

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES



**EFFECTS OF FEED QUANTITY ON GROWTH PERFORMANCE
AND WATER QUALITY IN CAGE CULTURE SYSTEM FOR
PRODUCTION OF NILE TILAPIA (*Oreochromis niloticus*, L., 1758)
IN LAKE BABOGAYA, ETHIOPIA**



By:
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*A Thesis presented to the School of Graduate Studies Addis Ababa
University in Partial Fulfillment of the Requirement for the Degree
Master of Science in Biology (Fisheries and Aquatic Sciences)*

**By
Solomon Hailu**

July 2008

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Abstract

This study was conducted in Lake Babogaya, one of Bishoftu's crater lakes in Bishoftu town, to determine the appropriate feeding level for tilapia, *Oreochromis niloticus* and the impacts of supplementary feed on water quality. A 16.9% crude protein diet, local made feed (Mill sweeping, oilseed cake and chicken dug cake) was fed to duplicate groups of *O. niloticus* fingerlings (29.70 ± 0.45 – 30.43 ± 0.70 gm) and (120.00 ± 0.56 - 122.97 ± 0.54 mm) in cages (1 m x 1 m x 1 m). Fingerlings obtained from Lake Babogaya and stocked at a density of 100 fish/cage. They were fed at 1, 2, 3, 4, and 5% of body weight daily. Water quality parameters, pH, temperature and dissolved oxygen (DO) were measured every month during the culture periods. The results of the experiment revealed that the final weight (224.63 ± 1.23 , 223.07 ± 1.23 , and 223.40 ± 1.23) and specific growth rate (1.22 ± 0.08 , 1.20 ± 0.07 , and 1.21 ± 0.06) of the fishes fed at 3, 4 and 5% body weights were similar ($p > 0.05$) but differed significantly ($p < 0.05$) from the final weight (118.30 ± 0.43 and 152.87 ± 0.40) and SGR (0.81 ± 0.08 and 0.99 ± 0.07) of the group of fishes fed at 1 and 2% body weight respectively. Moreover, there were significant differences in FCR of fishes fed at the various body weights (1.76 – 6.33). Survival rate was not affected by feeding level. In addition, pH, DO and temperature of the culture water were not affected by the treatments. The study established the optimum feeding rate for *O. niloticus* at 3% body weight daily reared in cages.

Keywords: Cage, Ethiopia, Feeding Levels, Lake Babogaya, *Oreochromis niloticus*.

1. Introduction

Ethiopia is a country with a considerable potential for fish farm. It has a surface area estimated at 7,334 km² of major lakes and reservoirs, and 275 km² of small water bodies, with 7,185 km length of rivers (FAO, 2003). This is suitable for artisanal and commercial fish production.

These water bodies provide the country a potential annual fish production estimated at 51,000 tones, distributed as follows: 28,000 tones in the lakes and reservoirs and 23, 000 tones in the rivers. Out of these potentials, about 15,000 tones were realized in 2003, representing 30% of the potential. Most of the fishing takes place in lakes (85%) with only 15% in the rivers (ADF, 2004).

The fishery is predominantly artisanal, currently involving 15,000 fishers of which 5,000 are considered full-timers (FAO, 2003). Their total landing was estimated at 10,400 tones from Lakes Abaya, Awassa, Chamo, Langano, Tana, Ziway and Koka reservoir (Reintjens and Wudneh, 1998). Fishing from 2,342 boats (366 motorized steel or wooden vessels, and the rest are reed or raft vessels), with some 17,240 nets and 28,000 hook gear (FAO, 2003).

Gears in use range from a variety of traps and spear, to gillnet and beach seine, and hooks on hand and long line. Motorized fishery is typical for Lake Tana. Primitive locally produced wooden boats are common in Lakes Ziway, Langano, Awassa and Koka reservoir. Beach seines are used on Lakes Ziway, Langano and Koka reservoir. The use of gillnets and hook gear is widespread in the country's water bodies (FAO, 2003).

The commercial fisheries are at a very small scale, and during the last decades they have developed to cover most of the countries freshwater systems (Reintjens and Wudneh 1998). This development increased fish production in the country. Due to this increasing fish production, several of the stocks show signs of over fishing. For instance, the yield of Nile perch (*Lates niloticus*) stock in Lake Chamo, Nile tilapia in Lake Awassa and Ziway

show sign of over fishing. (Reintjens and Wudneh, 1998; Felegeselam Yohannes, 2003). If this trend of fishing activities continues with environmental degradation, the country's fish stocks will collapse within a short period.

The average fish consumption in Ethiopia is the lowest in Africa (Breuil, 1995). The equivalent consumption is only 0.1kg per person per annum, which is very low compared to the fish consumption of Africa and world, which is about 8 Kg and 14 Kg per annum per person, respectively (FAO, 1995). However, the current demand for fishes in the country exceeds the supply by about four fold. The total annual demand of fish in the beginning of year 2000 was about 67,000 tones and is expected to grow nearly to 95,000 tones in 2015 and 118,000 tones in 2025 (Sileshi Ashine, 2003) .

Rapid population growth, increasing affluence and urbanization are leading to major changes in demand and supply for animal protein, from both livestock and fish (Delgado *et al.*, 2003), and fish eating habits during the fasting seasons promote the demand for fish consumption.

All the supply for this demand is provided by natural catch from the lakes, reservoirs and rivers. Unless other alternatives such as fish farming or aquaculture expand in the country, this growing demand will be in jeopardy by overexploitation of the natural catch. Thus, one of the ways to bridge the gap between the reduced fish supply and increasing demand is through farming of fishes in different natural and artificial water bodies. Aquacultures turn out to be the fastest-growing food producing industry worldwide, as a means of increasing fish supply as well as reducing the pressure exerted on capture fisheries (Avault, 1996).

However, aquaculture in Ethiopia is still virtually non-existent; despite the fact that the country's physical and socio-economic conditions support its development. The high central plateau above 2,500 m (11% of the total area) could be appropriate for all year round farming of cold water species. The adjacent and central highlands present temperate characteristics favorable to the breeding of a large number of species, from cold water to warm water fish (Breuil, 1995). In addition, the temperature conditions are

remarkably stable as compared to Europeans temperate climates and give a great scope for cultivating a large range of species in very good conditions.

The lowlands (33 % of the total area) offer ideal temperature condition for warm water tilapine species (Hussein Abegaz and Yared Tigabu, 2003). Therefore, aquaculture prospects on an extensive scale seem feasible when viewed in light of the high priority given to water harvesting, and from the physical suitability of the country for the best known cultured species.

Extensive aquaculture in the form of stocking and enhancing artificial lakes, reservoirs and small water bodies has been practiced since 1975 through the NFLARRC- Sebeta (NFLARRC = National Fisheries and other Living Aquatic Resources Research Center of the Ethiopian Institute of Agricultural Research (EIAR). Over 2.5 million fingerlings, primarily consisting of Nile tilapia (*Oreochromis niloticus*), *Tilapia zilli* and carp, have been released by the center, but in the absence of systematic monitoring and evaluation (due to weak institutional capacity) the success or failure of the program is unknown (FAO, 2003).

Cage aquaculture is a recent aquaculture innovation in Ethiopia which fish are raised in enclosures. The fish are placed in a cage or basket which allows water to pass freely between the fish and the water body (Swann, 1992). It is commonly practiced worldwide in both freshwater and marine environments including the open ocean, estuarine, lakes, reservoirs, ponds and rivers (Beveridge, 1987). Cage culture system is relatively cheap, easy to construct and uses existing water bodies (Beverage, 1984). This system of aquaculture could be a good response for problems of overexploitation, poverty and job opportunity in the country.

Even though the Ethiopian fish fauna has not been intensively studied, the country has about 153 indigenous and additional 10 exotic fish species (Abebe Getahun, 2003). Among these, six species are commercially most important ones and belong to the following families: Centropomidae (*Lates niloticus*), Cichlidae (*Oreochromis niloticus*), Clariidae (*Clarias gariepinus*), Bagridae (*Bagrus dockmak*), and Cyprinidae

(*Labeobarbus spp.* and *Labeo sp.*) (JERBE, 2006). Of these, *Oreochromis niloticus* (L., 1958) is the most exploited species and represents about 80 % of the total fish capture in Ethiopia (Breuil, 1995). It is one of the most important species in the ecology and fisheries of almost all Ethiopian inland waters (Shibru Tedla, 1973).

O. niloticus, is currently considered to be the most important and second cultured fish species around the world. They have earned the title “the aquatic chicken” (Pollock, 2003). They are fast-growing, breed easily with no need for special hatchery technology, eat a wide range of feed types and able to survive in poor water conditions. Moreover, it is suitable species for increasing protein production, profits and the quality of nutrition of poor fish farmers and consumers.

Furthermore, evaluate and convert remaining feed and domestic wastes into high quality protein and are delicious. These characters provide the farmers with relatively low cost of production and make tilapias among the excellent fishes for culture (Yi *et al.*, 1996; de Graaf *et al.*, 1999; Penna-Mendoza *et al.*, 2005).

Supplementary feed are needed in semi-intensive and intensive culture system. It can be either agricultural by products (of plant, or animal origin), or specially formulated diets. The use of supplemental feed improves aquaculture productivity economically (Brown *et al.*, 2002) and could results in higher survival rates (Wang and Zhang, 1995).

In Egypt small and large-scale commercial farmers prefer the semi-intensive system of aquaculture, which represented about 84% of total aquaculture production in Africa. In this system, fish density is usually higher than in extensive culture, and farmers use organic fertilizers plus some supplementary feeds from locally available agricultural by-products. However, the output from this system is still relatively low compared to that of other continents, because of lack of feed and feeding knowledge (Suloma and Ogatai, 2006).

Locally available supplementary feeds may consist of wheat bran, copra meal, wheat flour, oilseed cakes (for instance, rapeseed, peanuts and soybean), green fodder, maize bran, chicken waste, and/or kitchen waste (Suloma and Ogatai, 2006).

Ethiopia has many kinds of agricultural by-products, such as wheat bran, oil seeds, and poultry droppings and by-products which are promising as supplementary feeds in fish culture. The availability of these agricultural residues and industrial by-products for feed seems promising to support small-scale commercial aquaculture and commercial intensive aquaculture for export. However, the knowledge on different culture systems and how to use and how to process the agricultural by-products is deficient. Moreover, there is lack of experience and research on feeding level, feeding frequency and feeding time in different fish culture system.

Poor feeding practice is a common cause of cage culture problem (stress) (Masser, 1997). Mal feeding practices are acute in cage since no natural feeds are usually available to the caged fish and water quality deterioration from waste feed has a more direct effect on confined fish especially for cages that are placed in small shallow water bodies.

Feeding problems common in cage culture include poor quality feed, incomplete feeding, inadequate feeding or under feeding, over feeding and feeding at the wrong time of the day. Many of these problems have no simple solutions and need thorough investigations.

There were efforts to assess the effects of stocking density on the growth performance of *Oreochromis niloticus* in fresh water ponds in Jimma, Ethiopia (Kebede Alemu, 2003). Studies were also carried out by Abebe Tadesse (2007) and Ashagrie Gibtan *et al.* (2008) to evaluate the effects of stocking density and supplementary feeding on the growth performance, survival and production of *O. niloticus* reared in cages in Lakes Elen and Kuriftu, respectively. The investigators confirmed effects of stocking density and supplementary feeding on the growth performance and yield of *O. niloticus* but have reported no effects on survival rate by stocking density and supplementary feeding.

There is also another recent study conducted by Belsti Fetene (2008) to identify effects of local feed types on the growth performance of Nile tilapia cage culture in Lake Babogaya, Ethiopia. Best result of growth performance was achieved in ‘mill sweeping-chicken dung’ diet (Personal com.).

However, further studies are needed to develop feeding systems in the country to establish suitable feeding level. Therefore, the present study attempts to find out effects

of different feeding level on growth performance of Nile tilapia cage culture and water quality in Lake Babogaya, Ethiopia.

2. Objective of the study

2.1 General objective

General objective of the study is to generate baseline data on cage culture fisheries in order to improve food security, increase domestic fish production, generate employment, promote economic development of the country, improve use of resources, and reduce environmental impacts.

2.2 Specific objectives

- ◆ Assessing different feed quantity (feed/body weight) and their effect on growth performances of *O. niloticus* in cage systems.
- ◆ Comparing the difference in growth performance on natural feeds with different amounts of supplementary feed.
- ◆ Examining effect of supplementary feed on water quality.

3. Literature review

Aquaculture is a form of agriculture that involves the propagation, cultivation, and marketing of aquatic animals and plants in a controlled environment (Swann, 1992). It is important sector of fish production not only as an animal protein source to ensure food security but also to improve employment and income for poverty elimination in developing countries, improved waste water treatment, water reuse and crop irrigation opportunities, and improve nutrient recycling (FAO, 2006; Tacon, 2001; Halwart and Moehl, 2006).

The total world production of capture fisheries and aquaculture amounted to about 106 million tones in 2004, providing an apparent per capita supply of 16.6 kg. World aquaculture production in 2002 was 39.8 million metric tones and about 57.7% by quantity and 48.4% by values of the aquaculture production continues to come from the freshwater environment (FAO, 2007).

Modern concept of aquaculture was introduced from Europe into African countries during the colonial administrations (FAO, 2004a). In the 1950s, about 300,000 fish ponds were operating by mainly rearing tilapia in about 20 African countries (Meschkat, 1967).

Now despite the existence of aquaculture for the past 55 years in Africa, the total aquaculture output is still very low compared with the production from the capture fisheries. In 2002, total fish production in Africa was 7.5 million metric tones which were 5.6 % of world production. Egypt, Morocco, South Africa, and Nigeria contributed 41 % of the African total in 2002, while the other 50 African countries contributed the remaining 59 % (Suloma and Ogata, 2006).

On the other hand, the input of aquaculture in Africa is fairly insignificant compared to the rest of the world. African aquaculture contributed merely 1.2 % (463×10^3 Metric tones) of total world aquaculture production. Only four countries, Egypt, Nigeria, Madagascar, and Ghana, represented 90 % of the continental total aquaculture production

(FAO, 2004b). This is due to a lack of regular planning and exercises for aquaculture development in most African countries.

In addition, aquaculture in Africa is still a secondary and part-time activity in small farms with small freshwater ponds, and it is still an industry in its early developmental stage. Freshwater aquaculture in ponds is the most widespread type of aquaculture in Africa today, and it produces the greatest amount of fish equivalent to 80% of the total aquaculture harvests. Thus, freshwater aquaculture is the most promising avenue to increase aquaculture production in the short and medium term (Anetekhai *et al.*, 2004).

Cage culture is one of the alternative aquaculture systems among other culture systems such as open ponds, raceways, and tanks. It utilizes existing water resources (lakes, large reservoirs, farm ponds, rivers, cooling water discharge canals, estuaries and coastal embayment) that cannot be drained or seined and would otherwise not be suitable for aquaculture but encloses the fish in a cage or basket which allows water to pass freely between the fish and the pond (Swann, 1992).

The origin of cage culture is traced back almost two centuries ago to the Asian region, the use of cages for holding and transporting fish for short periods (Pillay and Kutty, 2005), and marine commercial cage culture was pioneered in Norway in the seventies with the rise and development of salmon farming (Beveridge, 2004).

The cage aquaculture sector has grown very rapidly during the past 20 years and is presently undergoing rapid changes in response to pressures from globalization and growing demand for aquatic products in both developing and developed countries, for instance, high fish consumption rate in developing countries, by 57 % from 62.7 million metric tons in 1997 to 98.6 million in 2020 (Delgado *et al.*, 2003; Tacon and Halwart, 2007).

In addition, the move within aquaculture toward the development and use of intensive cage farming systems which is driven by a combination of factors, including the increasing competition faced by the sector for available resources (Foley *et al.*, 2005; Tilman *et al.*, 2002), and the need for economies of scale and the drive for increased

productivity per unit area, particularly the need for suitable sites resulted in the sector accessing and expanding into new untapped open water culture areas such as lakes, reservoirs, rivers, and coastal brackish and marine offshore waters.

Cage culture is advantageous, it is flexible and easy to manage, low cost of harvesting, close observation of fish feeding response and health, ease and economical to treat parasites and diseases. Besides, it is of relatively low capital investment compared to ponds and raceways (Eng and Tech, 2002; McGinty and Rakocy, 1989).

Furthermore, in cage culture it is possible to disrupt breeding cycle of tilapia, and therefore mixed-sex populations can be reared without the risk of reproduction when mesh is large enough to let eggs fall through (Paz, 2004).

Cages can be floating surface or standing surface cages (McGinty and Rakocy, 1989). Standing cages are tied to stakes driven into the bottom substrate, whereas floating cages require a flotation device to stay at the surface. Flotation can be provided by metal or plastic drums, sealed PVC pipe (pipe made of Polyvinyl chloride), or Styrofoam. Cages should be constructed from materials that are durable, lightweight and inexpensive, such as galvanized and plastic coated welded wire mesh, plastic netting and nylon netting (Fitzsimmons, 2004).

Tilapias culture in floating cages set up in lakes, reservoirs and rivers is the most popular practice. The common dimension of cages is 6 x 4 x 3 m. Tilapias (>50 g) are stocked at 100-150 fish/m³ in cages, fed with artificial feed (28-35 % crude protein). Nile tilapias harvested after 120-150 days of culture, with harvested size of 600-800 g and gross yield of 30-60 kg/m³ giving on Feed conversion ratio of 1.5-2.0 (Guerrero, 2007).

Cage size may vary from 1 to more than 1,000 cubic meters. As cage size increases, costs per unit volume decrease, also production per unit volume decreases, resulting from a reduction in the rate of water exchange (McGinty and Rakocy, 1989).

Mesh size has a significant impact on production and vary depending on the size of fingerlings at stock. Mesh sizes for Nile tilapia cages should be at least 1/2 inch, but 3/4

inch is preferred because it provides adequate open space for good water circulation through the cage to renew the oxygen supply and remove waste (Dikel *et al.*, 2005). The use of large mesh size requires a larger fingerling size to prevent gill entanglement or escape. However, larger mesh size facilitates the entry of wild fish into the cage. These fish will grow too large to swim out of the cage, but they do not grow large enough to reach marketable size, thereby representing a waste of feed (Bocek, 1996).

Cages should be equipped with covers to prevent fish losses from jumping or bird predation. Feeding rings are usually used in smaller cages to retain floating feed and prevent wastage. Feeding rings should enclose only a portion of the surface area because rings surrounding the entire cage perimeter may reduce water movement through the cage (McGinty, 1991). However, feeding rings that are too small will allow the more aggressive fish to control access to the feed. If sinking feed is used, small cages may require a feed tray to minimize loss.

Cages may be tied up individually or linked in groups to piers, rafts, or lines of heavy rope suspended across the water surface. At least 4.5 meter should separate each cage to optimize water quality. The cage floor should be a minimum of 1 meter above the bottom substrate, where waste accumulates and oxygen levels may be depressed. However, greater depths promote rapid growth and reduce the possibility of parasitism and disease (Masser, 1991).

Large bodies of water are better suited for cage culture than small ponds since the water quality is generally more stable and affected less by fish waste. It is possible to use small ponds for cage culture, but provisions for water exchange or emergency aeration may be required. Cages should be placed usually to the windward side, where water currents are greatest. Calm, stagnant areas should be avoided (Konikoff, 1975).

Regardless of its obvious economic and technical success, cage farming sector has faced numerous issues and challenges during its development. In general, these issues and challenges have impacts not only on the system but also affect the surrounding aquatic environment and ecosystem.

The loss of large amount of nutrients from uneaten feed, faecal wastes and excreta from cage-reared fish has a potential impact (negative and/or positive) upon water quality and surrounding aquatic ecosystem health (Mente *et al.*, 2006) and the possibility of disease occurrence within cage reared fish (Merican, 2006) and the potential risk of transfer of diseases to (and from) natural fish populations (Ferguson *et al.*, 2007).

Other problems cage culture includes its dependency upon the capture of wild caught seed where hatchery development is new or production is not currently sufficient to meet demand (FAO, 2006; Merican, 2006; Ottolenghi *et al.*, 2004) is another drawback of cage culture system. Moreover, the risk of fish escapes from cages has potential impacts (negative and/or positive) on wild fish populations, including potential genetic, ecological and social impacts (FAO, 2006; Ferguson *et al.*, 2007; Hindar *et al.*, 2006; Naylor *et al.*, 2005; Soto *et al.*, 2001)

In particular concerning the long-term ecological sustainability of rearing carnivorous fish species within cage-based farming systems based upon the use of fishery resources as feed inputs (Costa-Pierce, 2003; Tacon *et al.*, 2006) are additional basic issues related with cage cultures.

So far, commercial cage culture has been mainly restricted to the culture of higher-value (in marketing terms) compound-feed-fed finfish species. In terms of diversity, 40 families of fish are cultured in cages, but only five families (Salmonidae, Sparidae, Carangidae, Pangasiidae and Cichlidae) make up 90 percent of the total production (Tacon and Halwart, 2007).

Tilapias are one of the most popular fish for culture in the world (El- Sayed, 2002). They contributed 2.37 million metric tones to global share production in 2003 with an average increase in 7.8 % per year from 1995 to 2003. Nile tilapia (*O. niloticus*) alone accounted for 50 % of this total (FAO 2005). It is responsible for the significant increase in global tilapia aquaculture production.

Tilapias are native to Africa and the Middle East. They have spread mainly through introductions for fish farming and are now found in all tropical and semi-tropical

continents. The most appropriate species or strains of tilapia for cage culture are *O. niloticus* (FAO, 1980; Masser, 1991; Altun *et al.*, 2006).

The attributes which makes tilapias especially Nile tilapia so suitable for fish farming are their general hardiness, great tolerance to adverse environmental conditions such as high stocking density of fish, lower water quality, organically polluted water, and low dissolved oxygen level of the water (less than 0.5 mg l^{-1}). Additional factors including, ease of breeding, rapid growth rate, ability to efficiently convert organic and domestic wastes into high quality protein, and good taste (Stickney *et al.*, 1979; Balarin and Haller, 1982; Pullin and Lowe-McConnell, 1982; Cruz and Ridha, 1994).

In addition they have tolerance to salinity in wide range in culture (Cruz and Ridha, 1994). Besides to their alimentary importance, some species are useful for controlling of water plants. These characters provide the farmers relatively low cost of production and make tilapias among the excellent fishes for culture (Yi *et al.*, 1996; de Graaf *et al.*, 1999; Peña-Mendoza, 2005).

Water temperatures between 20-30 °C are preferred for tilapia culture and can survive in pH ranging from 5 to 10 but do best in a pH range of 6 to 9 and survive in regular dawn dissolved oxygen (DO) concentrations of less than 0.3 mg/L, considerably below the tolerance limits for most other cultured fish (Coche, 1982; Popma and Masser, 1999).

O. niloticus feed on large variety of natural feed organisms found in fertilized ponds (Binh *et al.*, 2004). However, it is necessary to apply supplementary feeds under conditions of heavy stocking density and when natural feed supply declined or completely not available (Ahmad *et al.*, 2005).

According to Dikel *et al.*, (2005) fishes with supplementary feed resulted in higher yields and growth rates as compared to the non-feeding cages. However, improper combinations of feed ingredients, feed formulations and feeding practices impede aquaculture production (Sulmoa and Ogata, 2006).

The optimum protein requirement for tilapia species has been determined by several investigators and the results are not consistent. For instance, Wang *et al.*, (1985), estimated 30%, Shiau *et al.*, (1987) 32%, Cruz and Laudencia (1977) 29–38%, Mazid *et al.*, (1979) 30–35%, Davis and Stickney (1978) 36%, and Jauncey (1982) reported 40%.

In many fish including tilapia, it has been reported that the protein requirement of fish decreases with increasing size and age (Wilson, 1989). Fry and fingerlings require a diet higher in protein, lipids, vitamins and minerals and lower in carbohydrates as they are developing muscle, internal organs and bone with rapid growth.

Sub-adult fish need more calories from fat and carbohydrates for basal metabolism and a smaller percentage of protein for growth (Jauncey and Ross, 1982; El-Sayed and Teshima, 1991; and Stickney, 1996). Therefore, in aquaculture production the use of supplemental artificial feeds has to meet the nutritional requirements of the culture species.

Feeding with supplemental or complete feeds is critical in fish farm because it represents 60-70% of the total production cost (Patel and Yakupitiyage, 2003). Hence, effective and efficient feeding strategies must be developed to minimize feed wastage and eventually reduce production cost.

Poor development of fish feed sectors is a major constraint to aquaculture development in Africa (Sulmoa and Ogata, 2006), especially local farm-made feeds and feeding technology to increase production capacity and efficiency under unstable/hostile and poverty environments are necessary.

Appropriate feeding regime development for fishes is a major tool for fish culture effluents reduction and management without affecting the growth of fishes significantly. In aquaculture, feeding at levels for optimal growth is economically desirable (Lovell, 1989), because over-feeding usually leads to a deterioration of water quality, increased costs and inefficient production.

Nwanna (2003) observed insignificant differences in the mean weight gain (%) and specific growth rate of Nile tilapia fed 3, 4 and 5% of their body weights and suggest 3% BW⁻¹ as optimum feeding level for tilapia culture.

Similar studies on optimization of feeding techniques of *O. niloticus* in a semi-intensive system focused on exploitation of the synergetic interaction between natural feed and supplemental feed to reduce artificial feed input and their production costs (Tacon and De Silva, 1997).

For instance, Rowland *et al.* (2005) found that the optimal feeding rate in cage culture for small silver perch fingerlings (2 g) at 23.3°C was 7.5%, and this confirm the suggestion by Russell (1996) that the feeding level required to obtain optimal growth of juvenile silver perch (1.3 g) was between 5% and 10%.

Qin and Fast (1996) found that feeding rates of 5–6% are optimal for fingerling snakehead (*Channa striatus*) and the same result reported by Tucker and Robinson (1990) for channel catfish. In addition Adebayo *et al.* (2000) suggest that 3% day⁻¹ was optimal for hybrid clariid catfish (*Clarias gariepinus* × *Heterobranchus bidorsalis*) grown to a larger size of around 100 g.

Rowland *et al.* (2005) in his silver perch fingerling experiments find that FCR (food conversion ratio) increased with increasing feeding rate and similar result was reported for juvenile snakehead for which FCRs increases over feeding rates of 0–30% BW day⁻¹ (Qin and Fast 1996). In this study at high feeding level, the excess feed has lead to high FCRs.

Mancintosh and De Silva (1984) also reported that growth and survival of *O. niloticus* fry improved with increasing feeding level from 6-24 % BW day⁻¹ irrespective of fish stocking density. Another study by Santiago *et al.* (1978) shows that the growth of Nile tilapia fry increase with increasing feeding levels up to 65 %. However, the differences were insignificant in growth rate and survival between the 30 % and 65 % feeding levels.

Water quality is another major concern in semi-intensive or intensive aquaculture and is a key ingredient in successful fish farm. When the water quality is low, fish may present impaired productive performance and increased mortality, leading to lower production and profit. Lack of basic knowledge on water quality makes fish farmers contribute to this decrease in quality (Baccarin and Camargo, 2005).

In order to minimize the impact of these problems, improving feed management techniques and minimizing waste by using good quality, highly digestible feed (Rosenthal, 1994), with lower concentrations of nitrogen and phosphorus, without reducing its nutritive value (Boyd, 1999) are finest solutions.

Continuous release of wastes in the surrounding aquatic ecosystems from fish farm may lead to artificial eutrophication, with negative impacts on local biodiversity (Iwama, 1991; Beardmore *et al.*, 1997).

Eutrophication of the water from ponds leads to social and economical problems that are more and more evident, mainly in developing countries, where generally there are no specific regulations and the producers themselves are not sensitive to the problems resulted from fish culture. Thus, although it is impossible to rear animals without producing environmental changes, the impact may be mitigated or reduced to a minimum, such that there is no reduction in biodiversity, no draining or negative impact on any environmental resource, or no significant changes in ecosystem structure or functioning (Baccarin and Camargo, 2005).

Baccarin and Camargo (2005) find that the introduction of feed in the ponds affects the quality of water, and these conditions could decrease the productive performance of the fish, leading to serious economic and ecological losses, once these systems produce effluents and bad quality water that are sent back to the environment.

It is evident, therefore, that further studies are required to verify best feed type, effective feeding rate and feeding regimes on tilapia growth and the impacts of excessive fed/feeding on the water quality of the culture system. So, this study focuses on assessing the best feed quantity for cage culture in Lake Babogaya.

4. Description of the Study Area

4.1 Lake Babogaya

Lake Babogaya (Pawlo) is one of the volcanic crater lakes found in the vicinity of Bishoftu town at about 45 Km east of Addis Ababa (Figure 1). The lake is small, roughly circular and fairly deep (Max. depth 71m), and is found at an altitude of 1870 m and at about 9°N and 39 °E (Prosser *et al.*, 1968; Wood *et al.*, 1984).

Like the other volcanic crater lakes of the area, Lake Babogaya is a closed system surrounded by very steep and rocky hills. The vertical distance from the lake's surface to the crater rim is 20 m, and this affords moderate protection from wind (Baxter, 2002). It is fed directly by rain and water flowing down from the crater rims (Wood, *et al.*, 1976), which was formed from volcanic rocks of basalt, rhyolite and tuff (Mohr, 1961).

The temperature of its surface water was frequently found to be about 22 °C with a maximum of 24.5 °C and a minimum of 19.2 °C, while the bottom temperature was almost constant (19.2 °C - 19.4 °C) (Wood *et al.*, 1976 and 1984). In a recent study (Yeshemebet Major, 2006), the water temperature and dissolved oxygen of the lake range from 23 °C to 27 °C and 7 mg l⁻¹ to 14 mg l⁻¹, respectively.

Drier slopes around the lake support various tree species such as *Acacia spp.* where disturbance and grazing are minimal. Severely eroded areas are either bare or carry highly drought-tolerant shrubs, scramblers and succulents, the most conspicuous of which are *Carissa edulis*, *Euphorbia tirucalli*, *Pterolobium stellatum*, *Caesalpina spinosa* and *Opuntia ficus-indica* (Prosser *et al.*, 1968; Wood *et al.*, 1984).

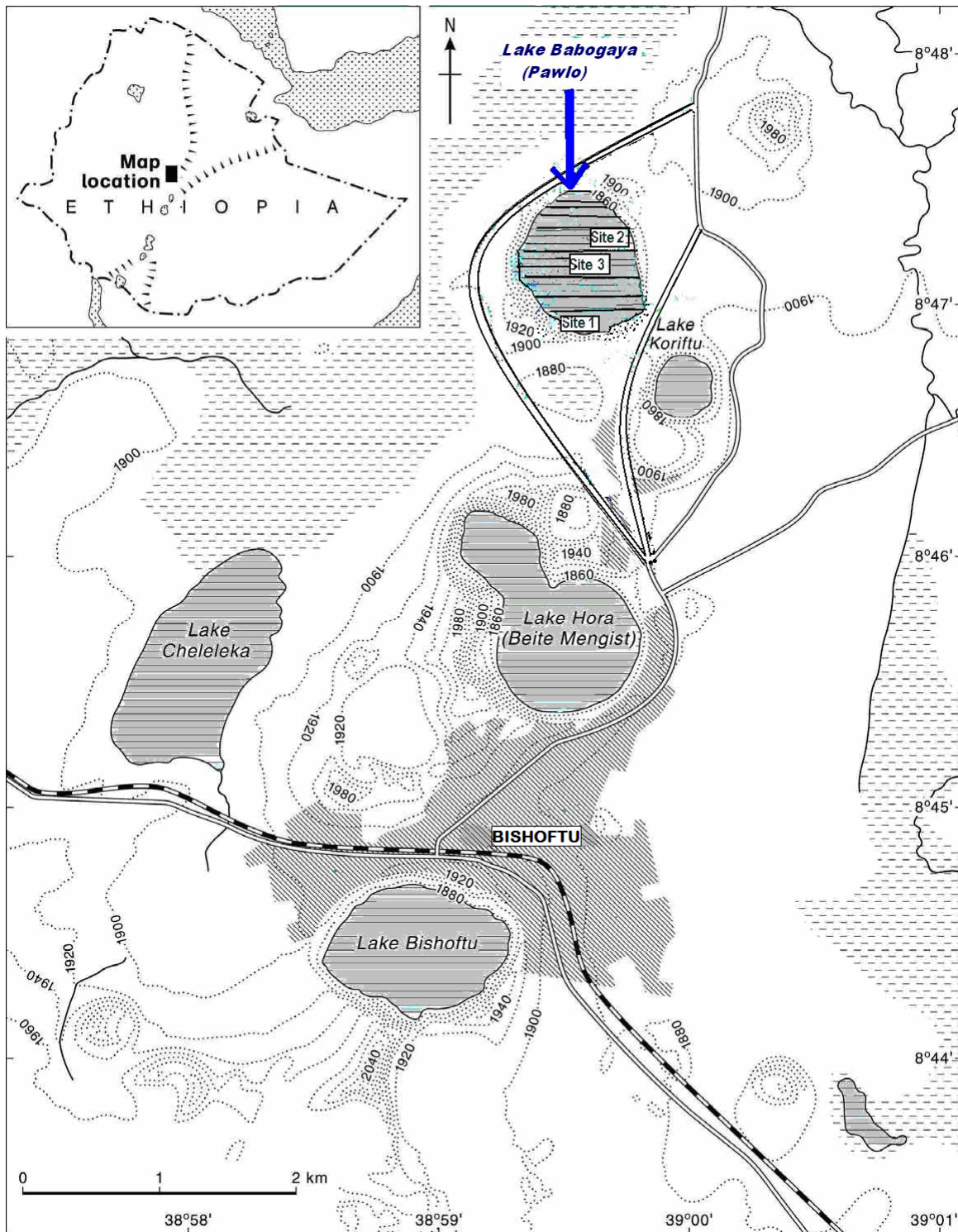


Figure 1 Location of Lake Babogaya (sampling sites: 1, 2 and 3) in relation to other Bishoftu Crater Lakes (Lamb, 2001).

Limnological studies made on Lake Babogaya described its bathymetry (Prosser *et al.*, 1968) (Table 1), water chemistry (Prosser *et al.*, 1968; Wood *et al.*, 1984; Rippey and Wood, 1985; Zinabu Gebre-Mariam, 1994; Baxter, 2002; Zinabu Gebre-Mariam, 2002), thermal stratification and mixing (Baxter and Wood, 1965; Wood *et al.*, 1976; 1984), chlorophyll *a* and phytoplankton (Wood and Talling, 1988; Zinabu Gebre-Mariam, 1994; Zinabu Gebre-Mariam and Taylor, 1997), bacterial abundance (Zinabu Gebre-Mariam and Taylor, 1997), temporal and seasonal variation of phytoplankton (Yeshimebet Major, 2006), temporal and spatial dynamics of zooplankton in relation to phytoplankton variation described by Dinbere Belay (2007) and reproduction, feed, length-weight relationship of African catfish (*Clarias gariepinus*) was studied by Lemma Abera (2007) and effects of supplemental feeding type on growth performance of Nile tilapia in cage culture was done by Belste Fetene (2008).

Lake Babogaya is alkaline with Na⁺ as the dominant cation and carbonate-bicarbonate as the dominant anion (Table 1). The erosion of basaltic and hyper-alkaline rocks surrounding the lake is playing an important role in increasing the alkalinity of the water (Wood and Talling, 1988).

The phytoplankton community is dominated by blue-green algae, particularly *Microcystis aeruginosa* (Kutz.) (Wood and Talling, 1988), while the zooplankton is composed of copepods (*Afrocyclus gibsoni*, *Lovenula africana*), rotifers (*Asplancha sieboldi*, *Brachionus calyciflorus* and *Hexarthra jenkiniae*), and cladocerans (*Diaphanosoma excisum*, *Moina dubia*, *Ceriodaphnia cornuta* (Green, 1986; Dinbere Belay, 2007). The fish community found in Lake Babogaya is composed of *O. niloticus*, *C. gariepinus* and *Tilapia zilli*.

C. gariepinus is the most dominant species next to *O. niloticus* (Lemma Abera, 2007). There is limited fishing activity by few local people but the lake is mainly used for recreation and domestic water-use purposes. Some morphological, physical and chemical features of the lake Babogaya are given in Table 1.

Table 1 Some morphological, physical and chemical characteristics of Lake Babogaya
From ^c Prosser *et al.*, (1968); ^b Zinabu Gebre-Mariam, (1994); ^a Yeshimebet Major,
(2006).

PARAMETERES	VALUES
Latitude	9 ⁰ N and 39 ⁰ E ^c
Altitude (m)	1870 ^c
Surface area (Km ²)	0.58 ^c
Volume (Km ³)	0.022 ^c
Maximum depth (m)	71 ^a
Mean depth (m)	38 ^c
Conductivity K ₂₅ , μscm^{-1})	900 ^b
Alkalinity (meq l ⁻¹)	10.80 ^a
pH	9.2 ^a
Salinity (gl ⁻¹)	0.9 ^a
SiO ₂ (meq l ⁻¹)	< .1 ^a
Na+ (meq l ⁻¹)	5.50 ^a
Cl ⁻ (meq l ⁻¹)	0.90 ^a
Sum of cations (meq l ⁻¹)	11.7 ^a
Sum of anions (meq l ⁻¹)	11.4 ^a

Meteorological data of the study area on mean monthly maximum and minimum air temperature, and monthly total rainfall were obtained from the National Meteorology Agency of Ethiopia (NMAE, 2008). According to the data, (Fig. 2) average mean monthly minimum air temperature ranged from 9.50 °C in November to 13.79 °C in August, while the average maximum mean monthly air temperature varied from 24.05 °C

in September to 29.13 °C in May. Average monthly total rainfall ranged from 5.65 mm in November to 228 mm in July.

According to the data the region has one minor rainy season, extending roughly from February to April and the major one between June and September, appreciable quantities of rainfall were recorded throughout from February to August including September, and the peak value was in July. Rippey and Wood (1985) documented that the lake area has moderate rainfall, varying around 850 mm per annum.

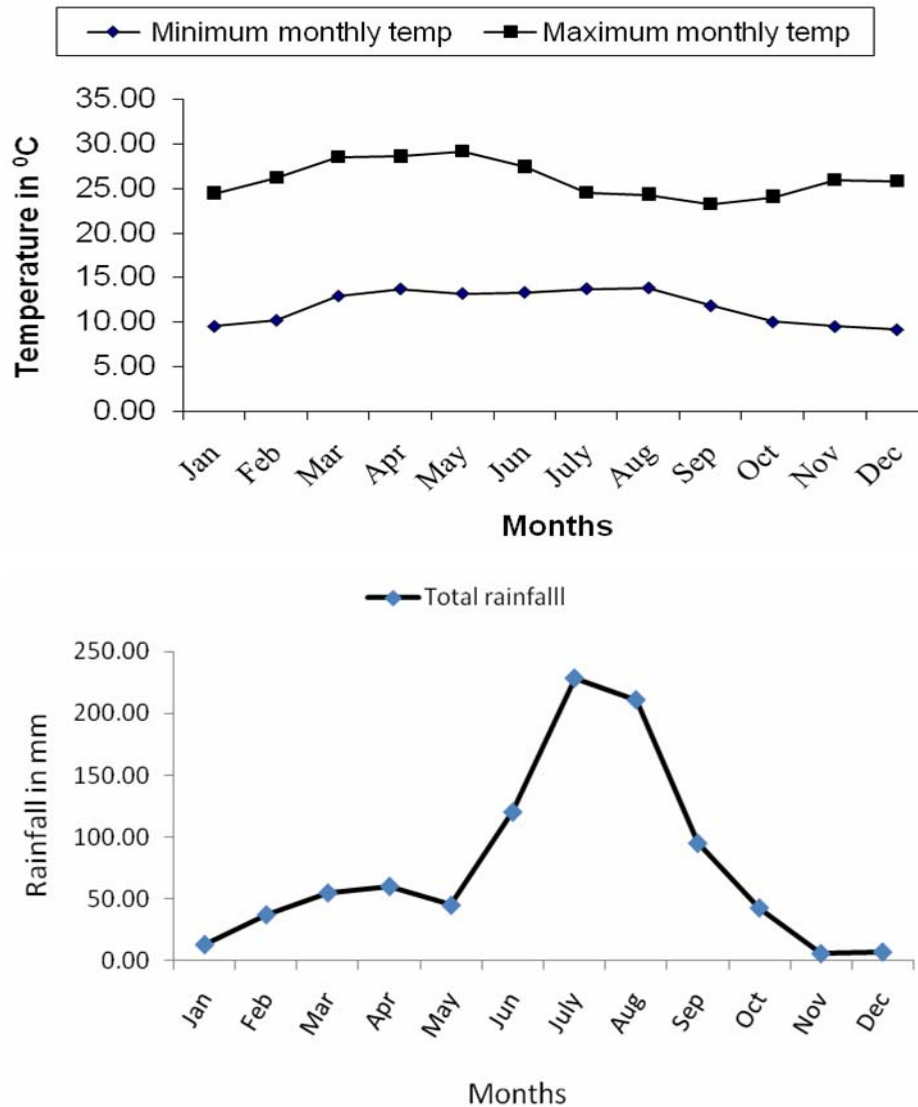


Figure 2 Average monthly minimum and maximum temperature and total rainfall of the study area from Jan - Dec 2007 (Source: National Meteorological Agency of Ethiopia)

5. Materials and Methods

5.1 Site selection

Suitable site for cage placement was selected based on security, appropriate depth, and accessibility of the lake in the compound of International Livestock Research Institute (ILRI) currently known as Ethiopian Meat and Dairy Technology Institute (EMDTI). It was assumed that there would be good protection for equipments and cultured fish. Moreover, there is a depth of >3.5 m below the cage that would enable sufficient water circulation for waste removal and enough oxygen circulation as recommended by Andrew *et al.* (1971).

For limnological comparisons three sites were selected; they were site 1 (cage area with 3-4 meter depth), site 2 (opposite side of the cage site 3-4 meter depth), and site 3 (around the middle of the lake with 30 meter depth) (Fig.1).

5.2 Cage construction

New cages were constructed in fisheries and aquatic science laboratory of the Department of Biology at Addis Ababa University and used cages by previous postgraduate student were repaired at the study site (Fig. 3). The size of each cage was 1 m³ (1m x 1m x 1m) and the frame was made from light and durable material, PVC tube and nylon net with a mesh size of 4 cm used as an enclosure material as suggested by Fitzsimmons (2004) .



Figure 3 Cage constructions at AAU fishery laboratory

5.3 Landing stage construction

The landing stage which was constructed previously at the site was repaired and a new wing was constructed to provide sufficient space for hanging all the cages and get easy access for monitoring. It was totally constructed from wood and has a T shape with a total length of 12 m (Fig. 4).



Figure 4 Landing with cages at Lake Babogaya

5.4 Cage placement

Cages were placed side by side and tied up on the landing by a nylon rope at 1.50 meter intervals so as to make it easily accessible for sampling, feeding of fishes and maintenance of the cage and landing. The bottom of the cage was kept at a depth of >3.5 meters above the lake bottom. Shades of large trees were removed by clearing their branches and swimming, fishing and some other human activities were prohibited to avoid disturbance.

Cages were equipped with a trapdoor through which feed was distributed, dead fish were removed and also sampling and final harvest were conducted.

5.5 Juvenile collection and stocking

Mixed sexes of *O. niloticus* juveniles were collected from the research site, Lake Babogaya by using beach seine of 50 m length, 2.5 m width and 20 mm stretched mesh

size (Fig. 5). After capturing, the right size were selected by measuring their length using measuring board (average TL = 120 mm to the nearest of 1 mm) and weighed (average TW = 30 gm to the nearest 0.1 gm). Small sized fingerlings and other species were returned back to the lake.

The collected fingerlings were transported in plastic bag with oxygen to the site and stocked in each cage at a rate of 100 fish cage⁻¹. The fish were allowed to acclimating the cage condition from 29 September to 7 October 2007 and mortality monitored. During acclimation period, dead fish were replaced with fish of similar size.



Figure 5 Fingerlings collected from Lake Babogaya

Cages were labeled for identification purposes as T1, T2, T3, T4, T5 and C with a corrugated foil tag. Where, T1 represents fish feed with 1% of their body weight, T2 fish feed with 2% of their body weight, T3 fish feed 3% of their body weight, T4 fish feed 4% of their body weight, T5 fish feed 5% of their body and C represent the control cages. All treatments were in duplicate including the control and all cages have equal access to natural feed and water circulation.

5.6 Feeding

Locally available feed was used because there is no prepared feed for fish aquaculture in the country. Mixtures of mill sweeping, chicken droppings and oil seed cake were used in proportion 60%, 20% and 20% respectively. Feed were mixed manually. The compositions of ingredients of experimental diets analyzed by Ethiopian Health and Nutrition Research Institute (EHNRI, 2008) laboratory and the results are shown in Table 2.

Table 2 Nutrient contents of the feed given for cultured fish (ENHRI, 2008)

Feed type	Moisture %	Fat %	Protein % (N x 6.25)	Ash %	Crude fiber %	Carbohydrates % (including fiber)
Mixed feed from Mill sweeping, Chicken droppings, and Oil seed cake	7.52	4.79	16.95	4.07	5.44	66.67

Feeding started 8 October 2007 and provided twice a day as suggested by Masser (1991), early in the morning around 7:30 am and late afternoon at 4:30 pm when the water is calm. This avoids flushing out of the feed from the cages by wave (Diana *et al.*, 1996).

Feed ration was placed on feeding plastic trays which were suspended at mid depth in each cage. Rations were adjusted every two weeks interval based on fish growth change for each cage.

5.7 Data collection and analysis

5.7.1 Physical parameter

Water temperature was measured with thermometer monthly at 25 cm below the surface at each site 1, 2 and 3. Visibility of the lake was measured monthly at 12:00 am using secchi disk at each site. The secchi disk depth was used to estimate the euphotic depth of

the lake. Similarly, pH was measured with pH meter (Hanna 9143) and DO was measured using the Winkler method.

5.7.2 Plankton

To assess the effects of supplementary feed amount on the lake ecology and to determine the composition of the Lake phytoplankton and zooplankton, sampling and analysis of plankton was conducted from October 2007 to March 2008.

Zooplankton sampling was done every month using zooplankton net of 67 micrometer mesh size and diameter of 31 cm from the three sites of equal depth (3m). Samples were preserved in 5 % formaldehyde solution. Abundance of zooplankton was estimated by taking a sub-sample of 10 ml from each well-mixed sample using a wide- mouth pipette. The sub-sample was poured into a gridded Petri-dish with 15 grids and enumerated at 40X magnification using WILD dissecting stereomicroscope. Three grids were counted and the average value was taken and extrapolated to the sample volume then to the filtered volume and abundance expressed as No/m^3 .

Phytoplankton sampling was also done monthly using phytoplankton net of 10-micron mesh size at 3 m depth. The samples were taken from the three different sites within more or less similar time (10:00 am) of a day through out the study period.

The samples were stored in brown bottles preserved using Lugol's solution (Wetzel and Likens 2000) and placed in a refrigerator. The samples were examined with an inverted microscope and the identification of phytoplankton to the genus or the species level was made using different identification keys including those of Whitford and Schumacher (1973), Talling (1987) and Willen (1991).

Counting of phytoplankton was done by using Sedgwick-Rafter cell under an inverted microscope following the procedures outlined in Hotzel and Croome (1999). Six grids (3 vertical and 3 horizontal) were counted and the result was extrapolated to the sample volume, and to the volume of the water filtered to get the abundance of phytoplankton per meter cube of the lake.

According to Hotzel and Croome (1999), the number of cells per 1ml was calculated using the formula:

$$C \text{ (ml}^{-1}\text{)} = \frac{N \times 1000 \times m^3}{A \times D \times F \times 10}$$

Where N= Number of cells, A is area of field (mm²), D the depth of field (mm), F is the number of cells counted and 1/10 is the concentration factor.

5.7.4 Fish

Initial weight, length and number of the stocks were recorded on 8 October 2007. Dead fish were removed and recorded daily. About 30 % of fishes in each treatment were sampled randomly by using scoop net every 2 weeks. Their length (by measuring board to the nearest 1mm) and weight (by Ohaus portable balance to the nearest 0.1gm) were recorded. At the end of the experiment, the fishes were harvested; all fish were weighted, measured and counted.

Growth performance parameters of the fish were calculated from the biweekly weight data as described by Olvera *et al.* (1990).

$$\text{survival rate (\%)} = \frac{N_2}{N_1} \times 100 ; \text{ Where } N_2 \text{ is number of fish harvested and } N_1 \text{ is number of fish stocked}$$

$$DGR \text{ (g / fish / day)} = \frac{\text{Final weight (g)} - \text{Initial weight (g)}}{\text{No of culture days}}$$

$$SGR \text{ (\% / day)} = \frac{\ln \text{ final weight (g)} - \ln \text{ initial weight (g)}}{\text{No of culture days}} \times 100$$

Assuming that all given feed was consumed, Feed Conversion Ratio (FCR) calculated from the amount of feed used to produce one kilogram of fish. Calculating the FCR shows whether the fish are overfed or underfed (Nandlal and Pickering, 2004).

$$FCR = \frac{\text{Feed taken (Kg)}}{\text{Weigh gain (Kg)}}$$

Also, the well being of fishes was studied by calculating the Fulton's Condition Factor (FCF). FCF (%) was calculated as:

$$FCF = \frac{TW}{TL^3} \times 100,$$

Where- FCF is Fulton's condition factor, TW: is weight in gram, TL: is total length in cm.

$$Net\ Yield = \frac{Biomass\ gain(Kg) \times 365}{cage\ area\ (size) \times time\ (days)}$$

Analysis of variance (ANOVA) was used to determine differences between treatments in mean final weight, daily growth rate, feed conversion ratio, survival rate of harvested fish and variation in water quality, zooplankton and phytoplankton abundance between the three sites. Duncan's multiple range test (Duncan, 1955) was applied to compare the significance of means of the various parameters among the tested treatments.

Differences were considered significant at $P \leq 0.05$. All data were analyzed using the SPSS 13 (1999) for Windows software program for statistical analysis.

6. Results

6.1 Physical parameters

The results of water quality parameters [Temperature, pH and dissolved oxygen (DO)] of the culture waters are presented in Table 3. The highest water temperature during the study period was 25.60 °C in March 2008. Mean water temperature decreases (17.60 °C) in December 2007. The water temperature was relatively high during February - March, medium in January and relatively very low in December in all sites (Fig. 13). Water temperature at different sampling periods was statistically different ($P < 0.05$). Despite the variation in measurement value, there was no significant difference in mean water temperature between the sites at each sampling periods ($P > 0.05$).

The maximum secchi depth was measured in October 2007 (2.8 m) then after it decreased considerably and reached to the minimum (1.54 m) in March 2008 (Figure 6). During all sampling periods secchi depth was not significantly different ($P > 0.05$) in all sites at each sampling periods.

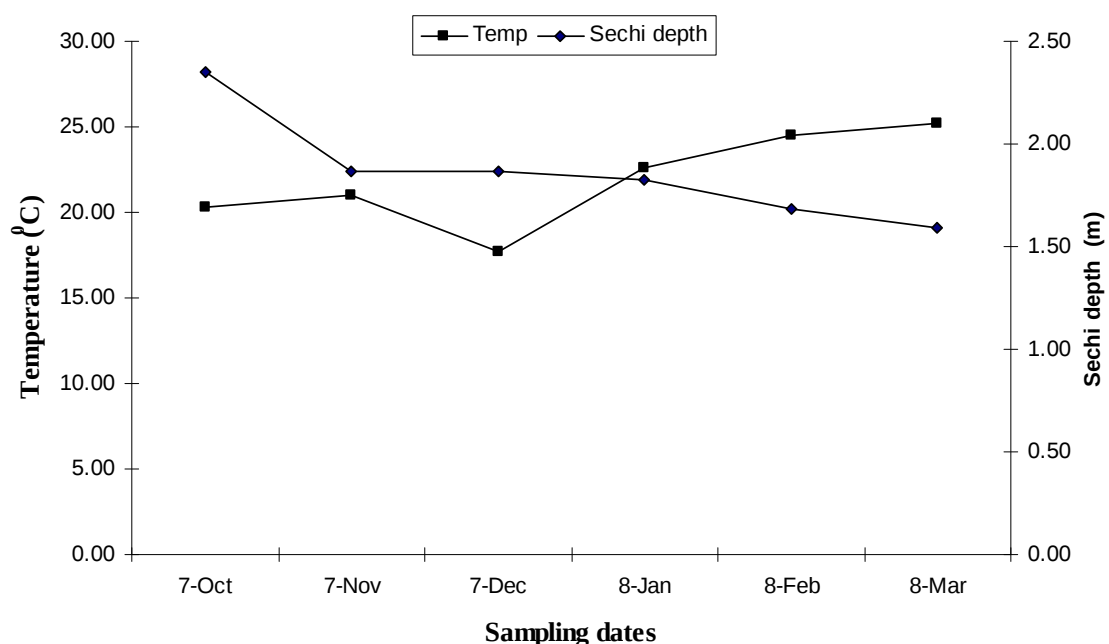


Figure 6 Surface water temperature and secchi depth of Lake Babogaya during the study period

The pH of the culture lake water in each site varied from 9.01 to 9.36, and there were no significant differences ($P > 0.05$) in the values. There were no significant differences ($P > 0.05$) in the DO levels, and the values varied from 7.7 to 11.9 mg/L during the study period.

Table 3 Water quality parameters in all stations during the experimental period in Lake Babogaya

Sampling Dates	Water Temperature	pH	Secchi depth (m)	Euphotic depth (m)	Dissolved oxygen (mg/l)	Stations
Oct-07	20.50	9.30	2.80	11.20	9.90	Site 1
	20.00	9.31	2.20	8.80	10.30	Site 2
	20.50	9.36	2.05	8.20	11.00	Site 3
Nov-07	20.2	9.22	2.35	9.40	7.70	Site 1
	20.4	9.14	1.70	6.80	9.70	Site 2
	20.3	9.20	1.55	6.20	11.90	Site 3
Dec-07	17.80	9.10	1.82	7.28	7.60	Site 1
	17.60	9.10	1.91	7.20	7.60	Site 2
	17.7	9.21	1.86	7.44	7.80	Site 3
Jan-08	22.30	9.12	1.82	7.28	8.30	Site 1
	22.40	9.20	1.80	7.20	8.90	Site 2
	22.30	9.20	1.86	7.44	9.00	Site 3
Feb-08	23.60	9.12	1.72	6.88	8.40	Site 1
	23.70	9.31	1.68	6.72	9.00	Site 2
	23.60	9.36	1.66	6.64	8.70	Site 3
Mar-08	25.6	9.01	1.68	6.72	9.55	Site 1
	25.50	9.30	1.54	6.16	10.45	Site 2
	25.40	9.21	1.56	6.24	11.9	Site 3

6.2 Planktons

6.2.1 Zooplankton

The taxonomic group of zooplankton identified during the study period is given in Table 4. In all sites, rotifers contribute the maximum No/m³ to the total abundance followed by copepods. The cladocerans contribute the least to the total abundance.

The zooplankton standing stock varied temporally (Fig. 7) and spatially (Fig. 8) over the study period. During all sampling periods, site 1 and 2 had the highest abundance than site 3 but the variation was not significant ($P > 0.05$). The total zooplankton number at the three stations was 52,560 m⁻³ (site 1), 50,247 m⁻³ (site 2) and 49,978 m⁻³ (site 3), respectively.

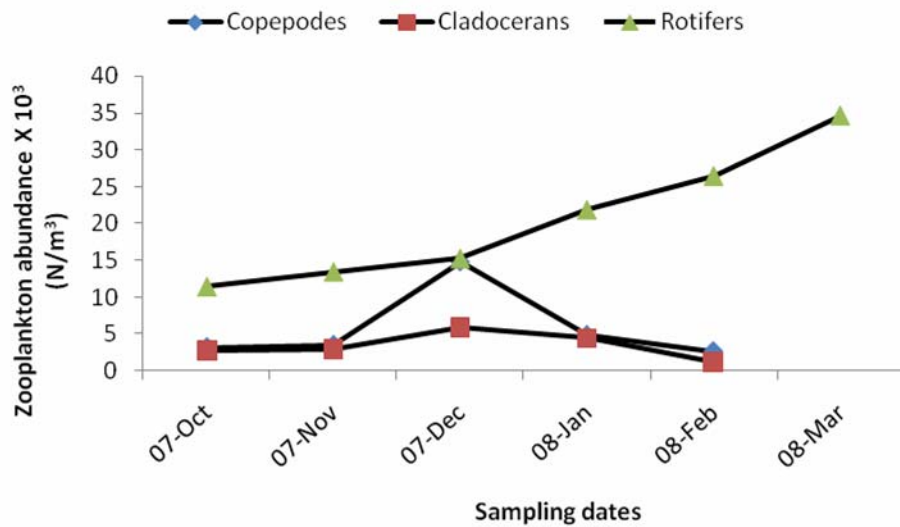


Figure 7 Temporal dynamics of zooplankton abundance in Lake Babogaya during the study period

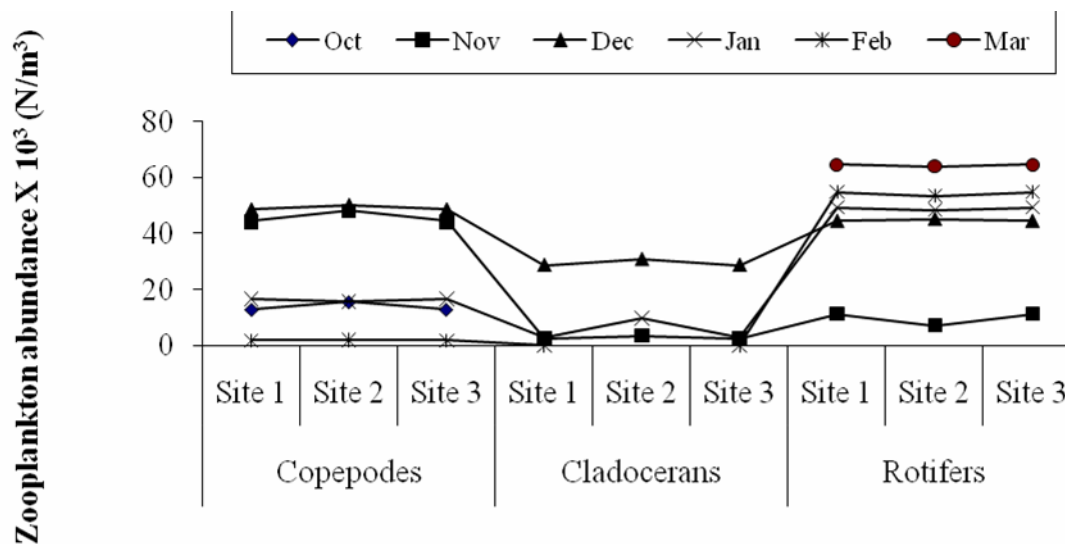


Figure 8 Spatial dynamics of zooplankton abundance in Lake Babogaya during the study period

Table 4 List of Zooplankton species identified during the study period in Lake Babogaya.

Copepods	Cladocerans	Rotifers
<i>Paradiaptomus africana</i>	<i>Diaphanosoma excisum</i>	<i>Asplanchnia spp</i>
<i>Afrocylops gibsoni</i>	<i>Moina micrura</i>	<i>Brachionus angularis</i>
<i>Mesocyclops aequatorialis</i>	<i>Ceriodaphnia Spp</i>	<i>B. calycifloris</i>
<i>Thermocyclops consimilis</i>		<i>B. urceolaris</i>
		<i>B. quadridentatus</i>
		<i>Cephallorella spp</i>
		<i>Keratella tropica</i>
		<i>K. quadrata</i>
		<i>K. cochelaries</i>

6.2.2 Phytoplankton

The list of species of phytoplankton recorded for Lake Babogaya is presented in Table 5. Four phytoplankton groups were identified over the study period. Diatoms, blue-green, dinoflagellates and green algae were the most dominant groups in terms of abundance.

The phytoplankton standing stock varied spatially (Figure 9) and temporally (Figure 10) over the study period. In all sampling period's Cyanophyceae (61%) were the most abundant followed by Dinoflagellates (20%) and Bacilarophyta (15%) and others including Chlorophyta constitute the remaining 4%. Blue green algae were the most dominant in almost all the months in all sites. There were no significant difference ($P > 0.05$) in abundance between sites.

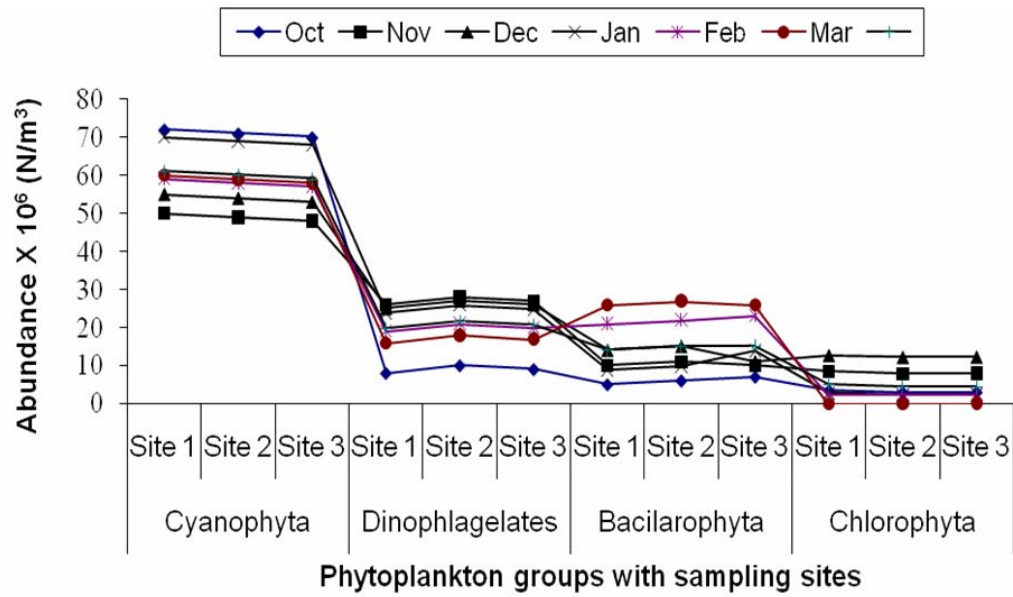


Figure 9 Spatial dynamics of phytoplankton abundance of Lake Babogaya during the study period

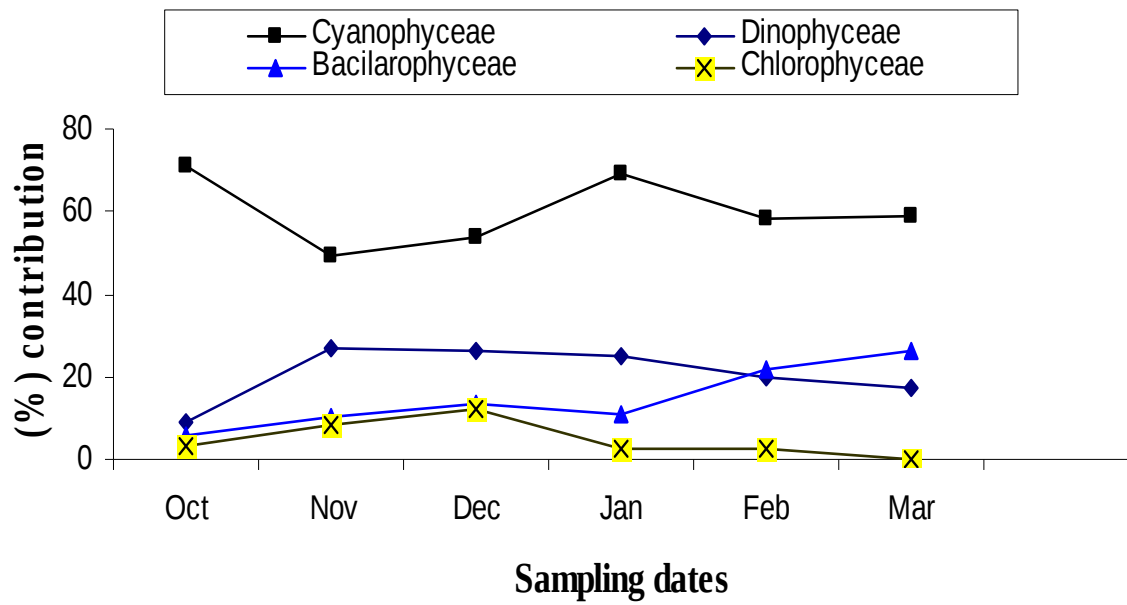


Figure 10 Temporal dynamics of phytoplankton abundance of Lake Babogaya during the study period

Table 5 List of Phytoplankton species identified during the study period in Lake Babogaya

Bacillariophyceae (Diatoms)	Chlorophyceae (Green algae)	Cyanophyceae (Blue-green algae)	Dinophyceae (Dinoflagellates)
<i>Cyclotella planctonica</i>	<i>Cosmarium depressum</i>	<i>Chroococcus limneticus</i>	<i>Peridinium aciculiferum</i>
<i>Cymbella cistula</i>	<i>Pediastrum duplex</i>	<i>C. turgidus</i>	<i>Peridinium spp.</i>
<i>Fragilaria capucina</i>	<i>Pediastrum spp.</i>	<i>Cylinrospermopsis sp</i>	
<i>F. ulna</i>	<i>Scenedesmus arcuatus</i>	<i>Microcystis aeruginosa</i>	
<i>Nitzschia nyassensis</i>	<i>Tetraedron minimum</i>	<i>Raphidiopsis spp.</i>	
<i>N. vermicularis</i>	<i>T. triangulare</i>		
<i>Surirella linearis</i>	<i>Tetrastrum hetercanthum</i>		
<i>Synedra dorsiventralis</i>			

6.3 Growth Performance

The growth and feeding performances of all replicates of each treatment were computed and since there were no significant variation between replicates of similar treatments ($P > 0.05$) pooled sample of replicates were used for all parameters.

The results of a one-way ANOVA showed that the feeding level significantly affected ($P < 0.05$) the general growth performance of the feeding and non feeding trials (Table 6). However, there were no significant difference between 3, 4, and 5 % feeding level per day ($P > 0.05$). The survival rates were generally high, from 93 % to 95.5 %, and independent of the feeding treatment ($P > 0.05$).

Maximum daily growth rate and specific growth rate were observed in T3 (1.16 ± 0.07) (1.22 ± 0.08) respectively (Table 6). This value is significantly different from T1, T2 and the non-feeding treatment ($P < 0.05$). However, there is no significant difference with T4 and T5 ($P > 0.05$).

Mean feed conversion ratio (FCR) increased with increased feeding level and was significantly different among treatments ($P < 0.05$) 1.76 for T1 and 6.33 for T5 (Table 6).

Table 6 Effects of feeding levels on the performance of Nile Tilapia in cage culture system in Lake Babogaya

Parameters	T1	T2	T3	T4	T5	C
Stocking density (No/m ³)	100	100	100	100	100	100
Sample size (n)	30	30	30	30	30	30
Initial weight (g)	29.70 ± 0.46 ^a	29.77 ± 0.45 ^a	30.43 ± 0.70 ^a	30.43 ± 0.70 ^a	30.43 ± 0.70 ^a	29.70 ± 0.43 ^a
Final weight (g)	118.30 ± 0.53 ^b	152.87 ± 0.49 ^c	224.63 ± 1.07 ^d	223.07 ± 1.13 ^d	223.40 ± 1.07 ^d	97.80 ± 0.55 ^a
Initial length (mm)	121.97 ± 0.80 ^a	120.00 ± 0.56 ^a	120.00 ± 0.56 ^a	120.00 ± 0.56 ^a	120.00 ± 0.56 ^a	122.97 ± 0.54 ^a
Final length (mm)	172.06 ± 0.59 ^b	179.43 ± 0.18 ^c	189.42 ± 0.33 ^d	189.17 ± 0.33 ^d	189.10 ± 0.33 ^d	165.10 ± 0.32 ^a
Daily growth rate (g/day)	0.52 ± 0.05 ^b	0.73 ± 0.05 ^c	1.16 ± 0.07 ^d	1.15 ± 0.06 ^d	1.15 ± 0.08 ^d	0.39 ± 0.04 ^a
Specific Growth Rate (%/day)	0.81 ± 0.08 ^b	0.99 ± 0.07 ^c	1.22 ± 0.08 ^d	1.20 ± 0.07 ^d	1.21 ± 0.06 ^d	0.67 ± 0.08 ^a
Survival rate (%)	93	95.5	94	94	93.5	93
FCF	2.32	2.65	3.31	3.30	3.30	2.17
FCR	1.76	2.80	3.62	4.80	6.33	-----
Initial fish biomass (Kg/cage)	2.97	2.98	3.0	3.0	3.0	2.97
Final fish biomass (Kg/cage)	11.00	14.67	21.12	20.97	20.99	9.10
Fish biomass gain (Kg/cage)	8.24	11.76	18.26	18.11	18.14	6.33
Net yield/individual fish (g/fish/cage)	88.6	123.10	194.20	192.64	192.97	68.10

*Similar superscripts along the same row are not significantly different (p>0.05)

6.3.1 Survival rate

Survival rate were 93 % for T1, 95.5 % for T2, 94 % for T3 and T4, 93.5 % for T5, and 93% for C during all the culturing period (Table 7). At the beginning of the culturing period exactly all fingerlings were survived and no mortality observed. However due to high water temperature drops in December causes the death of 74 fishes. Survival rate was not significantly affected by feeding level ($P > 0.05$).

Table 7 Number of deaths and survival rate in different treatments.

Treatment	Total death	Survival rate (%)
T1	14	93
T2	9	95.5
T3	12	94
T4	12	94
T5	13	93.5
C	14	93
Total	74	

6.3.2 Mean weight

The effects of growth performance for replicates of each treatment were computed and are given in Table 6. The minimum initial mean weight (mean $\pm$ standard error) were (29.70 ± 0.43 gm) in C and the maximum initial were (30.43 ± 0.70 gm) in T3, T4, and T5. The minimum initial mean length was (120.00 ± 0.55 mm) in T2, T3, T4 and T5 while the maximum were (122.97 ± 0.54 mm) for C. Although there was a slight difference in mean initial weight and length there were no significant difference among treatments ($P > 0.05$).

After 24 weeks of culturing periods, the maximum mean final length was 189.42 ± 0.33 mm for T3, 189.17 ± 0.33 mm for T4 and 189.10 ± 0.33 mm for T5 and the minimum mean final length (mean $\pm$ standard error) was 165.10 ± 0.32 mm for C (Table 6).

The highest weight (224.63 ± 1.07 gm) of fish was attained in T3 followed by (223.40 ± 1.07 gm) in T5 and (223.07 ± 1.13 gm) in T4 (Fig.11) and the lowest growth performance (118.30 ± 0.53 gm and 97.80 ± 0.55 gm) of fish were obtained at T1 and C respectively. These growth performance tested at 95 % confidence intervals and their growth were significantly affected by feed level between T1, T2, T3 and C. However, there were no significant difference between T3, T4, and T5 ($P > 0.05$).

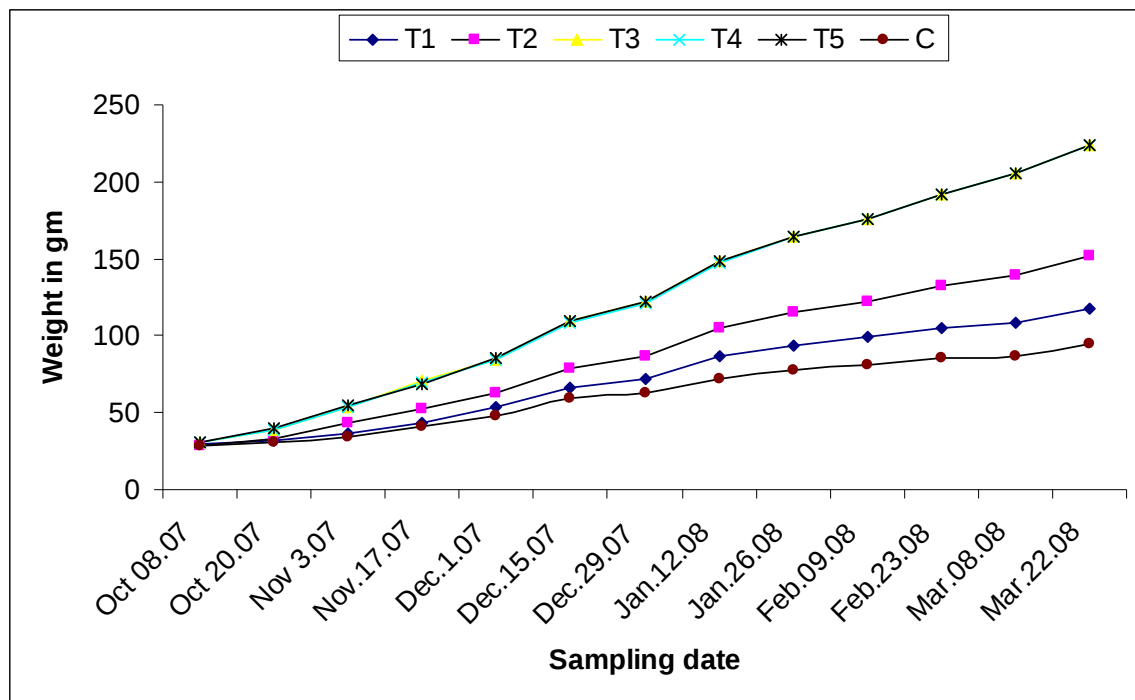


Figure 11 Growth in weight of the all treatments from October 2007 - March 2008.

6.3.3 Daily growth rate

The mean daily growth rate increases with increasing feed ration. The maximum mean value was 1.16 ± 0.07 gm/day in T3 (Table 6, Fig. 12) and the lowest mean daily growth rate were seen in T1 (0.52 ± 0.05 gm/day) and the non feeding treatment C (0.39 ± 0.04 gm/day).

DGR in all sampling periods was affected by feed ration (Fig. 13) and the mean daily growth of fish fed at 3, 4 and 5% body weight per day were similar ($P > 0.05$) but differed significantly ($P < 0.05$) from the daily growth rate of the group of fishes fed at 1% (0.52 ± 0.05) and 2% (0.73 ± 0.05) body weight per day.

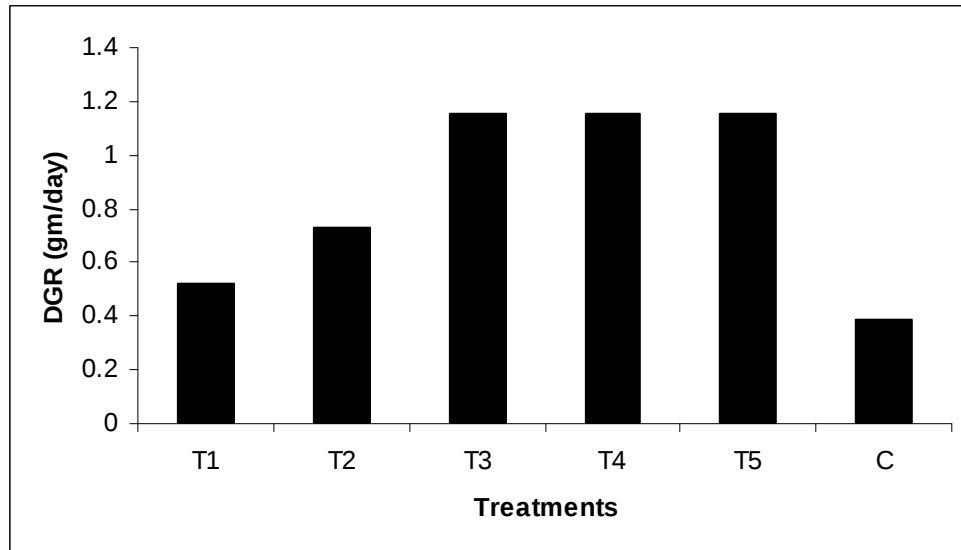


Figure 12 Average daily growth rate (DGR) with treatments

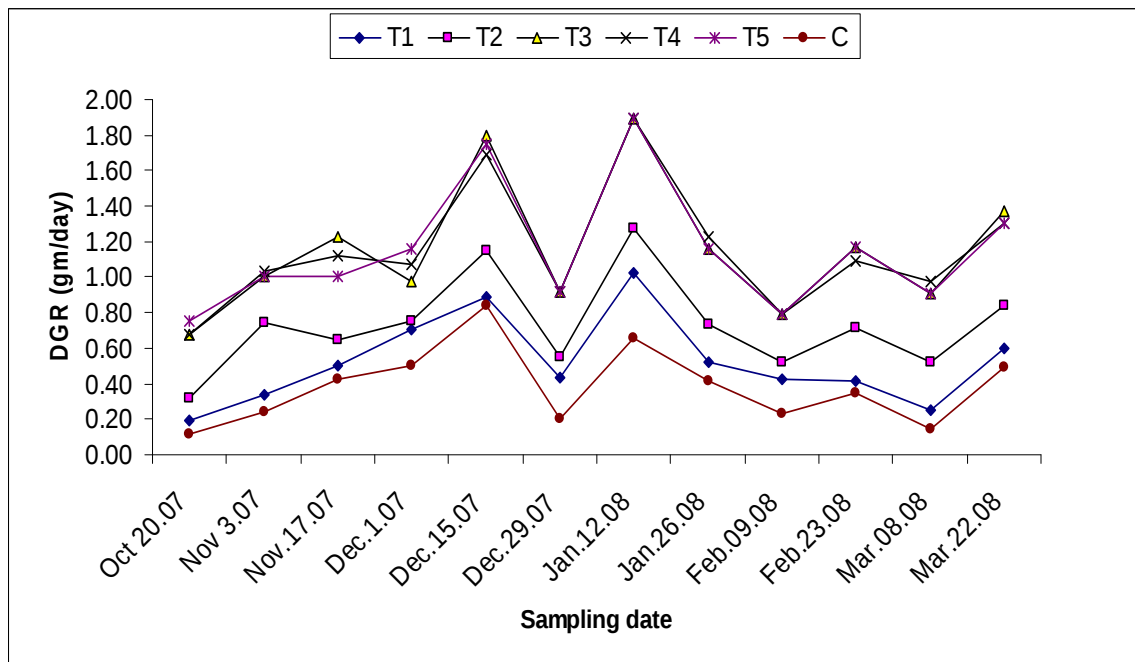


Figure 13 Variation in daily growth rate for each treatment from Oct 2007- March 2008

6.3.4 Specific growth rate

Comparisons of mean specific growth rate also were made between treatments (Table 6, Fig.14). From the feeding treatments T3 (1.22 ± 0.08 %/ind./day), T4 (1.20 ± 0.07 %/ind./day), and T5 (1.21 ± 0.06 %/ind./day) attain the maximum and T1 (0.81 ± 0.08 %/ind./day) the minimum mean average SGR. Where as, the smallest average SGR of all 0.67 ± 0.08 %/ind./day was attend by the control.

Feed amount affects specific growth rate of fishes significantly. However, there was no significant difference in specific growth rate between T3, T4 and T5, ($P > 0.05$) but they were significantly different with T1 and T2 ($P < 0.05$) and SGR increases as feed amount increases at the first five culturing weeks and decline at the end of the culturing periods (Fig. 15).

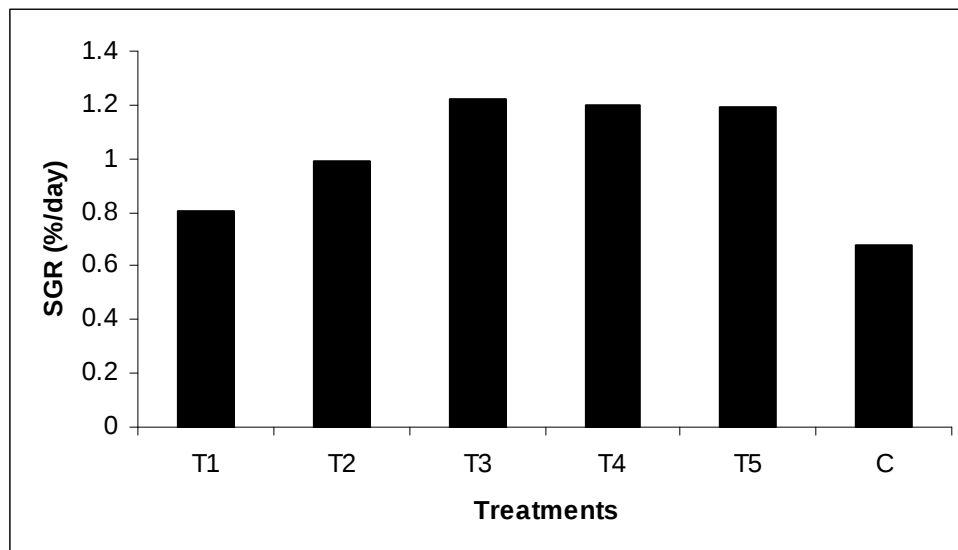


Figure 14 Average specific growth rate (SGR) for each treatment in relation to controls

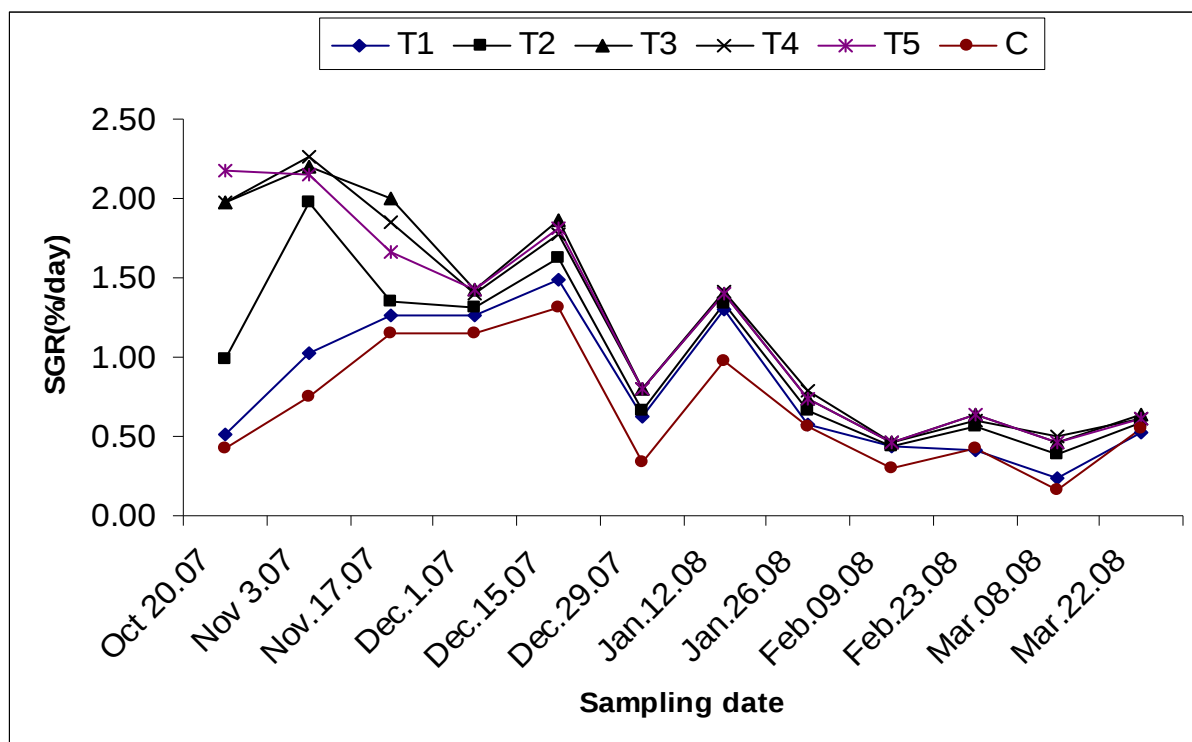


Figure 15 Specific growth rate for each treatment in all sampling periods

6.3.5 Feed conversion ratio (FCR)

Different proportion of feed (1%, 2%, 3%, 4% and 5% of body weight) was fed per day for fish throughout the culture period. As shown in Table 8, with increased culture periods, the amount of feed given per fish per day increase. The maximum and minimum overall feed conversion ratios (FCR) were (6.33) in T5 and (1.76) in T1 for 26 weeks of culture (Table 6).

FCR increases as the culture period extends and is significantly different among culture periods ($P < 0.05$) and increases with increasing feed level (Table 8).

Table 8 Mean weight, feeding rate and feed conversion Ratio (FCR) of fish for each culture periods.

Treatments	Parameter	8-Oct	20-Oct	3-Nov	17-Nov	1-Dec	15-Dec	29-Dec	12-Jan	26-Jan	9-Feb	23-Feb	8-Mar	22-Mar
T1	Mean weight (gm)	29.70	32.14	36.57	43.57	53.40	65.80	71.87	86.27	93.53	99.43	105.30	108.87	118.30
	feed/fish/day	-	0.30	0.32	0.37	0.44	0.53	0.66	0.72	0.86	0.94	0.99	1.05	1.14
	FCR	-	1.81	1.10	0.78	0.66	0.65	1.69	0.78	1.86	2.48	2.65	4.61	2.13
T2	Mean weight (gm)	29.77	33.17	43.47	52.68	63.07	79.17	86.87	104.77	115.00	122.37	132.33	139.67	152.87
	Feed/fish/day	-	0.60	0.66	0.87	1.05	1.26	1.58	1.74	2.10	2.30	2.45	2.65	2.87
	FCR	-	2.03	0.96	1.45	1.50	1.18	3.28	1.55	3.27	4.98	3.92	5.76	3.88
T3	Mean weight (gm)	30.43	39.27	53.37	70.50	84.13	109.27	122.17	148.70	164.87	175.90	192.23	204.93	224.63
	Feed/fish/day	-	0.91	1.18	1.60	2.12	2.52	3.32	3.67	4.46	4.95	5.28	5.79	6.33
	FCR	-	1.55	1.25	1.40	2.33	1.51	4.10	2.20	4.40	7.15	5.16	7.27	5.25
T4	Mean weight (gm)	30.43	39.25	53.88	69.50	84.77	108.47	121.38	147.92	164.69	175.45	191.88	204.21	223.07
	Feed/fish/day	-	1.22	1.58	2.13	2.78	3.37	4.33	4.85	5.91	6.59	7.04	7.67	8.34
	FCR	-	2.07	1.68	1.98	2.85	2.09	5.39	2.93	5.52	9.59	7.36	8.99	7.33
T5	Mean weight (gm)	30.43	40.27	54.37	68.56	85.18	109.33	122.56	148.44	164.38	175.90	192.72	204.93	223.40
	Feed/fish/day	-	1.52	2.01	2.72	3.43	4.26	5.46	6.11	7.44	8.24	8.80	9.64	10.56
	FCR	-	2.32	2.14	2.89	3.09	2.65	6.72	7.52	7.30	11.86	8.55	12.05	9.17

Table 9 Initial, final weight, weight gain and yields of fishes in all treatments

Treatment	Stocking Density (fish/cage)	Final total harvest number	Mean length of initial stocking density (mm)	Mean weight of initial stock (gm)	Mean length of final harvest (mm)	Mean weight of final harvest (gm)	Total weight gain (Kg/cage)	Total net yield (Kg year ⁻¹)
T1	100	93	121.97 ± 0.80	29.70 ± 0.46	172.06 ± 0.32	118.30 ± 0.55	8.24	18.10
T2	100	96	120.00 ± 0.56	29.77 ± 0.45	179.43 ± 0.18	152.87 ± 0.49	11.76	25.84
T3	100	94	120.00 ± 0.56	30.43 ± 0.70	189.42 ± 0.33	224.63 ± 1.07	18.26	40.13
T4	100	94	120.00 ± 0.56	30.43 ± 0.70	189.17 ± 0.33	223.07 ± 1.13	18.11	39.82
T5	100	93	120.00 ± 0.56	30.43 ± 0.70	189.10 ± 0.33	223.40 ± 1.07	18.04	39.66
C	100	93	122.97 ± 0.54	29.70 ± 0.43	165.10 ± 0.32	97.8 ± 0.55	6.33	13.91

6.3.6 Fulton condition factor (FCF)

The maximum FCF was 3.31 in T3 and 2.17 was the minimum in T1. FCF increased at the end of culturing periods with varying degree for all treatments. FCF was not statistically different in T3, T4 and T5 ($P > 0.05$). However, T1 and T2 had significantly lower mean FCF than T3, T4 and T5 ($P < 0.05$) (Table 6). In all sampling periods FCF increased as the feeding level increased (Fig. 16). The 1% (2.32) and 2% (2.65) feeding level had the least mean FCF while T3 (3.31), T4 (3.30) and T5 (3.30) had high mean of FCF. FCF of C was (2.17) the least of all treatments.

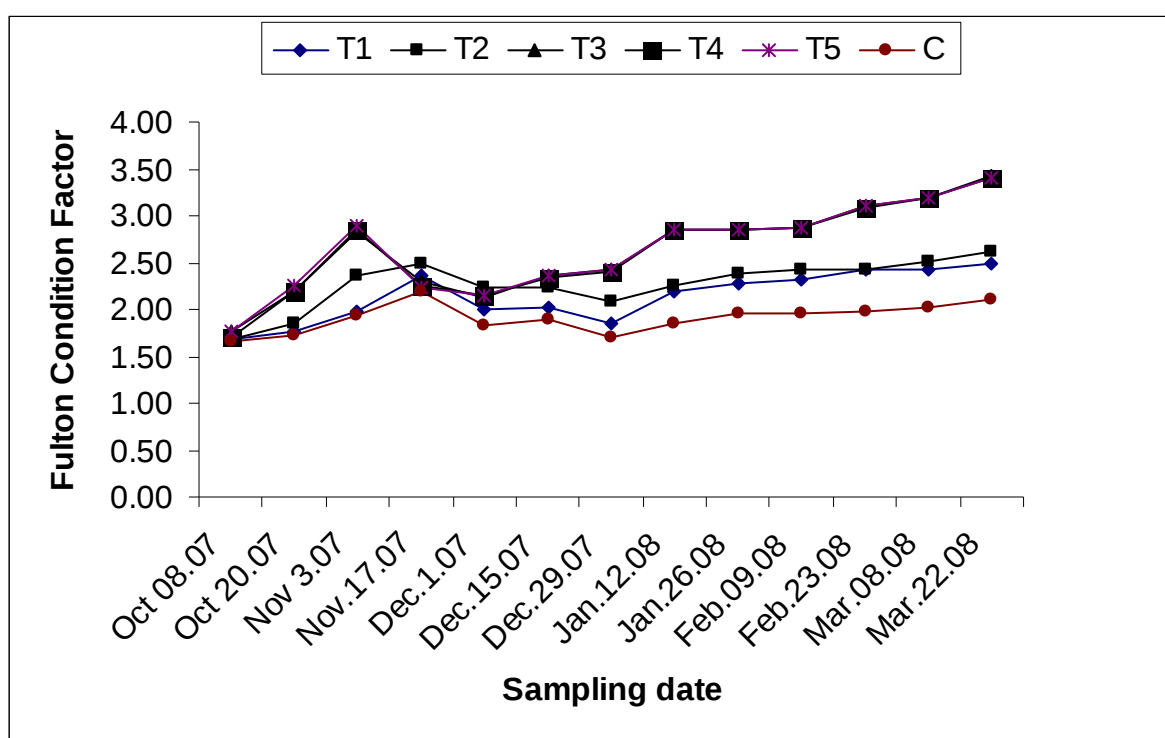


Figure 16 Fulton's Condition Factors for each treatment in all sampling periods

6.3.7 Yield

The total weight gained (yield) for each treatment is given in Table 9. The total weight gain were (8.24 kg/cage) in T1, (11.76 kg/cage) in T2, (18.26 kg/cage) in T3, (18.11 kg/cage) in T4, (18.04 kg/cage) in T5, and (6.33 kg/cage) in C. The weight increase were significantly different ($P < 0.05$) between the feeding and non-feeding treatments and among 1, 2 and 3% of feeding level. However, there were no significant difference between 3, 4, and 5% feeding level treatments ($P > 0.05$).

In addition, throughout the study period non-caged fish surround the cage especially during feeding time and under sized fish had been harvested at the end of the study period.

7. Discussion

Ranges of water quality parameters in lakes for the complete study period were as follows: temperature, 17.7–25.17 °C; DO, 7.7–11.9 mg L⁻¹; pH, 9.01–9.36 and Secchi-disk reading, 280–158 cm. the reason for high transparencies during October resulted from an increased lake volume with a consequent reduction in the concentration of suspended materials. All values were within the permissible limits, as recommended for tilapia culture (Boyd, 1982). Generally, there were no significant difference in physical parameters among cages or between cages and the open water. This indicates that all fishes had similar culture environments and equal access to natural feed. The following temperature ranges reported by Yeshimebet Major (2006) and Belsti Fetene (2008) 20.5 – 28.4 °C, 17.7–25.17 °C for Lake Babogaya respectively.

The zooplankton and phytoplankton species were reported by other authors in Lake Babogaya (Yeshimebet Major, 2006; Dinbere Belay, 2007). Rotifers were much abundant than other zooplanktons in this study.

Zooplanktons of Lake Babogaya were much abundant at cage area and shore (sites 1 and 2) than center (site 3). The insignificant variation in zooplankton abundance between site 1 (cage site), site 2 and 3 (control site) shows the less incidence of adverse effect of the experiment. Similar result reported in the study of cage culture system in Lake Elen by Abebe Tadesse (2007); Lake Kuriftu by Ashgrie Gibtan *et al.*, (2008) and Lake Babogaya by Belstie Fetene (2008).

This is further evidenced by the feeding behavior of Nile tilapia. Nile tilapia ingestion ratio of zooplankton decreased with increasing fish total length (Moriarty and Moriarity, 1973). These all evidenced that Nile tilapia cage culture do not have an adverse effect on the lake zooplankton abundance. But the effect of supplementary feed on zooplankton should be examined.

In this study the peak phytoplankton abundance was observed in January. Additionally, site 3 had the highest abundance than sites 1 and 2.

Even if the size of caged fish was within the range that they use phytoplankton the insignificant variation in abundance between sites 1, 2 and site 3 showed the absence of an adverse effect of the experiment on the lake phytoplankton abundance. However, it needs further investigation to see whether the supplementary feed alter nutrient concentration of the lake which favors eutrophication or not.

There was no significant difference ($P > 0.05$) in percentage survival of the fish in the treatments, indicating that the slight mortality recorded was probably not caused by dietary level, but may rather result from the natural weather condition. Particularly the relative low temperature recorded during December, 17.6°C caused the death of cultured fish as well as the natural stock in the lake.

Fishes exhibit behavioral changes during temperature changes in the Lake. First only large and medium fishes of the natural stock around (250-310 mm) size come out to the surface and exhibited a sudden loss of equilibrium as a result it was easy to capture them by hand. According to the information from the local people, such phenomenon occurs in every two year during November-December. This mass Fishkill coincided with an offensive odor of the lake water. This probably resulted from mixing of the water column after prolonged period of thermal stratification and associated deoxygenating of the water column. According to Baxter (2002), Lake Babogaya stratified during most of the time of the year with occasional occurrence of multiple thermocline. Although the weather conditions throughout the country may vary from year to year and hence the thermal stratification patterns of Ethiopian lakes, the near complete destratification of the water column in Lake Babogaya was observed during the coldest and driest period extending from November to February, as a result of the physical condition that resulted from a combination of low minimum temperature and high rate of evaporative cooling and that favors downward mixing of epilimnion. During a brief period of this isothermal condition, oxygen was absent almost throughout the water column (Baxter, 2002). Similar catastrophe also reported by Belstie Fetene (2008) and Yeshimebet Major (2006) for Lake Babogaya.

Yashouv (1960) reported that a sudden drop in temperature in culture ponds caused small Nile tilapia (5 cm) to lose equilibrium and roll over before larger fish (17 cm). Thus deaths of cultured fish here are not related with feed amount.

The growth responses of fish in all treatments were generally satisfactory, and the fish were all healthy and reached average sizes at the end of the experiment except the non-feeding trial (Table 6). Although stocked fish had similar weights, at the end of the experiment, their size diverged and overall growth (g day^{-1}), weight gains (g fish^{-1}) and final weights (g fish^{-1}) varied with feeding levels (Table 6). Therefore, the tested feeding levels affected fish performance and production.

The growth parameters were extremely poor at lower feeding level, and significantly improved ($P < 0.05$) with increasing feeding levels (Fig. 11). Further increasing feeding levels did not result in any significant improvement in fish growth rates. There were significant difference between 1, 2 and 3% feeding levels, however, no significant differences between 3%, 4%, and 5% feeding level in growth parameters. This result would seem to confirm the view that fish fed at higher than the optimum feeding rate do not necessarily benefit from excess feed. Therefore, feeding to 3% BW^{-1} appears to be the most appropriate and is recommended to maximize growth performance and production at limited feed amounts in this experiment.

Santiago *et al.*, (1987), found that the growth of Nile tilapia fry increased with increasing feeding levels up to 65%. However no significant differences were found in growth rate between the 30% and 65% feeding levels. They recommended 30-45% body weight feeding per day as optimal for Nile tilapia fry. This finding supports the results of the present study which showed insignificant differences in the mean weight gain (%) of Nile tilapia fed 3, 4 and 5% of their body weights.

In the same way, Rowland *et al.*, (2008) showed that small fingerlings fed 7.5% grew significantly faster ($0.32\text{-}0.33 \text{ g/day}$) than those fed 5% ($0.26\text{-}0.27$). In addition, Nwanna (2002) found parallel results in tank culture that indicate similar ($P > 0.05$) weight gain and specific growth rate in fishes fed at 3, 4, and 5% body weights but differed significantly ($P < 0.05$) from the weight gain and SGR of group of fishes fed at 2% body weight.

Therefore, the present study showed the best feed amount of feeding is at 3% rate for *O. niloticus* daily for optimum growth of fishes in cage culture. Feeding the fishes at 3% instead of at 4 or 5% could save a lot of costs. In intensive commercial fish farming, where fish feed alone constitutes over 60% of the operating costs, this saved costs could be transformed into rewarding returns to investment (Nwanna, 2003).

In addition, feeding level is a major tool for fish culture effluent reduction and management. Feeding regimes play a key role with feed type in determining the quality and potential environmental impacts.

Nwanna (2003) observed that feeding *O. niloticus* at 3, 4, and 5% of their body weight. This feed amounts did not affect their body weight gain and SGR but feeding at 4 and 5% of their body weight resulted in slight and continuous decreases in the pH and DO concentration of the cultured water from accumulation of uneaten feed, leached feed and fecal matters leading to increased biological oxygen demands and a tendency for water quality deterioration.

This determined feeding level is essential for aquaculture practice in the country to minimize water quality deterioration, ecological imbalances, feed wastes and costs. However, this require further detailed study in water chemistry

In this study, mean daily growth rate was found high in higher feeding levels than lower feeding trials. Comparing the feeding trials with the non-feeding in their growth rate, addition of supplementary feed resulted in higher growth rate and yield. The good growth of fishes in non-feeding cages indicates that natural feeds were abundant and important to growth in this experiment.

SGR were significantly affected by feeding levels ($P < 0.05$). Fish specific growth rate were extremely poor at 1% level of feeding and significantly improved ($P < 0.05$) with increasing feeding levels up to 3%.

Specific growth rates of the present study were ($1.22 \pm 0.08 \text{ \% day}^{-1}$) higher to those previously obtained by El-Saidy and Gaber (2002), $0.53\text{--}0.66 \text{ \% day}^{-1}$. Among the five different feeding levels, 3% BW day^{-1} appeared optimum, since it supported a maximum SGR of $1.22 \text{ \% day}^{-1}$ and FCR close to 3.62 (Table 6). At lower feeding levels T1 and T2, FCR was 1.76 and 2.80 respectively and the growth rate (0.52 ± 0.05 and 0.73 ± 0.05 respectively) was significantly lower (Table 6).

On the other hand, increasing of the feeding level to 4 or 5% shows no significant difference in growth rate, but significantly increases in FCR (4.80 and 6.33 respectively). So this demonstrates that feeding levels highly influences specific growth rate.

A reduction in feeding level to 1% BW day⁻¹ resulted in a decreased growth rate. Similar results were reported by Essa and El-Ebiary (1995) and Fontaine *et al.*, (1997). In addition, at the highest feeding levels of 4 and 5% there was a decline in weight gain as compared with the 3% feeding level (Table 6). Therefore, this confirms that 3% feeding level is optimum feed amount for Nile tilapia growth in cage culture in Lake Babogaya.

In the present study, with increasing feeding levels, the values of FCR significantly ($P < 0.05$) increased (Table 6 and 8). The differences in values of feed conversion among the test group reflected the mount of feed consumed not quality of feed because the feed used was the same.

Halver (1989) stated that feed conversion decreases as the amount of feed fed decreases and increases with an increase in the amount of feed fed. The increase FCR in the group fed at 5% of their BW day⁻¹ suggests that ample feed at T5 possibly represents overfeeding, and the decrease in FCR in groups fed at 1% or 2 % of their BW day⁻¹ possibly represents underfed fish (Table 8). However, fish fed at 3, 4, and 5% biomass per day (T3, T4. and T5) showed significant $p < 0.05$ values of FCR (Table 5). These results may be attributed to the comparable feed amounts consumed in these treatments.

Similar result also obtained by Qin and Fast (1996) for juvenile snakehead for which FCRs ranged from 0.99 to 6.3 over feeding rates of 0–30% BW day⁻¹. Here also FCR increases with increasing feeding level.

The excess feed at high feeding level has lead to high FCRs. This result is in agreement with the result observed in the study of feeding strategy for silver perch by Rowland *et al.*, (2008). To decrease this feed waste and maximize performance of fishes continuous or nighttime feeding has been suggested for some species, but not for others (Hossain, Haylor and Beveridge, 2001; Hung *et al.*, 2001).

At higher feeding level, significant amount of feed might be flushed from the cage in to the lake, leading to poor feed utilization efficiency (Mancintosh and De Silva, 1984; El-Sayed, 2002). The impact of this wasted feed was observed during the study period is that attracts non caged fishes around the cage and small fish enter to the cage and compete with caged fish for feed. Abebe Tadesse (2007); Ashagrie Gibtan *et al.*, (2008) and Belstie Fetene (2008) reported the effects of wasted feed and non-caged fish impacts in cage culture system on

cultured fish as well as the lake water. Therefore, the impact of this wasted feed as well as the non-caged fish requires further investigation.

In the present study FCF was significantly affected between different feeding levels. Better fish conditions was recorded in feeding treatment than non-feeding and in high feeding level trials the mean value were higher than low feeding level trials. This justifies the positive effects of supplementary feeding in fish culture.

The condition of fish in addition to the feed supply, it can be affected by factors such as environmental conditions, feed quality, feeding rate, degree of parasitization and reproductive activity (Eyualet Abebe and Getachew Tefera, 1992). Better fish condition recorded in 3, 4 and 5% feeding level (Table 6) justifies the positive effects of feeding rate on conditions of caged fish. In addition, reproductive activity is less in caged fishes and therefore, this contributes for the high value of caged fish conditions.

Moreover, the conditions of these fishes at harvest were significantly higher than the non-feeding C, as well as 1 and 2 % feeding treatments.

The condition of cultured fish in this study was much better than the condition of similar fish species in Lake Awasa and Ziway. The condition of Nile tilapia population in Lake Awasa were 2.12 (Demeke Admassu, 1990) and in Lake Ziway were 1.89 (Eyualet Abebe and Getachew Tefera, 1992) which were lower than computed in this study (2.32-3.31). Abebe Tadese (2007) reported similar high fish condition value (2.34-3.6) from cage culture in Lake Elen.

This is because the caged fish do not spend energy in activities like reproduction, searching feed and swimming. In addition, the variation between the lakes productivity might be another factor for, but it needs further study.

Feeding level is one of the most important factors affecting fish performance (Brett, 1979). In the present study total yield of fish in the non-feeding treatment (the control) was least and represented 6.33 kg/cage. Although this value is the least, it indicates the significant contribution of biota in the lake to the nutrition of this stock. Similar result also reported by Belste Feten (2008) for non-feeding treatments (6.53 kg/cage) in cage culture system.

Yields of fish in different feeding treatments ranged from 18.25 kg/year to 39.54 kg (Table 6). Supplemental feed cause increased in yields by 8.24 kg/cage in T1, 11.76 kg/cage in T2, 18.26 kg/cage in T3, 18.11 kg/cage in T4 and 18.09 kg/cage in T5 (Table 4). These results suggest the efficacy of supplemental feed and feeding levels for promoting better growth and production. Belste Fetene (2008) found net yield 16.13 kg/cage for 3% feeding levels. This value is lower than the result of this study 18.26 kg/cage for the same feeding level.

8. Conclusion and Recommendations

This study is the first of its kind to be conducted on Effects of feed quantity on growth performance and water quality in cage culture system for production of Nile tilapia in Lake Babogaya, Ethiopia. Therefore, further detailed studies are required on other aspects like feeding time, feed frequency and on other species like carp, cat fish etc. However, some conclusions and recommendations can be made based on the findings of the present study.

The best feed amount with considerable low FCR, good growth, condition and yield performance and potential for growing to greater size was 3% feeding rate.

The best yield per individual is obtained in 3, 4 and 5% feed per body weight. However, statistically T3 (3%BW⁻¹) was the optimal feed ration in this experiment. Therefore, it is possible to rear successfully Nile tilapia on local made artificial diets (mixture of Mill sweeping, chicken droppings and oil seed cake) in cage culture system in Lake Babogaya but the quality of local feed has to be analyzed to determine the type and amount of nutrients.

In this study feed ration does not have an adverse effect on the survival of fish. But, further investigation is needed on the size of stocked fish, fingerlings cohort and duration of stocking. In addition, the development of hatchery should be taken in to consideration for the provision of healthy fingerlings to the development of aquaculture in the country.

The supplementary feed had a positive effect on the growth performance, yield, and condition of fish. So, the use of supplementary feed has substantial contribution to the growth of fish. However, the frequency of feeding, cost and nutrient amount with high protein feed to come up with the best feed on the production of fish in cage, and composition of feed for best growth performance needs further investigation.

Even if we did not get any adverse effect on the lake plankton abundance by the experiment detail research in intensive cage culture aspect should be conducted. In addition, effect of cage culture on the lake nutrient loading, macrophyte, littoral and benthic community of the lake needs profound investigation.

Other aquaculture systems like pen, pond and tank culture should also be tested to expand the fish production technology in Ethiopia and other fish species should be tested to study their performance.

9. References

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