PERIPHERAL CO_2 CHEMORECEPTORS IN FISH:

DO THEY REALLY EXIST?

W.K. Milsom

Department of Zoology, University of British Columbia, 6270 University Blvd., Vancouver, B.C., Canada, V6T 1Z4

Lena Sundin[1], Stephen G. Reid[2], and F. Tadeu Rantin[3]
[1]Department of Zoophysiology, University of Göteborg, Sweden
[2]Division of Life Sciences, University of Toronto, Scarborough, Canada
[3]Department of Physiological Sciences, UFSCar, São Carlos, SP, Brasil

EXTENDED ABSTRACT ONLY- DO NOT CITE

In this report we examine the question of whether there are chemoreceptors in fish that are specifically responsive to changes in the CO_2 partial pressure of water or blood based on recent data from denervation studies performed on two species of neotropical fish; the traira (*Hoplias malabaricus*) and the tambaqui (*Colossoma macropomum*) (Sundin et al., 1999; Reid et al., 2000, Sundin et al., 2000, Milsom et al., 2002).

In traira, there are receptors on the first gill arch that reflexively mediate a bradycardia in response to changes in O_2 and CO_2 as well as receptors found within the other gill arches sensitive to CO_2 alone that also produce this response. In the tambaqui, the distribution of chemoreceptors is reversed. Here the receptors involved in producing the hypercarbic bradycardia are confined to the first gill arch while those involved in producing the hypoxic bradycardia are located possibly on all gill arches (Table 1).

The receptors involved in producing increases in breathing frequency in traira in response to hypercarbia appear to have a similar distribution to those involved in producing the increases in breathing frequency in response to hypoxia. In tambaqui, however, there is also a group of CO_2 sensitive receptors that stimulate breathing frequency in response to hypercarbia that appear to be located outside the gills and orobranchial cavity (Table 1).

The receptors involved in producing increases in breathing amplitude in response to hypercarbia also appear to have a similar distribution to those involved in producing the increases in breathing amplitude in response to hypoxia in traira but not tambaqui. The amplitude response to hypercarbia in tambaqui is highly variable but some individuals exhibit strong responses. These responses arise exclusively from receptors in the gills while the amplitude response to hypoxia in tambaqui also involves extrabranchial receptors (Table 1).

Most recently we have found also that there appear to be receptors present, possibly in the olfactory epithelium in tambaqui which, when stimulated by hypercarbia, inhibit ventilation.

The cases where only hypoxic or hypercarbic responses could be elicited from a particular site indirectly support the possibility of there being distinct peripheral CO_2 chemoreceptors and O_2 chemoreceptors in fish

In cases where hypoxic and hypercarbic responses arise from receptors at overlapping sites, it is possible that one common population of receptors, which can be stimulated by changes in both O_2 and CO_2, reflexively mediate the responses to changes in both gases, as is the case in the mammalian carotid body. It is also possible that, although the same receptors are involved in producing both sets of responses, the response to changes in CO_2 is a consequence of their effect on the O_2 carrying capacity of the blood. It has been suggested that CO_2 could act via changes in O_2 content due to Bohr and Root effects on haemoglobin binding of oxygen. This seems unlikely in the present scenario, however, given that the ventilatory response to hypoxia in traira, and the hypercarbic ventilatory response of tambaqui primarily involves changes in gas tensions in the water and not the blood. Yet another possibility based on the fact there are receptors at sites where only responses to CO_2 or O_2 could be elicited, is that the receptors involved in producing each response (to hypoxia and hypercarbia) belong to distinct chemoreceptor groups.

Thus, while there is extensive overlap in the receptor sites from which hypoxic and hypercarbic cardio-respiratory reflexes can be elicited, there is growing evidence to suggest that the distribution of receptors involved in each are not identical. Viewed subjectively, this evidence is not overwhelming since the differences often appear to be more quantitative than qualitative. Still, the data indirectly support the possibility of there being distinct peripheral CO_2

chemoreceptors in fish but true resolution will require single fibre recordings from each putative receptor site.

References

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Table 1: Location, innervation and orientation of chemoreceptors involved in cardio-respiratory reflexes in traira and tambaqui.

	Traira		Tambaqui	
	Hypoxia	Hypercarbia	Hypoxia	Hypercarbia
Bradycardia				
Receptor Location	First Gill Arch	All Gill Arches	All Gill Arches	First Gill Arch
Receptor Innervation	IX and X	IX and X	IX and X	IX and X
Receptor Orientation	Internal	???	Internal and External	???
Increased Respiratory Frequency				
Receptor Location	All Gill Arches	All Gill Arches	All Gill Arches	All Gill Arches + Extra Branchial Receptors
Receptor Innervation	IX and X	IX and X	IX and X	IX and X + ???

Receptor Orientation	External	???	Internal and External	External
Increased Respiratory Amplitude				
Receptor Location	All Gill Arches + Extra Branchial Receptors	All Gill Arches + Extra Branchial Receptors (some fish)	All Gill Arches + Extra Branchial Receptors	All Gill Arches (some fish)
Receptor Innervation	IX and X + ???	IX and X + ???	V, VII, IX and X	IX and X
Receptor Orientation	External	???	Internal and External	External