PLASMA CHLORIDE CONCENTRATIONS ARE NOT A GOOD MEASURE OF OSMOREGULATORY OR ACID-BASE STATUS IN EELS (OR OTHER FISH?)

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EXTENDED ABSTRACT ONLY- DO NOT CITE

Introduction

Plasma chloride ion concentration is easy to measure and is often used as an indication of osmoregulatory status, on the assumption that it is proportional to total ionic concentration. The plasma sodium minus chloride concentration difference is often used as a rough approximation to strong ion difference (SID). Since changes in SID are largely due to changes in bicarbonate ion concentration, it is used as an indicator of acid-base status. In the European eel, *Anguilla anguilla*, the ratio of plasma sodium to chloride concentrations is variable (Kirsch, 1972). There is an inverse relationship between plasma chloride and bicarbonate concentrations but this is nowhere near enough to account for the variation in sodium to chloride concentration ratio found (Farrell and Lutz, 1975). As part of a study on transfer to sea water of juvenile eels used in the Danish stocking programme, complete analyses of plasma inorganic ion concentrations were carried out with surprising results.

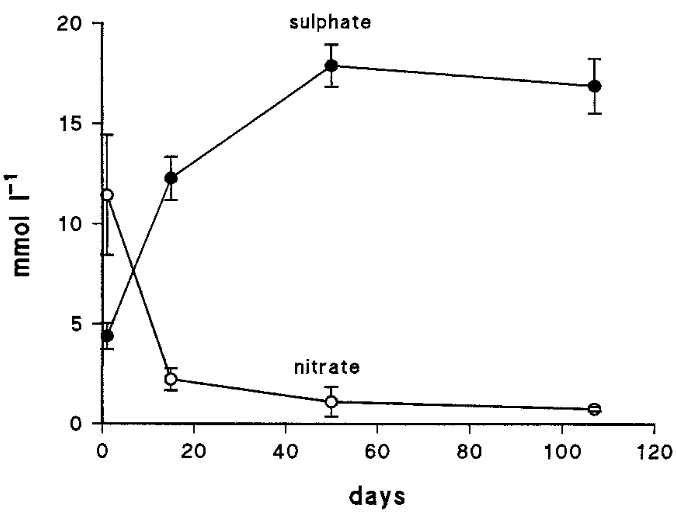
Materials and Methods

Eels were obtained from an eel farm in Jutland where they had been intensively reared in heated, recirculated, oxygenated freshwater. They were acclimated to running freshwater (Kerteminde tapwater) at 15^{o}C. Blood samples were taken from the caudal vessels of eels maintained in freshwater or following acclimation to 28 ppt sea water, and the plasma analysed using a Dionex 4500i ion chromatograph. The freshwater group was found to have very high sulphate concentrations. A fresh batch was obtained from the eel farm and groups sampled the following day and at intervals thereafter.

Results and Discussion

One day after collection the eels were found to have very high plasma nitrate levels. Nitrite concentrations were extremely low or undetectable. Presumably ammonia produced by the eels in the intensive recirculatory rearing system had been converted to nitrite and then nitrate by biological filters. Nitrate concentrations decreased over a period of days, mirrored by an increase in sulphate concentrations, which attained around 35mequiv. l^{-1} after 50 days (fig. 1)

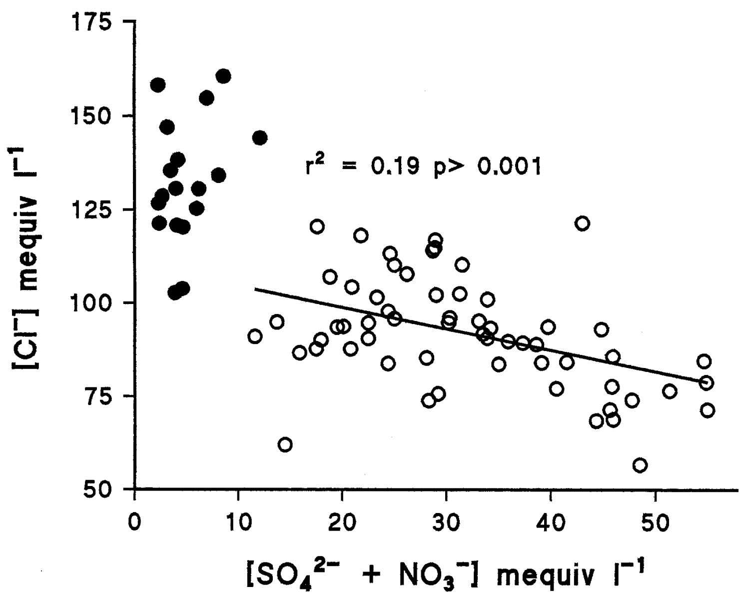
Figure 1. plasma nitrate and sulphate concentrations.



There was a significant negative correlation between plasma chloride and sulphate concentrations in freshwater eels (r^2 = 0.1, p<0.05). There was an even better correlation between sulphate + nitrate and chloride concentrations (r^2 =

0,19, p<0.001; fig. 2). Following transfer to sea water, plasma chloride concentrations rose and sulphate concentrations fell rapidly There was no correlation between plasma chloride and sulphate or sulphate + nitrate concentrations in plasma from sea water eels (solid circles, fig. 2)

Figure 2. Relationship between plasma chloride and sulphate + nitrate concentrations.



Plasma ion levels in a population of wild eels from the rivers Loire and Nive in France were also measured. In freshwater plasma chloride was 58.4 ± 16.5 and sulphate 19.1 ± 10.2 mmol l^{-1} (means ± standard deviations to illustrate variability, n = 32). The highest sulphate concentration found was 40.3 mmol l^{-1} (80.6 mequiv l^{-1}). Plasma nitrate concentrations were low (< 1 mmol l^{-1}) but inorganic phosphate was high (8.6 ± 3.7 mmol l^{-1}). A group of these fish was transferred to sea water and after 1 month the following plasma concentrations were found: chloride 142.7 ± 16.5; sulphate 7.8 ± 1.6; inorganic phosphate 4.0 ± 2.2 mmol l^{-1} (means ± SDs, n = 13).

The eels in the present study were all starved. A number of studies (e.g. Goss and Perry 1994) have shown no measurable uptake of chloride across the gills of the American eel, *Anguilla rostrata*. Presumably the slow losses of chloride across the gills and in the urine are normally balanced by dietary uptake. The present study shows that chloride can be partially replaced by other ions, including sulphate, nitrate and inorganic phosphate. How these enter the blood from the water or from tissue breakdown is unknown.

Plasma chloride concentration is obviously useless as an indicator of osmoregulatory or acid-base status in the eel. Could the same apply to other fish? In freshwater-acclimated American shad, *Alosa sapidissima*, plasma chloride concentration at winter (non-feeding) temperatures fell to 38mM compared to 93mM in fish maintained at 24^{o}C (Zydlewski and McCormick, 1997). Since osmolality only fell from 318 to 288 mOsm kg^{-1} something must presumably have been replacing chloride. In rainbow trout over a third of the plasma chloride was replaced by bromide after 2 weeks in freshwater (1.39mM chloride) with 1mM bromide added (Stormer et al, 1996). Teleosts seem to be able to substitute plasma chloride with other ions to a considerable degree without apparent ill effects. This should be borne in mind when interpreting measurements of plasma chloride concentrations.

References

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Acknowledgements

This work was supported by the Elisabeth og Knud Petersens Fond and European Union grant Q5RS-2001-018369.