The 7th Balkan Conference on Operational Research
"BACOR 05"
Constanta, May 2005, Romania

THE POTENTIAL OF PHYTOPLANKTON-BASED CULTURE OF TILAPIA (Oreochromis Niloticus) IN FLOATING CAGES IN SEYHAN DAM LAKE

SUAT DİKEL
GÜL A. KİRİŞ
M.VEDAT ALEV

Faculty of Fisheries University of Çukurova, Balcalı/ Adana, Türkiye

Abstract
This study was conducted for 90 days to investigate the growth rate and weight gain of overwintered Nile tilapia (Oreochromis niloticus) cultured in completely extensive conditions in floating cages placed in Seyhan Dam Lake, Adana (Lat 36° 59' N – Long 35° 19' E). Individuals with a mean weight of 61.92±11.80 g were stocked at 20 fish m^{-3} in cages. According to the final results, tilapia showed a weight gain of 50.09±0.52 g., (from 61.92±11.80 g to 112.01±0.77 g.) reaching to 17.07±0.41 cm average length (mean ± standard deviation; n=40) by the third month. At the end of the culture period the daily weight gain (0.556±0.005 g per fish day^{-1}) and the specific growth rate (0.654±0.27%) were calculated.

***Keywords**: Extensive fish culture, Floating Cage, Tilapia, Phytoplankton-based Culture.*

1. INTRODUCTION

Fish production through aquaculture is realized in a wide variety of culture systems, from extensive seasonal ponds to intensive concrete raceways or floating cages [1]. Production in extensive pond systems is based on the natural productivity of the pond and solar energy. In semi-intensive systems, organic and chemical fertilizers and supplemental feeds are added whereas intensive systems are based predominantly on high-quality complete feeds. Only 5–15% of the nitrogen added to the ponds as fertilizer is harvested as fish biomass [2], [3]. In feed-driven systems, only 20–30% of the nitrogen in the feed is retained in the fish biomass [4], [5], [6]. The nutrients that are not harvested as fish biomass either accumulate in the pond sediment, volatilize, or are discharged into the environment. From economic and environmental points of view, there is a need to examine options to make aquaculture systems more nutrients efficient. Generally, three food pathways can be distinguished in aquaculture systems: (1) direct feeding by the fish on feeds; (2) the autotrophic pathway, in which solar energy is used by primary producers (mainly algae) to convert carbon dioxide into organic matter that can be utilized by fish; and (3) the heterotrophic pathway, in which heterotrophic organisms (bacteria, protozoa, and other invertebrates) decompose organic matter that can be utilized by the fish [7]. These three pathways are linked through fluxes of organic and inorganic nutrients. In waste fed systems, the heterotrophic pathway can be more important than the autotrophic pathway, but stable isotope studies show that a large part of the microbial production in ponds is based on algal detritus ([7], [8],[1].

Extensive culture is defined as management highly dependant on the natural food web and physical conditions of the natural environment. This system is carried out in earthen ponds or in floating cages located in natural water compounds. Phytophagous tilapias are the preferred species for the extensive cage culture. Extensive culture of tilapias in cages is the most the carried out in eutrophic tropical lake and rivers. In such cases, fish feed only on suspended organisms which flow through the cages [9]. The maximum carrying capacity of a cage is determined by temperature, primary production of water environment [10], and most of all by the dissolved oxygen (DO) level throughout the cage [11]. This in it's turn depends heavily on the mesh size of the cage netting. The larger the mesh the higher the water exchange rate in the cage. In cage aquaculture, fouling is traditionally considered to be a problem resulting in decreased water flow and oxygen supply [12]. Fouling by periphyton and filamentous algae is found to at varying degrees on the nets of cages used in open-water culture, depending on the material and mesh size of the net. Most tilapias are able to use phytoplankton ([13], [14], and fish-grazing activity can keep fouling at low levels. This property of tilapias has been considered as a positive side-effect in terms of increased water flow [15].

Periphyton is composed of attached plant and animal organisms embedded in a mucopolysaccharide matrix [1]. Periphyton-based aquaculture was in recent years perceived to have real potential in extensive culture system [16], [17].

With the recent financial problems in many countries and the devaluation of local currencies, fish feed costs have risen to new highs. In general, aqua feed constitutes 50-70% of the total production cost in aquatic farming [18]. This percentage is highly effective on the benefit of the operations. Some alternative culture systems may be applied for less expensive culture operation e.g. semi intensive ponds with fertilization and supplemental feed, cage culture and extensive culture when the production cost is to consider. In particular cage culture of tilapia due to many advantages is highly preferred in South Asia. Many small-scale farmers have been encouraged to build and utilize cages to increase their household income and nutrition. After the construction of cages, cost of feed becomes the major input cost for fish production [19]. Therefore; extensive cage culture is widely applied in many countries.

This study sets out to assess the potential economical and technical feasibility of periphyton-based culture of Nile tilapia in small cages in Seyhan Dam Lake by the extensive culture model.

2. MATERIAL DEFINITION AND METHODS

2.1 EXPERIMENTAL FISH

Individuals of Nile tilapia (*Oreochromis niloticus*) were obtained from the Fresh Water Fish Culture and Research Station of Fisheries Faculty of Cukurova University. The overwintered and mixed sex fish were stocked for the experiment and the average weight and length of fish were 61.92±11.80 g. and 12.285±0.67 cm respectively.

2.2 CULTURE SYSTEM

The experiment was carried out between 11 August and 13 November 2004 in the cages of a private company conducting collaborate studies with the Fisheries Faculty of Cukurova University. The Seyhan Dam Lake in which the study was carried out is located in the North of Adana in Eastern Mediterranean region of Turkey. Lake surface area is 6782 ha and there are only two aquaculture unites in the lake. 1m³ cages with unknotted and 12 mm mash size nets prepared for experimental purposes, and the stocking density was 20 fish/m³ (approximately 1.238±0.02 kg.m^{-3}). Single application with two replicates was planned. The average depth of the water the cages were located in was around 10 meters and the water temperature was recorded throughout the experiment (Figure-1).

2.3 FEEDING

Fish were cultured in extensive conditions in natural water compound. Artificial feed wasn't used in any period of the experiment. Most abundant plankton groups found in and around of the cages are shown in table 1.

Figure 1 Experimental fish culture unit in Seyhan Dam Lake, Adana

Chlorophyta	Bacillariophita	Cyanophyta
Cladophora spp.	*Pinullaria* spp.	*Oscillatoria* spp.
Zygnema spp.	*Synedra* spp.	*Phormidium* spp.
Scenedesmus spp.	*Cyclotella* spp.	*Chroococcus* spp.

Table 1 Most abundant plankton groups found in and around of the cages

2.4 DATA SAMPLING AND ANALYSIS

In order to determine the growth performance, daily growth rate and the total weight gain of fish were measured and recorded once a fortnight. The Specific Growth Rate (SGR= (LnWt–LnWt)/t * 100) utilized for the evaluation of growth. In this equation [20];

Wt : weight obtained in the previous measurement (g)

t : one measurement period in the experiment (day)

Condition factors (CF) were derived from the equation: k=Weight (g)/Length(cm)^3 * 100

At the end of the study, daily weight gain, net weight gain, and total harvest yield were determined.

3. RESEARCH FINDINGS

The fish stocked for 90-days in floating cages reached an average weight of 112.03±0.3 g at the end of the experiment (Table 2). The net weight and daily weight gain per fish were 50.09±0.52 g and 0.556±0.005 g.d^{-1} respectively (Figure 2).

According to measurements had been made throughout the culture period, the highest SGR level (0.822 %) was observed in the first month of the experiment. Nevertheless, average SGR was 0.654±0.22 % at the end. Condition factor (CF) of the fish was high (3.363±0.48) at the initial stage of the study, but it declined during the following periods and almost leveled off on 2.314±0.015 (Table 2). Mortality was not observed during the experiment.

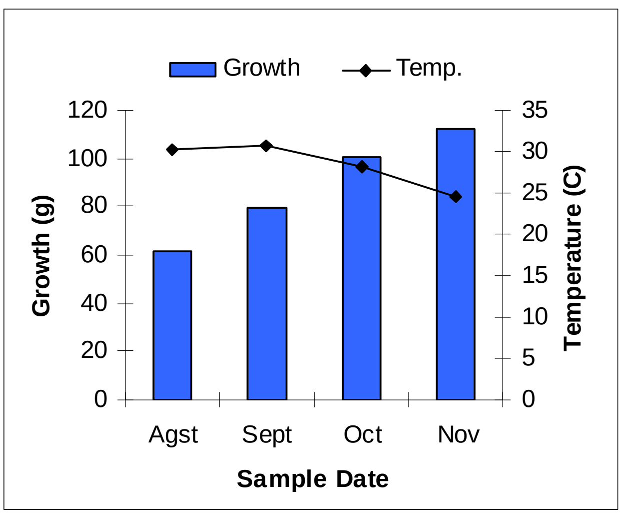

Figure 2 Growth performance values of Nile tilapia in extensive cage culture conditions

Performance Measure	Initial	Final
Weight gain		
Weight (g)	61.92±0.8	112.03±0.3
Length (cm)	12.285±0.67	17.075±0.41
Condition Factor (%)	3.363±0.48	2.314±0.16
Harvested Yield		
Total Yield ($kg.m^{-3}$)		2.240±0.015
Net Yield ($kg.m^{-3}$)		1.0018±0.054
Daily Weight gain ($g.d^{-1}$)		0.556±0.005
SGR (% day)		0.654±0.22

Table 2 Performance results (mean ± sd.) for O. niloticus raised at extensive cage culture conditions for 90 days

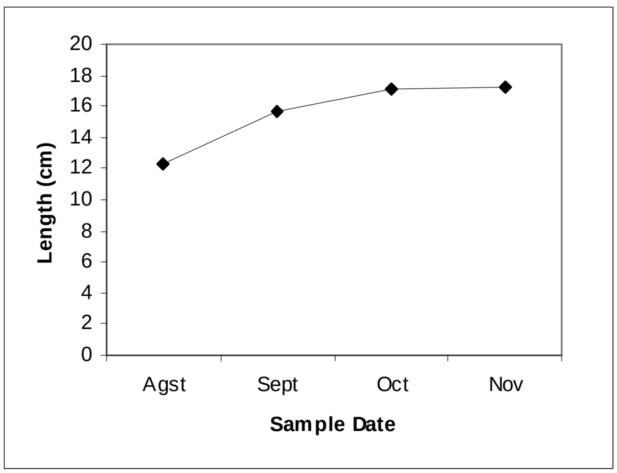

Figure 3 Total length values of Nile tilapia during the culture period.

4. DISCUSSION

The results of the present study showed that the growth performance of Tilapia reared in extensive condition is lower than that of intensive and semi-intensive culture conditions. However, when costs of production are considered, extensive cage culture of tilapia could be an alternative among the other culture models.

Some previous culture experiments carried out in the same research station conditions pointed out that 4.69 kg m^{-3} net yields with 1.12 and 1.349 FCR can be produced in floating cages in 90-day culture period [21]. In another experiment, 1.439 and 2.098 FCR and 11.14 and 9.834 kg m^{-3} net yields were obtained in 75-days trial [22]. In the present study, 1.0018 kg m^{-3} net yields produced in 90-day culture period in completely extensive conditions. Yields obtained in extensive cage aquaculture of tilapia in Philippines and Bangladesh ranged from 0.05 to 1.25 kg m^{-3} $month^{-1}$ [23] and 0.12–0.24 kg $m^{-3}month^{-1}$ [24] which are in agreement with the result of this study (0.33 kg m^{-3} $month^{-1}$). These weight gain values are naturally lower than the weight gain values of other culture methods. However, low cost of production is considerable. As it is known, feed cost is 60% of all production expenses in Tilapia culture [17]. For instance, total and the feed cost producing 1 kg tilapia in same culture unit were 1.30 $ and 2.13 $ respectively [21]. For this reason extensive culture of Nile Tilapia in subtropical conditions could be a considerable cost effective culture system for small scale aquaculture units.

ACKNOWLEDGEMENTS

We would like to thank ÜNALAN BALIKÇILIK for farming services and thanks are also Dr. Fatma ÇEVİK for technical assistance. We wish to thank Dr. M.Ali GÖKÇE for the constructive comments and suggestions on the manuscript.

BIBLIOGRAPHY

[1] Van Dam, A.A., Beveridge, M. C.M., Azim, E:A., Verdegem,M.J.C.,2002. The potential of fish production based on periphyton. *Reviews in Fish Biology and Fisheries* 12:1–3;

[2] Edwards, P. 1993. Environmental issues in integrated agriculture aquaculture and wastewater fed fish culture systems. *In*: Pullin, R.S.V., Rosenthal, H. and Maclean, J.L. (eds.), *Environment and Aquaculture in Developing Countries*. ICLARM Conf. Proc., Vol. 31, pp. 139–170;

[3] Gross, A., Boyd, C.E. and Wood, C.W. (1999) Ammonia volatilization from freshwater fish ponds. *J. Environm. Qual.* 28, 793–797;

[5] Avnimelech, Y. and Lacher, M. (1979) A tentative nutrient balance for intensive fishponds. *Bamidgeh* 31, 3–8;

[6] Boyd, C. (1985) Chemical budgets for channel catfish ponds. *Trans Am. Fish. Soc.* 114, 291–298;

[6] Jiménez-Montealegre, R. (2001) *Nitrogen Transformation and Fluxes in Fish Ponds: A Modelling Approach*. PhD-thesis, Wageningen University, the Netherlands, 185pp;

[7] Schroeder, G.L. (1978) Autotrophic and heterotrophic production of microorganisms in intensely-manured fish ponds, and related fish yields. *Aquaculture* 14, 303–325;

[8] Schroeder, G.L., Wohlfarth, G., Alkon, A., Helevy, A. and Krueger, H. (1990) The dominance of algal-based food webs in fish ponds receiving chemical fertilizers plus organic manures. *Aquaculture* 86, 219–229;

[9] Mires,D., 1995. The Tilapias. Chapter 7. Selected Articles on Aquaculture in Israel. Shefayim 2001. 90-110 pp;

[10] Aquino, L.V., and Nielsen, H., 1983. Primary production and growth rates of *Tilapia nilotica* in cages in Sampaloc. İn: Proc. İnt. Symp. Ti!apia in Aquaculture, Nazareth, Israel. May 8-13, 1983. Tel Aviv University, İsrael. 455- 463;

[11] Coche, A.G., 1982. Cage culture of tilapias. In: Pullin, R.S.V., Lowe-McConnell, R.H. (Eds.), The Biology and Culture of Tilapias. ICLARM Conference Proceedings, vol. 7. International Centre for Living Aquatic Resources Management, Manila, Philippines, pp. 205–246, 432 pp;

[12] Lovegrove, T. 1979. Control of fouling in farm cages. Fish Farming International 6, 35±37;
[13] Dempster, P.W., Beveridge, M.C.M., Baird, D.J., 1993. Herbivory in the tilapia Oreochromis niloticus: a comparison of feeding rates on phytoplankton and periphyton. J. Fish Biol. 43, 385– 392;
[14] Dempster, P.W., Baird, D.J., Beveridge, M.C.M., 1995. Can fish survive by filter feeding on microparticles? Energy balance in tilapia grazing on algal suspensions. J. Fish Biol. 47, 7– 17;
[15] Norberg, J., 1999. Periphyton fouling as a marginal energy source in tropical tilapia cage farming. Aquacult. Res. 30, 427–430;
[16] Wahab, M.A., Azim, M.E., Ali, M.H., Beveridge, M.C.M., Khan, S., 1999a. The potential of periphyton-based culture of a native major carp calbaush, Labeo calbasu Hamilton. Aquac. Res. 30, 409–420;
[17] Wahab, M.A., Mannan, M.A., Huda, M.A., Azim, M.E., Tollervey, A., Beveridge, M.C.M., 1999b. Effects of periphyton grown on bamboo substrates on growth and production of Indian major carp rohu (Labeo rohita Ham.). Bangladesh J. Fish. Res. 3, 1–10;
[18] Alceste, C. C. 2000. Tilapia alternative protein sources in tilapia feed formulation. Aquaculture Magazine, Vol. 26, No. 4, 3p;
[19] Fitzsimmons, K.,1997. Tilapia Aquaculture.Proceedings from fourth International Symposium on Tilapia in Aquaculture.Orlando Florida. Nov. 9-12. 9-13, pp;
[20] Okumuş, I., Değirmenci, A., Başçınar, N., Çelikkale, S. 2001. Comperative performance , approximate biochemical composition and consumer preference of albino and normal pigmented vareties of Rainbow trout (*Oncorhyncus mykiss*). *Turk. J. of Fisheries and Aquatic Sci*. 1: 23-28;
[21] Dikel, S., Alev,V., Kiriş, G., Kumlu, M., 2002."Growth And Yield Of Two Tilapia Species *Tilapia zillii a*nd *Tilapia rendalli* Raised In Floating Cages In Seyhan Dam Lake". *J. of Faculty of Agriculture Univ. of Cukurova* 17, (2): 93-98;
[22] Dikel, S., Alev, M.V., Ünalan, N.B., 2004. Comparison of Growth Performances of Nile Tilapia (*Oreochromis niloticus*) at Two Different Stocking Size in Floating Cages. *J. of Faculty of Agriculture Univ. of Cukurova* 19, (4):85-92;
[23] Beveridge, M.C.M., 1996. Cage Aquaculture, 2nd ed. Fishing News, Oxford, p. 346;
[24] Huchette, S.M.H., Beveridge, M.C.M.,2003. Technical and economical evaluation of periphyton-based cage culture of tilapia (Oreochromis niloticus) in tropical freshwater cages. Aquaculture 218. 219–234.