ACID-BASE TRANSFERS IN THE LONG-HORNED SCULPIN (MYOXOCEPHALUS OCTODECIMSPINOSUS) FOLLOWING ACID INFUSION: EFFECT OF LOW EXTERNAL CHLORIDE

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Long horned sculpin (Myoxocephalus octodecimspinosus) can excrete an infused acid load over 12-24 h when in seawater or dilute (20%) seawater, but the excretion is impaired when external [Na^+] is reduced (Claiborne, Perry, & Bellows, Bull. MDIBL 32:95-97, 1993). Surprisingly, net HCO_3^- loss to the water increased during the low Na^+ period. We have hypothesized that both presumed acid-base transfers (Na^+/H^+, and Cl^-/HCO_3^- exchange; Evans, in "Fish Physiology", eds. W. S. Hoar & D. J. Randall, Vol Xb, pp. 239-283, 1984) were active in the sculpin gill and that Cl^-/HCO_3^- exchange was revealed only when Na^+/H^+ transfer was inhibited by low external [Na^+] (Claiborne et al., 1993, ibid.; Claiborne & Perry, Bull. MDIBL 30:107-108, 1991). To investigate the role of potential Cl^-/HCO_3^- transfer mechanisms in these fish, we have studied acid-base transfers in animals exposed to low external [Cl^-] (<1% of normal seawater) following acid infusion (2 meq kg^{-1} HCl).

Long-horned sculpin (Myoxocephalus octodecimspinosus) were pre-adapted for 7-13 days in 20% seawater and then cannulated and placed in experimental chambers according to the methods of Claiborne, Walton & Compton-McCullough (J. Exp. Biol., in press, 1994) and Claiborne & Perry (Bull. MDIBL 31:54-56, 1992). The infusion protocol followed the methods described by Claiborne et al.(1993, ibid.) except that water Cl^- rather than Na^+ was substituted with 100 mM sodium isethionate (final [Cl^-]: 1.5 ± 0.6 mM, mean ± S.E., n=5).

Figure 1 shows the transfer rates of NH_4^+, HCO_3^-, and H^+ between the fish and the ambient water measured over the pre-infusion, post-infusion (low Cl^-; 4 h), and recovery (9 h) periods. ΔNH_4^+ increased both during and after the low Cl^- period. ΔHCO_3^- loss was reversed to an uptake during the low Cl^- period and then returned to a reduced excretion once again during

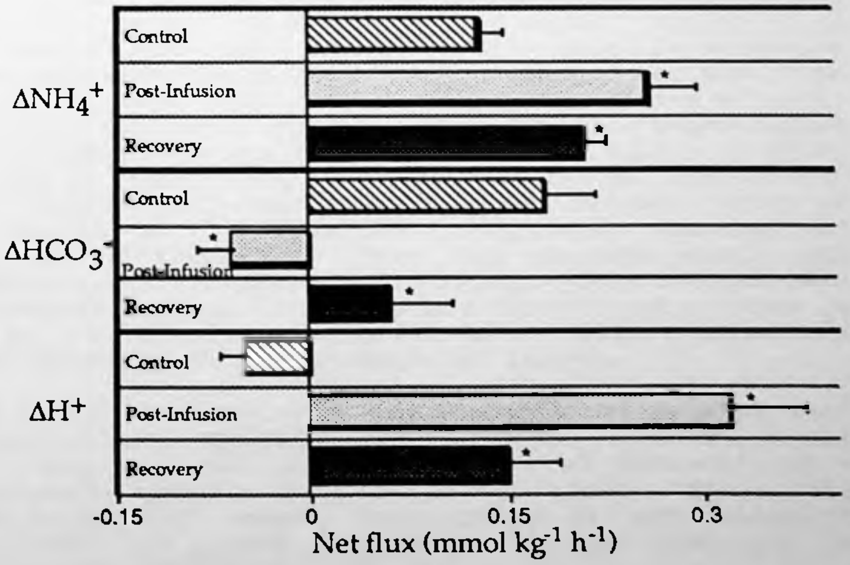

Figure 1. Transfer rates of NH_4^+, HCO_3^-, and H^+ (mmol kg^{-1} h^{-1}) before (Pre-infusion;), immediately after (Post-infusion), and then 13 h after (Recovery) an acid infusion in fish which were pre-adapted to 20% (~100 mM NaCl) seawater. During the Post-infusion period the fish were exposed to 100 mM sodium isethionate (low Cl^-). A positive transfer rate indicates a net efflux from the animal. mean ± S.E., n=5; *: flux is significantly different from the Pre-infusion value.

the recovery. The sum of these transfers resulted in a large positive ΔH^+ (excretion) of 0.32 ± 0.06 mmol kg^{-1} hr^{-1} during the post-infusion period. When the external Cl^- was restored in the recovery period, H^+ excretion continued. Thus, during the 4 h low Cl^- exposure, the animals exhibited a net (post-infusion minus control) H^+ excretion of ~1.5 meq kg^{-1} which amounted to ~75% of the infused load. When ambient Cl^- was again available, the rate of net H^+ loss was reduced, but an additional 1.8 meq kg^{-1} of acid was still lost during the subsequent 9 h recovery period.

Interestingly, the rate of net H^+ loss during the Post-infusion period (~100 mM Na^+, 1.5 mM external Cl^-) was >50% higher than that measured in animals which were allowed to remain in 20% seawater (~100 mM NaCl; Claiborne et al., 1993, ibid.) and even 15% higher than in seawater adapted animals (Claiborne & Perry, 1992, ibid.). Thus, a reduction in available ambient Cl^- increased the ability of the sculpin to excrete the administered acid load. These data support our hypothesis that a transbranchial Cl^-/HCO_3^- exchange (Cl^- influx for HCO_3^- efflux) is operating in opposition to a gill Na^+/H^+ transfer (Na^+ influx for H^+ efflux; Claiborne et al., 1993, ibid.) and the loss of HCO_3^- continues even in the face of an internal acidosis as long as significant external Cl^- is available. It is likely that these transfers are responsible for the rapid and sometimes lethal loss of HCO_3^- to the water observed in this species as it is exposed to dilutions greater than 20% seawater (Claiborne, Walton & Compton-McCullough, 1994, ibid.). It remains to be seen whether these transfers can be regulated by the animal, or if the persistent base loss is an important limitation to true euryhaline adaptation in the sculpin.

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