Changes in plasma somatolactin levels during spawning migration of chum salmon (*Oncorhynchus keta*)

Sho Kakizawa¹, Toyoji Kaneko¹, Tsuyoshi Ogasawara² and Tetsuya Hirano¹

¹Ocean Research Institute, University of Tokyo, Nakano, Tokyo 164, and ²Faculty of Science, Kanagawa University, Hiratsuka, Kanagawa 259-12, Japan

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Abstract

Plasma somatolactin (SL) concentrations were examined in chum salmon in relation to gonadal maturation; immature salmon in the Bering Sea at various stages of maturation, and mature salmon during upstream migration caught at the ocean, bay and river. Plasma SL concentrations as well as plasma prolactin (PRL) and growth hormone (GH) levels in the immature fish caught in the Bering Sea were maintained essentially at similar levels. Plasma SL in mature salmon increased significantly from the fish in the ocean to the fish in the river in both sexes. Although all the fish had fully developed gonads, females completed ovulation while still in the bay, whereas final spermeation in males was achieved after entry into the river. Thus, no clear correlation was seen between plasma SL levels and final gonadal maturation. On the other hand, plasma PRL concentrations in both male and female fish were higher in the fish in the river than those in the ocean and bay, and plasma GH levels were higher in both sexes in the fish in the bay and river than those in the ocean. Plasma levels of triglycerides, glucose, free fatty acids and ionized sodium and calcium were also examined. Significant-negative correlations were seen between plasma SL and plasma ionized calcium in mature male salmon, and between plasma SL and plasma triglycerides in mature female salmon. Although our findings do not rule out the possibility of the involvement of SL in final maturation, the results indicate that SL seems to be involved at least in energy and/or calcium metabolism during the spawning migration.

Introduction

Somatolactin (SL) is a putative protein hormone, which was isolated for the first time from the pituitary of the Atlantic cod, *Gadus morhua* (Rand-Weaver et al. 1991a). A similar protein was isolated from the Japanese flounder, *Paralichthys olivaceus*, and the complete structure of the protein was elucidated by cDNA sequencing (Ono et al. 1990). This protein is structurally related to both growth hormone (GH) and prolactin (PRL), and consequently it was named somatolactin (Ono et al. 1990; Kawauchi 1993; Rand-Weaver and Kawauchi 1993).

SL appears to be involved in various biological processes. Elevation of plasma SL levels was observed during final maturation (Rand-Weaver et al. 1992; Rand-Weaver and Swanson 1993) and during smoltification (Rand-Weaver and Swanson 1993) of coho salmon, *Oncorhynchus kisutch*. Steroido-
genic activity of SL was suggested in coho salmon (Planas et al. 1992). According to a recent study by Olivereau and Rand-Weaver (1994), SL cells, identified immunocytochemically, were activated during final maturation of sockeye salmon (Oncorhynchus nerka) and chum salmon (Oncorhynchus keta). All these results suggest that SL may play a role in the regulation of gonadal function in salmonids. On the other hand, plasma SL levels in rainbow trout (Oncorhynchus mykiss) increased in response to stress (Rand-Weaver et al. 1993). Activation of SL cells also was observed in rainbow trout transferred from calcium-rich water to low-calcium water (Kakizawa et al. 1993). Furthermore, involvement of SL in lipid metabolism has been suggested by the study using the cobalt variant of rainbow trout, which lacks SL-producing cells and accumulates a large amount of fat tissue in the abdominal cavity (Kaneko et al 1993).

From cDNA sequence analysis, SL has been suggested to have one and two N-glycosylation sites in the flounder and cod (Ono et al. 1990; Takayama et al. 1991). In some teleost species, including flounder and cod, SL-producing cells correspond to PAS-positive cells in the pars intermedia (PIPAS cells), although this is not the case with salmonids which have no PIPAS-cells (Rand-Weaver et al. 1991b), possibly due to the absence of N-glycosylation sites in salmon SL (Takayama et al. 1991). Even before the discovery of SL, PIPAS-cells have been known to be activated when fish were exposed to low osmolality, low calcium, and low pH of the ambient water, or to black background (see a review by Kaneko and Hirano 1993). Although several functions of SL have been suggested, its definite physiological role(s) has yet to be determined.

In this study, changes in plasma SL concentrations were examined during various stages of gonadal development of chum salmon, using fish captured during migration in the Bering Sea and mature fish during upstream migration. Plasma levels of PRL and GH, along with plasma metabolites, were also examined. The results indicate that SL may be involved at least in energy and/or calcium metabolism during spawning migration.

Materials and methods

Fish in the Bering Sea

Chum salmon (Oncorhynchus keta) at various stages of gonadal development were caught in the Bering Sea by trawl lines or gill nets during the cruise of the R. V. Oshoro-Maru of Hokkaido University in the summer of 1987, as described by Tagawa et al. (1994). The gill net was set in the evening and pulled up early in the morning, and the trawl line was set for a few hours. Only active fish were sampled. Blood was drawn from caudal vessels with a syringe, and centrifuged at 3000 rpm for 10 min to separate plasma. Plasma was stored at -20°C until hormone and metabolite assays. The gonads of the fish captured in the Bering Sea were at various stages of development, although none of them were fully matured. Based on gonadosomatic index (GSI) values, males (1.0-4.2 kg) were separated into three groups (n = 10 in each group) [Group I (GSI: 0-0.3), Group II (0.3-1.0) and Group III (more than 1.0)] and females (1.0-3.5 kg) into four groups (n = 10 in each group) [Group I (GSI: 0-1), Group II (1-2), Group III (2-6) and Group IV (more than 6)].

Fish during final maturation

Chum salmon during upstream migration (2.0-5.7 kg) were captured in early December 1992 by a salmon set-net placed 1 km outside Otsuchi Bay [ocean fish; n = 9 (male), 12 (female)], close to the mouth of Otsuchi River (bay fish; n = 10, 10), and in the river 500 m from the river mouth (river fish; n = 15, 15), as described by Hirano et al. (1990). In the ocean fish, gonads were fully developed and mean GSI values reached 4% in males and 22% in females. Most of the female ocean fish had not yet ovulated, whereas the females had already completed ovulation while in the bay. In the male fish, the amount of milt obtained by pressing the abdomen was much less in the ocean and bay fish than that in the river fish; final spermeation was achieved after entry into the river (or fresh water). Because GSI values do not reflect gonadal status around final