PYLORIC CAECA IN CHINOOK SALMON:

OSMOREGULATORY FUNCTION

AND RESPONSIVENESS TO CORTISOL

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EXTENDED ABSTRACT ONLY – DO NOT CITE

Pyloric caeca, found in some, but not all fish, are blind-end outpocketings of the anterior intestine. In salmon and trout, the caeca are numerous and account for a major proportion of the surface area of the post-gastric intestinal tract. Although the pyloric caeca are known to be a major site for nutrient absorption (Collie, 1985; Buddington and Diamond, 1987), little is known of their potential role in the intestine's other major function, salt and water balance. In the present study, we demonstrate that the pyloric caeca of chinook salmon (*Oncorhynchus tshawytscha*) have a functional role in osmoregulation, are a site for adaptive changes during seawater entry, and that these changes may be directly regulated by cortisol during parr-smolt transformation.

Osmoregulatory changes during seawater adaptation

We first established a technique to make volumetric measurements of fluid absorption on individually isolated caeca. We also measured concurrent changes in mucosal Na^+, K^+-ATPase activity in these same caeca, since this enzyme is part of the mechanisms for epithelial ion transport. Fluid absorption was found

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to be highly dependent on Na^+, K^+-ATPase activity, as evidenced by a 92% inhibition of fluid absorption by ouabain (10^{-4} M). Adaptation of salmon to seawater for 10 days or 6 months resulted in significantly elevated rates of both fluid absorption and Na^+, K^+-ATPase activity over salmon remaining in fresh water, indicating that the pyloric caeca undergo functional changes that are adaptive for seawater. Comparing the relative amounts of total fluid absorbed between the caeca and posterior intestine (a known osmoregulatory site) suggests that the caeca make a much more significant contribution to the absorption of imbibed water when the salmon are adapted to seawater.

Cortisol stimulates osmoregulatory mechanisms

We next asked whether the seawater-adapting hormone, cortisol, could stimulate functional changes in the caeca associated with seawater adaptation, as has been shown for the posterior intestine (Veillette et al., 1995). Cortisol implanted into fresh water adapted salmon, at 50 μg/g body weight for 10 days, significantly elevated plasma cortisol and stimulated both fluid absorption rate and Na^+, K^+-ATPase activity in the caeca to levels equal to those seen during seawater adaptation. Thus, the pyloric caeca are a site for adaptive, osmoregulatory changes in the salmon intestine that may be regulated by cortisol. Additionally, the concurrent increases in Na^+, K^+-ATPase activity and rate of fluid absorption, resulting from seawater adaptation or cortisol implants, suggest a functional link between the two during the development of osmoregulatory mechanisms in the caeca.

Parr-smolt transformation and responsiveness of Na^+, K^+-ATPase to cortisol

Chinook salmon may migrate to sea during their first or second year of life in spring or summer. In our facility, they undergo parr-smolt transformation at these times. We examined seasonal changes in Na^+, K^+-ATPase activity of the pyloric caeca and found that this enzyme increases during parr-smolt transformation in both yearlings and underyearlings. In these same fish, the *in vitro* responsiveness of Na^+, K^+-ATPase activity to cortisol was assessed by exposing explants of caeca to cortisol for six days in culture. A response was restricted to the several months immediately preceeding endogenous increases in Na^+, K^+-ATPase activity and a month afterward. At a time when explants were responsive to cortisol, in vitro exposure to 0.01-10 μg/ml cortisol maintained Na^+, K^+-ATPase activity over controls (0 μg/ml cortisol) in a dose-dependent manner. These results show that the pyloric caeca exhibit increased Na^+, K^+-

ATPase activity that is preadaptive for seawater entry during parr-smolt transformation, and that changes in tissue responsiveness to cortisol may play a part in regulating these changes.

Conclusion

The numerous pyloric caeca of salmonids, in addition to their role in nutrient uptake, appear to have a major role in osmoregulation. This is evidenced not only by its large surface area and absorptive capacity, but also by our demonstration of functional changes during seawater adaptation and parr-smolt transformation, and the response to cortisol. These findings suggest that the pyloric caeca deserve attention in future studies examining osmoregulatory changes in the intestine of salmon, and other euryhaline fish.

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