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OXYGEN CONSUMPTION OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) JUVENILES UNDER DIFFERENT WATER TEMPERATURES AND FEEDING FREQUENCIES

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ABSTRACT

The objective of this study was to determine the influence of the temperature and feeding frequency on the oxygen consumption by Nile tilapia (*Oreochromis niloticus*) reared in intensive conditions of a close water system. This was done by feeding the fish (100 g average body weight) at different temperatures (22 ºC and 2 ºC) and at different number of feeds (0 time/day, 1 time/day and 2 times/day). The measurements of oxygen consumption was carried out each hour for 24 hours. The temperature significantly increased the rate of metabolism of this fish and the oxygen consumption reached its maximum 4-5 hours after each feeding. Also the fish fed once/day consumed more oxygen than those fed twice/day. Generally, tilapia support concentrations of oxygen lower than 1 ppm without any effect on its health, thus indicates the suitability of low-oxygen water bodies for tilapia culture.

1. INTRODUCTION

Many factors affect the oxygen consumption by cultured fish. These factors are:- abiotic, such as temperature and oxygen concentration or biotic, such as body weight and feeding. For example, the temperature exerts an accelerated effect on the chemical reactions thus affects the metabolism (Waller, 1992 & Garcia Garcia, 1994) which consequently increases the oxygen consumption of living organisms. Increasing temperature causes problem in oxygen transport in fish. Temperature elevation reduces not only the oxygen solubility in water but also the hemoglobin-oxygen relationship which makes the oxygen transfer between the water and the blood more difficult.

The oxygen consumption rate in fish is greatly affected by the oxygen concentration in the water. In the natural habitat, most of the mobile species such as fish are capable of avoiding these types of situations by escaping from the water mass which contains lower dissolved oxygen levels. In some cases, it is impossible for a fish to move from this water mass, for this reason the fish is obliged to be subjected to hypoxia.

This situation usually occurs during the phytoplankton blooming. The oxygen level is then increased over the saturation during the light hours followed by an effective deficiency at night hours especially during dawn.

The oxygen consumption in fish is said to be directly associated with feeding activity (Forsberg, 1997 & Alsop and Wood, 1997).

The determination of oxygen requirement is fundamental to establish the adequate water flow in the installation of intensive system or for the development of aeration-oxidation strategies in semi-extensive systems.

The present study was conducted to determine the daily variation in oxygen consumption of Nile tilapia fed once or twice/day, or otherwise no feed and maintained at two different temperatures (22 and 27 ºC).

2. MATERIALS AND METHODS

Nile tilapia (*O. niloticus*) juveniles weighing 100±1.2 g (mean ± S.E., n = 180) were randomly stocked in seven homogenous plastic tanks with 65 l capacity, these tanks were covered by plastic bags to avoid any oxygen exchange between the air and the water. A close water system with aeration in each tank was used, this fresh water was previously heated by using electric central heater to maintain the temperature at 28 ºC and was aerated individually, the fish were fed till apparent satiation and the feed was supplied in different number of feeds/tank. Three tanks were examined by feeding fish one time/day, three tanks were given two times/day and one tank without any feed given. Feeding was carried out at 10:00 am and at 4:00 pm. The oxygen consumption was calculated by the difference between the oxygen concentration when the water is opened and the air was supplied in each tank and the second measurement, which was done after 15 minutes from water closure and air removal manually. The measurements start at 10:00 am, and was carried out each hour for 24 hours, i.e. till 9:00 am in the next day. This experiment was carried out for 2 days to study the oxygen consumption at two different temperatures (26.8 and 22.3 ºC). At the end of each cycle of measurements, all fish in each tank were weighed to express the oxygen consumption as a function of fish weight. After the termination of the first experiment, water temperature was gradually reduced to 22 ºC and the fish were adapted to this temperature for 2 weeks before beginning the second experiment. Oxygen consumption was measured by Oxyguard Handy MKlll (portable). The statistical analysis of the results was realized by subjecting the variables to one way analysis of variance (ANOVA) (Snedecor and Cochran, 1971). This statistical analysis was carried out using statistical software, STATGRAPHICS Plus, Version 4.1.

3. RESULTS

The oxygen consumption in mg O_2/kg/h for the three feeding strategies and the two tested temperatures are shown in Figures 1 and 2. It was found that when feeding fish once/day (10:00 h), the oxygen consumption starts to increase at 2-3 hours after feeding, reaching its maximum levels after 4-5 hours, then the oxygen consumption starts to decrease till it reaches the minimum level, and remained stable afterwards.

In the case of applying feed two times/day (10:00 h and 16:00 h), the oxygen consumption behaves similar to the former case (feeding once/day) with the unique difference that it presented a second peak few hours after the second meal ingestion.

In case of the unfed fish, the oxygen consumption did not remain constant due to the increase of the metabolic rate.

Tables 1 and 2 present the maximum, minimum and mean values of the oxygen consumption expressed in mg O_2/kg/h for three feeding strategies and the two temperatures in the different experiments.

The oxygen consumption by tilapia increases with increasing the temperature at both feeding frequencies (one meal or two meals /day).

Likewise, significant differences appeared between feeding frequencies. Tilapia fed once/day consumed more oxygen than those fed twice/day.

No significant difference in the oxygen consumption was recorded between the light and the dark periods of the day.

Table (1): Maximum, minimum and mean oxygen consumption expressed in mgO_2 /kg/h, for the three different feeding strategies at 26.8ºC.

OXYGEN CONSUMPTION	ONE FEED/DAY	TWO FEEDS/DAY	WITHOUT FEED
Maximum	214.11	190.47	176.43
Minimum	165.67	110.8	80.2
Mean	189.84^{a}±10.66	160.38^{b}±18.99	131.66^{c}±27.99
LIGHT PERIOD (10:00 - 21:00 h)			
Maximum	214.11	190.47	176.43
Minimum	165.67	110.8	112.28
Mean	191.66^{b}±13.44	160.87^{a}±24.54	152.37^{a}±21.35
DARK PERIOD (22:00 - 9:00 h)			
Maximum	198.04	182.03	136.34
Minimum	176.05	140.2	80.2
Mean	188.02^{a}±7.06	159.89^{b}±12.30	110.94±^{c}15.61

Means followed by different superscripts in the same row indicates statistical significant differences (Student Newman-Keuls Test).

Table (2): Maximum, minimum and mean oxygen consumption expressed in mgO_2 /kg/h, for the three different feeding strategies at 22.3ºC.

OXYGEN CONSUMPTION	ONE FEED/DAY	TWO FEEDS/DAY	WITHOUT FEED
Maximum	179.35	172.33	187.33
Minimum	139.27	118.36	103.03
Mean	154.51^{b}±8.74	140.44^{a}±13.62	133.89^{a}±22.37
LIGHT PERIOD (10:00 - 21:00 h)			
Maximum	179.35	159.93	187.33
Minimum	139.27	118.36	103.03
Mean	154.55^{b}±10.56	138.27^{a}±11.69	137.42^{a}±25.39
DARK PERIOD (22:00 - 9:00 h)			
Maximum	167.92	172.33	168.6
Minimum	144.33	122.88	103.03
Mean	154.46^{a}±6.95	142.6^{ab}±15.54	130.35^{b}±19.34

Means followed by different superscripts in the same row indicates statistical significant differences (Student Newman-Keuls Test).

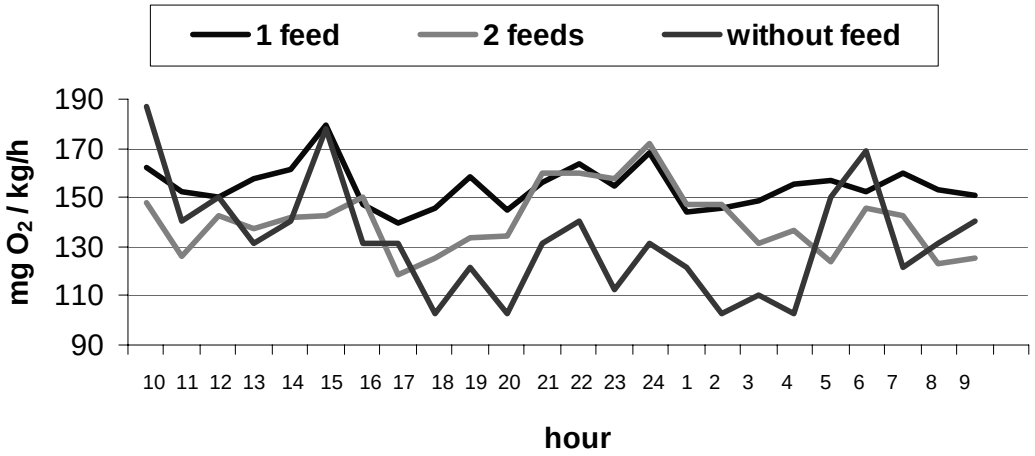

Fig. (1): Evolution of the oxygen consumption in mg O_2/kg/h for the three feeding strategies at 26.8 ºC

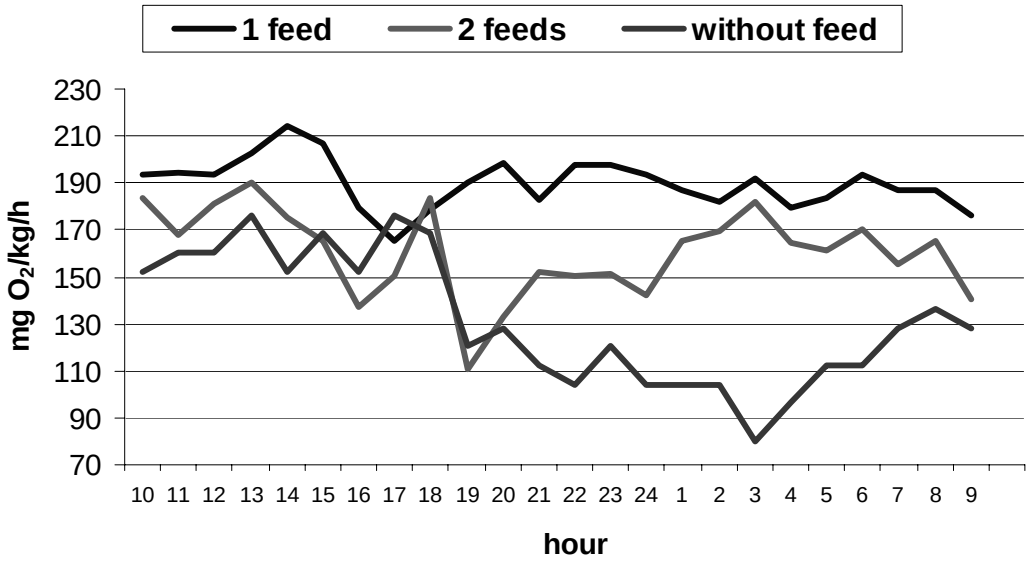

Fig. (2): Evolution of the oxygen consumption in mg O_2/kg/h for the three feeding strategies at 22.3 ºC

4. DISCUSSION

From a quantitative point of view, the tilapia manifest specific consumption of oxygen which could be compared with that of marine fish species such as seabream and seabass, which ranges from 100 to 400 mg O_2/kg/h. General comparison of oxygen consumption values observed in *O. niloticus* demonstrates that their consumption is higher than those presented by sedentary flat fish as the Pleuronectiformes (Heterosomata) with oxygen consumption values lower than 100 mg O_2/kg/h but inferior than those presented by grand pelagic swimmers as Coryphaenidae (Dolphins) with values ranging from 358 to 726 mg O_2/kg/h.

Increasing the metabolic rate -which resulted after feeding- depends not only on the ingested quantity but also on other factors such as temperature, fish size, diet distribution frequency, diet composition,…etc.

The amplitude of the effect which feeding provokes on the oxygen consumption decreases with increasing the number of feeds, this conclusion agrees with the results obtained by Yager and Summerfelt (1993) who studied the relationship between number of feeds/day and the oxygen consumption in *Stizostedion vitreum*. As for the influence of the light and dark phases of the day, no significant differences was recorded, however, Requena *et al*. (1997) observed that gilthead sea-bream (*Sparus aurata)* presenting a minor value of oxygen consumption during the night and increasing during the day this could be explained by a clear pattern of activity associated with light phase.

In the present study, oxygen consumption has reached to the maximum peak 4 to 5 hours after the feed was provided This agrees with the results obtained by Wells *et al*. (1983) who observed that the maximum peak of oxygen consumption was achieved 1 to 3 hours of meal supply to common octopus (*Octopus vulgaris*), this due to increasing of the metabolic rate as a consequence of the movement.

From the present results, we can see that increasing the feeding ratio has no influence on the maximum oxygen consumption. This is contrary to the observations recorded by Beamish (1974), Guinea and Fernández (1991) who demonstrated that oxygen consumption increases with increasing feeding level.

Respecting to the unfed fish, the oxygen consumption changed due to increasing the metabolic rate as the fish stressed once distributing the feed for the other treatments.

Another result obtained in the present study, is that the maximum oxygen consumption was not affected by the number of daily feeds. This disagrees with De La Gandara (2003), who observed that increasing the number of feeds provoke an increase in the maximum peak of oxygen consumption, in yellowtail (*Seriola dumerili*). The oxygen consumption appears low as a result of the great biomass stocked in each tank with respect to the tank size. Hence if the oxygen existing in each tank is very low reaching less or equal to 0.5 ppm, it will continue to decrease till a moment where the fish has no oxygen to use (oxygen depletion).

5. CONCLUSIONS

The temperature increases the metabolism of this species significantly, but this effect is more apparent by the feeding. The oxygen consumption starts to increase 2-3 hours after the fish being fed, reaching to the maximum consumption 4-5 hours after the feed supply. The method used to estimate the oxygen consumption detects the variations in the oxygen concentration in the water, so it appears appropriate, but it is necessary to reduce the density of fish to limit the consumption. The tilapia can tolerate concentrations of oxygen lower than 1 ppm

without any apparent consequences on its health.

REFERENCES

Alsop, D.H. and Wood, C.M.: 1997, 'The interactive effects of feeding and exercise on oxygen consumption, swimming performance and protein usage in juvenile rainbow trout (*Oncorhynchus mykiss*)', *Journal of Experimental Biology* **200**: 2337-2346.

Beamish, F.W.H.: 1974, 'Apparent specific dynamic action of largemouth bass, *Micropterus salmoide.*', *Journal of the Fisheries Research Board of Canada* **31**: 1763-1769.

De La Gandara, F.: 2003, 'Efecto de diversos factores sobre el consumo de oxígeno de juveniles de seriola (*Seriola dumerili* Risso, 1810) en condiciones de cultivo', Ph.D. Thesis, Murcia University, Spain. Pp 253 .

Forsberg, O.I.: 1997, 'The impact of varying feeding regimes on oxygen consumption and excretion of carbon dioxide and nitrogen in post-smolt Atlantic salmon *Salmo salar* L.', *Aquaculture Research* **28**: 29-41.

Garcia Garcia, B.: 1994, 'Factores que influyen sobre el consumo de oxígeno, ingesta y crecimiento en la dorada *(Sparus aurata* L.): una aproximación al establecimiento de modelos lineales', Ph.D. Thesis, Murcia University, Spain. Pp 231.

Guinea, J. and Fernandez, F.: 1991, 'The effect of SDA, temperature and daily rhythm on the energy metabolism of the mullet *Mugil saliens*', *Aquaculture* **97**: 353-364.

Requena, A.; Fernandez-Borras, J. and Planas, J.: 1997, 'The effects of a temperature rise on oxygen consumption and energy budget in gilthead sea bream', *Aquaculture International **5***: 415-426.

Snedecor, G. and Cochran, W.: 1971, 'Métodos Estadísticos', Compañía Editorial Continental, Mexico-España-Argentina-Chile. Pp. 513-542.

Waller, U.: 1992, 'Factors influencing routine oxygen consumption in turbot, *Scophthalmus maximus', Journal of Applied Ichthyology* **8**: 62-71.

Wells, M.J., O'Dor, R.K., Mangold, K. and Wells, J.: 1983, 'Feeding and metabolic rate in *Octopus* sp.', *Marine Behaviour and Physiology 9*: 275-187.

Yager, T. and Summerfelt, R.C.: 1993, 'Effects of fish size and feeding frequency on metabolism of juvenile walleye', *Aquaculture Engineering* **12**: 19-36.