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Full length Research paper

Fish growth performance in ponds integrated with poultry farm and fertilized with goat manure: a case in Ethiopian Rift Valley

Megerssa Endebu[1]*, Daba Tugie[1] and Tokuma Negisho[1],

[1]Zeway Fisheries Resources Research Center, P.Box 229.Zeway, Ethiopia.

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Extensive fish farming is expanding among farmers in Ethiopia where integration with other system is opting to combat the limiting fish feed supply. This experiment was conducted in earthen ponds to evaluate fish growth performance in pond integrated with poultry farm (T2) against fish growth in goat manure fertilized pond (T1) without feed supplement. Tilapia *(Oreochromis niloticus)* and carp (*Cyprinus carpio*) poly-culture was used. The size of fish at stocking for *O.niloticus* and *C.carpio* were32.0±7.51 g and 13.1±2.81 g at density of 1.5 and 0.6 m^{-2} respectively. Fish were weighed individually at harvest and the average weight of the two groups were compared in independent sample t-test for both species separately. The *O.niloticus* significantly ($p<0.05$) higher average final weight of 174.2±40.8 g at a faster daily growth rate (DGR) of 0.75 g.day^{-1}inT2 than in T1 with 80.0±15.8 g final weight at DGR of 0.25g.day^{-1} during the culture period of 190 days. Similarly, *C.carpio* attained a significantly higher ($p<0.05$) average final weight of 277.1±33.79g at a rapid DGR of 1.8g.day^{-1} in T2 than in T1, which attained average final weight of 55.0±15.6 g atDGR of 0.28 g.day^{-1} during 150 days culture period. Hence, integrating fish pond with poultry farm results in faster fish growth rate which can be used as a good option to solve the feed problem facing extensive fish farms in Ethiopia.

Key words: *Cyprinus carpio,* Integration, *Oreochromis niloticus,* Pond, Poultry.

INTRODUCTION

More than 500 million people depend, directly or indirectly, on fisheries and aquaculture for their livelihoods (FAO, 2011). Demand for fish and fishery products is predicted to remain increasing because of population growth, economic development and changes in food habits (FAO, 2001). Supply from capture fisheries is expected to remain constant, or even to decline. Indeed, fish supply from the capture fisheries in most countries is believed to have reached or be close to the maximum sustainable yield suggesting that an increase in aquaculture fish supply could help reduce the expected shortage of fish. Besides availing fish to a wider range of consumers, aquaculture can also provide jobs; generate income, increase food security and contributing to alleviation of hunger in countries like Ethiopia.

*Corresponding author's: e-mail: iamendebu@yahoo.com

Aquaculture in Ethiopia is at its infancy level. Farmers in Oromia region practiced extensive fish farming in small ponds using Nile tilapia since 2008 (DabaTugie, 2010). The performances of these fish farms were mentioned promising. However, it was not supported with a package to attain potential production level. One of the many constraints of fish farming in Ethiopia is feed supply. On the other hand, many farmers in Ethiopia are rearing animals like cattle, poultry, sheep, goat equines and/or camels. They also grow vegetables using irrigation in addition to production ofother field crops. Under an extensive management, the problem of feed supply in fish farm can be managed under low cost system and maximized resources utilization by integrating different farms which can supply organic fertilizer to the fish pond.Organic fertilizers are usually animal manures or plant wastes and cuttings ("green manure").Manure from chickens, goats, sheep, ducks, pigs, rabbits, cattle and horses are excellent fertilizers for fish ponds. Direct use of the waste from livestock production in fish ponds is wide spread and conventionally recognized and the practice increases the efficiency of both livestock farming and fish culture (Nnaji *et al.*, 2009). Other examples of organic fertilizers suitable for ponds are digestedsludge from biogas generators, molasses from sugar cane factories, composted vegetation,table scraps and waste water from animal slaughter houses.

Addition of organic fertilizers like poultry droppings to a fish pond increases fish production (Enamul Hoq *et al.*, 1999: Abbas *et al.,* 2004). Moreover, integrated pond management with poultry, fish and vegetables was proofed to be excellent approach for sustainable production, income generation and employment opportunity of the resource poor rural households (Alam *et al.,* 2009).

In livestock-fish farming system there is a possible transfer of pathogens between livestock and humans. Moreover, spilled chicken feed and manure contains heavy metals like As, Zn, and Cu that are added as feed supplements to boost poultry production. These metals possibly accumulates to unsafe levels in fish tissue when fish is cultured in such a system for long period (Nnaji *et al.,* 2011). Adequate measures should be taken to prevent the risk of these metals. Hence, there should be a regular monitoring of the metals by testing water, sediment and fish for the metals to be within the permissible limits. The risk is also minimized in such a way that heavy metals accumulate more in the visceral tissues like kidney, liver and gut of fish where these organs are removed before the fish is sold or consumed in Ethiopia.

Provided the advantages of the integrated livestock-fish culture, this experiment was sought to find a better approach of fish pond culture that can be practiced among farmers as a strategy for poverty reduction, ensuring nutritional security, creating job opportunity and diversifying income.

Specifically the objective of this study was to evaluate the fish growth performance under poultry-fish andgoat-fish integration systemsin a participatory approach on farmer’s land.

MATERIALS AND METHODS

Description of the study area

This study was conducted in the Awash basin of Ethiopian Central Rift-Valley at Fentale, $8^0$45'34’’N and $39^0$48’00’’E with an altitude of 1094 m.a.s.l.The area is characterized by warm climatic condition where fish *Oreochromis niloticus, Cyprinus carpio* and *Clarias gariepinus* thrive in the Awash River and dams on the river upstream. Though rain deficit, the area is suitable for fish pond culture using water from irrigation canals diverted from Awash River. Cattle, goats and sheep are major livestock reared in the area in addition to camels, potential for integration.

Experimental ponds

Two earthen ponds of area 6m x 8m having separate water inlet and outlet were used. The ponds wereexcavated on a gentle slope land near to a water source of main irrigation canal to secure the permanent water supply through gravity flow. Each of the ponds had capacity to hold water to a depth of 120cm, and have free board of 30 cm above water level. Before stocking the experimental fish, the ponds were prepared by drying for three weeks and liming the bottom to control transmission of any parasite and disease from previous stocks. The ponds were then filled with water from the irrigation canal via pipe. The new water was maintained in the pondsfor two weeks fertilized either with goat manure (T1) or with poultry manure (T2) to enable plankton establishment after which the experimental fish were stocked.

Treatments

1. Treatment 1, pond fertilized with goat manure (T1),
2. Treatment 2, pond integrated with poultry farm (T2).

Intreatment 1, pondwas fertilized by applying 7 kg of goat manure every week at a rate of 2 kg/100m^2/day (Libunao, 1990). The goat manure was sun dried with about 94% DM content and 1.3-2.8%, 0.02-0.42%, 0.003-0.93% N,P,K respectively(Osuhor *et al.*, 2002, Adejobi *et al.*, 2011). Taking the mean values of the figures and estimating the nutrient load from the goat manure; the load is at a rate of 240 g, 2.1g, 4.4gof N,P, K respectively per day in T1.Manure application started from the first day pond filled with water by hanging the manure in pond corners tied in sacks.

Fertilization continued by adding new manure weekly until the end of the experiment when fish were harvested. No supplementary feed was given to the fish during the experiment period.In the second treatment (T2), poultry house having two classes, the first class on land and the second class hanging over the pond was constructed. Fifteen layers of Rhode Island Red breed were kept in the poultry house at a proportion of 30 chicken per 100m^{-2} pond. Commercially formulated poultry feed ad-lib was given to them and the chicken were managed as recommended by the breed supplier. The chicken discharge fresh manure at an average of 96 g/chicken/day (Enamul Hoq *et al.,* 1999) which provides 10 kg of fresh poultry manure in a pond every week. Though the chemical composition of manure varies based on the type of feed given to the chicken, age, and their condition, fresh poultry manure contains about 74-80% water but in the dry matter bases 1.3% is N, 1.1% is P and 0.55% is K (Zublena *et al.,* 1997).

Estimating the nutrient load to the pond from the integrated poultry assuming 23% DM, the daily load was 4.4g, 3.6g, 1.8g of N,P,K respectively per pond per day.
In both cases, controlled water from irrigation canal flow to the ponds via gate valve pipe by gravitational force.After staying in the ponds, the nutrient rich water goes to the vegetable farm as a fertilizer when one third of pond water is refreshed twice a week via outlet pipes. The pipes were designed for each pond to let the exchanged water out, towards the vegetable farm below the ponds. In this experiment a farmer was trained on how to manage fish, poultry and horticulture as it was a participatory research.

Experimental fish (Tilapia and carp poly-culture)

The tilapia-carp poly-culture was done in the earthen ponds after drying and treating the ponds with lime before use. Uniform size tilapias were collected from Lake Hora using seine net of narrow mesh, length to the nearest millimeter and weight to 0.1 g was measured by digital sensitive balance, fish counted and packed in to oxygenated polyethylene bags in buckets. They were transported and stocked in to the two experimental ponds the same day. The size of fish at stocking was 12cm total length and 32.0±7.51 g average weight, while stocking density was 1.5 tilapia per square meter for both ponds.
About month (40 days) later, common carp (*Cyprinus carpio*) was collected from Koka reservoir using narrow mesh beach seine, measured, counted, packed, transported and stocked in to the ponds. The size of the common carp at stocking was 9.4 cm TL and 13.1 ±2.81 g average weights at stoking densityof0.6 carp per square meter for both ponds. African catfish (*Clarias gariepinus*) of average length 10.2 cm or 7.5 g weight was also collected from Koka reservoir and introduced with common carp in to both ponds at a density of 0.5 catfish per square meter to control the tilapia recruitment.
In the first pond (T1), goat manure fertilized pond, no other supplementary feed was given to the fish than the manure. Fish were sampled monthly to take length, weight data from the ponds.Similarly, no supplementary feed was given to the fish in the second pond (T2), integrated with poultry. However, the fish in thisgroup gets the spilling off poultry feed in smaller amount, difficult to quantify.Fertilization of the pond in T2 was by poultry droppings in the integration. The fish were let to grow in the ponds for 190 days and finally harvested. Sexes were identified for tilapia at harvest.

Data collection and analysis

Water quality parameters; temperature, pH and secchi depth were measured monthly during the experimental period. Water sample for phyto and Zoo plankton abundance was taken late in the culture period. Lab analysis on plankton identification and quantification was made at Zeway Fisheries Resources research center.
Fish samples were taken monthly and growth parameters were measured throughout the experimental period. Minimum of ten fish samples per species from each pond was measured monthly. Monthly growth pattern of tilapia and carp was presented in graph.The fish were finally harvested after six months of culture period. Total count and measurement was made at the last harvesting day. Daily growth rate (DGR) and survival rates were calculated by using the following formula.

$$\text{Survival rate (\%)} = \frac{No.of stocked - No.of death}{No.of stock} X100\%$$

$$\text{DGR(g/fish/day)} = \frac{Finalweight(g) - initialweight}{Number of culture days}$$

Growth in terms of weight was calculated for tilapia and carp in both treatments. The difference in mean value of fish weight among T1 and T2 was compared using two sample t-test at significance level of 0.05.

RESULTS AND DISCUSSION

Water parameters

Water parameters such as temperature, pH, secchi depth; and zoo and phytoplankton abundance were assessed in this experiment as these parameters influence the fish growth.
The results are given in table 1.
The water temperature was measured monthlyduring the culture period.
The temperature was measured at the depths of 60-70 cm (bottom) and 15-20 cm (surface) all during the day time. The temperature fluctuates between 22°C at bottom and 27°C at the surface. The maximum temperature at the surface was measured during May in the afternoon. There was no temperature difference between the two ponds and the flowing water in the canal.
The temperature of the canal water was relatively cooler than that of the pond water.
This was because of the fact that running water cools itself while the stagnant pond water absorbs the solar energy and makes water stratification due to the temperature effect. This temperature range is near the optimum (25-30°C) range for the growth and reproduction of both *O. niloticus* and ***C. carpio***.
The pH and secchi depth did not vary among the treatments (table 1) but they were slightly higher in the treatment groups than the canal water.
The secchi depth in the canal water was lower, less than 11cm, because of the disturbance of the water at many diversion points for irrigation, causing turbidity. The inlet water to the ponds carried this turbidity and reduced the secchi depth to 8cm during the water exchange.

Table 1. Water parameter measured from the ponds and feeder canal during the culture period.

Parameter	T1	T2	Canal water (Control)
Water T° (day)	22 – 26.5°C	22-26.5°C	22-24.5°C
pH	8.5	8.7	8.4
Secchidepth (cm)	8-13	8-13	8-11
Phytoplankton	• Ankistrodesmusfalcatus • Pediastrumbradiatum (**) • Euglenophyceae (*) • Mycrocystine • Lauterborniella elegantissime • Scendesmus (*) • Volvox	• Ankistrodesmusfalcatus, • Pediastrumbiradiatum • Euglenophyceae (**) • Scendesmusquadricauda • Actinastrumhantischii, • Gyanophyceae	• Ankistrodesmusfalcatus (***) • Euglenophyceae (*) • Pediastrum (*) • Scendesmus
Zooplankton	-Rotifers -Copepods	-Rotifers (***) -Copepods	Not observed in 2ml sample

Note:(***) over 10 organisms/ml sample, (**) 6-9 organisms/ml, (*) 3-5 organisms/ml and no star shows only the appearance of one or two organisms of the spp in the sampled water.

The maximum secchi depth measured in the two treatment ponds was 12 cm, two to three days after water exchange when the suspended particles settled to bottom partially.

The secchi depth was lower in general as compared to the transparency range of 20-40 cm secchi depth. Pond fertilization is normally made when the transparency is 40-60 cm to initiate plankton growth in the pond (Tepe and Boyd, 2001). The lower transparency may limit the vision of fish in pond to look for their feed. Though the water transparency was lower, pond fertilization was made to initiate the plankton growth, especially the zoo plankton (Table 1).

The average pH range measured in the morning (10:00-11:00 am) was 8.4 in inlet water to 8.7 in poultry integrated pond. Significant variation in pH among the treatment groups and the canal water is not expected usually (Sipauba-Tavares *et al.,* 2006). The pH measured in the treatment ponds and the inlet water was within the 6.5 to 9.0 acceptable ranges for fish culture (Zweig *et al.,* 1999).

Algal diversity and Abundance is higher in both treatment ponds than in canal water (Table 1). The nutrient release from the goat manure and the poultry droppings had initiated the algal growth. The abundance of phyto-plankton in fish ponds have an important contribution in fish growth especially tilapia which filters the algal flocculates. Zoo planktons, rotifers and copepods were observed in treatment groups while they were not observed in the inlet water samples. Nutrient concentrations in aquaculture ponds have also been reported by a number of authors to be one of the environmental factors affecting the hatchability of resting eggs of some species of zooplankton, including rotifers (Pourriot *et al.,* 1980; Lubzens, 1981).

The nutrients enhanced the primary productivity of the pond. Poultry integrated pond consisted large number of rotifers, 17 rotifers/ml, than the goat manure fertilized pond, 6 rotifers/ml. The abundance of rotifers in poultry integrated pond is expected to have positive contribution in fish growth.

Fish growth

The tilapia (*O.niloticus*) were stocked in to ponds at an average weight of 32.0±7.51 g per fish at a density of 1.5 tilapia per square meter. Later on after about a month,African catfish was alsostocked at an average size of 10.2 cm total length and 7.5g to control tilapia recruitment. Common carp (Cyprinus *carpio*) were also added to the ponds in the second month as a poly-culture with tilapiafor a growth period of five months. Tilapias were stocked 40 days before the carp stocking just to compensate their growth rate over the fast growing carps. The common carp had an average weight of 13.1±2.81 g per fish at stocking with a density of 0.6 carp per square meter. In the poly-culture, the common carp, bottom feeder fish, re-suspended sink feed in to the water column and avail it to the tilapias. The poly-culture was aimed to use the advantage in this experiment. The first pond was fertilized with goat manure (T1) and the second pond was integrated with poultry farm (T2). No supplementary feed was given for the fish under both treatments than the contribution from the integration.

Survival rate of the fish was calculated at the end of the experiment. The survivalrate for *O. niloticus* was 71% and 73% in T1 and T2 respectively. The survival rate of *O. niloticus* in this experiment was lower as compared to 84% survival rate attained in concrete ponds of similar environment (DabaTugie *et al.*, 2014).Mortalities observed

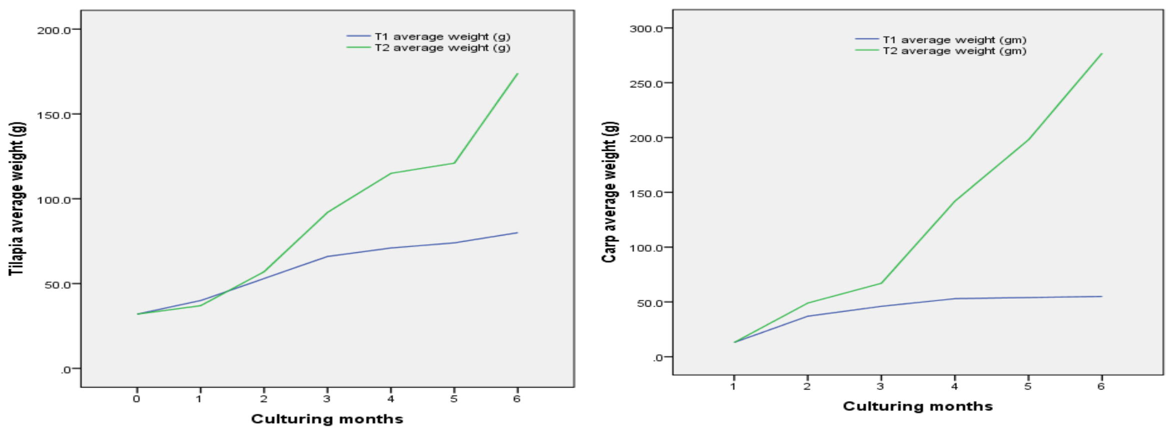

Figure 1. The monthly growth performance of *Oreochromis niloticus*(left) and *Cyprinus carpio* (right) poly-culture under T1 and T2.

Table 2. Final average weight of fish under T1 and T2 by species, group statistics

	Treatment	N	Mean	Std. Deviation	Std. Error Mean
Tilapia weight(gm)	Pond fertilized with goat manure (T1)	51	80.0000	15.75056	2.20552
	Pond integrated with poultry (T2)	53	174.1698	40.81984	5.60704
Carp weight (gm)	Pond fertilized with goat manure (T1)	25	55.0000	15.59647	3.11929
	Pond integrated with poultry (T2)	26	277.0769	33.78748	6.62627

in the first weeks because of the transporting stress and adaptability of fish to the new pond environment contributed to the lower survival rate. Treatments did not affect survival of *O. niloticus* differently as the values are close to each other. Though relatively few in number, the Cyprinus *carpio* which were brought from Koka reservoir, the source water to the ponds, were adapted to the ponds. Out of the 29 stocked to each pond, survival rate was 86.2%in T1 and 89.7% in T2 at the end of 150 culturing days. Tilapia recruitment was efficiently controlled by the *Clarias gariepinus* stocked in the ponds. Few tilapia larvae appears in the two ponds but not grown to fingerling size because of the predation by the catfishes.

Growth of the tilapia and the carp in terms of weight under the two treatments is presented in graph below (Figure.1). For both the species, the fish under the poultry integration achieved comparatively rapid growth rate, than the fish grown in goat manure fertilized pond during the culture periods.The final size of fish varied among the treatments (Table 2, Figure 2). Mixed sex tilapia, the *O. niloticus* achieved 80.0±15.6 g in pond fertilized with goat manure T1, while they reached at size of 174.2±40.8 g under poultry integration (Table 2). The difference in mean weight of mixed-sex tilapia was highly significant ($p<0.05$) between T1 and T2. Similarly, the *C. carpio* grown in T1 reached at final average size of 55.0±15.6 g/fish in 150 days while they reached at average size of 277.1±33.8 g/fish in T2 (Table 2). The difference in mean weight of carp among the two treatments was highly significant ($p<0.05$).

Calculating daily growth rate (DGR) of fish under the two treatments, the growth of mixed-sex *O.Niloticus* from average of 32.0 g/fish at stocking to 174.2 g/fish in 190 days was faster, 0.75 g/day in T2 as compared to the growth rate of 0.25 g/day observed in T1 which was from average of 32.0 g/fish at stocking to 80.0 g/fish in the same culture period of 190 days. The difference in growth rate was even higher for *C.Carpio* between the two treatments (Figure 1). The growth rate for carp was rapid, 1.7 $g.day^{-1}$ in poultry integration (T2) while it was very slow 0.28 $g.day^{-1}$in T1.

Estimated nutrient load from goat manure in T1 was higher, 24.0 g, 2.1g and 4.4 g of N,P,K respectively per day as compared to the estimated nutrient load from poultry droppings in T2, 4.4g, 3.6g, 1.8g of N,P,K respectively per day. In T1, the goat manure remained in sacks while only the nutrients were leached out to fertilize the pond water. The fish in T1 only benefits from the enhanced phyto-planktons and zoo-planktons. There was no direct consumption of goat manure by fish. The filter feeder tilapias in T1 were relatively benefited than the bottom feeder carps in the same pond.

Though the estimated nutrient load in T2 was lower as compared to T1, the spilling off poultry feed and the protein rich droppings from the poultry house in T2 helped the fish under the integration to grow faster. The fish in T2 benefited by directly consuming the feed and indirectly from the fertilized pond harboring sufficient planktons. Hence, the reason for the faster growth rate of fish under poultry integration was because of two reasons. Poultry manure is consumed directly as a feed

Figure.2 Fish harvested from goat manure fertilized pond (T1, left) and poultry integrated pond (T2, right) at the end of the experimental period.

Table 3. Final average weight of female and male tilapia under T1 and T2, group statistics

	Sex	N	Mean	Std. Deviation	Std. Error Mean
T1 Tilapia weight (gm)	Female	24	68.000	9.5962	1.9588
	Male	27	90.667	12.0224	2.3137
T2 Tilapia weight (gm)	Female	18	121.944	16.0421	3.7812
	Male	35	201.029	15.3670	2.5975

and also reach in nutrients, especially the fresh drips, to harbor the desired planktons in the ponds (Enamul Hoq *et al.,* 1999: Abbus *et al.*, 2004). The higher relative abundance of rotifers (Table 1) in the pond integrated with poultry also helped the fish to nourish on nutrient rich live feed.

Further examination of growth in terms of sex shows that the final weight of tilapia was also varied among sexes when individuals were grouped in to male and female. Under both T1 and T2, males were significantly ($p<0.05$) higher in weight than their corresponding females at the end of the 190 days culture period (Table 3).

Female tilapia invest their energy for egg production and incubation after fertilization. Maternal care is high in *O. niloticus* that they do not feed during egg incubation. As a result, growth of female *O. niloticus* is limited as compared to their corresponding male batch.

The world tilapia culture is practicing male mono-sex in commercial farms because of their faster growth rate than the mixed-sex tilapia (Chakraborty and Banerjee 2010). The faster growth of male *O. niloticus* than its female corresponding in all the treatments confirms the fact, alarming for the need of male mono-sex tilapia in Ethiopian Aquaculture.

CONCLUSIONS AND RECOMMENDATIONS

The daily growth rate of *O.niloticus* under poultry integration is higher than the rate in pond fertilized with goat manure under extensive pond culture resulting in bigger sized fish at harvest. Similarly, the daily growth rate of common carp is faster under poultry integration as compared to the slower growth rate under goat manure pond fertilization. Poly-culture of tilapia with common carp under poultry integration can increase the production and productivity of fish in small scale farms at house hold level in suitable agro-ecologies.

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