Comparative Study of Maize Bran and Chicken Manure as Fish Feed Supplement: Effects on Growth Rate of Oreochromis Niloticus in Pond Culture Systems

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Abstract
Aquaculture is an emerging reasonable answer to overexploitation of wild fish stock as the demand for wild fish stock is outstripping supply due to several geo-socio-economic reasons. However, productivity and profitability of aquaculture in Zimbabwe is affected by high costs of fish feeds. This study was done to compare and evaluate the effects of maize bran and chicken manure on growth of Oreochromis niloticus cultured in ponds at Lake Chivero. Three replicate spherical concrete ponds were each applied with chicken manure, maize bran and others left to be the control ponds. A complete randomized experimental design was used. Fish sampled from maize bran fed ponds had the highest growth rate, followed by fish fed with chicken manure ponds and, the control ponds respectively. The use of locally available waste products and feed materials in can be useful in the profitability of Oreochromis niloticus culture locally as cereal bran such as maize bran is generally cheap and chicken manure are readily available in Zimbabwe. Further studies should be undertaken on how maize and chicken manure should be applied with proper feeding regimes and ratios to stimulate algae production as well as to prevent fish mortality.

Keywords
Pond aquaculture; Feed supplement; Growth rate; Tilapia; Survival rate; Lake Chivero

Introduction
Despite numerous efforts from governments and the donor community, aquaculture production in Africa has remained miniscule. The aquaculture infrastructure built in the 1970s and 1980s is in a state of disrepair in most African countries (FAO, 2004). One of the major reasons that led to the collapse of the many aquaculture enterprises is the cost of formulated feed. Fish feeds represent over 50% of the total variable production costs (El-Sayed and Kawanna, 2008). Traditionally, fishmeal has been used as the major protein source in fish feeds because of its nutritional value and palatability (Nguyen et al., 2009). However, due to the limited world supplies and increasing price of fish meal, the majority of research on fishmeal replacement with alternative proteins in fish diets has focused on the use of protein derived from plant and animal sources (Enami, 2011). Aquatic plants, grain legumes, animal by-products and single cell proteins have also been tried in tilapia diets but with variable results (El-Saidy and Gaber, 2005; El-Sayed and Kawanna, 2008).
Natural food supply is enhanced by using organic and inorganic fertilizers and low-cost supplemental feeds derived from agricultural by-products (Halwart et al., 2003). It is well known that high fish yield can be achieved by higher abundance of plankton in culture system (Jha et al., 2008). Teferi et al. (2000) found that Oreochromis niloticus is essentially planktivorous, thus any food supplement that favour plankton growth will result in high yields of Oreochromis niloticus. Organic fertilization practices using animal wastes such as chicken manure, cattle dung are widely used in many countries to sustain productivity at low costs (Hossain et al., 2004) since soluble organic matter supplied to ponds by using manure stimulate phytoplankton growth (Sevilleja et al., 2001). It also increases biomass of zooplankton and benthic organisms (Solomon et al., 2007). Although organic fertilizers may be consumed directly or as manure-derived detritus after heterotrophic microbial activity, the role of manure or manure-derived detritus as a source of food for fish is not universally agreed upon. Recent studies by (McAndrew et al., 2004; Koprucu and Ozdemir, 2005), suggested that organic matter from the manure contributed very little to growth of common carp, silver carp, grass carp and tilapia hybrids grown in poly culture. Maize bran
protein supplement has been found to perform better than a diet of fishmeal (Wu et al., 1995; Tudor et al., 1996). Maize bran has a very high energy value and an appreciable level of crude protein (Solomon et al., 2007).

Studies on the growth performance of *O. niloticus* fed on maize, rice and wheat brans in semi-intensive earthen culture ponds have reported good growth with maize and wheat bran but a poor growth performance of fish fed with rice bran. The potential use of maize bran as a growth promoter in fish has been explored, with studies offering conflicting/inconsistent results (Liti et al. 2006). Efforts are under way to promote low-input production strategies for small-scale fish farmers in Africa and to integrate aquaculture production with other economic activities on the farm. At present, the high cost and low quality of fish feeds are major factors limiting the development of aquaculture in Zimbabwe and are more likely to remain challenging in the near future. A comparative study to evaluate the effects of chicken manure (14% crude protein) and white maize bran (30% crude protein) on the growth of *O. niloticus* was done from 20 September 2011 to 20 February 2012. The study was designed to provide information on the most efficient and less expensive supplementary feed for *O. niloticus* reared in pond culture.

1 Results
1.1 Physico-Chemical Parameters
Conductivity was found to be significantly high in chicken manure fed pond compared to the maize bran and the control pond (ANOVA, p<0.05) Figure 1. There was however, no significant difference between the chicken manure and maize bran fed ponds. Chicken manure fed ponds had the highest conductivity of (550 μm·S⁻¹·cm⁻¹), followed by the control (538 μm·S⁻¹·cm⁻¹) and maize bran fed pond (521 μm·S⁻¹·cm⁻¹). Total dissolved substances for maize bran pond, chicken manure and the control pond were significantly different (ANOVA, p<0.05). Chicken manure had the highest total dissolved substance with a recording of (239 mg/L), whilst the control had (184 mg/L) and the least being the maize bran which had a recording of (164 mg/L) which is shown in Figure 2. Transparency (secchi disk reading) for the maize bran, chicken manure and control was significantly different (ANOVA, p<0.05). The control pond had the highest secchi disk readings from the start of the experiment to the end of the experiment having (42 cm) as the highest reading. Due to the different supplement application maize bran and chicken manure had a lower transparency compared to the control which ranged from 17 cm~27 cm, respectively (Figure 3).

![Figure 1 Conductivity of the three ponds carried out in the experiment](image1)

![Figure 2 Total, dissolved substances readings done for maize bran, chicken manure and the control pond](image2)

![Figure 3 Secchi disk readings done for maize bran, chicken manure and the control pond](image3)

1.2 Growth parameters
Growth rate increased significantly (ANOVA; p<0.05) in both maize and chicken manure fed ponds. Fish sampled from the maize bran fed ponds had the highest percentage weight gain followed by fish sampled from chicken manure fed pond and the control pond.
respectively (Figure 4). There was significant differences (ANOVA, p<0.05) in growth rate among ponds, with fish sampled from maize bran fed ponds having the highest growth rate, followed by fish fed with chicken manure pond and, the control pond had the least growth: Specific Growth Rate: was significantly different (ANOVA, p<0.05) among the three experimental ponds. The specific growth rate of fish sampled from maize bran and chicken manure fed ponds decreased significantly from week 8 to week 24. However, the fish from maize bran and chicken manure fed ponds showed considerably higher specific growth rate than the control pond (Figure 5). Condition factor: results for each pond are shown in Figure 6. High condition factor value ranges were observed in maize bran fed fish which had a mean condition factor of (9.46±0.91) K, chicken manure (7.17±0.16) K and for fish in the control pond it was with (3.88±0.16) K. Condition factor difference were statistically significant (ANOVA, p<0.05) in fish sampled from all the ponds.

1.3 Survival rate
Survival was variable among ponds, but was not significantly (ANOVA, p>0.05) different among pond treatments and the fish in control pond had the highest survival rate (90%) as shown in Table 1.

| Pond          | Number | Survival rate (%) |
|---------------|--------|-------------------|
| Maize bran    | 22     | 76.7±12.3         |
| Chicken manure| 19     | 63.3±9.6          |
| Control       | 27     | 90.0±4.9          |

2 Discussion
Total dissolved substances, electrical conductivity and light penetration recorded during this study are important ecological variables in aquaculture (Ellis et al., 2002). Okpokwasiti and Obah (1991) reported highly significant seasonal variations in total dissolved solids, electrical conductivity and light penetration of ponds, the same to what was done in this study. Similar results were also reported by (Ahmad et al., 2008) who observed that planktonic biomass and fish production depend highly on conductivity and total dissolved solutes to maintain a high specific growth rate.

The light penetration varied significantly during this experiment and the variations maybe attributed to the different chemical constituents in the maize bran and the chicken manure feeds which absorb components of light differently when dissolved in water. Water transparency was consistently higher in the control pond which could be possibly due to low or no phytoplankton production in the water because there was no feed applied. Light penetration depends
upon the roughness of the water surface and angle of radiation. In the maize bran and chicken manure fed ponds there was low transparency because of stimulation of algae production from the manure. When secchi disk visibility is shallower, this reflects a high algal abundance in the photic zone which is positively correlated with fish growth and nutrition (Abbas and Hafeez-Ur-Rehman, 2005). Natural water can never be pure and contains substances (plankton, debris etc.) which further interfere with light penetration. Light exerts a profound influence upon the whole series of biological phenomenon of water by controlling the occurrence and abundance of phytoplankton (Corpei, 2001).

In aquaculture, the ultimate aim is not to achieve the highest mean weight (De-Silva et al., 1989), the emphasis is on a low environmental burden and the cost effectiveness. *O. niloticus* is considered a prime species for culture in tropical and subtropical regions, because it has a fast growth rate and adapts to a wide range of environmental conditions (Marshall, 2010). This could be due to the better performance and utilization of the diets in spite of high fibre levels. Comparison of means showed significant difference in mean weight, specific growth rate, percentage weight gain and condition factor between chicken manure, maize bran and the control pond. Li and Yakupitiyage (2003) reported that pond fertilization such as organic matter enhances natural food productivity for omnivorous fish like *O. niloticus*. Consequently, depending on the actual conditions, phytoplankton and zooplankton may be an important source of nutrients, supplementing the diets of fish raised in pond culture (Rakocy and McGinty, 1989; Bentsen et al., 2001). The pond which had chicken manure applied to it had high plankton, which fish fed on and led to a high specific (growth) rate though, maize bran fed fish grew faster because they consumed the bran directly when fed. Manure from poultry droppings promotes natural food webs that improve *O. niloticus* production. Diana et al. (1994) demonstrated that organic fertilizers result in higher primary production in lakes and consequently larger sized algivorous fish.

The standard total length in maize bran pond and chicken manure pond had a small difference showing that the weight increased more regardless of feed and time. During a five-month culture period, *O. niloticus* increased from an initial weight of 13.5 g to a final weight of 108.7 g in the maize bran treated pond. In the Philippines, Guerrero (1980) cited in Beveridge et al. (2002) indicated that diets with 25% maize bran was economical for cage culture of *O. niloticus*. Fish fed on maize bran ponds had significantly higher mean weight than fish fed chicken manure and the control. Liti et al (2001) compared the performance of chicken manure with commercial fish diet and observed better growth on *O. niloticus* with the chicken manure than with other fish feeds. Supplemental feeding permits fish to continue to grow rapidly (Hepher, 1988). Condition factors increased in week 8 for maize bran and chicken manure ponds showing that there was a significant difference in the treatments applied. The condition factor reflects the physiological state of the fish in relation to its welfare (Shakir et al., 2008). In this study, the condition factor and survival rates were significantly different showing that the composition and mode of action of the maize bran and chicken manure were different as we used the same fish species. The condition factors of fish in previous studies revealed that 4 fish species; *C. gariepinus, L. altivelis, O. mossambicus* and *T. rendalli* had their K values outside the 2.9–4.8 recommended range for matured freshwater fish according to (Bagenal and Tesch, 1978).

The survival rate was highest in the control pond and least in the chicken manure fed pond, organic fertilizer particularly the chicken manure used in this study encourage growth of detrimental microorganisms during their degradation (Leveque, 2002). However, the high survival rate of *O. niloticus* at high density in the control pond and maize bran fed ponds indicates its amenability to the intensive culture practice (Pardon, 2001). Chicken manure as a fish feed is useful because the carbon dioxide released after decomposition provides the inorganic carbon needed for photosynthesis or slowly enters the carbonic acid-bicarbonate-carbonate system that acts as a pH buffer (Nath, 1993). This buffer is important in protecting fish and other aquatic organisms from the adverse effects of pH fluctuations. Parts of the organic material settle as pond sediments that significantly contribute towards seepage reduction. Some benefits of chicken manure fertilization,
including release of inorganic carbon and improving sediment. Phosphorus mobility, may be obtained without subjecting fish to dangerously low DO concentrations by adding manure to ponds about a week prior to stocking (Jha et al., 2008).

Results of chicken manure in the study clearly indicate that chicken manure is neither a preferred sources of particulate organic matter for \textit{O.niloticus} or in non-integrated systems an economically wise choice of fertilizer to provide N and P for production of natural foods. This is very useful to the farmer in that adding manure to ponds can degrade water quality, fill in ponds, and be labour intensive. Factors which can limit primary productivity include low inorganic carbon availability, reduced light penetration from inorganic turbidity (e.g. wind mixing or bioturbidation in shallow ponds), water coloration from dissolved organic matter, or algal self-shading, and relatively low soluble nitrogen and phosphorous inputs (Rahman 1992; Francis et al., 2001; Froese, 2006). The most common is over enrichment (excessive feeding or inflow of nutrients) of ponds, which causes heavy phytoplankton blooms resulting in high respiration or consumption of oxygen.

From the results of the present study and those of previous studies (Veverica et al., 1998), it is apparent that the performance of the diets can be ordered as follows the control with the least performance followed by maize bran and chicken manure with moderate performance and the present formulated diets with the highest performance among all the diets that have been studied at Sagana fish farm.

3 Conclusion and Recommendation
This study provides evidence that supports the use of locally available waste products and feed materials in \textit{O.niloticus} production and has immediate usefulness in the profitability of \textit{O.niloticus} culture locally as cereal bran such as maize bran is generally cheap and chicken manure are readily available in Zimbabwe. However, further studies should be undertaken on how chicken manure should be applied with proper feeding regimes and ratio to stimulate algae production, as well as to prevent mortalities in cage aquaculture.

4 Materials and Methods
4.1 Source of Fingerlings
The fingerlings were obtained from Lake Chivero located 37 km away from Harare (17°54' South to 30°47' East). The lake is found in agro-ecological region 2 with temperatures ranging between 13.1°C and 26.3°C in winter and summer respectively (Moyo, 1997). The lake is hyper eutrophic due to discharge of treated and untreated sewage effused. The \textit{O. niloticus} was first introduced in Tiger Bay of Lake Chivero as an exotic culture species. In 1997, \textit{O. niloticus} first appeared in commercial catches in the lake and to date it is the most dominant species caught by the commercial co-operatives.

4.2 Experimental design
Three spherical concrete ponds with a surface area of 5 566 m² each were identified. Pond one was applied with chicken manure, the second pond maize bran was applied and pond three was left to be the control pond and also as a bench mark pond. A complete randomized experimental design was used. The experimental ponds were completely drained and lime was applied to correct pH to 6.5. The ponds were filled with water pumped direct from the lake a week before stocking. The fingerlings were collected on the 20th of September 2011 at 11:40 am from the National Parks Fisheries Research Station bay using a seine net. Fingerlings were transported from the bay in two twenty litter buckets filled with water mixed with malachite green to prevent the fish from any diseases before being stocked. \textit{O. niloticus} fingerlings of a mixed sex were used for the study. Initial body weight of each fish was (0.15±0.05) g. Stocking density was thirty fingerlings per pond, with a mixed sex ratio. The fish were acclimatised to the experimental environment for 2 days prior to the start of the experiment. Water was replaced occasionally and addition of water in the three ponds was done periodically to compensate the evaporated water. Composition of dry feed maize bran was given two times a day (early morning at 8 am and late afternoon 4 pm). Feeding started a day after the fish were stocked. Feeding for maize bran pond was adjusted every two weeks based on the mean weight of fish. Feed was offered to the fish only at 5% of the body weight for the feed treatment. The chicken manure pond was fed with 4 kg of chicken manure tied in a sack bag which stayed in the water for five days and removed depending on the change of colour and development of algae bloom of the water.

4.3 Sampling
After every two weeks, ten fish specimens were randomly captured from each treatment using a small
seine net and their mean body weights and total lengths were recorded. In each pond, the total dissolved substances (TDS), conductivity and transparency were measured using appropriate probes after every fortnight. All the water test meters were calibrated before use. Surface water samples for nitrates, phosphates and ammonia analyses were collected using sterilised clean 500 mL polythene bottles. The samples were placed in a cooler box and then taken to the laboratory for analyses.

4.4 Data analysis

Specific growth rate (SGR) was calculated from data on changes in body weight over a given time intervals according to the method of Brown (1957) as follows:

\[
SGR = \frac{\ln W_f - \ln W_i}{T} \times 100\%
\]

Where, \( W_f \) = final mean individual fish weight; \( W_i \) = initial mean individual fish weight; \( T \) = number of days elapsed.

Survival rate was calculated as follows:

\[
SR = \frac{N_f}{N_y} \times 100\%
\]

Where \( N_f \) = number of fish harvested; \( N_y \) = number of initially stocked.

Percentage weight gain was calculated as follows:

\[
WG = \frac{W_t - W_O}{W_O} \times 100\%
\]

Where \( W_t \) = final weight; \( W_O \) = initial weight.

Condition factor was calculated as follows:

\[
CF = \frac{W_f}{L_2^2} \times 100
\]

Where: \( W_f \) = Final fish weight; \( L_2 \) = Standard length.

Two way analysis of variance (ANOVA) was used to determine if there was any significant difference in the growth rates, final weight, final length and survival rate of the harvested fish of the three treatments and to test for significant differences within the physic-chemical parameters and growth parameters at 5% level of significance using the SysStat 12 for Windows version 12.02.00 (Systat, 2007).

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References

Abbas K. A., and Hafeez-Ur-Rehman M., 2005, Growth response of major carps in semi-intensive culture ponds supplemented with rice polishing, Pakistan Vet. J., 25(2): 59-61

Ahmad N., Ahmed I., Saleem M., and Ashraf M., 2008, Effect of different levels of mineral phosphorus with and without nitrogen on the dry weight of planktonic biomass, increase in fish production and biomass conversion efficiencies, Pak. J. Agri. Sci., 45: 122-128

Bagenal T. B., and Tesch F. W., 1978, Age and growth, In: Bagenal, T.B. (Ed). Methods for the assessment of fish production in fresh waters, Third edition.IBP Handbook No 3, Blackwell Scientific Publications, Oxford: pp.101-136

Bentsen S., Mallison P., and Rubright B., 2001, Pond culture feeding practices, Australian Journal of Marine and Fresh Water Research, 61:10-12

Beveridge P., Dall K., and Alanson C., 2002, The life history of Tilapia, Third edition Cambridge University Press, Cambridge, pp.10-15

Brown M. E., 1957, The physiology of fishes, Volf, Academic Press Inc., New York, pp.447

Corpe A., 2001, Product profile tilapia, Expansion of Ecuador Export Commodities, CBI Project

De-Silva S. S., Gunasekara R. M., and Atapattu D., 1989, The dietary protein requirements of young tilapia and evaluation of the least cost diet protein levels. Aquaculture, 80: 271-284, http://dx.doi.org/10.1016/0044-8486(89)90175-0

Diana J. S., Lin C. K., and Schneeberger P. J., 1994, Relationships among nutrient inputs, water nutrient concentrations, primary production, and yield of Oreochromis niloticus in ponds, Aquaculture, 92: 323-341, http://dx.doi.org/10.1016/0044-8486(91)90038-9

Ellis T., North B., Scott A.P., Bommage N. R., Porter M., and Gadd D., 2002, The relationships between stocking density and welfare in farmed rainbow trout. J. Fish Biol., 61: 493-531, http://dx.doi.org/10.1111/j.1095-8649.2002.tb00893.x

El-Saidy D. M. S. D., and Gaber M. M. A., 2005, Effect of dietary protein levels and feeding rates on growth performance, production traits and body composition of Nile tilapia, Oreochromis niloticus (L.) cultured in concrete tanks, Aquaculture Research, 36(2): 163-171, http://dx.doi.org/10.1111.j.1365-2109.2004.01201.x

El-Sayed A. F. M., and Kawanna M., 2008, Optimum water temperature boosts the growth performance of Nile tilapia (Oreochromis niloticus) fry reared in a recycling system, Aquaculture Res., 39(6): 670-672, http://dx.doi.org/10.1111.j.1365-2109.2008.01915.x

Enami H. R., 2011, A review of using canola/rapeseed meal in aquaculture feeding, J. Fish Aquatic Science, 6(1): 22-36, http://dx.doi.org. /10.3923/jfas.2011.22.36

FAO (Food and Agriculture Organization of the United Nations), 2004, Fish stat plus, Aquaculture production, 1950-2002

Francis T. F., Vathy A. P. P., and Than N. R. A., 2001, Integrated Fish Farming, A review, World Aquaculture, 35: 24-29

Froese R., 2006, Cube law, condition factor and weight-length relationships: history, met analysis and recommendations, J. Applied Ichthyric., 22(4): 241-253, http://dx.doi.org/10.1111/j.1439-0426.2006.00805.x

Halwart M., Smith S. F., and Moechl J., 2003, The role of aquaculture in rural development, FAO fish circular No. 942 Rev.1 FAO fisheries department, Rome, Italy

Hepher B., 1988, Nutrition of pond fishes, Cambridge University Press, Melbourne, Australia, http://dx.doi.org/10.1017/CBO9780511735455

Hossain G., Lee P., and Laniar M., 2004, Comparative assessment of culture system in Tilapia farming, Australian Journal of Marine and Fresh Water Research, 61: 10-12

Jha P., Barat S., and Nayak C. R., 2008, Fish production, water quality and bacteriological parameters of Koi carp ponds under live-food and manure based management regimes. Zoological research, 29(2): 165-173, http://dx.doi.org/10.3724/SP.J.1141.2008.00165

Kopruca K., and Ozdemir Y., 2005, Apparent digestibility of selected feed ingredients for Nile tilapia (Oreochromis niloticus), Aquaculture, 250(1–2): 308-316, http://dx.doi.org/10.1016/j.aquaculture.2004.12.003

Leveque C., 2002, Out of Africa: the success story of tilapias, Environ. Biol. Fishes, 64(4): 461-464, http://dx.doi.org/10.1023/A:1016190529097
Li L., and Yakupitiyage A., 2003, A model for food nutrient dynamics of semi-intensive pond fish culture, J. Aquaculture. Eng., 27(1): 9-38, http://dx.doi.org/10.1016/S0144-8609(02)00037-7

Liti D. M., Mugo R. M., Munguti J. M., and Waidbacher H., 2001, Growth and economic performance of Nile tilapia (Oreochromis niloticus L.) fed on three brains (maize, wheat and rice) in fertilized ponds, Aquaculture. Nutr., 12: 239-245, http://dx.doi.org/10.1111/j.1365-2095.2006.00397.x

Liti D.M., Waidbacher H., Straif M., Mbaluka R. K., Munguti J. M., and Kyenze M. M., 2006, Effects of partial and complete replacement of freshwater shrimp meal (Caridinea niloticus Roux) with a mixture of plant protein sources on growth performance of Nile tilapia (Oreochromis niloticus L.) in fertilized ponds, Aquaculture Research, 37(5): 477-483, http://dx.doi.org/10.1111/j.1365-2109.2006.01450.x

McAndrew A., Siddiqui H., and Takeuchi Y., 2004, Tilapia pond culture productivity in the Asian countries, Journal of Fish Farming, 45: 13-15

Moyo S., 1997, A comparative study on aspects of ecology of zooplankton in Lake Chiveror and Mazvikadei Dam, Zimbabwe. MSc thesis. University of Zimbabwe, Harare

Nath S. S., and Lannan J. E., 1993, Dry matter nutrient relationships in manures and factors affecting nutrientavailability from poultry manures, In: Egnra, M. McNamara J., Bowman R. and Astin N. (Eds.) Tenth Annual Admin. Report, 1991-1992. CRSP Office of International Research and Development, Oregon State University, Corvallis, Oregon: pp.110-119

Nguyen T. N., Davis D. A., and Saoud I. P., 2009, Evaluation of alternative protein sources to replace fish meal in practical diets for juvenile Tilapia, Oreochromis spp., Journal of the World Aquaculture Society, 40(1): 113-121, http://dx.doi.org/10.1111/j.1749-7345.2008.00230.x

Okpokwasili G. C., and Obah O. O., 1991, Relationship between the water quality and bacteria associated with the brown patch disease of Tilapia fingerlings reared in tropical fresh water culture ponds, J. Aqua. Trop., 6: 157-172

Pardon S., 2001, Tilapia Growths and Feeding, Elsevier Science, Amsterdam, Aquaculture Society, 13: 340-341

Rahman M. S., 1992, Water quality management in aquaculture, BRAC Prokashana, Dhaka, Bangladesh, pp.84

Rakocy J. E., and McGinty A. S., 1989, Pond culture of tilapia, Southern Regional Aquaculture Centre, SRAC Publication No. 280

Sevilleja R., Torres J., Sollows J., and Little D., 2001, Using animal wastes in fish ponds, Halwart M., Gonsalves J., and Prein M. (Eds.), Integrated agriculture aquaculture: A primer, FAO Fisheries Technical Paper 407, FAO, Rome: 49-53

Shakir H. A., Mirza M. R., Khan A. M., and Abid M., 2008, Weight length and condition factor, relationship of Sperata Sarwari (Singhari), from Mangla Lake, Pakistan, Journal of Animal and Plant Science, 18(4): 158-161

Solomon S. G., Tamiyu L. O., and Agaba U. J., 2007, Effect of feeding different grain sources on the growth performance and body composition of tilapia, (Oreochromis niloticus), fingerlings fed in outdoor hapas, Pakistan Journal of Nutrition, 6(3): 271-275, http://dx.doi.org/10.3923/pjn.2007.271.275

Systat, 2007, Mystat: A student version of Systat 32-bit UNICODE English, Version 12.02.00.

Teferi Y., Admassu D., and Mengistou S., 2000, The food and feeding habit of Oreochromis. Niloticus L. (Piscex. cichlidae) in Lake Chamo, Ethiopia, Ethiopian J. Science, 23(1): 1-12

Tudor K. W., Rosarti R. R., O’Rourke P. D., Wu Y. V., Sessa D., and Brown P., 1996, Technical and economic feasibility of on-farm fish feed production using fishmeal analogs, Aquaculture Engineering, 15(1): 53-65, http://dx.doi.org/10.1016/0165-7836(95)00026-0

Veverica K. L., Gichuri W., and Bowman J., 1998, Relative contribution of supplemental feed and inorganic fertilizers in semi-intensive Tilapia production, In: Mcellwee, K., D. Burke and H. Egnra (eds.): Sixteenth Annual Technical Report. Pond Dynamics in Aquaculture CRSP, Oregon State University, Corvallis, Oregon, pp.43-45

Wu Y. V., Rosarti R., Sessa D. J., and Brown P., 1995, Utilization of corn gluten feed by Nile tilapia, Prog. Fish Cult, 57(4): 305-309, http://dx.doi.org/10.1577/1548-8640(1995)037<0305:UGBNE>2.3.CO;2