ION FLUXES OF *Metynnis hypsauchen*, A TELEOST FROM THE RIO NEGRO, AMAZON, EXPOSED TO AN INCREASE OF TEMPERATURE

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(With 2 figures)

ABSTRACT

The aim of this study was to investigate the effect on an increase of temperature on the net ion fluxes on *Metynnis hypsauchen*, a teleost species from the Rio Negro. Fish were collected in the Anavilhanas archipelago, Rio Negro, Amazon. After 24 h adaptation fish were placed in individual chambers served with a steady flow of recirculated water. Na^+ and Cl^- fluxes were determined at 26 and 33°C. After 18 h in the chambers, fish presented an influx of Na^+ and Cl^-, and the temperature raise to 33°C led to an efflux of both ions, which remained even after 6 h in this temperature. Six hours were not enough to promote a significant reduction of net ion effluxes, but certainly the fluxes would be in net balance after a longer period of time, since this species can be exposed to this temperature in its natural environment.

Key words: *Metynnis hypsauchen*, temperature, ion fluxes.

RESUMO

Fluxos iônicos em *Metynnis hypsauchen*, um teleósteo do rio Negro, Amazonas, exposto a aumento de temperatura

O objetivo deste trabalho foi verificar o efeito do aumento de temperatura nos fluxos iônicos de *Metynnis hypsauchen*, uma espécie de teleósteo do Rio Negro, Amazonas. Os peixes foram coletados no arquipélago de Anavilhanas, Rio Negro, Amazonas. Após adaptação de 24 h, os peixes foram colocados em câmaras individuais com fluxo constante de água recirculada. Os fluxos de Na^+ e Cl^- foram determinados a 26 e 33°C. Após 18 h nas câmaras, os peixes apresentaram influxo de Na^+ e Cl^-, e o aumento da temperatura para 33°C provocou efluxo de ambos os íons, o qual se manteve mesmo depois de 6 h nessa temperatura. Seis horas não foram suficientes para promover redução significativa dos efluxos iônicos, mas certamente esses fluxos atingiriam equilíbrio após um período mais prolongado, uma vez que essa espécie é regularmente exposta a essa temperatura em seu ambiente natural.

Palavras-chave: *Metynnis hypsauchen*, temperatura, fluxos iônicos.

INTRODUCTION

Fish of the Rio Negro, a tributary of the Amazon River, are exposed to extremely dilute waters, low pH and buffering capacity, and large amounts of organic compounds (Furch, 1984). The mechanisms involved in the resistance of these fishes to such water seems to be a high branchial affinity for Ca^{++} or some interaction of the organic compounds to the branchial tight junctions, both avoiding the increase of branchial ion permeability (Gonzalez *et al.*, 1998).

Temperature changes alter the noncovalent forces that stabilize biological membranes and interactions among proteins (Hazel, 1993), and apparently influence branchial ion permeability in rainbow and lake trout (Gonzalez & McDonald, 1994). Therefore, the aim of this study was to investigate the net ion fluxes on *Metynnis hypsauchen*, a teleost species from the Rio Negro, when exposed to an increase of temperature.

MATERIAL AND METHODS

Specimens of *Metynnis hypsauchen* (Serrasalmidae) (40-120 g) were collected with drift nets in the Anavilhanas archipelago, Rio Negro, Amazon. Fish were kept without feeding in a running 1,000 L freshwater tank (27-28°C) for at least 24 h. Measured water composition was (in $\mu M\ L^{-1}$): Na^+, 12.3; Cl^-, 34.9; pH 6.37.

After adaptation fish were placed in individual chambers (850 ml) served with a flow of 110 ml min^{-1} of recirculated water. The fish chambers were housed on a wet table that drained water back into the recirculation reservoir. Total volume of the system, serving a maximum of 4 fish, was 50 L. The chambers were operated as closed systems (with aeration) for 120 min at 2, 6, and 18 h after the transference of the fish. Water samples (5 ml) were taken at the beginning and end of this time for analysis of Na^+ and Cl^- concentrations.

In another series of experiments, fish were maintained 18 h in the chambers before collecting water samples for analysis of Na^+ and Cl^- concentrations as explained before. After the first collection, temperature was raised from 26°C at about 1°C h^{-1} (rate of temperature increase suggested by Elliott, 1991) to a final temperature of 33°C (*M. hypsauchen* died at higher temperatures in this experiment). Water samples were collected when temperature reached 33°C and six hours later. Na^+ concentrations were measured with a B262 flame spectrophotometer (Micronal), and Cl^- concentrations were measured by the colorimetric assay of Zall *et al.* (1956). Ion fluxes were calculated according to Gonzalez *et al.* (1998).

Temperature and oxygen measurements in the Rio Negro were determined with an oxygen meter YSI, model 55. The measurements were made near the drift nets in the Lago do Prato, Anavilhanas archipelago, at several depths, and every 4 h for one day.

Homogeneity of variances was verified by the Bartlett test, and net ion fluxes at different times were compared by one-way analysis of variance and Tukey test, with the aid of the GraphPad Instat program (version 2.05a). Data were expressed as mean ± SEM, and the minimum significance level was $p < 0.05$.

RESULTS AND DISCUSSION

Oxygen levels usually were in the 5.0-6.5 mg/L range, and temperature range was 29.7-34.3°C. Higher oxygen levels and temperature were observed at 12:00-16:00 h, while lower values were determined at 4:00 h. Depth of water column did not influence temperature, but oxygen levels were 0.3-1.0 mg/L higher at surface than bottom (0.5-1.0 m).

There was a net loss of Na^+ and Cl^- in the first 6 h of maintenance of *M. hypsauchen* in the chambers. After 18 h a slight influx of these ions could be detected (Fig. 1). In the other experiment, after 18 h (control) there was also an influx of Na^+ and Cl^-, and the temperature raise to 33°C led to an efflux of both ions, which remained even after 6 h in this temperature (Fig. 2).

The Na^+ and Cl^- effluxes observed at the first hours after confinement of *M. hypsauchen* in the chambers was expected, since stress of handling or confinement led to an increase of branchial ion efflux in some teleosts species (McDonald *et al.*, 1991).

The augmentation of temperature to 33°C increased net Na^+ and Cl^- efflux in *M. hypsauchen*. An increase in water temperature increased gill ventilation and heart rate in some teleosts (Hazel, 1993; Fernandes *et al.*, 1999).

The increase of these physiological parameters could lead to an elevation of the branchial perfusion pressure, promoting an increase of the lamellar flow, and a higher oxygen uptake. Both situations can promote an augmentation of ion loss (Gonzalez & McDonald, 1992, 1994). An increase of Na^+ loss was also observed in *Oncorhynchus mykiss* and lake trout after an increase of water temperature from 10 to 18°C. However, since there was a much greater effect of temperature on Na^+ efflux than on oxygen uptake, the authors supposed that the highest temperature could affect the gill epithelial membrane (Gonzalez & McDonald, 1994). Perhaps the same mechanism would be responsible for the increase of ion effluxes in *M. hypsauchen* at 33°C. Six hours were not enough to promote a significant reduction of net ion effluxes, but certainly the fluxes would be in net balance after a longer period of time, since this species can be exposed to this temperature in its natural environment. The maintenance of the ion effluxes at this level would lead to the death of the fish in a few days. Additional studies are needed to solve these doubts.

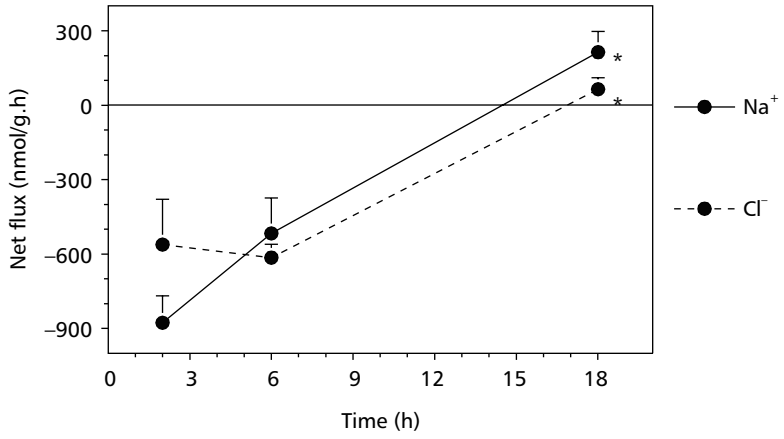

Fig. 1 — Net Na^+ and Cl^- fluxes of *Metynnis hypsauchen* as a function of time after maintenance in the chambers. Asterisks indicate significant difference of fluxes ($p < 0.05$) at 18 h from previous measurements.

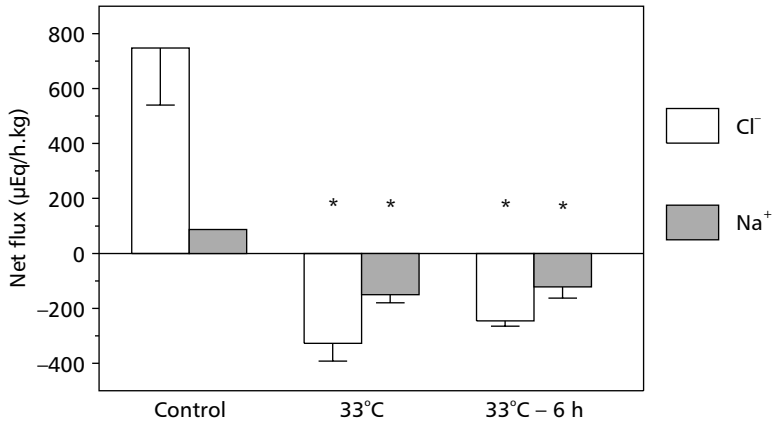

Fig. 2 — Effect of temperature on net Na^+ and Cl^- fluxes of *Metynnis hypsauchen*. Asterisks indicate significant difference ($p < 0.05$) from control.

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