Morphofunctional studies on branchial ionocytes in fish osmoregulation

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Osmoregulation is a mechanism for maintaining internal homeostasis to ensure the normal operation of cell functions and activities. Teleost fish maintain their plasma osmolalities within narrow physiological ranges, equivalent to about one-third seawater (SW) osmolality, although they inhabit various osmotic environments such as rivers, lakes and oceans. Osmoregulation in teleosts is achieved by integrated ion- and water-transporting functions of the gill, kidney and intestine. In particular, ionocytes located in the gill are essential for maintaining ionic balance in fishes. Ionocytes are known to be responsible for ion uptake in fresh water (FW) and ion secretion in SW.

Whereas the molecular mechanism for salt secretion in SW fish has been well established, the mechanisms for ion uptake by ionocytes of FW-acclimated teleosts are less understood, possibly varying according to species. In order to clarify the ionoregulatory mechanisms in the gills, we developed a methodology of scanning electron microscopic immunocytochemistry for the simultaneous observations of the apical morphology and occurrence of ion-transporting proteins in ionocytes. Based on our findings, we have successfully established the morphological and functional classification of ionocytes in Mozambique tilapia gills [1].

In euryhaline fishes, the function and morphology of ionocytes change when animals move between FW and SW. To know how ionocytes respond to environmental salinity change, we examined independent local effects of extracellular osmolality and FW-adapting hormone prolactin on branchial ionocytes. Our results showed that ionocytes of tilapia may function as osmoreceptors as well as directly respond to prolactin, to modulate branchial ionoregulatory functions [2].

A salinity-induced change in the distributional pattern of ionocytes has been reported in a variety of euryhaline teleost species. In order to investigate spatiotemporal changes in ionocyte distribution, we examined the time-course changes in localization of ionocyte subtypes in the gills of Japanese seabass transferred from SW to FW. Our findings indicated that ionocytes originated from undifferentiated cells in the filaments and expanded their distribution to the lamellae during FW acclimation [3].

In a series of our studies, we have established the morphofunctional classification of ionocytes, and clarified the alteration process of their ion-transporting function following environmental salinity changes. Our integrated investigation of the functional diversity and alteration process will hopefully contribute to understanding a whole picture of osmoregulatory mechanisms of gill ionocytes.

1) Inokuchi et al.: *J. Exp. Biol.* 212: 1003-1010 (2009).
2) Inokuchi et al.: *Am. J. Physiol. Regul. Integr. Comp. Physiol.* 309: R1251–R1263 (2015)
3) Inokuchi et al.: *J. Exp. Biol.* 220: 4720-4732 (2017).