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Original article

Effect of high concentration of dissolved oxygen in the rearing water on the rearing performance and stress response in red sea bream and Japanese eel

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Introduction

In order to keep high performance in the rearing of finfish, it is important to maintain the dissolved oxygen level high. Recently, the system or machine to generate the oxygen supersaturation water has been developed, e.g., Nano-bubble generator [1]. Although some effects of oxygen supersaturation water have already been known [2,3], enough information has not been obtained yet.

This study aimed to clarify the effect of oxygen supersaturation water on the rearing performance of red sea bream and Japanese eel. And the stress reception under oxygen supersaturation was also investigated. The oxygen supersaturation water was generated with the unit for dissolution of high oxygen concentration (Sanso Electronic Co. Ltd., Japan).

Materials and methods

In the rearings, the dissolved oxygen level was adjusted by mixing the oxygen supersaturation water with saturation one in a certain ratio (Fig. 1).

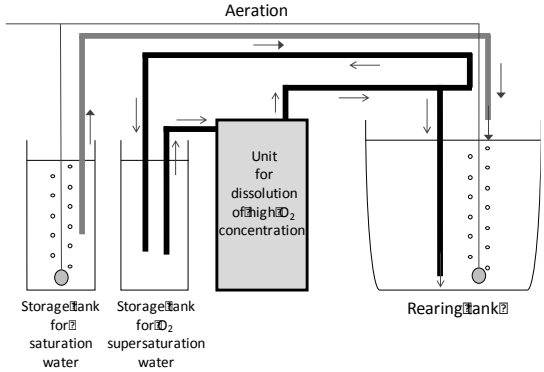

Fig. 1. Schematic overview of the rearing system with the unit for controlling dissolved oxygen level.

In each rearing, three experimental designs, control (100% of O_2 saturation) and two types of supersaturation (125% and 200% of saturation), were set up. To control 125% of saturation level, the generated supersaturation water and saturation one were mixed at the ratio of 1:1. To control 200% of saturation level, only the generated supersaturation water was added to the rearing tank. For rearing tank, 100L of black polyethylene cyclical tanks were prepared. One tank was used for each experimental condition.

Five of red sea bream (104.2 ± 2.3 g ave.wt) was stocked for each tank. The rearing period was 15 days. Water temperature was controlled at 23 °C and salinity was 33 psu. The light and dark cycle was controlled at 12L12D. Fishes were fed twice a day with saturation amount. Body weight was measured at the first, 5th, 10th and last days of rearing.

Five of Japanese eel (21.0 ± 0.7 g ave.wt) was stocked for each tank. The rearing period was 42 days. Water temperature was controlled at 21 °C. Dechlorinated tap water was used as rearing water. The rearing was conducted under dark condition. Fishes were fed once a day with 3.5% of total fish weight. Body weight was measured every 7 days.

At the last day in each rearing, blood was sampled from each experimental fish. The cortisol concentration in the blood was measured using the cortisol measuring kit (Cortisol EIA Kit, Oxford Biomedical Research, MI, USA).

Results

The body weight of red sea bream increased at control and 125% of saturation (Fig. 2). On the other hand, fishes exposed to 200% of saturation did not change their weight during the rearing period. The growth of body weight significantly differed between 125% and 200% of saturation (2way ANOVA, $P < 0.05$).

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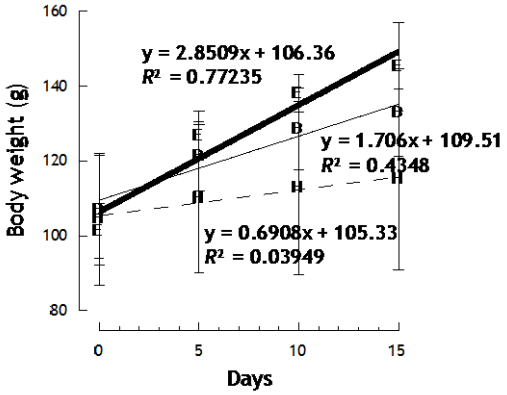

Fig. 2. Growth of red sea bream under the different oxygen saturations. Each plot indicates the average of 5 fishes and each vertical line is its SD. Black squares indicates the result of control (100% saturation), open circle 125% saturation and black triangle 200% saturation. Thin line indicates the approximate line of the result of control (100% saturation), bold line 125% saturation and dashed line 200% saturation.

The body weight of Japanese eel did not increase in the control (100% saturation; Fig. 3). But it tended to increase under the supersaturations (Fig. 3). There was no significance among conditions.

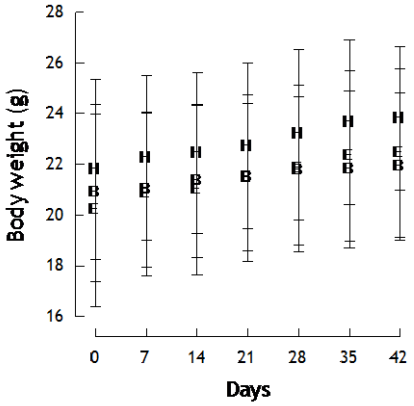

Fig. 3. Growth of Japanese eel under the different oxygen saturations. Each plot indicates the average of 5 fishes and each vertical line is its SD. Black squares indicates the result of control (100% saturation), open circle 125% saturation and black triangle 200% saturation.

The cortisol concentration in the blood of red sea bream was the highest in the 125% saturation and the lowest in the control (Table 1, $P < 0.05$). On the other hand, that of Japanese eel was the highest in the 200% saturation and the lowest in the control.

Table 1. Cortisol concentration in the blood (ng/mL) of fishes sampled at the last day of the rearings.

Fish species	Oxygen saturation level		
	100% (control)	125%	200%
Red sea bream	5.6 ± 5.3 ^{b}	68.0 ± 17.6 ^{a}	43.6 ± 36.4 ^{ab}
Japanese eel	12.7 ± 9.3 ^{b}	29.2 ± 11.4 ^{ab}	44.6 ± 7.6 ^{a}

Values indicate mean ± SD. Each alphabetical subscript indicates the result of a Tukey-Kramer HSD test ($P < 0.05$, a>b).

Discussion

The effect of oxygen supersaturated sea- or freshwater has been known just little [2,3]. Rather, several studies reported on the negative effects of oxygen supersaturation in the wild water [4,5]. In this study, fishes could increase their body weight under oxygen supersaturation except red sea bream in the 200% saturation (Fig. 2). On the other hand, fishes also increased their cortisol concentration in the blood under the supersaturation (Table 1). Generally, the cortisol concentration in the blood is measured as the indicator of stress in fish [6]. Therefore, we can conclude that fishes received the stress under oxygen supersaturation.

Moreover, this means that some fishes in this study gained their body weight under the stress acceptance. Negative growth is commonly observed during stress [7]. However, mild-stress can lead to gaining the body weight of mice [8]. If the oxygen supersaturation is a mild-stress for red sea bream and/or Japanese eel, it might have resulted in the gain of body weight of fishes. But, like 200% saturation in red sea bream, too much supersaturation consequently could give over-dose of stress to fishes and they might reduce the body weight.

In further studies, moderate oxygen saturation level for each aquacultural species and that other physiological effect should be investigated.

Acknowledgements

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