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| 著者 | KASHIWAGI Masaaki, SATO Ryuhei |
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A Comparison of Some Blood Properties between the Two Groups of Chum Salmon, *Oncorhynchus keta* (Walbaum), Reared in a Salt Water Pond and in a Fresh Water Pond

Masaaki KASHIWAGI and Ryuhei SATO

*Department of Fisheries, Faculty of Agriculture,
Tohoku University, Sendai, Japan*

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Summary

1. The chum salmon, *Oncorhynchus keta* (Walbaum), have been reared in a salt water pond and in a fresh water pond. Some of their blood properties were examined and a comparison made between the two.

2. The average percentage of water content of blood of the salt water chum salmon group is 77.8 percent at 18 months after hatching and 76.5 percent at 25 months. That of the fresh water fish group is 86.9 percent at 18 months and 83.3 percent at 21 months.

3. The average freezing point depression is $\Delta-0.68^{\circ}\text{C}$ and $\Delta-0.58^{\circ}\text{C}$ at 18 and 25 months for the salt water fish group, and is $\Delta-0.71^{\circ}\text{C}$ and $\Delta-0.47^{\circ}\text{C}$ at 18 and 21 months for the fresh water fish group.

4. The average erythrocyte counts of the salt water fish group is 133.0×10^4 and 137.9×10^4 per mm^3 at 18 and 25 months, and 87.5×10^4 and 121.5×10^4 per mm^3 at 18 and 21 months for the fresh water fish group.

5. The average value of hematocrits for the salt water fish group is 47.1 percent at both 18 and 25 months, and for the fresh water fish group 36.7 percent at 18 months and 46.8 percent at 21 months.

6. The mean corpuscular volume of the salt water fish group is $354.1 \mu^3$ and $341.3 \mu^3$ at 18 and 25 months, and of the fresh water fish group $417.0 \mu^3$ and $383.6 \mu^3$ at 18 and 21 months.

The chum salmon, *Oncorhynchus keta* (Walbaum), migrating to the sea shortly after hatching in a fresh water region, a greater part of their life has been a problem beyond our grasp. Recently, it has been possible to rear the chum salmon not only in a salt water pond, but also in a fresh water pond (1, 2). And we can use them as material for studies throughout their whole life.

First of all, some blood properties of the two chum salmon groups reared in the salt water pond and in the fresh water pond were examined and compared in order to get a look at their physiological condition.

Materials and Methods

The chum salmon used as material in this study had been reared in a salt water and a fresh water ponds at a controlled water temperature below 20°C. The chlorinity of the salt water was 10.96 to 15.95 permill during the rearing of the fish. The fish were fed on some kinds of fresh fishes and a dry mixed ration. The growth of the fish, which is better in the salt water fish group than in the fresh water fish group, is shown in Fig. 1. The mortality was low in the two fish groups during the first year. But at the end of the second year, that of the fresh water fish group increased and reached about fifty percent cumulative mortality, though that of the salt water fish group was only about ten percent.

Blood of the salt water chum salmon group was collected on August in 1965 and on March in 1966; at that time, the fish was 18 and 25 months from hatching. The average body weight was 290 g and 380g, the water temperature was 15.4°C and 6.3°C, and the chlorinity was 12.97 permill and 14.99 permill, respectively. Also that of the fresh water fish group was performed on August and November in 1965; the fish were 18 and 21 months old, the average body weight was 158g and 243g, and the water temperature was 13.5°C and 14.0°C, respectively.

Fifteen fish, at one examination, were anesthetized with one percent urethane solution (ethyl calbamate) and bled by a cardiac puncture. The blood was treated with heparin sodium as an anticoagulant except in the water content examination. Each blood property was examined as follows:

- a) Water content; whole blood of about one hundred mg in a capillary of known weight was weighed accurately, and dried for twenty hours at 100–110°C and reweighed.
- b) Freezing point depression; plasma was collected from the blood by centrifuging for fifteen minutes at 3,000 rpm, and the freezing point depression of the plasma was measured by the use of a melting point apparatus with Beckman's thermometer.
- c) Erythrocyte counts; blood was diluted to two hundreds times with Hendrick's solution (3) and the number of erythrocytes were counted on the Thoma's hemocytometer according to the routine method.
- d) Hematocrits (or Packed cell volume); heparinized blood in a Kato's micro-hematocrit tube with 0.1 ml capacity was spun for fifteen minutes at 3,000 rpm in a centrifuge.

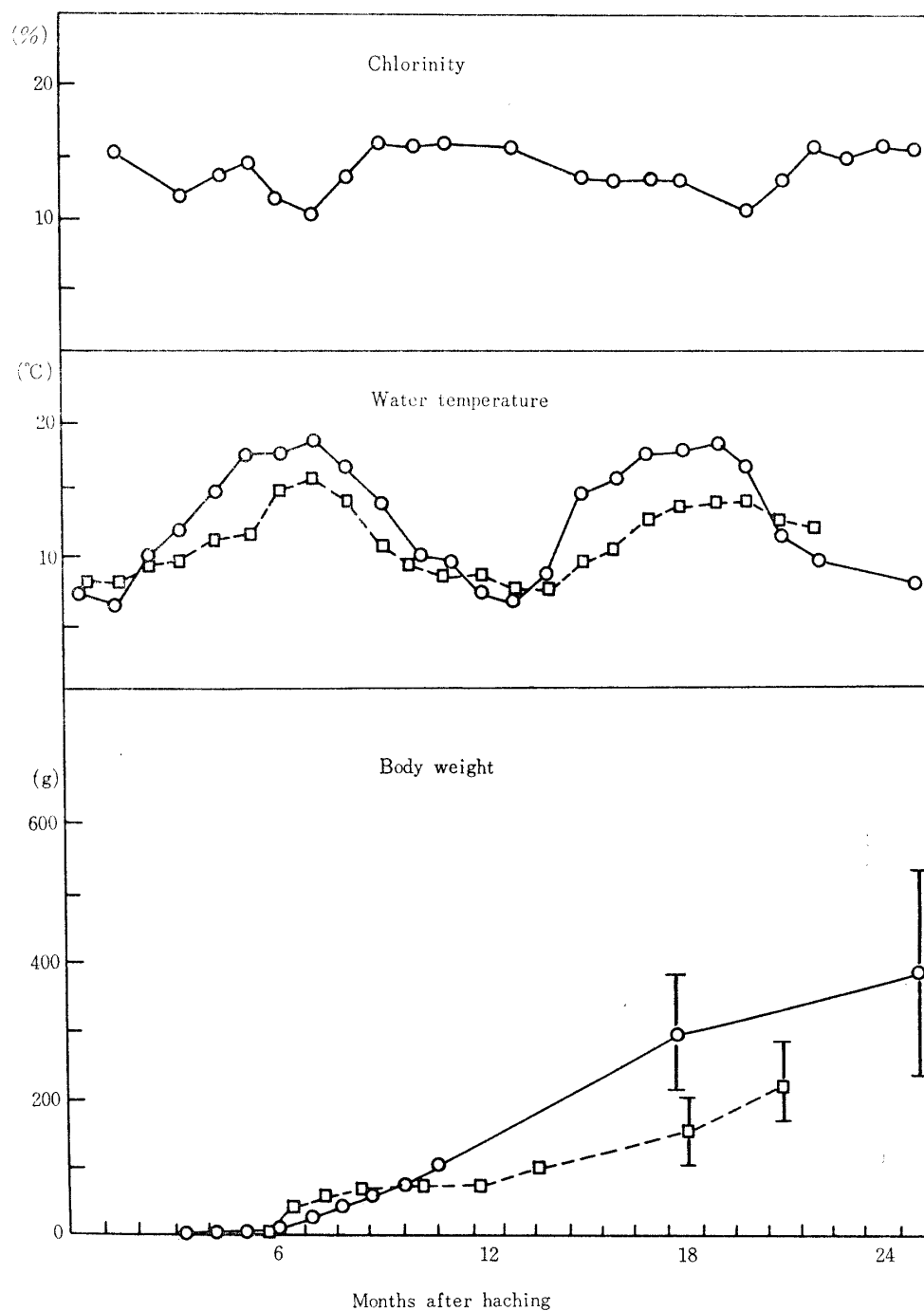


FIG. 1. Growth of the chum salmon reared in a salt water pond (○—○) and in a fresh water pond (□---□).

Results and Discussion

The results are given in Table 1.

The average percentage of water content of the blood of the salt water chum salmon group showed 77.8 percent at 18 months and 76.5 percent at 25 months. And that of the fresh water fish group was 86.9 percent at 18 months and 83.3

TABLE 1 The Examination of Blood Properties of the Chum Salmon Reared in a Salt Water Pond and in a Fresh Water Pond.

| | Salt water fish group | | | | Fresh water fish group | | | |
|--|-----------------------|--------------|-----|--------------|------------------------|-------------|-----|-------------|
| | No. | 18 months | No. | 25 months | No. | 18 months | No. | 21 months |
| Body Length (cm) | 15 | 28.4 ± 1.9 | 15 | 30.4 ± 3.0 | 15 | 21.5 ± 2.3 | 15 | 24.9 ± 2.9 |
| Body Weight (g) | 15 | 290 ± 87 | 15 | 380 ± 158 | 15 | 158 ± 47 | 15 | 243 ± 57 |
| Water content (%) | 12 | 77.8 ± 4.3 | 14 | 76.5 ± 3.9 | 11 | 86.9 ± 4.3 | 10 | 83.3 ± 3.9 |
| Freezing point depression (-Δ°C) | 15 | 0.68 ± 0.14 | 9 | 0.58 ± 0.13 | 15 | 0.71 ± 0.19 | 8 | 0.47 ± 0.01 |
| Erythrocyte counts (x10 ⁴ per mm ³) | 13 | 133.0 ± 18.8 | 14 | 137.9 ± 22.8 | 11 | 87.5 ± 10.0 | 11 | 121.5 ± 9.0 |
| Hematocrits (%) | 11 | 47.1 ± 8.5 | 14 | 47.1 ± 4.0 | 14 | 36.7 ± 10.2 | 9 | 46.8 ± 8.5 |
| Mean corpuscular volume (μ ³) | | 354.1 | | 341.3 | | 417.0 | | 383.6 |

percent at 21 months. These data showed that the values of the former group are lower than those of the latter group. They disagree with the results of Kuroda and Li (4) that the average percentage of water content of some diadromous fishes were rather higher in the sea life stage than in the fresh water life stage; *Anguilla japonica* was 85.09 percent for the sea life and 82.40 percent for the fresh water life, *Mugill cephalus* was 85.62 and 78.35 percent, and *Latiolabrax japonica* was 84.45 and 79.92 percent, respectively.

The average freezing point depression of the plasma of the salt water fish group was Δ-0.68°C and Δ-0.58°C at 18 and 25 months and that of the fresh water fish group was Δ-0.71°C and Δ-0.47°C at 18 and 21 months, respectively. Greene (5) and Benditt et al. (6) stated that the value of freezing point depression of *Oncorhynchus tshawytscha* and *Salmo salar* decreased when they entered the river from the coastal sea for spawning.

The average number for the erythrocyte counts of the salt water chum salmon group was 133.0×10⁴ per mm³ at 18 months and 137.9×10⁴ per mm³ at 25 months, and that of the fresh water fish group was 87.5×10⁴ per mm³ at 18 months and 121.5×10³ per mm³ at 21 months. The values of the former group were higher than those of the latter group. There is no data on the blood properties of salmonid fishes in the sea life stage but in the fresh water life stage; the 'Land locked form' of *Oncorhynchus masou* (7), *Salmo trutta* (8), *Salmo iridius* (9), and *Salvelinus fontinalis* (10) was 146×10⁴, 120-170×10⁴, 130×10⁴ and 101×10⁴ per mm³, respectively.

The average value of hematocrits for the salt water fish group was 47.1 percent at both 18 and 25 months, and 36.7 percent at 18 months and 46.8 percent at 21 months for the fresh water fish group. The values of the former group were higher than those of the latter group.

From the results of erythrocyte counts and hematocrits, the value of the mean corpuscular volume can be calculated by the expression of (Hematocrits in percent $\times 10$)/(Erythrocyte counts in million per mm^3): that is, the value of the salt water fish group was $354.1\mu^3$ and $341.3\mu^3$ at 18 and 25 months, and that of the fresh water fish group was $417.0\mu^3$ and $383.6\mu^3$ at 18 and 21 months, respectively. It is said that the erythrocytes of the latter group were somewhat macrocytic as compared with those of the former group.

The results obtained in this study at first led us to suppose that the blood of the fresh water chum salmon group tended to be diluted. Therefore it may be said that the osmotic regulation of the fresh water fish group is a greater tax on their metabolic energy than that of the salt water fish group. A discussion of this subject can be found in many publications on the excretion and osmotic regulation (11, 12, 13). This idea may be supported by the fact that the growth and survival rate of the salt water fish group were better than those of the fresh water fish group, a definitive report on this subject has been published by Sato et al. (1, 2).

It is, further, an interesting fact that we found the size of the kidney, which plays an important role in the function of water balance, is greater in the fresh water fish group than in the salt water fish group, i.e. the ratio of the kidney weight to the body weight was 0.87 percent for the former group at 18 months old and 0.49 percent for the latter group at the same age. The problem of osmotic regulation of the chum salmon must be studied more in order to grasp the physiological conditions throughout their whole life if we are to better understand migration.

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