00±1.41^{B}
June	5.00±1.41^{A}	2.00±1.41^{A}	12.00±2.83^{B}	10.00±0.00^{B}
July	6.50±2.12^{A}	3.00±2.12^{A}	14.00±2.83^{B}	8.00±1.41^{AB}
August	6.50±2.12^{B}	2.00±1.41^{A}	13.00±1.41^{C}	9.00±1.41^{BC}

Mean (±SD, Standard Deviation) with the same superscript letter in a row are not significantly differently ($P > 0.05$) in the Duncan Multiple Range Test (DMRT).

The mean standard lengths of the fish in each tank were determined at the beginning and at the end of the experiment. The body weight of the fish in each tank was determined fortnightly by placing a bowl on the Sartorious top loading balance and then the balance was adjusted to zero and the fish was weighed by placing it in the bowl and the weight observed. The condition factor was calculated using the equation:

$$K = \frac{100W}{L^3}$$ (Bannister, 1976)

Where;
K = condition factor;
L = standard length in centimetre (cm);
W = weight of fish in grams (g)

The fingerlings were fed with artificial feed compounded by the Nigerian Institute for Oceanography and Marine Research (NIOMR), Victoria Island, Lagos. The daily food ratio for the fingerlings in each tank was 5% of their body weight. The fingerlings were fed two times a day in equal proportion. The feed was adjusted to 5% of their new body weights fortnightly. Table 1 shows the composition and proximate composition of NIOMR feed.

The food conversion ratio (FCR) was calculated by dividing the mean food fed (g) by the gain in weight (g):

$$\text{Feed Conversion ratio (FCR)} = \frac{\text{Mean food fed (g)}}{\text{Total weight gain (g)}}$$

Statistical analysis

Statistical analysis was done using Duncan Multiple Range Test (DMRT) using the computer package SPSS Version 10.

RESULTS

Oreochromis niloticus originating from the freshwater is known to be very hardy and can withstand transportation stress. The mortality rate was affected by temperature and weather condition as indicated in Tables 2 and 3. The percentage mortality was tested on rainy day (8%) in container with aerator compared to the container without aerator on rainy day (36%) in May. On the overall more

Table 4. Weekly mortality rate and percentage survival of *Oreochromis niloticus* at different stocking density.

Tank	Stocking	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week	8th Week	% Mortality	% Survival
A	10	-	-	-	-	1	-	-	-	10	90
B	20	-	-	-	-	5	-	-	-	25	75
C	30	-	-	-	-	-	-	-	-	0	100
D	40	-	-	-	-	-	-	-	-	0	100

Table 5. Mean weight of *O. niloticus* (in grams) over a period of eight weeks.

Tank	Initial mean weight	2nd Week	4th Week	6th Week	8th Week	Mean weight gained	% Weight gained
A (10 fingerlings)	7.89	8.40	10.70	11.20	13.76	5.87	74.40
B (20 fingerlings)	6.73	7.60	9.50	11.46	13.04	6.31	93.76
C (30 fingerlings)	7.06	7.10	9.70	11.00	14.15	7.09	100.42
D (40 fingerlings)	7.83	7.70	8.90	9.97	13.98	6.15	78.54

Table 6. Mean growth in length of *O. Niloticus.*

Tank	Initial mean length (cm)	Final mean length (cm)	Gain in length (cm)	% Gain in length
A	7.81	9.20	1.39	17.80
B	7.02	8.74	1.72	24.50
C	7.33	8.59	1.26	17.19
D	7.51	8.41	0.90	11.98

mortality was recorded in the containers without aerators. Also in the sunny days than rainy days with or without aerator in May there was no significant difference between tanks on sunny day with aerator and rainy day without aerator but the mortality on sunny day without aerator is statistically higher than fingerling on transported on rainy day with aerator.

Stocking density on the survival and growth of *O. Niloticus*

Mortality

Tank A had a mortality of 1 (10%) which occurred in the fifth week of the experiment. Tank B had a mortality of 5 (25%) which also occurred in the fifth week of the experiment but no mortality was recorded in Tank C and D. A summary of the mortality and survival is presented in Table 4.

The initial weight of the 10 fingerlings in Tank A was 7.89 g and the final mean weight was 13.7 g giving an increase in weight of 5.87 g representing a percentage gain in weight of 74.4%. Tank B had 20 fingerlings with an initial weight of 6.73 g and attained a mean final weight of 13.0g giving an increase in weight of 6.31 g, representing a percentage gain in weight of 93.76%. Tank C had 30 fingerlings with an initial weight of 7.06 g and a final weight of 14.15 g with an increased mean weight of 7.09 g, representing a percentage gain in weight of 100.42%.

Similarly, Tank D with 40 fingerlings had an initial weight of 7.83g and a find mean weight of 13.98 g with an increase in mean weight of 6.15g representing a percentage weight of 78.54% (Table 5).

Growth in length

The initial final mean length and percentage gain in length shown in Table 6. Tank A had an initial mean length of 7.81cm and a final mean length of 9.20cm giving an increased mean length of 1.39cm representing 17.80%.

Those in Tank B had an initial mean length of 7.02cm, attained a final length of 8.74cm giving an increase mean length of 1.72cm which represented 24.5% gain in length. Fingerlings in Tanks C and Tank D had initial mean lengths of 7.33cm and 7.51cm and attained final lengths of 8.59cm and 8.41cm respectively, giving increased mean lengths of 1.26cm (17.19%) and 0.90cm (11.98%) respectively.

Table 7. Initial and final condition factor (K) of *O. niloticus.*

Tank	Initial weight (g)	Initial length (cm)	Initial (k)	Final weight (g)	Final length (cm)	Final (k)
A	7.89	7.81	1.66	13.76	9.20	1.77
B	6.73	7.02	1.95	13.04	8.74	1.95
C	7.06	7.33	1.79	14.15	8.59	2.23
D	7.83	7.51	1.85	13.98	8.41	2.35

Table 8. Food conversion ratio (FCR) of *O. Niloticus.*

Tanks	2nd Week	4th Week	6th Week	8th Week	Total mean food fed (g)	Cumulative mean weight gained	Food conversion ratio (FCR)
A	55.30	58.80	67.20	70.56	4.50	5.87	0.77
B	93.80	106.40	99.40	120.40	7.50	6.31	1.19
C	149.10	149.10	197.26	224.14	12.85	7.09	1.81
D	918.40	215.60	242.76	276.50	17.02	6.15	2.77

Condition factor (K)

At the end of the experimental period fingerlings in Tank A had a final condition factor of 1.77, those in Tanks B had 1.95 also Tanks C and A had condition factors of 2.23 and 2.35 respectively as shown in Table 7.

Food conversion ratio (FCR)

The food conversion ratio for the fingerlings recorded in Tank A was 0.77, Tank B (1.19) and Tank C (1.81) and Tank D (2.77) respectively. Table 8 shows the food conversion ratio for *O. niloticus*. The FCR indicated that the fingerlings in the tanks were able to convert 0.77, 1.19, 1.81 and 2.77 unit weight of feed into unit body weight of fish.

DISCUSSION

Transportation of fingerling is one of the most difficult aspects of fish culture. If the containers were the fingerling are stocked has a very limited space, the fish move turbulently around competing for space and available oxygen (Djajadiredja, 1958). The stress created by the medium was related to the environmental factors like temperature and dissolved oxygen which are affected by the weather as reported by Jensen (1990) where it was reported that some fish species are very sensitive to temperature shock and that smaller fish are more sensitive than larger ones.

In the culture of *O. niloticus* under four different stocking densities of 10, 20, 30, and 40 in glass tanks for eight experimental weeks there was a high percentage of survival ranging between 75% and 100%. This means that the mortality was relatively low with a percentage mortality ranging between 0 and 25% in the four experimental tanks. The low morality could be related to the hardy nature of *Tilapia* spp as observed by Bardach et al. (1972).

The growth in weight increased considerably with percentage gain in weight in the tanks comparing the mean weight gained, it was observed that the tank with 30 fingerlings had the highest gain in weight. Although the other tanks had relatively high percentage weight gain with the tank (10 fingerlings) having the lowest percentage of 74.4% gain weight among them. This agreed Al-Harbi and Siddiqui (2000) who reported that there is decline in fish growth rate and feed utilization with increasing levels of stocking densities.

The tank with 20 fingerlings had the highest gain in length of 24.5% at the end of the experiment. Bardach et al. (1972) suggested that in order to obtain a higher yield and effective production in *Tilapia* culture, the culture ponds should be stocked at a lower density. This explained why the tank with 40 fingerlings had lowest growth in length of 11.98% probably the stocking density was too high in relation to the container size used. The condition factor shows the state of the fish well being or how robust the fishes. The condition factor of 1.77 to 2.35 indicate a healthy scenario this also displayed considerable changes in average condition, thus, reflecting fluctuation in their metabolism balance, the pattern of maturity and the state of fullness of the alimentary canal which may influence their condition factor (Reed et al., 1967; Boulenger, 1965).

Food conversion ratio may serve as an indicator of the nutritional value of feed and specific growth rate (% per day) with increase in feeding frequency and weight (Balamin and Hatton, 1979). The tank with 10 fingerlings had an efficient food conversion ratio of 0.77. Increase in body weight influenced the amount of food needed in each tank per body weight. In this study the feed consumption rate was found to be affected by the stocking density of fish, that the higher the density the higher the conversion rate.

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