REGULATION OF CARDIORESPIRATORY REFLEXES

IN THE TROPICAL FISH TAMBAQUÍ (*COLOSSOMA MACROPOMUM*):

O_2 CHEMOSSENSITIVITY

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EXTENDED ABSTRACT ONLY - DO NOT CITE

The present study examined the location and physiological roles of branchial and extra-branchial O_2 chemoreceptors in a neotropical aquatic surface breather, the tambaquí (*Colossoma macropomum*), that skims the upper well-oxygenated surface water layer (aquatic surface respiration - ASR) during periods of hypoxia in the bulk water. During ASR the inferior lip swells and acts as a funnel directing the surface well-oxygenated water through the gills.

Animal preparation

Fish were anaesthetized in a solution of benzocaine (100 mg/L). After achieving a surgical level of anesthesia, impedance electrodes were sutured to each operculum in order to monitor the breath by breath displacement of the operculum and measure ventilation rate (f_V) and an index of ventilation amplitude (V_{AMP}). A catheter was inserted in the mouth cavity allowing the administration of NaCN solution into the buccal cavity in order to stimulate putative O_2 chemoreceptors (external) on the gills monitoring the respiratory water. A second cannula was inserted into the afferent

branchial arch artery of the 3rd. gill arch and advanced towards the ventral aorta. This cannula served to measure ventral aortic blood pressure (P_{VA}) and heart rate (f_H) as well as to inject solutions of saline and NaCN to stimulate putative O_2 chemoreceptors (internal) that monitor the blood. For branchial denervation, the cranial nerves were accessed and the nerve IX (glossofaryngeal) and the pretrematic branch of the cranial nerve X (vagus) inervating the first gill arch (G1 group, n = 11) were sectioned. For complete denervation the branchial nerves to all gill arches were sectioned. In all cases, the cardiac and visceral branches of the vagus (X) were left intact. Animals were allowed to recover for a minimum of 24 hours prior to experimentation.

Experimental protocol

First the fish were subjected to a series of internal and external injections of NaCN to stimulate putative O_2 chemoreceptors. Injections of the vehicle alone (saline for internal and water for external injections) served as controls. The injections were administered in the following order: 1. internal saline, 2. internal NaCN, 3. external water and 4. external NaCN. After each injection, cardiorespiratory variables were recorded for 3 min. Next, the animals were subjected to progressive environmental hypoxia, from an air-saturated level of 18.6 kPa (140 mmHg, 25 C) to 1.3 kPa (10 mmHg) over approximately a 10 min. time period. At this point the water PO_2 was allowed to gradually return to normoxic levels. Due to a persistent decrease in f_H during hypoxia in the G4 group, these fish were subsequently treated with atropine and run a second time to test for direct effects of hypoxia and NaCN on the heart. The effects of denervation on the degree of inferior lips swelling and the incidence of ASR were also monitored visually in the intact and G4 groups of fish when exposed to environmental hypoxia for approximately 3.5 hours.

Results and Discussion

Hypoxia produced a significant bradycardia as well as increases in f_V and V_{AMP}. The bilateral denervation of the 1st gill arch did not eliminate any of the reflex responses. The reflex bradycardia presented by tambaqui is a typical response in fish, but in contrast to most teleost, where this reflex arises from receptors located on the 1st gill arch, in this species this reflex could only be abolished by denervation of the IX and X cranial nerves to all of gill arches. When all gill arches were denervated only the reflex increase in V_{AMP} remained. Together with the results of the NaCN injection experiments, the data suggest that there are hypoxia-sensitive receptors that are 1)

both internally and externally oriented and located within the gills, possibly on all gill arches, that elicit a reflex bradycardia and increase in ventilation rate, 2) primarily internal and extra-branchial (central ?), but also external branchial and extra-branchial that elicit increases in V_{AMP}. When the nerves to all gill arches were sectioned, the fish still performed ASR and began to develop swelling of the lower lip in response to hypoxia. The degree of swelling was, however, attenuated. This suggests that there are extra-branchial, and possibly branchial hypoxia sensitive receptors, that induce ASR and swelling of the inferior lip.

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