Respiratory responses and tolerance to hypoxia in two marine teleosts, *Epinephelus akaara* (Temminck & Schlegel) and *Mylio macrocephalus* (Basilewsky)

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Abstract

The respiratory responses and tolerance of hypoxia were studied in two marine teleosts, the red grouper (*Epinephelus akaara*, a sluggish species) and the black sea bream (*Mylio macrocephalus*, an active species). Neither species showed abnormal behaviour or mortality when exposed to 2 mg O₂ l⁻¹ for 7 h. The black sea bream was, however, comparatively more tolerant when exposed to 1 mg O₂ l⁻¹, but tolerance of both species became similar under extremely hypoxic conditions (i.e. 0.5 mg O₂ l⁻¹). In contrast to most other teleosts, both species showed a reduction in opercular beating rate during hypoxia, and oxygen conformity was found in the range of 0.5 to 7.0 mg O₂ l⁻¹. O₂ dissociation curves were constructed, and the P₅₀ value of the black sea breams (27 ± 5.6 mm Hg) was found to be much lower than that of the red groupers (50 ± 2.5 mm Hg). For both species, the general levels of venous PO₂ showed a direct relationship to ambient PO₂, and were markedly reduced after 1 h exposure to various levels of hypoxia. Compared with the red groupers, the black sea breams appeared to be more able to maintain its venous PO₂ levels during prolonged hypoxic exposure.

Introduction

The great majority of the studies on response of fish to hypoxia has been concentrated on changes in cardiovascular and respiratory physiology of freshwater and euryhaline species; and it has been well established that hypoxia has a pronounced effect on the behavioural, physiological and biochemical responses of freshwater fish (Davis, 1975). For example, hypoxia causes bradycardia and an increase in ventilatory rate and stroke volume of the heart (for a review see Randall, 1970). The tolerance limit to hypoxia in fish, however, remains poorly known (Vernberg, 1970), and effects of hypoxia have only been studied in comparatively few marine species, for example, in the dragonet *Callionymus lyra* (Hughes & Ballintijn, 1968), the pile perch *Rhacochilus vacca* (Webb & Brett, 1972), the starry flounder *Platichthys stellatus* (Watters & Smith, 1973) and the Atlantic menhaden *Brevoortia tyrannus* and spot *Leiostomus xanthurus* (Burton et al., 1980). Moreover, differences in experimental conditions between studies make it difficult to compare the tolerance and responses between species (Davis, 1975).

The present study was designed to compare the tolerance and respiratory responses to hypoxia of two marine teleosts, the red grouper *Epinephelus akaara* and the black sea bream *Mylio macrocephalus*. These two species were selected for this study because they are common cultured species in Hong Kong. Overstocking, algal blooms and red tides often lead to oxygen depletion and hence fish kills at the culture sites. In these incidents, the red grouper was often found to be the first victim while the black sea bream was often the least affected (Wu, pers. obs.).
Materials and methods

Setup of a continuous flow system with a constant level of dissolved oxygen

A continuous flow system was set up (Fig. 1) to provide constant, controlled levels of ambient dissolved oxygen throughout the entire experimental period. The system consisted of a sea water reservoir (500 l) connected to eight plexiglas experimental tanks (30 l each). Sea water (30%) was pumped from the reservoir to the experimental tanks by a submersible pump (pumping rate: 40 l min⁻¹), and the water was drained back to the reservoir after overflowing the experimental tanks. Red groupers (Epinephelus akaara) of 281 ± 19 g (x ± SEM) and black sea breams (Mylio macrocephalus) of 254 ± 14 g were obtained from a local culturist, and were acclimated in the experimental tanks for 24 h prior to experiments. Fully aerated seawater (8.0 to 8.5 mg O₂ l⁻¹) was provided during acclimation. At the start of the experiments, the level of dissolved oxygen in the system was adjusted to the desired level by bubbling pure nitrogen/oxygen into the reservoir and the experimental tanks through a series of air stones. The time required to bring the dissolved oxygen level in the system down from 8 mg O₂ l⁻¹ to 4 and 1 mg O₂ l⁻¹ was about 5 and 15 min. respectively. The levels of dissolved oxygen entering and leaving the experimental tank series were continuously monitored by two O₂ electrodes (WTW OXI DIGI 88). Throughout the experimental period, the level of dissolved oxygen in the system was maintained within ± 0.1 mg O₂ l⁻¹ of the desired level by bubbling nitrogen or oxygen into the systems. When low levels of dissolved oxygen (i.e. 0.5 and 1 mg O₂ l⁻¹) were required, the water surfaces of the experimental tanks and the reservoir were sealed by polythene sheets to cut down oxygen diffusion. In all experiments, the water temperature was kept at 25 ± 0.5 °C.

Effects of ambient O₂ on behaviour and survival

Twenty fish were introduced into the experimental tanks of the continuous flow system, and were