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Assessing Growth Performance of Local Tilapia Co-Cultured with Nile Tilapia Under Varying Fertigation Conditions in Liberia

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Abstract

This study explores the integration of aquaculture and livestock farming by examining the growth performance of *Tilapia zilli* co-cultured with *Oreochromis niloticus* in pig-manure-enriched ponds. The ponds (400m^2) were drained, bottom-dried, followed by

lime treatment, and flooded with clean water. Fingerlings were acclimatized in for two weeks before introduction to the experimental ponds. In the first treatment, three ponds were enriched with 25 g of pig manure twice a week, while in the second treatment the ponds were unfertilized. The fingerlings were stocked at 0.5 fish/m^2 resulting in a population of 200 male juveniles (100 local Tilapia and 100 Nile Tilapia) approximately 25g each per pond. The growth performance indicators were length, mean weight gain (MWG), specific growth rate (SGR) yield and survival rate (SR). The highest SGR (2 %) was noted amongst *Oreochromis niloticus* (nile tilapia) in fertilized ponds while the lowest (0.45%) from the *Tilapia zilli* in the pond with no manure. Average weight gain attained by *O. niloticus* was significantly higher ($P < 0.001$) than those for *T. zilli*. The fish in fertilized ponds attained the highest mean weight gains (ranging from 300g for *T. zilli* to 488g for *O. niloticus*). The lowest weight gain (42 g) was generally observed in the *T. zilli* raised in the unfertilized ponds. Survival rates (SR %) of the fish ranged from 17 % in the ponds lacking pig manure to 87% in fertilized ponds. The highest mortality rates were recorded in the unfertilized Pond, which had 17%-42% survival from zilli and Nile respectively. Productivity was higher in the fertilized ponds than in the unfertilized pond. Growth performance of *Oreochromis niloticus* (nile tilapia) was higher than *Tilapia zilli* (local tilapia). Farmers should frequently practice the best extensive growth out fertilization system to obtain good fish yield.

Keywords: Aquaculture, organic fertilizer, feeds, Liberia

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Introduction

Despite the vastness of brackish and marine water, 84% of global fish production occurs in freshwater sources (Naylor *et al*., 2020). Aquaculture is diverse however, fish production is the dominant activity (Tacon, 2020). Compared to most terrestrial agricultural production systems, over 95% of global aquaculture is realized

within developing countries, where production has been increasing at an average annual rate of 6.1% (FAO, 2019). However, this predominance in fish production within developing countries is largely attributed to Asia (Naylor *et al*., 2021). China is the major player in Asian aquaculture, being the region's largest producer, processor, and consumer. Aquaculture growth rates in Africa have exceeded those in Asia over the past two decades, although this growth starts from a much smaller production base (Boyd *et al*., 2020). Feed technology advancements, breeding practices and domestic demand drive this growth (Munguti *et al*., 2021). It is possible to scale up aquaculture production more efficiently in Africa as sustainable aquaculture practices become more popular.

The rapid expansion of aquaculture in developing countries is vital for improving livelihoods. In Africa, the aquaculture sector is a critical component of food security and economic development. Egypt and Nigeria lead Africa in aquaculture, focusing on species like Nile tilapia and catfish, which are well-adapted to local conditions and highly demanded in regional markets (Adekele *et al*., 2020). As a major aquaculture fish, tilapia is unique, as it is a key product in international markets through vertically integrated operations and a subsistence crop for some of the poorest farmers in the world. The tilapias, with their unique characteristics form of reproduction and extreme hardiness, allow farmers with the most meager resources an opportunity to rear the fish. Some farmers have even been known to rear tilapia in reservoirs or barrels. In contrast to carps, farmers do not need access to hatcheries or specialized information to rear Tilapia in captivity.

The fact that fish can utilize natural feeds in the ponds, makes it the most popular method of rearing tilapia. Tilapia pond management ranges from extensive systems using only organic or inorganic fertilizers. The major drawback of pond culture is the high levels of uncontrolled reproduction that may occur in grow-out ponds (James *et al*., 2010). For a long time, fish farmers have increased fish yields by fertilizing their fish ponds using inorganic fertilizers. Ponds' fertilization stimulates algal growth (autotrophs) mostly phytoplankton fed upon by fish and other microorganisms (zooplanktons). However, due to the rising cost of inorganic fertilizers, their continued use is unsustainable (Boyd, 2018). Organic fertilizers are a viable option (Dróżdż *et al*., 2020). Because of its herbivory characteristics, *O. niloticus* is a good candidate for organically fertilized ponds (Bwala & Omoregie, 2009).

In Liberia, farmers practicing piggery and fish production mainly use organic fertilizer for fish pond fertilization. The production systems are mostly small-scale where the high cost of feeds is the major constraint (Wuor & Mabon, 2022). Characterization of the use of organic fertilizer could better inform its implementation. Organic fertilizer has the advantage of availing natural foods in the ponds, producing a secondary feed for fish. Tilapia is particularly suitable for co-culturing and pond fertigation due to its ability to improve water quality, efficient nutrient utilization, and compatibility with various aquaculture systems. By consuming plankton and detritus matter, tilapia helps in controlling algal blooms hence reducing organic waste in the water (Perschbacher, & Stickney, 2017). This is particularly beneficial in penaeid shrimp ponds where tilapia can alter pathogenic bacterial populations, thereby improving the overall health of the pond ecosystem (Diana *et al*., 1994). Reduced feeding strategies combined with pond fertilization can enhance the biodiversity of gut flora in

tilapia, leading to improved feed efficiency and overall health (An & Anh, 2020).

The primary objective of the current research is to assess the growth performance of local Tilapia co-cultured with Nile tilapia in earthen ponds using comparable fertilization systems. This is with a view to offer more sustainable options for fish rearing in Liberia.

Materials and Methods

Study site

Experiments were carried out at the Central Agricultural Research Institute, CARI, (06° 57.635' N and longitude 009° 34.165' W) situated in Suakoko, in Bong County, Liberia. Bong County has more than 500 aquaculture farmers which enables the county to maintain the higher fish farming activities among all the 15 Counties in Liberia (Todd, 2016).

Local tilapia (*zilli*) was collected from farms identified by CARI and Fish-Lib research teams. Fish-Lib technicians carried out the fish's identification and collection process in collaboration with CARI research team.

Stocking

Ponds (400m^2) were first emptied, bottom-dried, followed by lime treatment, and refilled with clean water. Fingerlings were then acclimatized in hapas for two weeks before introduction to the experimental ponds. The fingerlings of both Local and Nile Tilapia were stocked at 0.5 fish/m^2. Hence, there were 200 male juveniles (100 local Tilapia and 100 Nile Tilapia) approximately 25g each in each pond. To deter predators, bird watchers and scarecrows were employed.

Total length (TL) was measured to the nearest 0.1 cm using a 1-m measuring board. Wet weight of the males was determined using an electronic balance scale (KERN & Sohn GmbH, Shanghai, Yueping Scientific Instrument, China) accurate to the nearest 0.01g. The growth was then observed for six months.

Three ponds were enriched with 25 kg of pig manure twice a week (treatment 1), while the other three had no enrichment (treatment 2).

Growth performance indicators

The growth performance indicators were length, mean weight gain (MWG), specific growth rate (SGR) and survival rate (SR). Monthly weight and length measurements were taken from 15 fish per treatment. The growth performance indicators were determined from these formulas;

MWG = (final mean body weight-initial mean body weight)/ (initial body weight) *100%

$$SGR = \frac{\text{In (final body weight)} - \text{In (intial body weight)}}{\text{Culture period (in days)}} * 100\%$$ (Ricker, 1979)

$$SR = \frac{\text{Initial number of fish stock} - \text{Total mortality (counts)}}{\text{Initial number of fish stock}} * 100\%$$ (Attipoe *et al.,* 2009)

Data analysis

Data collected were entered into an electronic spreadsheet and then subjected to analysis of variance (ANOVA). Multivariate ANOVA was then performed for weight and other measurements. In cases where significant differences were obtained, Turkey test was applied to further separate the means. All the analysis were done using the JASP (version 0.17.1) statistical package for windows. Microsoft Office Excel 2017 was used to illustrate the results using tables and graphs.

Results and Discussion

Specific growth rates (SGR) recorded for all the treatments were

relatively low, ranging from 0.45 % to 2 %. The highest (2 %) was noted amongst *Oreochromis niloticus* (nile tilapia) in treatment 1 and the lowest (0.45) from the *Tilapia zilli* in the pond with no manure (Table 1). These SGR values were statistically different ($P < 0.05$).

Table 1: Specific growth rate of the *O. niloticus* and *zilli* in the experimental ponds

Experimental fish	Fertilized (%)	Control (%)
Nile	2 ± 0.01^{a}	1.88 ± 0.008^{b}
Zilli	1.78 ± 0.009^{b}	0.45 ± 0.005^{c}

The range of SGR recorded from this study differed from those observed by Bwala & Omoregie (2009), who noted a range between (0.31-0.57% day) from *Oreochromis niloticus* grown in tanks using different levels of pig manure application. Kang'ombe et al. (2006) also reported SGR of (0.42 and 0.43 %/day) in similar experiment for *Tilapia rendalli* grown in ponds enriched with cattle and pig manure respectively. This variation in specific growth rate was probably due to the concentration of comparable level of manure applied, low stocking density of fish, and the desirable physicochemical parameters of the water.

In all the ponds, the mean weight gains attained by *O. niloticus* were significantly higher ($P < 0.001$) than those for *T. zilli* (Table 2). The fish in fertilized ponds attained the highest mean weight gains (ranging from 300g for *T. zilli* to 488g for *O. niloticus*). The lowest weight gain (42 g) was generally observed in the *T. zilli* raised in the controls.

These results differed from similar work conducted with fish grown in highly concentrated pig dung (HCPD) tanks which recorded the highest growth of 123.49g gain in weight; followed by fish in the medium concentrated pig dung (MCPD) with weight gain of 115.11g, while those in low concentrated pig dung (LCPD) recorded the least growth of 55.40g weight gain (Bwala *et al*., 2009). The fish feed on the zooplanktons thriving from feeding on the bacteria and fungi produced from the decomposing manure (Dhawan, 2002). The main differences between the current study and the previously alluded to are the regime of fertilization and the fact that the current study co-cultured the fish species.

Table 2: Mean weight gain of the *O. niloticus* and *Tilapia zilli* in each treatment in (grams)

Experimental fish	Fertilized	Unfertilized
O. niloticus	$488.25^{a} \pm 12.3$	$375.32^{c} \pm 10.4$
T. zilli	$300.64^{b} \pm 9.4$	$42.26^{d} \pm 2.1$

Survival rates (SR %) of the fish ranged from 17 % in the ponds lacking pig manure to 87% in fertilized ponds. The highest mortality rates were recorded in the unfertilized Pond, which had 17%-42% survival from zilli and Nile respectively (Table 3). The low survival rates in the unfertilized ponds can chiefly be attributed to low quantity of both zooplanktons and phytoplanktons. Pig dung in the fertilized ponds nurture the growth of phytoplanktons and zooplanktons (Endebu *et al*., 2016). The lack of pig dung in the unfertilized ponds led to low planktons' levels, depriving the fish of the required nutrition and therefore higher mortality.

Table 3: Survival rate of the Nile and Zilli in each pond in (%)

Experimental fish	Fertilized	Unfertilized
O. niloticus	$66^{a} \pm 5.6$	$42^{b} \pm 3.3$
T. zilli	$87^{c} \pm 8.2$	$17^{d} \pm 1.2$

Conclusion and Recommendation

Pond productivity was higher in the fertilized ponds which obtained better growth in both species than in the unfertilized pond. Growth performance of *Oreochromis niloticus* (nile tilapia) was higher than *Tilapia zilli* (local tilapia).

Farmers should frequently practice the best extensive growth out fertilization system to obtain good fish yield and profit margin by integrating their farms with piggery that will provide easy access to pig dung.

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