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Balancing the competing requirements of air-breathing and display behaviour during male-male interactions in Siamese fighting fish *Betta splendens*

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Abstract:

Air-breathing fish of the Anabantoidei group meet their metabolic requirements for oxygen through both, aerial and aquatic gas exchange. Siamese fighting fish *Betta splendens* are anabantoids that frequently engage in aggressive male-male interactions which cause significant increases in metabolic rate and oxygen requirements. These interactions involve opercular flaring behaviour that is thought to limit aquatic oxygen uptake, and combines with the increase in metabolic rate to cause an increase in air-breathing behaviour. Air-breathing events interrupt display behaviour and increase risk of predation, raising the question of how Siamese fighting fish manage their oxygen requirements during agonistic encounters. Using open-flow respirometry, we measured rate of oxygen consumption in displaying fish to determine if males increase oxygen uptake per breath to minimise visits to the surface, or increase their reliance on aquatic oxygen uptake. We found that the increased oxygen requirements of Siamese fighting fish during display behaviour were met by increased oxygen uptake form the air with no significant changes in aquatic oxygen uptake. The increased aerial oxygen uptake was achieved almost entirely by an increase in air-breathing frequency. We conclude that limitations imposed by the reduced gill surface area of air-breathing fish restrict the ability of Siamese fighting fish to increase aquatic uptake, and limitations of the air-breathing organ of anabantoids largely restrict their capacity to increase oxygen uptake per breath. The resulting need to increase surfacing frequency during metabolically demanding agonistic encounters has presumably contributed to the evolution of the stereotyped surfacing behaviour seen during male-male interactions, during which one of the fish will lead the other to the surface, and each will take a breath of air.

Keywords: agonistic behaviour, bimodal gas exchange, metabolic rate, opercular flaring, aquatic O_2