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Water quality and growth performance of *Oreochromis niloticus* under integration with mallard and muscovy ducks

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Abstract

A study was conducted to evaluate the effect of duck manure and spilled duck feed on water quality and production of Oreochromis niloticus in an integrated system utilizing two local duck breeds. Treatment 1 (T1) consisted of fish (mean weight, 20.17 ±1.28g) stocked at a density of 5 fish/m² in a 72m² pond and integrated with 12 Mallard ducks (Anas platyrhynchos); treatment 2 (T2) consisted of fish (mean weight, 21.86 ±0.93g) stocked at a density of 5 fish/m² in a 72m² pond and integrated with 12 Muscovy ducks (Cairina moschata) while treatment 3 (T3) was the control (72m² fish pond without integration). Fish in T3 was fed compounded feed of 30% crude protein content three times daily while those in T1 and T2 fed on duck manure and spilled duck feed (15% crude protein content). Water quality parameters of the fish ponds, growth parameters of fish and ducks were monitored. After a 12-week experimental period, mean weight gain of fish were 140.68, 122.11 and 157.19g in T1, T2 and T3 respectively while percentage survival was highest in T3 and lowest in T2. Water quality parameters were generally favourable for fish growth in all the treatments. Mallard ducks are recommended for the duck-fish system since they performed better than Muscovy ducks both in survivability and ability to engender fish growth.

Keywords: *Oreochromis niloticus, mallard, muscovy, integration, water quality.*

Introduction

Integrated duck-fish farming is an age old practice in Central Europe and South East Asia but little literature exists on integrated duck-fish farming in Nigeria. Nigerian poultry farming is dominated by chicken (Duru et al., 2006) and the vast majority of poultry-fish farming studies have been on chicken-fish farming (Ibiwoye et al., 1996; Nnaji et al., 2011 etc.). It is important that other poultry animals are integrated with fish farming in order to increase poultry and fish production through the adoption of the generated technologies by farmers who raise other poultry animals. Little and Muir (1987) stated that the combination of fish and duck farming is an inexpensive way of fertilizing ponds for fish production. Advantages of ducks over chickens include their relatively high disease tolerance, hardiness and excellent foraging ability (NAERLS, 2013). According to Ola (2000) ducks survive better than the best laying strains of chicken even under adverse conditions like high rainfall, temperature, poor housing etc. However, duck meat and eggs generally command lower market prices than chicken in Nigeria and due to the shovel-shape of their bills, ducks are prone to spill and waste more feed than chicken when confined.

This study will determine the growth performance of *O. niloticus* under integration with Mallard and Muscovy ducks, the effect of duck manure on water quality and the potential of duck-fish farming in Nigeria.

Materials and Methods

The experiment was carried out at the fish farm site of the National Institute for Freshwater Fisheries Research (NIFFR), New Bussa and six earthen ponds (each 72m²) were used for the study consisting of three duplicate treatments. Four duck sheds (each 7.5m²) were constructed over four ponds. The duck sheds were built directly over the ponds and ducks were sourced from the local markets. Treatment 1 involved integration with 12 adult Mallard ducks *(A. platyrhynchos)* while Treatment 2 involved integration with 12 adult Muscovy ducks (*C. moschata*). The ducks in both treatments had an average age of 10 months (with initial mean weight of 1.02 ±0.21kg in T1 and 1.16 ±0.18kg in T2) and were stocked at a density of 1600 ducks/ha and a male to female ratio of 1:3. Treatment 3 was the control and involved no integration. The ponds were stocked with *O. niloticus* juveniles at a density of 5 fish/m². The integrated treatments were fenced so that the ducks were confined within the fish pond area but adequate playground was provided for them and they were fed *ad libitum* with compounded feed (crude protein content, 15%) containing maize bran, millet and guinea corn in a 50:30:20 ratio. Fish in the integrated treatments fed on duck manure and spilled feed from the duck shed while fish in the control was fed compounded feed of 30% crude protein content.

Water samples were collected at a depth of 10cm with acid washed polyethylene bottles for the determination of physico-chemical parameters. Temperature, pH, dissolved oxygen, nitrite and ammonia were determined on a weekly basis while transparency, total solids, total dissolved solids, alkalinity, hardness, conductivity, nitrate, phosphate, phytoplankton and zooplankton were determined monthly using standard methods (APHA, 2005). A total of 40 *O. niloticus* samples were collected monthly with a net from each pond and weighed with a weighing balance. Standard and total lengths were also determined with meter rule. Faecal droppings and spilled feed were collected on a 24-hour basis every week for the determination of daily manure and spilled feed loading rates for each treatment. Proximate composition of duck manure was also analysed using standard methods described in FAO (1994). The study lasted 12 weeks.

Results and Discussion

The relevant parameters of duck and fish which were determined are outlined in Table 1. Mallard ducks (under T1) survived better than Muscovy ducks (under T2). One Mallard and 4 Muscovy ducks died and were replaced in the course of the experiment. Fish production was significantly lower ($P<0.05$) in T2 than in the other treatments. Compounded feed (T3) led to higher fish growth than duck manure (T1 and T2) and this contrasts with the findings of other authors (Men et al., 2003; Barash et al., 1982 and Chand et al., 2006) who concluded that fish growth was better in the duck-fish system than in the control where fish was fed compounded feed . However, there was no significant difference ($P>0.05$) in fish survival in the treatments. Proximate composition of duck manure is shown on Table 2. Moisture content was significantly higher ($P<0.05$) in Mallard duck manure compared to that of Muscovy duck but there was no significant difference ($P>0.05$) in crude protein content of dry manure from the two duck species.

Table 1: Weight of ducks, manure/spilled, feed rates and fish production

Parameters	Treatments		
	T1	T2	T3
No. of ducks stocked	12	12	–
Initial mean weight of duck (kg)	1.02 ±0.21	1.16 ±0.18	–
Final mean weight of duck (kg)	1.36 ±0.16	1.48 ±0.24	–
No. of eggs produced	20	4	–
Manure loading rate (g/day)	153.49 ±8.72	162.04 ±5.68	–
Spilled feed loading rate (g/day)	18.26 ±0.32	15.33 ±1.81	–
No. of fish stocked	360	360	360
No. of fish at the end of the experiment	332	324	338
Survival of fish (%)	92.22	90.00	93.88
Initial mean body weight/fish (g)	20.17 ±1.28	21.86 ±0.93	22.63 ±0.88
Final mean body weight/fish (g)	160.85 ±12.29	143.97 ±15.87	179.82 ±20.44
Mean weight gain /fish(g)	140.68	122.11	157.19

Table 2: Proximate composition (%) of fresh duck manure

Parameters	Treatments	
	T1 (Mallard)	T2 (Muscovy)
Moisture	74.80	70.59
Dry Matter Basis		
Potassium	0.84	1.06
Nitrogen	4.25	4.73
Phosphorus	1.89	2.01
Crude Fat	7.15	8.83
Crude Protein	22.60	21.45
Crude Fibre	9.33	10.61
Ash	14.92	16.40
NFE	32.96	29.62

Table 3 shows mean values for physico-chemical parameters in the various treatments. Mean values for all the parameters except temperature and transparency were significantly lower ($P<0.05$) in the control (T1) compared to the integrated treatments (T1 and T2). The levels of the parameters were generally favourable for fish production and dissolved oxygen (DO) was higher in the integrated treatments probably due to duck activity in the ponds. This result is similar to the conclusions reached by Prinsloo et al. (1999).

Table 3: Mean (±SD) values of physico-chemical parameters of water in the integrated system

Parameter	Treatments		
	T1	T2	T3
Temperature (°C)	28.23 ± 0.25	28.50 ± 0.20	27.92 ± 0.35
pH	8.85 ± 0.21	8.78 ± 0.13	6.25 ± 0.27
Electrical conductivity (μScm⁻¹)	87.58 ± 4.72	96.45 ± 3.18	79.05 ± 2.15
Total solids (mgL⁻¹)	3.50 ± 2.89	3.22 ± 1.03	2.16 ± 0.93
Total dissolved solids (mg/l)	2.17 ± 10.74	1.95 ± 0.63	1.06 ± 0.55
Transparency (cm)	10.08 ± 0.95	11.70 ± 1.34	15.16 ± 1.72
Dissolved oxygen (mg/l)	8.27 ± 1.84	7.10 ± 1.93	5.80 ± 0.87
Hardness ($mgCaCO_3$/l)	140.77 ± 11.24	127.9 ± 14.30	109.26 ± 7.53
Alkalinity (mg/l)	323.40 ± 3.81	429.28 ± 9.07	280.17 ± 5.49
Nitrate (mg/l)	1.639 ± 0.581	1.452 ± 1.073	0.300 ± 0.128
Nitrite (mg/l)	0.062 ± 0.006	0.040 ± 0.017	0.029 ± 0.009
Ammonia (mg/l)	0.057 ± 0.028	0.045 ± 0.013	0.032 ± 0.016
Phosphate (mg/l)	0.619 ± 0.813	0.502 ± 0.238	0.297 ± 0.150

Table 4: Mean (±SD) Phytoplankton Abundance in the different Treatments

Composition	Abundance (cells /ml)		
	T1	T2	T3
Microcytis sp.	1205.36 ±3.22	0.00 ±0.00	160.54 ±0.53
Anacytis sp.	17250.11 ±4.95	28500.11 ±19.25	1100.95 ±3.28
Fragillaria sp.	100.51 ±0.66	0.00 ±0.00	0.00 ±0.00
Chlorella ellipsoidea	513.70 ±0.81	2405.37 ±5.84	200.55 ±1.10
Athrospira sp.	340.22 ±1.20	9000.48 ±6.10	128.74 ±0.59
Nitzchia sp.	203.16 ±0.51	311.18 ±3.92	0.00 ±0.00
Scenedesmus incassatulus	60.02 ±1.88	3302.49 ±12.71	20.14 ±0.35
S.s quadricanda	120.73 ±1.29	2400.66 ±9.43	20.99 ±0.26
Hormidium sp.	24.65 ±0.73	310.84 ±2.80	0.00 ±0.00
Anabaena spirodes	40.47 ±1.31	1825.60 ±10.77	25.72 ±0.84
Stanrastrum rotula	20.33 ±0.47	0.00 ±0.00	20.16 ±1.73
Closterium sp.	0.00 ±0.00	300.88 ±3.62	0.00 ±0.00
Pediastrum simplex	0.00 ±0.00	0.00 ±0.00	20.48 ±0.55
Tetraspora sp.	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00
Navicula digitoria	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00
Total	19879.26 ±17.03	48357.61 ±74.44	1698.27 ±9.23

Table 4 shows species composition and mean abundance of phytoplankton in the different treatments. A total of 15 phytoplankton species were identified in the treatments during the study. Phytoplankton abundance was significantly higher ($P<0.05$) in the integrated treatments (T1 and T2) than in control with *Anacytis* sp. being the most abundant. Similar results were obtained by other authors (Sasmal et al., 2010; Prinsloo and Schoonbee, 1987). Duck manure stimulated the production of high quantities of phytoplankton compared to the control.

Table 5 shows the species composition and abundance of zooplankton in the different treatments. A total of 13 zooplankton species were identified in the treatments. *B. angularis* was the dominant zooplankton in all the treatments and abundance was significantly higher ($P<0.05$) in the integrated treatments (T1 and T2) than in the control (T3). Plankton analyses shows that duck manure engenders the growth of plankton and fish species like *O. niloticus* are expected to do well. This result is similar to the conclusion reached by Islam et al. (2003) and Little and Edwards (2005).

Table 5: Mean (±SD) Zooplankton abundance in the different treatments.

Composition	Abundance (cells /10 ml)		
	T1	T2	T3
Brachionus falcatus	200. 11 ±3.25	100.33 ±4.28	60.59 ±1.84
Brachionus angullaris	6198.04 ±8.30	10105.22 ±35.90	1900.17 ±10.55
Cyclopoid copepods	400.25 ±3.98	200.55 ±3.72	80.77 ±5.20
Copepodites	511.71 ±1.42	211.50 ±5.41	160.31 ±12.34
Asplanchna sp.	223.60 ±2.95	122.57 ±6.90	20.88 ±0.59
Lecane decipens	414.00 ±4.81	0.00 ±0.00	20.45 ±1.22

Composition	Abundance (cells /10 ml)		
	T1	T2	T3
Nauplii	409.60 ±5.66	98.10 ±4.36	340.56 ±5.37
Trichocerca cylindrical	100.27 ±1.73	101.63 ±7.88	142.19 ±2.94
Moina micrura	100.19 ±3.44	112.09 ±3.67	125.61 ±8.05
Brachionus Calyciflorus	516.70 ±6.52	0.00 ±0.00	260.44 ±2.57
Bosmina sp.	0.00 ±0.00	110.52 ±2.30	20.17 ±1.55
Diaphanosoma exicusm	0.00 ±0.00	100.35 ±5.86	20.93 ±5.18
Branchionus diversiconis	0.00 ±0.00	0.00 ±0.00	20.41 ±0.96
Distance trawled (m)	10	10	10
Total zooplankton / 10ml	9074.47 ±42.06	11100 ±80.28	3140 ±58.36

Conclusion and Recommendations

The experiment shows that duck–fish farming is a feasible and potentially profitable venture in Nigeria. However, adequate awareness creation is needed for the adoption of this system since duck farming in Nigeria is still at a low level and integrated duck–fish farming is not widely practiced among duck farmers. Muscovy ducks are not recommended for the system since they do not stay long in water and easily get sick when confined in such a system. Mallard ducks are recommended and more research is needed on the performance of other duck breeds and fish species in the system.

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