PRELIMINARY DATA REGARDING TILPIA GROWTH PERFORMANCES IN A RECIRCULATING AQUACULTURE SYSTEM

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Abstract

The aim of this paper is to assess the growth performance of tilapia (Oreochromis Niloticus) in a recirculating aquaculture system, in order to review the possibility of introducing this species in Romanian aquaculture. The experiments was done in October-December 2011, during which feeding was done only with fodders grain proper age, from Nutra category. At the start of experiments, the system was populated with tilapia which present an average body weight of around 8 g. Average daily growth rate recorded was 0.8 g/day and a specific growth rate of 3.6%/day on the average fish biomass. The evolution of physical-chemical parameters of the technological water during the experiment was within the limits of optimal growth. Biological material (tilapia) presented a good development rate, registering a 100% survival, while the water temperature fluctuated and at certain times was not optimal for development of tilapia.

Key words: tilapia, recirculating system, aquaculture, intensive

INTRODUCTION

Aquaculture, the sector which began his development in the late 1960s, is today the fastest growing branch of food industry producing almost 50% of all fishing and aquaculture product in the world. Annual consumption of aquaculture products increased from 9.9 kg/capita, in 1961, to 17.0 kg/capita in 2007, with an average annual growth rate of 7% [11]. Aquaculture development has a very high potential, determined both by the need to meet product market, which is constantly increasing, and the stopping the decline of wild fish population due to over-fishing and pollution of natural waters.

Tilapia is one of the major genres of world aquaculture, being introduced almost worldwide, recording in 2010 a total production of 3.2 million tons. The world's largest producer by far is China followed by Indonesia, Thailand, Philippines and Egypt.

At this point, is the second species of world aquaculture, after carp, and has all the prerequisites to be the most important species in aquaculture in the 21st century. [12, 13, 19].

Growth of these species is expanding both in developed and developing countries because they are very resistant to environmental conditions, in which they live, have a very good growth rate and can be reared in any production system: ponds, net-pens, cages, raceways, recirculating systems.

Of all tilapia species, Nile tilapia (*Oreochromis Niloticus* L.) is currently the most important and high species worldwide, representing over 70% of the tilapia production [13]. According to an FAO study, world production of Nile tilapia grew very important in recent years, from 970,756 tonnes in 2000 to 2,333,432 tonnes in 2008 [14].

The aim of this paper is to assess the growth performance of tilapia (*Oreochromis Niloticus* L.) in a recirculating aquaculture system, in order to review the possibility of introducing this species in Romanian aquaculture.

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MATERIAL AND METHODS

Experiments were conducted at the Institute of Research and Development for Aquatic Ecology, Fishing and Aquaculture Galatz, from October to December 2011. They have assumed rearing Nile tilapia in a recirculating system, organization of researches being made in conjunction with the technology applied, monitoring in parallel the values of physical-chemical parameters of the technological water and technological indices of culture biomass.

Recirculating aquaculture system, used in this experiment, is represented by an aquarium type tank with a technological water flow of 1 cubic meter/hour, and consists of:

- *Rearing tank* – represented by a glass aquarium with a water volume of 0,2 mc;
- *Filtering system* – Fluval 404 type,composed from: mechanical filter - sponge, chemical filter – activated charcoal and biological filter – plastic and ceramic balls;
- *Aeration system* – represented by an air pump ELITE 802 type, with a water flow of 2 l air/minute at a pressure of 3,5 PSI;
- *Heating system* – represented by a two thermometers RESUN THERM 25/3000 – RH 9000 type with a power of 150 W.

Rearing system is represented schematically in Figure 1.

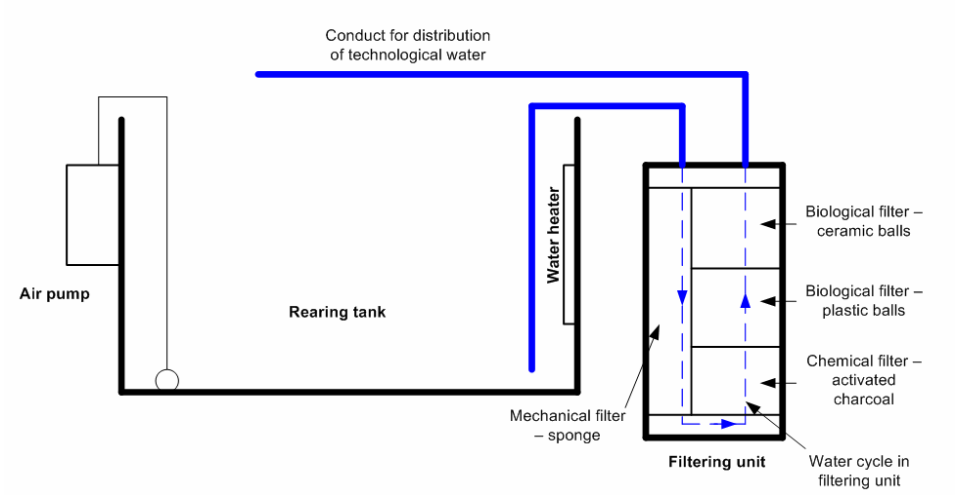

Fig.1 Rearing system scheme used in the experiment

At the start of experiments, rearing system was populated with Nile tilapia (*Oreochromis Niloticus* L.) with average body weight of 8 g/fish. Fish was fed, throughout the experimental period, with Nutra extruded feed (from Skretting), Classic K 1P, 3 mm grain size and a biochemical composition that is shown in Table 1. Frequency of feed was 2 times per day, respectively 08.00 and 16.00; the amount administered being between 1.5 - 2% of fish biomass in 24 hours.

Table 1 Biochemical composition of the feed used during the experiment

Feed Nutra Classic K 1P	
Biochemical composition	***Quantity***
Crude protein	43 %
Lipids	11.5 %
Crude cellulose	4 %
Ash	7.5 %
Sodium	0.2 %
Calcium	1.1 %
Phosphorous	0.7 %
Vitamin A	3.000 UI/kg
Vitamin D3	600 UI/kg
Manganese	9 mg/kg
Iron	24 mg/kg
Zinc	54 mg/kg
Copper	3 mg/kg
Iodine	1 mg/kg

Samples for analyses were collected using plastic containers, in compliance with standard procedures and were then stored for a maximum period of 24 hours at a temperature between 2-5°C. The main physical-chemical parameters monitored were: temperature (°C), pH (upH), dissolved oxygen (mg/l), nitrites (NO2-N - mg/l), ammonia (NH3 - mg/l) and chlorides (mg/l).

Technological indicators analyzed at the end of the experiment, in order to obtain information on applied technology and performance of the rearing system used, were:

Real growth rate – (S_r) – was calculated with the formula: $S_r = B_f - B_i$ [kg] were, B_f, B_i – final and initial fish biomass [kg].

Individual growth rate – was determined with the formula: (Wf – Wi)/ N [g/ex.] were, Wf, Wi – final and initial fish weight [g]; N – fish number [ex.].

Daily growth rate – (DGR) – was determined with the formula: (Wf – Wi)/ T [g/day] were, Wf, Wi – final and initial fish weight [g]; T – rearing period [days].

Specific growth rate – (SGR) – was determined with formula: SGR = (lnWf-lnWi)*100/T [%/day] were; Wf, Wi – final and initial fish weight [g]; T – rearing period [days].

Food conversion rate – (FCR) – was calculated with formula: FCR = F/ (B_f – B_i) [kg/kg] were; F – administrated fodder quantity [kg]; B_f, B_i – final and initial fish biomass [kg].

Statistical processing of data obtained was performed by using descriptive statistics and ANOVA single factor test in Microsoft Office Excel utility.

RESULTS AND DISCUSSIONS

The present research aimed to obtain optimal technological bio-indicators for rearing Nile tilapia (*Oreochromis Niloticus* L.), in a recirculating system, so as to create opportunities to introduce this species in Romanian aquaculture.

Organization of researches was done in conjunction with the technology applied, monitoring in parallel the values of physical-chemical parameters of the technological water and technological indices of culture biomass.

The most important influence on growth parameters is carried by water chemistry. During the experiment were monitored the values of the most important water parameters namely temperature (T), pH (pH), dissolved oxygen (DO), nitrite (N-NO2), ammonia (NH3) and chloride (Cl^-), whose average is shown in Table 2.

T, during the experimental period, ranged between 21,9 and 29,4°C, with an average value (T ± SD) of 24,6± 3,5°C. Temperature values were located in a gap where tilapia can be raised with good parameters. Most authors consider the range for normal development between 20 and 35°C, with an optimal spacing between 25 and 30°C [8, 18, 19, 20, 22]. Also this was observed from our experiments, the development over 25°C being much better and much faster. Popma and Masser (1999) believes that at a temperature of 30-32°C growth of tilapia is 3 times better that at a temperature of 22°C, while they become stressed at temperatures lower than 18°C.

Table 2 Average, minimum and maximum values of the main physico-chemical parameters of technological water

Physico-chemical parameter	***Measure unit***	***Average ±SD****	***Minimum***	***Maximum***
T	°C	24.6 ± 3.5	21.9	29.4
pH	upH	7.32 ± 0.16	7.19	7.55
DO	mg/l	2.6 ± 1.5	1.14	4.18
$N\text{-}NO_2$	mg/l	0.065 ± 0.05	0.02	0.132
NH_3	mg/l	0.052 ± 0.05	0.0012	0.107
Cl^-	mg/l	165.95 ± 15.85	143.61	178.72

* SD – standard deviation; T – temperature; DO – dissolved oxigen

pH ranged in optimal spacing for fish rearing. Average 0.16 ± 7.32 was upH (7.19 upH minimum, maximum upH 7.55), being similar to values observed by other authors [8, 18, 19, 20]. **DO** was monitored daily throughout the experiment recording values ranged from 1.14 mg/l and 4.18 mg/l with an average value of (DO ± SD) of 2.6 ± 1.5 mg/l. This value lies below the optimum and the value reported by Ridha et. al. in 2006 of 6.1 to 7.2 mg/l [22]. Several authors consider that tilapia can tolerate levels up to 0.3 mg/l, but despite this ability to survive acute low DO concentrations, tilapia systems should be managed to maintain DO above 2 mg/l because chronic exposure to low DO depresses metabolism, growth and disease resistance [19, 24]. **$N\text{-}NO_2$** showed an average value of 0.065 ± 0.05 mg/l (minimum of 0.02 mg/l, maximum of 0.132 mg/l) in this study, slightly lower than 0.01 to 0.46 mg/l reported by Ridha et. al. in 2006 [22], but that is situated in the optimal range of exposure. At the same time we can say that the level of chlorides reduces the toxic effects of nitrites if present in a ratio of 1.5:1 and up to 5:1 [9]. **Cl^-** values recorded in this study ranged from 143.61 mg/l and 178.72 mg/l with an average of 165.95 ± 15.85 mg/l, framed over the optimal level of chlorides in recirculating systems in the range 100-150 mg/l [19]. **NH3** showed an average value of 0.052 ± 0.05 mg/l (minimum of 0.0012 mg/l, maximum 0.107 mg/l) situated over the range reported by Ridha (2006) of 0.011 to 0.029 mg/l [22]. In another study, Popma and Masser (1999) reported values above those recorded in this study, 0.08 mg/l, and they consider that a long-term exposure to levels greater than 1 mg/l causes death especially up to early life stage of fish [19]. Also Evans et al. (2006) reported values higher than tilapia optimal limit, 0.277 mg/l, at a TAN of 2.16 mg/l, pH 8.41 and a temperature of 34.1°C [10].

Bio-indicators obtained in this study are presented in Table 3. Analyzing these indicators obtained, stand 100% survival throughout the experimental period of 50 days, achieving a real growth rate of 2.84 kg and a maximum density of 20 kg/m^3. Individual growth rate obtained was 40 g/ex.. In terms of statistically significant differences were found (ANOVA - $p < 0.05$) between the initial individual weight values recorded from the final individual weight.

DGR - daily rate of growth - recorded in this study was 0.8 g/day comparable to that reported by Racoky (1989) for Nile tilapia reared from 5g to 50g, 0.75 g/day [21]. Most recent data reported higher values of this parameter, from 1.28 to 2.6 g/day [22], from 0.98 to 1.36 g/day [4] and even from 1.89 to 3.53 g/day in a study by Muangkeow et al. from 2007 reared in a density of 0.4 to 1 ex./m^2 [16]. Also Muir et al. (2000) obtained after 240 days of rearing tilapia from 5 to 350g a rate of 1.44 g/day [17]. On the other hand Peterman (2011) in his dissertation presents a daily growth rate, obtained in a recirculating system, of 0.2 ± 0.02 g/day [18] lower than that obtained in this study.

Table 3 Bio-indicators obtained following tilapia rearing

Parameters	**Values**
Population	
Individual weight - g -	8
Initial biomass - g -	568
Harvesting	
Final individual weight - g -	48
Final biomass - g -	3.408
Rearing parameters	
Days of rearing	50
Survival - % -	100
Real growth rate - kg -	2.840
Individual growth rate - g/ex. -	40
Total distributed feed - kg -	4.6
Daily growth rate (DGR) - g/day -	0.8
Specific growth rate (SGR) - %/day -	3.6
Food conversion rate (FCR) - kg fodder/ kg fish -	1.62

Regarding SGR - specific growth rate - it had a value of 3.6%/day higher than data reported by Ridha (2006), between 0.80 and 0.83%/day, and Azaza et al. (2008), between 1.99 and 2.34%/day [4, 22]. Abdel-Tawwab et al. (2010) have obtained specific growth rate of 1.007; 1.143 and 1.107 at the administration of feed with different protein concentrations, respectively, 25, 35 and 45% [1]. Data from this study are consistent with data obtained by Rad et al. in 2006, which reported a specific growth rate of 3.46%/day by continuous exposure to light [20]. Several authors support that photoperiodic manipulations have been found to influence metabolic rate and growth of Nile tilapia through energy conservation and stimulated food intake [5, 6, 7, 9].

FCR - feed conversion ratio - showed a value of 1.62 kg fodder/kg fish that is close to most of the data from the literature studied. Ridha (2006) reported values between 1.27 and 1.68 kg fodder/kg fish, Peterman (2011) obtained in the recirculating system values between 1.4 and 1.6 kg fodder/kg fish, Rad et al. (2006) obtained a value of 1.77 kg fodder/kg fish reared in continuous light [18, 20, 22]. Higher values than those presented in this study reported Azaza et al. (2008), between 1.67 and 2.57 kg fodder/kg fish, and Abdel-Tawwab et al. (2010) that following administration of protein feed with 25, 35 and 45% have obtained values of 2,22; 1,92 and 1,98 kg fodder/kg fish [1, 4].

The data published by several authors show that the FCR increases with increasing of tilapia individual weight [2, 3, 15, 23].

CONCLUSIONS

Tilapia presented a good growth while the water temperature fluctuated and at certain times was not within the optimal limits for development.

Fish survival was 100% what confirms that tilapia lives in water less than optimal for fish growth, affecting only growth parameters.

Tilapia are highly suited for production in recirculating aquaculture systems, showing high tolerance to crowding, ready acceptance of a wide range of foods, good feed conversion efficiency and rapid growth rate.

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REFERENCES

[1] Abdel-Tawwab M., Ahmad M.H., Khattab Y.A.E, Shalaby A.M.E.: Effect of dietary protein level, initial body weight, and their interaction on the growth, feed utilization, and physiological alterations of Nile tilapia, *Oreochromis niloticus* (L.), Aquaculture, 2010, 298: p 267 – 274.

[2] Abdelghany A.E.: Optimumdietary protein requirements for *Oreochromis niloticus* L. fry using formulated semi-purified diets, 5th International Symposium on Tilapia Aquaculture, Rio de Janeiro, Brazil, 2000, 1: p 101–108.

[3] Al-Hafedh Y.S.: Effects of dietary protein on growth and body composition of Nile tilapia, *Oreochromis niloticus* L., Aquac. Res., 1999, 30 (5): p 385–393.

[4] Azaza M.S., Mensi F., Ksouri J., Dhraief M.N., Brini B., Abdelmonleh A., Kraieni M.M.: Growth of Nile tilapia (*Oreochromis niloticus* L.) fed with diets containing graded levels of green algae ulva meal (*Ulva rigida*) reared in geothermal waters of southern Tunisia, Journ. Of. Appl. Ichth., 2008, 24: p 202–207.

[5] Biswas A.K., Endo M., Takeuchi T.: Effects of different photoperiod cycles on metabolic rate and energy loss of both fed and unfed young tilapia Orochromis niloticus: part I, Fisheries Science, 2002, 68: p 465–477.

[6] Biswas A.K., Takeuchi T.: Effects of different photoperiod cycles on metabolic rate and energy loss of both fed and unfed adult tilapia *Orochromis niloticus*: part II, Fisheries Science, 2002, 68: p 543–553.

[7] Biswas A.K., Takeuchi T.: Effects of photoperiod and feeding interval on food intake and growth of Nile tilapia *Orochromis niloticus* L., Fisheries Science, 2003, 69: p 1010–1016.

[8] El-Sayed A.F.M.: Tilapia culture, 2006, Alexandria University, Egypt.

[9] El-Sayed A.F.M., Kawanna M.: Effects of photoperiod on the performance of farmed Nile tilapia *Oreochromis niloticus*: I. Growth, feed utilization efficiency and survival of fry and fingerlings, Aquaculture, 2004, 231: p 393–402.

[10] Evans J.J., Pasnik D.J., Brill G.C., Klesius P.H.: Un-ionized ammonia exposure in Nile tilapia: toxicity, stress response, and susceptibility to

Streptococcus agalactiae, North AmericanJournal of Aquaculture, 2006, 68: p 23–33.
[11] Food and Agriculture Organization of the United Nations: The state of world fisheries and aquaculture, 2010.
[12] Fitzsimmons K.: Tilapia: themost important aquaculture species of the 21st century, Fifth International Symposium on Tilapia in Aquaculture, Rio de Janeiro, 2000, Panorama da Aquicultura Magazine, p 3–8.
[13] Fitzsimmons K.: Potential to increase global tilapia production, Global Outlook for Aquaculture Leadership, Kuala Lumpur, 2010.
[14] Fitzsimmons K.: Development of new products and markets for the global tilapia trade, Sixth International Symposium on Tilapia in Aquaculture, Manila, 2004, BFAR, p 624–633.
[15] Khattab Y.A.E., Ahmad M.H., Shalaby A.M.E., Abdel-Tawwab M.: Response of Nile tilapia (*Oreochromis niloticus* L.) from different locations to different dietary protein levels, J. Aquat. Biol. Fish., 2000, 4: p 295–311.
[16] Muangkeow B., Ikejima K., Powtongsook S., Gallardo W.: Growth and nutrient conversion of white shrimp *Litopenaeus vannamei* (Boone) and Nile tilapia *Oreochromis niloticus* L. In an integrated closed recirculating system, Aquacul. res., 2011, 42: p 1246–1260.
[17] Muir J., van Rijn J., Hargreaves J.: Production in intensive and recycle systems, In: Beveridge, M.C.M., McAndrew, B.J. (Eds.), Tilapias: Biology and Exploitation, 2000, p 405–445.
[18] Peterman M.A.: Evaluation of production characteristics of four strains of Nile tilapia *Oreochromis niloticus* and a Red variety under two sets of intensive culture conditions, Master thesis Auburn University, Alabama, 2011.
[19] Popma T., Masser M.: Tilapia: Life History and Biology, Southern Regional Aquaculture Center (SRAC) Publication No. 283, 1999.
[20] Rad F., Bozaoğlu S., Gözükara S.E., Karahan A., Kurt G.: Effects of different long-day photoperiods on somatic growth and gonadal development in Nile tilapia (*Oreochromis niloticus* L.), Aquaculture, 2006, 255: p 292 – 300.
[21] Rakocy J.E.: Tank culture of tilapia, Southern Regional Aquaculture Center (SRAC) Publication No. 282, 1989.
[22] Ridha T.M.: Comparative study of growth performance of three strains of Nile tilapia, *Oreochromis niloticus* L. At two stoking densities, Aquacul. res., 2006, 37: p 172–179.
[23] Siddiqui A.Q., Holder M.S., Adam A.A.: Effects of dietary protein levels on growth, food conversion and protein utilization in fry and young Nile tilapia (*Oreochromis niloticus*), Aquaculture, 1988, 70: p 63–73.
[24] Teichert-Coddington, D., Green, B.W., 1993. Tilapia yield improvement through maintenance of minimal oxygen concentrations in experimental grow-out ponds in Honduras. Aquaculture 118, 63–71.