

Physiological Study on Homing Related Olfactory Functions in Salmon

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As for the upstream homing migration of salmon from the coastal sea to the home stream, the olfactory hypothesis, proposed by Hasler and Wisby (1951) has been discussed with many behavioral and electrophysiological studies (Hasler and Scholz 1983; Ueda 1985; Stabel 1992; Dittman et al. 1996; Ueda and Shoji 2002). However, these odor substances of home stream are still unknown. We analyzed the compositions of amino acids, inorganic cations and bile acids in waters from three streams flowing into Lake Toya (Shoji et al. 2000). Application of mixtures of bile acids or inorganic cations reconstituted from the compositions of the stream waters, to the olfactory epithelium of masu salmon (*Oncorhynchus masou*) induced only very small responses. On the other hand, application of mixtures of amino acids induced large responses. The response of masu salmon to artificial stream water based on the compositions of amino acids and salts closely resembled the response to the corresponding natural water. From these results of electrophysiological experiments, we proposed that amino acids dissolved in the home stream water were possible substances used by salmon for homing.

In present study, we carried out behavior experiments to test whether or not amino acids mixtures have attractive effects on chum salmon (*O. keta*) and lacustrine sockeye salmon (*O. nerka*) upstream selective movement. Behavior experiments were conducted in a 15 m long two-choice test tank consisting of two 12 m long water inlet arms and a 3 x 1.8 m pool, which has one outlet at the end of tank. Mature male chum salmon (mainly 4 year olds, average fork length 73.0 cm, and average body mass 4,252.5 g) were captured by the wire in Osaru River, transferred to the Toya Lake Station, Hokkaido University, and reared for several days before experiments. In addition, homing of mature landlocked sockeye salmon (average fork length 27.3 cm, and average body mass 220.4 g) to the Lake Shikotsu Hatchery were also used for test fish. The artificial home stream water was prepared to reflect the amino acid and related substance composition of the Osaru River waters and Lake Shikotsu Hatchery waters, and dissolved in artificial freshwater. In each experiment, three to four fish (chum salmon) or five to 10 fish (sockeye salmon) were placed in the pool in the early afternoon, reared for several hours, and the experiment started from evening to midnight. Each amino acid mixture was added to the water inlet of left or right arm for nine hours in the same concentration as natural water. The fish movement was monitored by a remote camera system, and the number of fish that moved to each arm was counted. Of the 44 male chum salmon that were tested, 28 fish showed up stream movement to one of the choice arm. Among these fish, 24 (86%) were found in the arm running artificial home stream water, and 4 fish (14.3%) were observed in the arm running natural water (Fig. 1). There was no selectivity between left and right arm when natural lake water flowed from two arms. In sockeye salmon, of the 151 fish tested, 61 fish were found in one of the choice arms and 47 (76%) of these fish were found in the arm running artificial home stream water, and 14 fish (24%) were observed in the arm running natural water (Fig. 2). There was no selectivity between left and right arm when natural lake water flowed from two arms. There is no difference between male and female in selectivity. Taken together, our results support the hypothesis that amino acids dissolved in the home stream water are possible cues used by salmon for homing.

Fig. 1. Selectivity of stream water in mature male chum salmon in two-choice water arm. The number in parenthesis indicates fish move to each stream water.

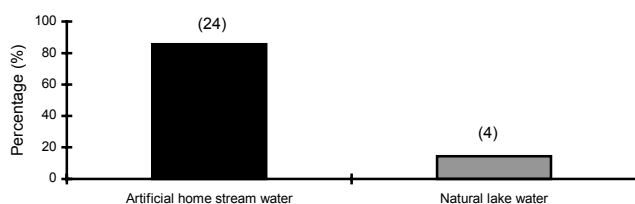
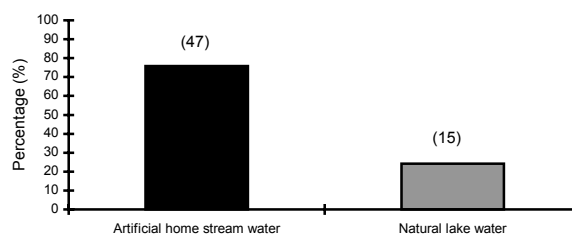


Fig. 2. Selectivity of stream water in mature sockeye salmon in two-choice water arm. The number in parenthesis indicates fish move to each stream water.



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