EVALUATION OF LOCALLY MADE FISH CAGE ON THE GROWTH PERFORMANCE OF *OREOCHROMIS NILOTICUS* (L, 1758)

Abelneh Yimer [1] and Yared Tigabu [2]

Abstract

Aquaculture is now fully comparable to capture fisheries when measured by volume of output on global scale. The contribution of aquaculture to the world total fish production has increased significantly. Aquaculture grew from 25.7% to 42.2 % during the past 12 years. This study was conducted to evaluate the durability, cost effectiveness and growth performance of Oreochromis niloticus in locally made fish cage. Locally available 210d/15 polyamide twine thread for making the body of the cage and bamboo trunk is used for cage frame. For imported cages PVC pipe were used as a floater and sinker frame. Both treatments were in triplicates and Tilapia juveniles with an average weight of 46.2 gm stocked in the treatments. The fish were fed on a composite mixture of wheat bran, brewery waste and "noug" cake in powder form at 2% of their body weight twice per day for six months. The final mean weight of Oreochromis niloticus ranged 74.8 ± 4.9 gm in the locally made cage and 78.6 ± 2.5 gm in the imported cage. The mean daily weight gain was 0.2 ± 0.01gm/ day in both cage systems. The locally made fish cage can replace the costly imported fish cage because the growth performances of Oreochromis niloticus were almost similar ($p > 0.05$).

Key words: *Aquaculture, cage, feed, oreochromis niloticus*

[1] EIAR - National Fishery and other Aquatic Life Research Center Sebeta, Ethiopia Box 64 Sebeta-Ethiopia.

[2] EIAR - National Fishery and other Aquatic Life Research Center Sebeta, Ethiopia Box 64 Sebeta-Ethiopia.

INTRODUCTION

Aquaculture is an important weapon in the global fight against malnutrition and poverty, especially in developing countries, like Ethiopia (Tacon, 2001). Increases in human population in the developing countries along with changing perceptions on healthy food in affluent regions have led to increased demand for food fish. The total fish catch from wild fishing have reached their natural limits (FAO, 2006). Aquaculture is now fully comparable to capture fisheries when measured by volume of output on global scale. The contribution from aquaculture to the world total fish production of capture and aquaculture grew from 25.7% up to 42.2 %, during the past 12 years. Asia is the only continent producing more fish (54%) from aquaculture than capture fisheries (FAO, 2014).

Hence, aquaculture has been and still is growing faster than other animal food production sectors at a rate of 11% per year over the past decades (FAO, 2006). According to the newly released FAO (2014) statistics, the world aquaculture production in 2012 was 90.43 million tons, including 66.63 million tons of food fish, 23.78 million tons of aquatic algae (mostly marine macro algae / seaweeds), and 22.4 thousand tons of non-food products (pearls and shells, etc.). It is one of the fastest growing food processing and economic sectors in the world. Its production grew at 11 % per year over the past decades. Among these fish culture techniques, cage culture, the practice of farming of aquatic organisms in cages and nets, is widespread around the world. Cage aquaculture is an old practice dating back to the early 10th century, when Chinese fishermen grew fish fry in cages made of bamboo sticks (Beveridge, 1996). This form of aquaculture has expanded rapidly in the past three decades, particularly since the late

1980s. The growth is attributed to several factors, including high market value, demand for fish, and decline in protein food supply and food insecurity in developing countries. Improvement of technology in cage culture in reservoirs and water bodies not suitable for conventional fisheries must be supported through generation of technical aid for high-quality inputs like fish feed or fry (Eng and Tech, 2002).

In recent years, there has been increased effort on promoting cage culture as one of the major methods for intense fish production in lakes and reservoirs in the tropics (Guo and Li, 2003). Cage culture has a high potential, especially in water bodies that cannot be drained or seined and that would otherwise be unsuitable for conventional fisheries. These include lakes, large reservoirs, farm ponds, rivers, estuaries, night storage units (temporary reservoirs) and micro dams. Compared to pond culture, cage culture has a number of advantages. In cages, mixed-sex populations of Tilapia (*Oreochromis niloticus*) can be reared without the problems of unwanted reproduction and stunted growth, noted as key issues in pond culture. Additional cage advantages include simple management (can be practiced by both men and women); ease and low cost of harvesting, and close monitoring of fish growth. Research on small-scale cage culture operations in irrigation canals, rivers, and lakes is still in its infancy in Africa, but these systems have the potential to contribute to rural income and fish production (Mikolasek, *et al*., 1997). For example, experience in Asia indicates that small cages can provide rapid returns to the rural poor who do not have access to land for pond aquaculture (Hambrey, *et al*., 2001).

In Ethiopia, the practice of cage culture began recently as a pilot study by BOMOSA project team on small-scale cage culture in Tilapia (*Oreochromis niloticus*), which focused on utilizing small water reservoirs situated in semi-arid areas. The experience and results obtained from the project outcome were promising, and there is a need for up-scaling (OEAW, 2009). Nonetheless, the costly imported cage materials are a tailback to promote and up-scale the technology at large scale in the country.

For decades, polyamide net has been used as the main source of cage material. However, the periodically occurring low availability, competition and continuously fluctuating and rising prices of the nets are affecting aquaculture (cage culture) production and consequently the profitability. Apparently, no effort has been made so far on cage material alternatives to polyamide nets from locally available sources. In order to enhance and promote cage culture at large scale in Ethiopia, a research for cheap and locally available cage material is required. Ethiopia is endowed with many indigenous plants, grasses, macrophytes and bamboo trees, which have a high potential to replace the costly imported materials. However, none of them have been evaluated for their potential as fish cage material. The present study, therefore, is launched with an aim to evaluate the durability, cost effectiveness and growth performance of O*reochromis niloticus* in locally made cage in comparison with the costly imported fish cage materials.

MATERIALS AND METHODS

Description of Experimental Site

The experiment was conducted at National Fisheries and other Aquatic Life Research Center (NFALRC), Ethiopia. The research Center is situated at a distance of 24 km southwest of Addis Ababa (8^o55.076 N; 38^o38.161E), and located at an altitude of 2240 meters above sea level (masl).

Experimental Design

The experiment was conducted using cages made up of locally available materials and imported cages. Locally available 210d/15 polyamides twine threads for making the body of the cages and bamboo trunks were used for cage frame. For imported cages PVC pipe were used as a floater and sinker frame. The local materials were selected based on their availability in the local market and suitability for fish cage construction. These materials were purchased and collected from Addis Ababa and designed at National Fisheries Research Center with a dimension of 1.68 m^3, 1.4 m (top bar) x 1.2 m (bottom bar) x 1m (depth of the cage body). The length of net mesh was 2.5 cm stretch (Fig. 1) and so was the size of the imported cages. The lower tube-frame contains holes that allows entry of water and helps the tube to sink while the upper tube was sealed and waterproof for floating the cage. The cage was easily folded and transported by one or two persons easily. A typical plot consisted of the pier or walk way (made up of wood) to which the cages are attached and fixed. The numbers of cages attached to the pier were nine and 50 fingerlings per cage were stocked.

Figure 1. Locally made cage lifted up for sample collection.

Cage Installation and Stocking

A typical plot consisted of the constructed pier on which the cages were attached and fixed. Three locally made cages and three imported cages were attached to the pier and 50 fingerlings of Nile tilapia (*Oreochromis niloticus*) were stocked on each cage. The fish in the cage were fed a composite mixture of wheat bran, brewery waste and "noug" cake in powder form at 2% of their body weight twice per day, half of the feed at 10:00 am and the remaining half at 4:00 pm (Table 1). Feeding rates per cage were adjusted monthly after weighting a minimum of 50% of the fish stocked. The study conducted for 180 days from August 2014 to end of January 2015.

Table 1. Proximate composition (dry weight basis) of locally available feeds.

Composition	Test diets
Brewery waste	40
"Noug" cake	51
Wheat bran	9
Total	100
Proximate composition (g per 100 g)	
Dietary protein levels	29
Lipid	5
Crude fiber	22

Proximate analysis of the feeds was carried out as described in AOAC (1990) in triplicates. Protein content of the diets was determined by using micro-Kjeldhal method, percent fat by using ether extraction method, crude fiber by acid-alkali digestion method.

Fish total length (TL) and total weight (TW) were measured every month to monitor growth and to make feed adjustment.

Water samples were taken from two different points (inlet and inside the cage) in the experimental pond between 9.00 am and 10.00 am every two weeks. In *situ* measurements for temperature and oxygen, and laboratory analysis for ammonia were also performed.

Note: The cost of one locally made cage was ETB 898.00, but the cost of one imported cage was ETB 3000.00 (Table 2).

Table 1. Cost of Locally Made Cage

Cost of locally made cage material	Cost (ETB*)
Cost of one cage net	300
Cost of one cage sewing material	48
Cost of sewing for one cage (sewing twine, needle, labor)	100
Cost of bamboo floater per cage	200
Cost of bamboo sinker per cage	150
Cost of mounting a net to the bamboo (per cage)	100
Total	898

- ETB = Ethiopian Birr

Data Analysis

SPSS version 18 software and excel 2013 were used for data analysis. One-way ANOVA was used to test for significant differences among variables at $P < 0.05$ level.

Results and Discussion

Growth performance of *Oreochromis niloticus*

The present study compares the availability, durability, material cost and the growth performance of the fish in the two cage systems (Table 3).

The final mean total weight of the fish grown in the locally made cages and the imported fish cages were almost similar in weight and there was no statistically weight differences ($P > 0.05$) (Table 3).

Table 2. Growth Performances of *Oreochromis Niloticus* in the Two Types of Cages

Parameters	New cage	Imported cage
Initial weight (gm)	44.0 ± 3.5^a	48.4 ± 2.6^a
Initial length (cm)	10.5 ± 1.5^a	14.1 ± 0.6^a
Final weight (gm)	74.8 ± 4.9^a	78.6 ± 2.5^a
Final length (cm)	16.0 ± 2.8^a	16.6 ± 1.9^a
Weight gain (gm/fish)	30.8	36.2
Average daily gain (gm/fish/day)	0.2	0.2
Specific growth rate	0.3	0.3
Feed conversion ratio	4.4	3.9
Survival rate	100	100

*Values with the same superscript in each row are not significantly different.

The growth trend of the fish in this study showed differences in weight among months. At the beginning of the experiment until the end of December, in both cages the fish grew slowly; the growth was 0.1 gm $fish^{-1}$ day^{-1} and 0.13 gm $fish^{-1}$ day^{-1} in locally rate made cage and imported cage, respectively (Fig. 2).

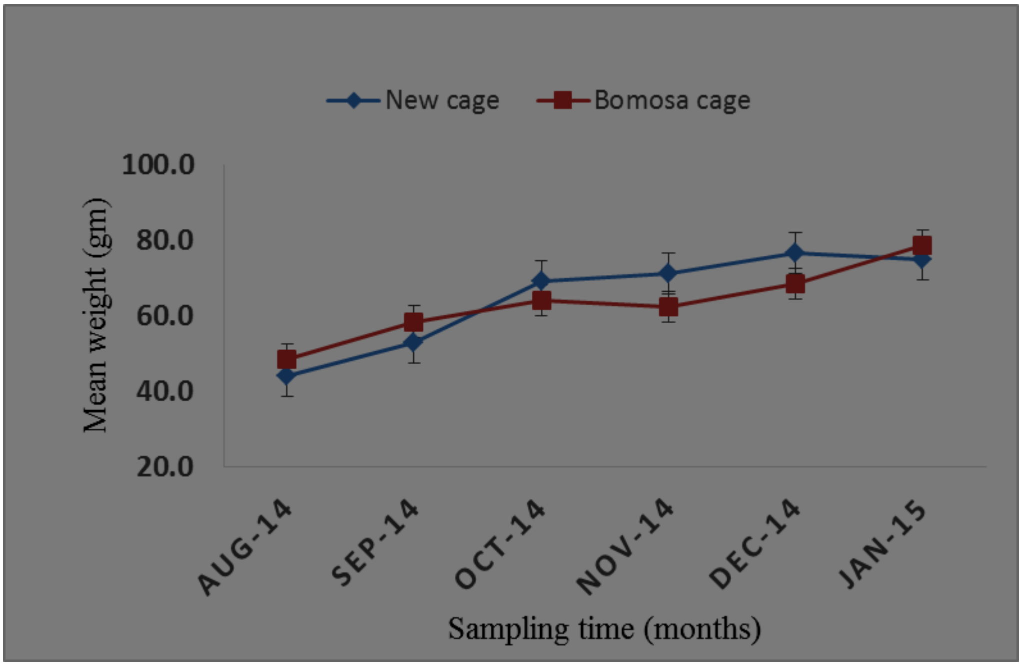

Figure 1. Growth curve for *O. niloticus* in two cage systems (mean ± SE)

The growth rate was very slow as compared to other studies (Ashagre, *et al*., 2008 and Fasil, *et al*., 2011). The slow growth may be due to low water temperature (17.6 – 19.5 ^{0}C) of the ponds. According to Zenebe, *et al*. (2003), water temperature below 20 ^{o}C can lead to reduced feeding of the fish. The fish relatively grew faster (0.2 gm fish^{-1} day^{-1}) in January. This could be due to an increase in temperature (19.3 – 22.5 ^{0}C) and the fish were very active and had consumed the feed instantly.

Therefore, the insignificant difference in the two types of cages is that the locally made cage can totally replace the costly imported cage. At the end of the experimentation period the physical conditions of both cages were sound as there was no visible damage observed. However, during the culture period we had observed that the mesh size of the locally made cage was somehow stretched from 2.5 cm to 3 - 4 cm, which was due to lack of experience in net making that need to be rectified in the future in the promotion of the technology.

Water quality parameters

Temperature

The minimum and maximum temperatures of the experimental cage pond at the beginning of the experiment period in August and December were 17.6^{0}C and 19.5^{0}C, respectively (Fig. 3).

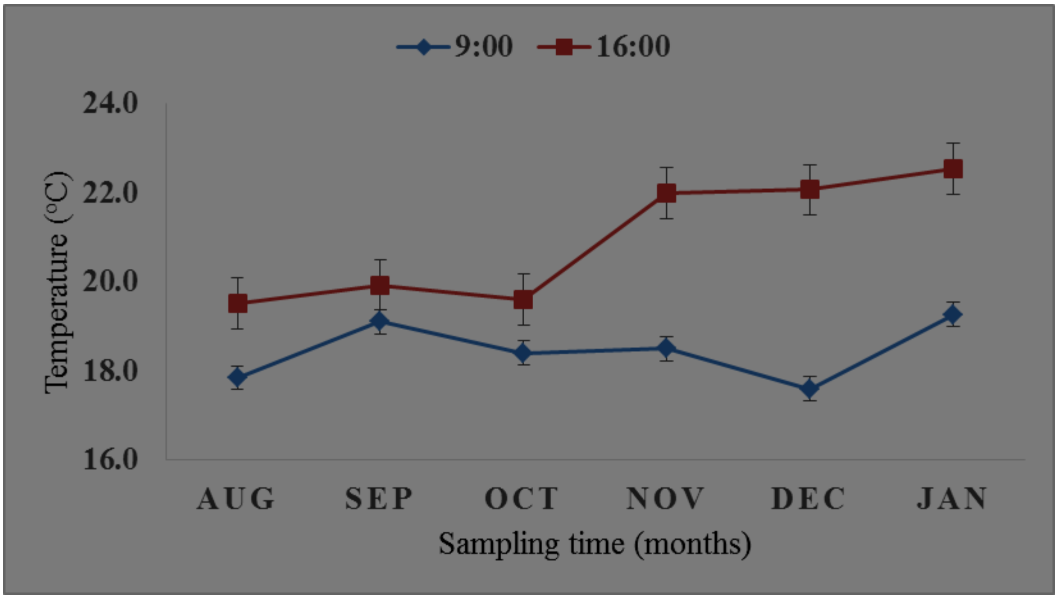

Figure 2. Mean monthly surface water temperature of the experimental cages during the experimental period (mean ± SE)

The low water temperatures in those months are expected because in most parts of Ethiopia the rainy season starts in June and ends in September. The coldest season is from October to December. However, there was increasing trend in water temperature after the month of December, whereby the minimum and maximum were 19.3 ^{0}C and 22.5 ^{0}C, respectively. The temperature situation in a water body has significant impact on chemical and biological features of the aquatic systems. According to Kassaye (2012), when the temperature becomes low or below the recommended level, the fish stop feeding and even could die. The metabolic activity and physiological functions of aquatic animals (e.g. feed utilization, feed conversion, growth rates of fish) can be affected by water temperature (Halver and Hardy, 2002; Azaza, *et al.*, 2008; Kassaye, 2012; Zenebe *et al*., 2012). This is also shown in the results of this study; the fish growth rate in August to December was very low, and in January, when temperature increases, the growth rate was almost double.

Dissolved Oxygen

According to Wetzel (2001), the solubility of dissolved oxygen (DO) which is essential to all forms of aquatic life depends on temperature, pressure and altitude. Dissolved oxygen (DO) concentration in the pond water at two different times of the day ranged between 3.8 ± 0.3 and 14.5 ± 0.41 mgl^{-1} (Fig. 4). The solubility of oxygen decreases as temperature increases (Wetzel, 2001; Brook, 2008) which is also observed in this study where the concentration of DO was higher during the relatively low temperature condition in November-December and started to decline as the temperature increases.

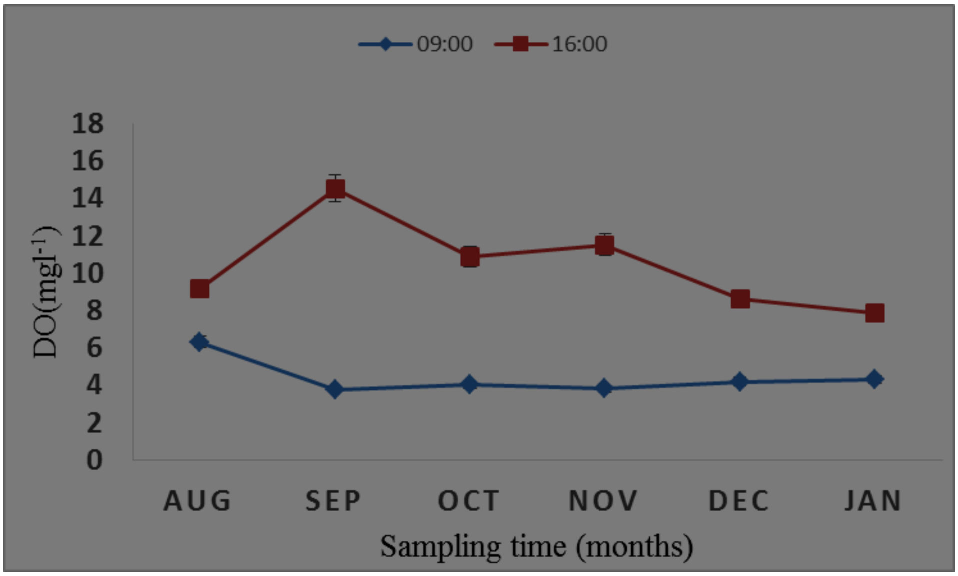

Figure 3. Mean monthly surface water dissolved oxygen of the experimental cages during the experimental period (mean ± SE)

Ammonia-Nitrogen (NH3-N)

The level of Ammonia-Nitrogen in the water was analyzed in this study (Fig. 5). The reason behind measuring this parameter was to identify the concentration of ammonia which is responsible for the formation of toxicity to the aquatic lives which again was essential to take intervention measures. For example when Ammonia (which is in unionized form) is high in the pond water, may be from waste food, fish excreta, dead plankton etc., it will be toxic (El-Shafai, *et al*., 2004; Brook, 2008). In the present study the mean concentration of ammonia-N was 0.18mg l^{-1} (Fig. 5). During the study period, the concentration of ammonia was not in the range which could lead to toxicity. This may be due to movement of supplemental feed left-over, fish excreta and dead plankton into the pond bottom (Fasil, *et al., 2011*).

During the whole culturing period no mortality of fish was observed.

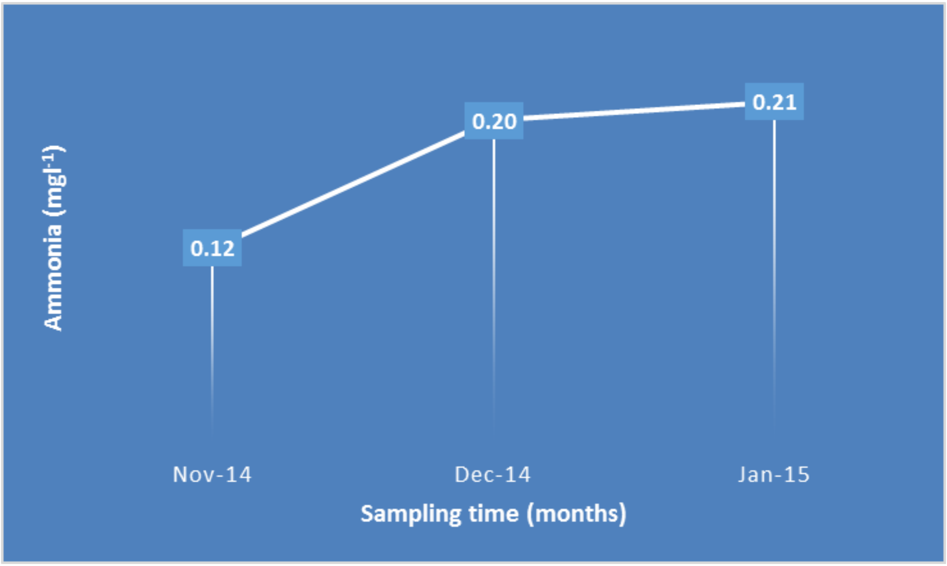

Figure 4. NH_3-N concentration in the cage, during the study periods

CONCLUSION

This study suggests that locally made cage can replace the costly imported cage materials. The result of this study ensures application of cage culture by small-scale fish farmers and interested investors and organizations in community water reservoirs, dams, etc., who want to establish fish farm in cage system at low cost.

Cages made up of locally available 210d/15 polyamide twine net making materials was equally productive, and has good potential to replace the costly imported cage materials. There are different locally available and suitable cage-making materials. Thus, it is necessary to conduct more research in order to come-up with more efficient, inexpensive and durable materials which can substitute the imported cages in different parts of the country.

REFERENCES

AOAC. 1990. Official Methods of Analysis, 15th edn. (Sidney Wil- liams ed). Association of Official Analytical Chemists Inc., Arlington, USA.

Ashagrie Gibtan, Abebe Getahun and Seyoum Mengistu, 2008. Effect of Stocking Density on the Growth Performance and Yield of Nile Tilapia [Oreochromis niloticus (L., 1758)] in a cage culture system in Lake Kuriftu, Ethiopia. J. Aquac.

Azaza, M. S., Dhraief, M. N. and Kraiem, M. M., 2008. Effects of Water Temperature on Growth and Sex Ratio of Juvenile Nile Tilapia Oreochromis niloticus (Linnaeus) reared in geothermal waters in southern Tunisia. J Therm. Biol.

Beveridge, M. C. M., 1996. Aquaculture and Environment: the supply and demand for environmental goods and services by Asian aquaculture and the implications for sustainability. J. Aquac., 28, 797-807.

Brook lemma, 2008. Introduction to Lake Ecology, Aquaculture and Fisheries in Ethiopia, Haramya University.

El-Shafai, S. A., El-Gohary, F. A., Nasr, F. A., Van der Steen, N. P. and Gijzen, H. J., 2004. Chronic Ammonia Toxicity to Duckweed-fed Tilapia (Oreochromis niloticus). J. Aquac.

Eng, C.T., and Tech, E., 2002. History of Cage Culture. In: Woo, P.T.K., Bruno, D.W., Lim, L.H.S.

(Eds.), Disease and Disorders of Finfish in Cage Culture. CABI Publishing, Oxon.

FAO, 2006. State of World Aquaculture 2006. FAO fisheries technical paper 500. Rome, Italy.

FAO, 2014. Fishery and Aquaculture Statistics, ISSN 2070-6057.

Fasil Degefu, Seyoum Mengistu, Schagerl, M., 2011. Influence of Fish Cage Farming on Water Quality and Plankton in Fish Ponds: A case study in the Rift Valley and North Shoa reservoirs, Ethiopia. Aqua. (2011).

Guo, L., Li, Z., 2003. Effect of Nitrogen and Phosphorus from Fish Cage on the Communities of Shallow Lake in middle Yangtze River Basin of China. Aquaculture226.

Halver, J. E. & Hardy, R. W., 2002. Fish Nutrition. London, Academic Press: An imprint of Elsevier Science.

Hambrey, J., L. A. Tuan and T. K. Thuong. 2001. Aquaculture and Poverty Alleviation. Cage culture in coastal waters of Vietnam. World Aquaculture 32(2):34-40.

K. Fitzsimmons (ed.) Tilapia Aquaculture. Proceedings from the Fourth International Symposium on Tilapia in Aquaculture, Northeast Regional Agricultural Engineering Service Cooperative Extension, Ithaca, New York.

Kassaye Balkew, 2012. Evaluation of Growth Performance, Feed Utilization Efficiency and Survival Rate of Juvenile Nile tilapia, Oreochromis niloticus(Linnaeus, 1758) Reared at Different Water Temperature. J Int. Aquac., 2(9).

Mikolasek, O., O. Patout, J. Lazard and M. Massou. 1997. Aquaculture Development facing the reality: example of cage tilapia in the Niger River (Niger).

MoARD, (2008): Ministry of Agriculture and Rural Development Annual Report. Addis Ababa, Ethiopia.

Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. NACA, Bangkok and FAO, Rome.

Tacon, A.G.J., 2001. Increasing the Contribution of Aquaculture for Food Security and Poverty Alleviation. In R.P.

Wetzel, R. G., 2001. Limnology: Lake and River Ecosystems. 3rd edition. Academic press. N. Y. 1006pp.

Zenebe Tadesse, Abeba W/gebriel, Mulugeta Jovani, Fekadu Tefera and Fasil Degefu, 2012. Effect of Supplementary Feeding of Agro-industrial by-products on the Growth Performance of Nile Tilapia (O. niloticusl) in concrete ponds. Ethiopian J. Biol.Sci.

Zenebe Tadesse, Boberg, M., Sonesten, L. and Ahlgren, G., 2003. Effects of Algal Diets on the Growth and Fatty Acid content of the cichlid fish Oreochromis niloticusL. A laboratory study. Aquat. Ecol.