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Oxygen uptake in a freshwater air-breathing fish with macrophytes

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Abstract

In the cultivation of various fish species in aquaculture is an important to have enough dissolved oxygen available for fish respiration.This oxygen can be produced by the photosynthesis of aquatic plants and algae. The purpose of this study is to investigate the influence of two macrophytes *Myriophyllum spicatum* and *Lemna minor* on uptake of oxygen in the feeding of perch. The experimental part was consisted of three tanks with *Perca fluviatilis* - as one without macrophytes (like a control) and the other two with macrophytes (*Lemna minor*, *Myriophyllum spicatum*). Oxygen uptake rate was measured at water temperature 23±1°C. The measurement of pH, dissolved oxygen and temperature was made with a portable combined meter. The mean oxygen uptake rate is better in the cultivation of *Perca fluviatilis* with *Lemna minor*.

Key words: *Lemna minor*, *Myriophyllum spicatum*, oxygen uptake, *Perca fluviatilis*

Introduction

In the cultivation of various fish species in aquaculture is an important to have enough dissolved oxygen available for fish respiration. Oxygen is essential to the survival (respiration) of fish, to sustain healthy fish and bacteria which decompose the waste produced by the fish, and to meet the biological oxygen demand (BOD) within culture system. Dissolved oxygen levels can affect fish respiration, as well as ammonia and nitrite toxicity. When the oxygen level is maintained near saturation or even at slightly super saturation at all times it will increase growth rates, reduce the food conversion ratio and increase overall fish production.

Sipaúba-Tavares et al. (2003) suggest that to sudden reduction of DO, started medium acidification and increasing levels of ammonia. The availability of dissolved oxygen (DO) can influence the distribution and movement of fishes (Kobza et al. 2004; Cucherousset et al. 2007), the composition of fish assemblages (Chapman et al. 1996; Chapman et al., 2000; Crampton, 1998; McKinsey and Chapman, 1998). In freshwater systems, dissolved oxygen (DO) saturation frequently fluctuates, falling at night and rising during the day in response to respiration and photosynthesis, respectively, of aquatic biota (Stoyanova, 2014). Oxygen as a gas has a low solubility in water. In addition, the amount of oxygen contained in water varies with temperature and salinity (Buentello et al., 2000). Less oxygen can be held in fully air-saturated warm sea water than fully air-saturated cold freshwater. The oxygen content of the water sets the absolute availability of oxygen in the water. It is the oxygen partial pressure gradient that determines how rapidly oxygen can move from the water into the fish's blood to support its metabolic rate. This is because oxygen moves by diffusion across the gills of fish. However, dissolved oxygen is the most important and critical parameter, requiring continuous monitoring in aquaculture production systems. This is due to fact that fish aerobic metabolism requires dissolved oxygen (Timmons et al., 2001).

The oxygen can be produced by the photosynthesis of aquatic plants and algae, or it can simply diffuse from air to water. Environmental conditions in macrophytes are variable. Water temperature and dissolved oxygen concentration change throughout the day and night and may be related to water currents, macrophyte stand types and depth (Junk, 1973; Jedicke et al., 1989; Velichkova and Sirakov, 2013). In the fish farm is allowed over growing of plants by 25% of water as species composition influences the growth and development of the fish in them. The perch is sensitive species and often controlled of oxygen levels at its cultivation.

There are few studies on the qualitative composition of macrophytes in fish farms and their impact on the indicators of the water in the cultivation of fish. Therefore, the aim of this study is to investigate the influence of two macrophytes *Myriophyllum spicatum* and *Lemna minor* on uptake of oxygen in the feeding of perch.

Materials and Methods

The perches taken from the fish farm Nikolaevo, Bulgaria and transported in the experimental base of the Department of Biology and Aquaculture, Trakia University. The weight of the fish ranged 66-68 g.

The experiments were conducted by the method of Stroganov (1962) in closed tanks. The fishes were placed in three liter tanks (diameter 12cm, depth 13 cm). The first tank was control without plants. The second tank was put *Myriophyllum spicatum*, and *Lemna minor* in the third. The experiment was conducted in two stages: before and after eating the fish. In the beginning, 1min, 1 hour was detected a pH, nitrates, temperature and dissolved oxygen. The measurement of pH, dissolved oxygen and temperature was made with a portable combined meter (Hach Lange). Nitrates were measurement with Nitrate meter (HANNA). Fish were maintained in the laboratory in 3 liter holding tanks with de-chlorinated tap water set at 25°C. Light was adjusted to a 16L : 8D cycle and all fish were fed 10% of their body weight with pelleted feed.

Result and Discussion

One of the basic principles of good aquaculture is that the water is well aerated, so that enough dissolved oxygen is available for fish respiration. Dissolved oxygen (DO) is the most fundamental parameter in water. Extremes of DO and pH may develop when respiration and photosynthetic activity are intense (Carpenter and Lodge, 1986).

In the beginning of the experiment conducted before feeding the fish was measured alkaline pH (8.3) with tends reducing to 1 hour (7.6).

The water temperature in the control and experimental tanks was 25.2°C. The dissolved oxygen in the beginning of trial was with the highest value in the control variant - 5.98 (Fig.1). In the first minute and 1 hour the oxygen level decreased in the control tank, and in the 1 hour fell by 80.2% of the initial. A similar trend was observed in the experimental baths with presence of macrophytes. When comparing the level of oxygen in the three tubs from the beginning to the end of the experiment was reported a high content of oxygen in the presence of *L. minor.* Furthermore, the levels of dissolved oxygen in the tank of *L. minor* are with 42.8% higher compared to *M. spicatum*.

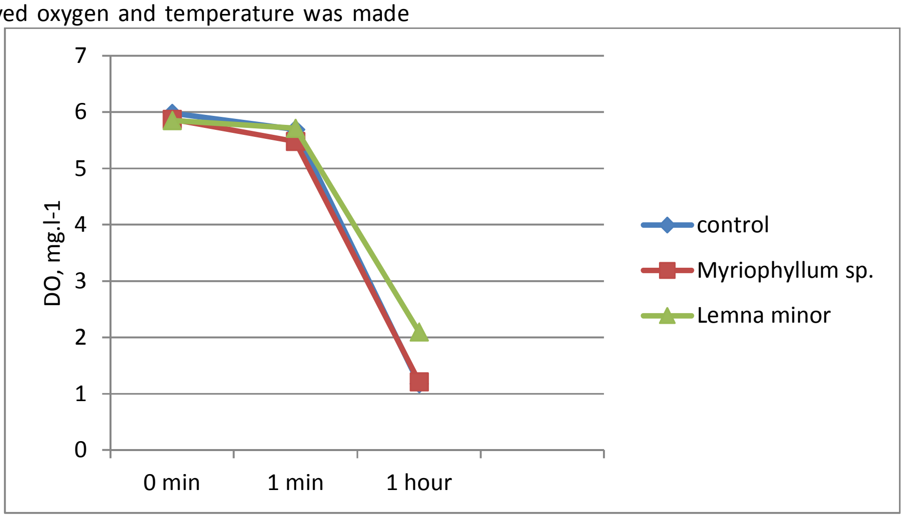

Fig. 1. Dissolved oxygen before feeding the fish.

Dissolved oxygen decreases during feeding the fish. These however, depend on many biotic and abiotic factors (Beamish, 1964; Jobling, 1981, 1993).

During the experiment after fish feeding the pH varied in a narrow range for the three tanks from 8.0 to 8.3. The water temperature in the control and experimental tanks was 25.1 °C. The dissolved oxygen in the beginning of the experiment was with the highest value in the tank containing *L. minor* – 6.03. During the first hour the oxygen level dropped in the control tank with 86.6% compared to the beginning (Fig. 2). The same trend was repeated in the experimental tanks with presence of macrophytes. When comparing the level of oxygen in the three tanks from the beginning to the end of the experiment was reported a high content of oxygen in the presence of *L. minor*. The quantity dissolved oxygen in the tank with *M. spicatum* is with 5.2% more compared to the control tank without macrophytes and with 28.9 % less compared to *L. minor*. In the first hour in the tank with duckweed the level of oxygen was measured by 33.9% higher in comparison to that in the control.

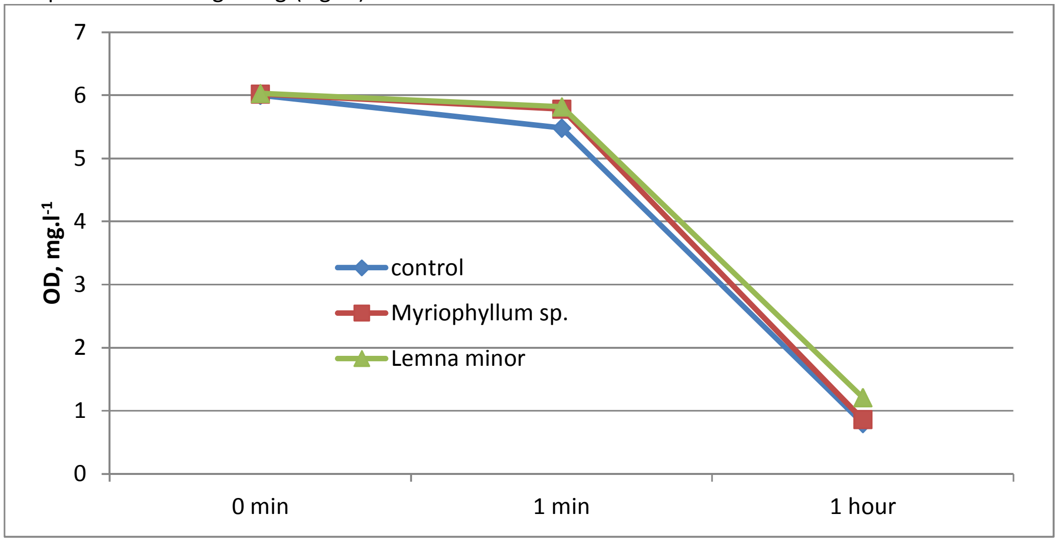

Fig. 2. Dissolved oxygen after feeding the fish.

The level of nitrates after feeding the fish was with a constant value of 0.32 $mg.l^{-1}$.

The first sign there may be a dissolved oxygen problem in the water is when the fish become unusually lethargic and stop feeding. As oxygen levels decrease, the fish do not have enough energy to swim and feeding utilizes yet more oxygen.

Comparing the two stages of the experience we found reduction the quantity of oxygen during feeding. Dissolved oxygen in the water after the feeding of the fish decreases with 32.2% compared to this before feeding.

Conclusion

Macrophytes have a conducive effect on the respiration of fish, because it increases the amount of dissolved oxygen in the water. Dissolved oxygen in the water decreases significantly after feeding the fish. The presence of *L. minor* increases the concentration of dissolved oxygen in feeding of the fish compared to *M. spicatum* with 28.9%. The pH and nitrates was not significantly affected by the presence of macrophytic plants in the tanks.

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