Sodium Metabolism of the Freshwater Cyprinodont, *Fundulus catenatus*

Douglas W. Duff and W. R. Fleming

Division of Biological Sciences, University of Missouri, Columbia, Missouri, U.S.A.

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Summary. 1. Transfer of the freshwater cyprinodont, *Fundulus catenatus*, into 40 % sea water caused a slow rise in serum sodium levels, total body sodium, and the rate of sodium efflux.

2. Serum sodium levels were first reduced by expanding sodium space. In some cases the animals eventually brought sodium parameters (except efflux) back to fresh water levels; in other cases the sodium space remained expanded.

3. Transfer of animals adapted to 40 % sea water on to 52 % or 65 % sea water caused a second rise in the sodium load and expansion of the sodium space. The animals could not survive indefinitely in 65 % sea water.

4. Water permeability first decreased, and then increased after transfer into saline. The changes in water permeability correlated roughly with changes in serum cortisol levels.

5. The animals remained hyposmotic to the environment in both 40 % and 65 % sea water and drank sufficient sea water to stay in positive water balance. They were not able carry out a net excretion of sodium in salinities above 40 % sea water.

Introduction

Teleosts maintain an internal osmolarity much lower than sea water and many times that of fresh water. Therefore, regulation of solutes and water is necessary for maintenance of the relatively stable internal environment.

Much data is available on the processes employed by teleosts to regulate their internal environment (see reviews by Parry, 1966; Maetz, 1968, 1970, 1971; Potts, 1968; Conte, 1969; Hickman and Trump, 1969), however, most studies deal with euryhaline teleosts that are capable of adjusting to rapid salinity changes. While a number of studies which deal with the adjustments made by teleosts with limited osmoregulatory capabilities have been presented (Motais et al., 1966; Evans, 1967a, 1967b, 1967c, 1969a; Ogawa, 1968; Lahlou and Sawyer, 1969; Lahlou et al., 1969; Foster, 1969; Holmes and Lockwood, 1970) relatively few such teleosts have been studied in detail.

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The studies reported here deal with the modifications in sodium metabolism, water permeability, drinking rates and plasma cortisol levels that occur in the fresh water cyprinodont *Fundulus catenatus* after transfer into dilute saline environments.

**Material and Methods**

*Fundulus catenatus*, the Ozark studdish, was collected by seining from Linn Creek, located in Osage County, Missouri. After transfer to the laboratory they were held in large fresh water tanks maintained at 20 ± 1°C, and fed chopped worms. Most of the animals used weighed between 2 and 6 g.

The test salinities were prepared by dissolving a commercial sea-salt mixture (Instant Ocean) in deionized water. The saline solutions were made up in aquaria equipped with aerators and filters, and the sodium content of the water was checked regularly by flame photometry.

The methods used to estimate sodium efflux, water permeability, and drinking rates have been published elsewhere (Potts and Fleming, 1970, 1971) and need not be repeated here. Serum cortisol levels were determined by a competitive protein-binding radio assay method modified from Murphy (1967) and described by Ball et al. (1971). Serum and total-body sodium levels were estimated by flame photometry. The latter determinations were made by a dry-ash method modified from Grove et al. (1961). Serum osmolarity was measured with a Mechrolab vapor-pressure osmometer. Blood was collected from the caudal artery in a capillary tube heparinized with the ammonium salt of heparin. The heparin slowed but did not stop clotting. Serum was obtained by centrifuging the clotted blood. Water content was determined by measuring body weight before and after 24 hours drying at 110°C.

Preliminary tests showed that the studdish would easily tolerate transfers from fresh water to salinities of less than 45% of sea water. The animals used here were first held in 40% sea water before being subjected to a higher salinity.

**Results**

In Fig. 1 the changes are shown that occur in serum sodium levels following transfer of *F. catenatus* from fresh water to 40% sea water and, after adjustment to that salinity, a second transfer on to either 52% or 65% sea water. Serum sodium levels peaked on the 3rd day after the first transfer, followed by a slow decline, eventually reaching a value near that of fresh water adapted fish. A second rise in serum sodium levels occurred after transfer on to 52% or 65% sea water. The animals were not able to bring the serum sodium levels down again; after a delay there was a slow increase which continued for the duration of the experiments.

After fish were transferred from fresh water to 40% sea water, total-body sodium concentrations increased for the first 4 days (Fig. 2). After that time, the total-body sodium load decreased—occasionally to fresh water levels, but in most cases the animals stabilized at levels well above the fresh water values. Fig. 2 includes similar data for fish