

**LIMITED ACID-BASE COMPENSATION DURING ENVIRONMENTAL
HYPERCAPNIA IN THE AMAZONIAN ARMoured CATFISH,
LIPOSARCUS PARDALIS.**

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Introduction

Environmental hypercapnia (elevated environmental CO₂) results in a respiratory acidosis that in many freshwater fish species is compensated within 24-96 h. Recovery is associated predominantly with acid-base relevant ion transfer across the gills, with the kidney playing only a minor role. The most frequently observed response to hypercapnia is a net accumulation of HCO₃⁻ and reduction of Cl⁻ in the plasma, implicating gill Cl⁻/HCO₃⁻ exchange as the specific mechanism for compensation.

In rainbow trout in fresh water, environmental ionic composition has a large influence on both the rate and degree of acid-base compensation following exposure to hypercapnia (Larsen and Jensen, 1997). In “soft water” (40 fold dilution of tap water with deionized water), pH compensation following exposure to 1% CO₂ was slow and incomplete following 72 h. However, following addition of HCO₃⁻, Ca²⁺ or Cl⁻ to “soft water” the ability of trout to

acid-base compensate was significantly improved. In the case of HCO_3^- addition, the dynamics of pH compensation were not significantly different from that observed in hard water, where almost full compensation was achieved within 24 h.

Waters of the Amazon are characteristically dilute in ions, and in some cases approach that of distilled water (Val and Almeida-Val, 1995). Given the importance of counter ions for acid-base regulation observed in trout, how capable are fishes of the Amazon at compensating for environmental hypercapnia?

The armoured catfish, *Liposarcus pardalis*, lives in stagnant waters within the Amazon basin where they experience large fluctuations in oxygen and carbon dioxide of the water. As a consequence, they are routinely exposed to bouts of environmental hypercapnia in the natural environment, and appear to be quite tolerant of large disturbances in plasma pH (Brauner and Val, 1996). The objective of this study was to investigate the magnitude and degree of pH compensation in *L. pardalis* during exposure to differing levels of hypercapnia (1, 2 and 6% CO_2) in the dilute waters of the Amazon.

Materials and Methods

Liposarcus pardalis were obtained from a commercial fish supplier and held at the National Institute for Research of the Amazon (INPA), Manaus, Brazil, for at least 2 weeks prior to experimentation. Fish were maintained in well water that was vigorously aerated to remove CO_2 , thus raising water pH from 4.1 to 6.5. The water composition was (in μM) Na^+ , 15, Cl^- , 16, K^+ , 9, Ca^{2+} , 9, Mg^{2+} , 2. Fish were anaesthetized with MS 222, and an indwelling catheter was placed in the dorsal aorta according to (Soivio et al., 1975) and fish were left to recover for 24-48 h in black perspex gang boxes.

A submersible pump circulated water from a 200 l reservoir tank to the perspex boxes and water was returned to the reservoir tank resulting in a recirculating system. Blood samples were taken from each fish, and then water in the reservoir tank was bubbled with CO_2 and air to achieve 1, 2 or 6% CO_2 in the water. CO_2 levels stabilized between 30 min-1 h and then blood samples were drawn from the cannulae at 2, 6, 24 and 96 h. Blood pH and total CO_2 in true plasma was measured, and plasma HCO_3^- and PCO_2 were calculated according to the Henderson-Hasselbach equation.

Results and Discussion

When transferred to hypercapnic water of 1, 2 and 6% CO₂, blood pH in *L. pardalis* fell within 2 h from a normocapnic value of 7.90 ± 0.03 to 7.56 ± 0.04 , 7.34 ± 0.05 and 6.99 ± 0.02 , respectively. Over the following 24 h, there were very small increases in plasma HCO₃⁻ levels and blood pH remained low. Thus, arterial pH only increased to 7.57 ± 0.05 , 7.53 ± 0.06 and 7.22 ± 0.03 , at the three respective CO₂ levels. Despite the very blunted degree of acid-base compensation, *L. pardalis* survived exposure to 6% CO₂ for longer than 96 h. The armoured catfish, therefore, appears to be extremely tolerant of changes in extracellular acid-base status. Presumably intracellular acid-base status is more tightly regulated, although these measurements were not conducted in this study. Whether the limited compensation observed in *L. pardalis* is related to the ionic composition of the water remains to be investigated.

References

- Brauner, C. J. and Val, A. L. (1996). The interaction between O₂ and CO₂ exchange in the obligate air breather, *Arapaima gigas*, and the facultative air breather, *Lipossarcus pardalis*. In *Physiology and Biochemistry of the fishes of the Amazon*. (Eds A. L. Val V. M. F. Almeida-Val and D. J. Randall), pp. 101-110. Manaus, Brazil: INPA.
- Larsen, B. K. and Jensen, F. B. (1997). Influence of ionic composition on acid-base regulation in rainbow trout (*Oncorhynchus mykiss*) exposed to environmental hypercapnia. *Fish Physiology and Biochemistry* 16, 157-170.
- Soivio, A., Nyholm, K. and Westman, K. (1975). A technique for repeated sampling of the blood of individual resting fish. *Journal of Experimental Biology* 63, 207-217.
- Val, A. L. and Almeida-Val, V. M. F. (1995). *Fishes of the Amazon and Their Environment: Physiological and Biochemical Aspects*. Berlin: Springer-Verlag.

