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Low nutritional status in the freshwater phase and temperature at seawater entry reduce swimming performance of juvenile chum salmon

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1. Background and purpose

Chum salmon (*Oncorhynchus keta*) is an important commercial fish in Hokkaido in northeastern Japan, and its resources are maintained by stock enhancement programs.

Japanese chum salmon likely experience substantial mortality during entering the sea and reaching the Sea of Okhotsk; however, little is known about the causes of this early mortality.

Following their release, juvenile chum salmon spend days to weeks in the river, but the nutritional condition of individuals decreases during this time. In the salmon of eastern Hokkaido, the adult return rate tends to be low when coastal water temperatures are low during the early stages of marine life. Thus, sea surface temperature (SST) has been implicated as being a key factor in determining the distribution and outmigration of chum salmon along the coast.

When juvenile chum salmon experience low water temperatures (≤5˚ C) in coastal waters, their movements are restricted and their growth ceases. However, it is unclear whether the nutritional conditions of freshwater and SST interact to affect the growth and swimming ability of juvenile chum salmon.

The purpose of this study is to elucidate the combined effects of freshwater feeding status and seawater temperature on the swimming ability of juvenile chum salmon under laboratory conditions.

2. Method

Juveniles weighing approximately 1.0 g were categorized into the following three groups and reared in freshwater for 5 days at different feeding rates (FR): 0% (fasted), 1%, and 3% per body weight.
Fish from each group were then acclimated for 5 days to seawater at low (5˚ C), medium (7˚ C), or high (10˚ C) temperatures, creating nine treatments.
Fish were then reared for an additional 5 days in which they were fed to satiation.
Critical swimming speed (*U*crit, Brett1964) was evaluated using a stamina tunnel as an indicator of swimming ability.

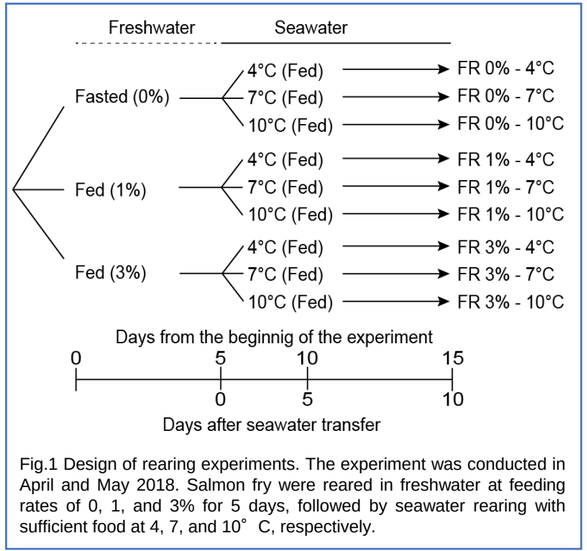
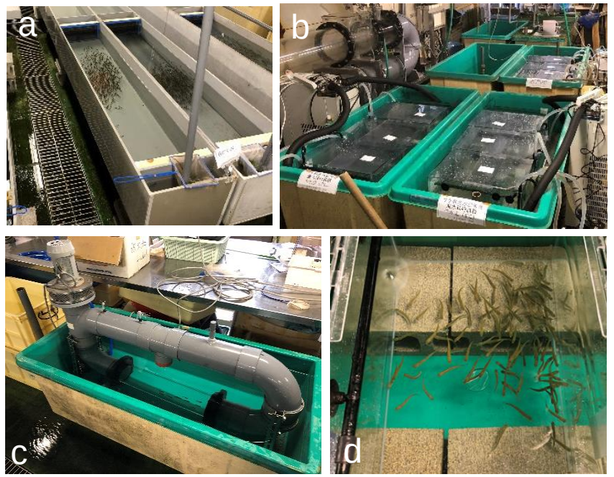


Fig.1 Design of rearing experiments. The experiment was conducted in April and May 2018. Salmon fry were reared in freshwater at feeding rates of 0, 1, and 3% for 5 days, followed by seawater rearing with sufficient food at 4, 7, and 10˚ C, respectively.



a: rearing in fresh water. b:rearing under controlled seawater temperature. c: Equipment for measuring swimming speed. d: reared juvenile chum salmon in seawater.

3. Results

- No difference was observed in Ucrit during the freshwater rearing period depending on the feeding rate.
- *U*crit on the 5th day of seawater rearing was not affected by the feeding rate during freshwater rearing, but the effect of seawater temperature was observed and was significantly lower in the 5˚ C.
- On the 10th day of seawater rearing, there was a significant difference in *U*crit between the FR 0% group and the FR 3% group. The lower the water temperature, the lower the *U*crit was significantly.

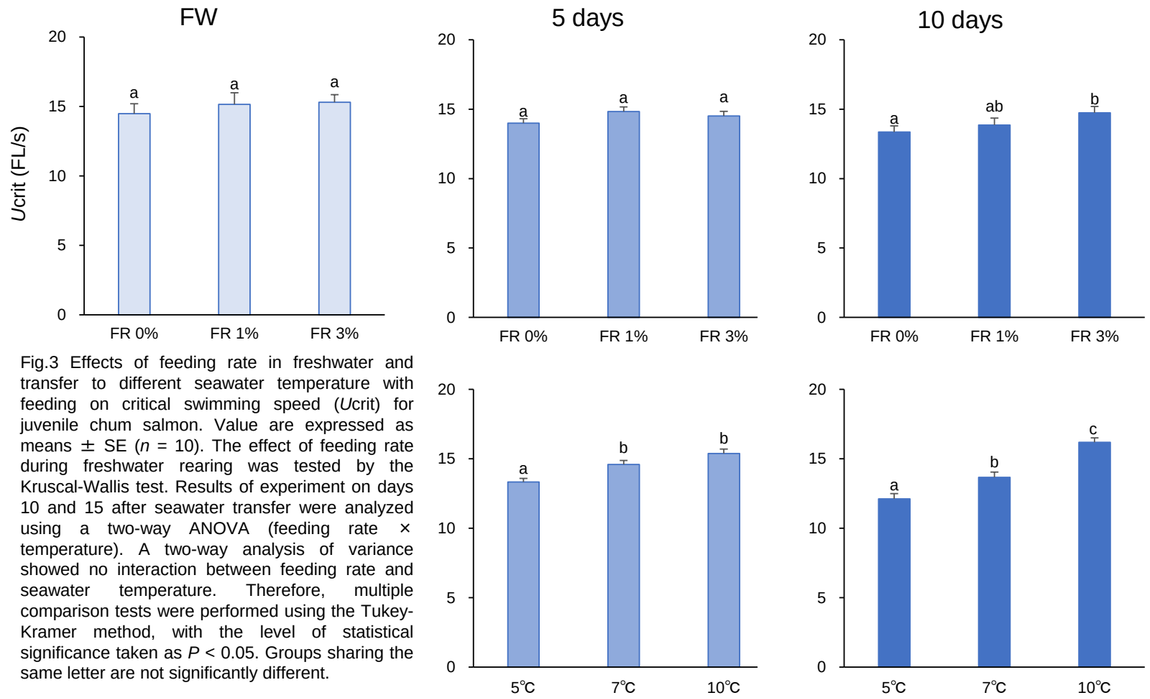


Fig.3 Effects of feeding rate in freshwater and transfer to different seawater temperature with feeding on critical swimming speed (*U*crit) for juvenile chum salmon. Value are expressed as means ± SE (n = 10). The effect of feeding rate during freshwater rearing was tested by the Kruscal-Wallis test. Results of experiment on days 10 and 15 after seawater transfer were analyzed using a two-way ANOVA (feeding rate × temperature). A two-way analysis of variance showed no interaction between feeding rate and seawater temperature. Therefore, multiple comparison tests were performed using the Tukey-Kramer method, with the level of statistical significance taken as $P < 0.05$. Groups sharing the same letter are not significantly different.

4. Conclusion

- ✓ The results of this study indicate that low seawater temperatures reduce the swimming ability of juvenile chum salmon, and that relatively short periods of freshwater fasting affect swimming ability.
- ✓ The effect of water temperature on swimming ability is known in many salmonid fishes. However, the possibility that nutritional status during freshwater life affects swimming ability after the transition to seawater is a new finding.
- ✓ The improvement of nutritional status may contribute to the improvement of survival rate of hatchery juvenile chum salmon after release.