

**O₂ AND CO₂ TRANSPORT DURING SUSTAINED EXERCISE IN
DIPLOID AND TRIPLOID CHINOOK SALMON,
*ONCORHYNCHUS TSHAWYTSCHA***

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Introduction

Triploidy, which involves creating individuals with an extra set of chromosomes, is an effective method to produce sterile fish. In general, aside from having larger but fewer cells, triploids are remarkably similar to diploids (Benfey 1999). However, despite these similarities and the advantages of chromosome manipulation for channeling energy into somatic growth instead of sexual maturity, the production of triploid fish has not gained acceptance as a standard practice in the salmonid aquaculture industry. In general, the performance of triploids is inferior to diploids when reared under suboptimal environmental conditions and the cause for this physiological difference is not understood (Benfey 1999). By limiting O₂ uptake and/or CO₂ excretion, the larger erythrocytes of triploid fish may contribute to their poorer performance under culture conditions. Therefore, as a means of improving our basic understanding of the respiratory physiology of triploid fish, we conducted an analysis of O₂ and CO₂ transport during aerobic swimming and at maximal critical swimming velocity (U_{crit}) in diploid and triploid chinook salmon

(*Oncorhynchus tshawytscha*). Although the swimming performance of triploid salmonids has previously been assessed (Small and Randall 1989; Stillwell and Benfey 1996), neither the pattern of CO₂ excretion nor the O₂-carrying capacity of exercising triploid fish has been examined.

Materials and Methods

Mixed sex diploid and triploid chinook salmon were obtained from Yellow Island Aquaculture Ltd. (Campbell River, BC, Canada) and held at the Department of Fisheries and Oceans (West Vancouver, BC, Canada) in separate 200 L tanks for at least 1 month prior to experimentation. Fish were fed to satiation with a commercial diet and maintained in 29 ppt seawater at 9°C. Triploidy was induced by heat shock and the ploidy of fish was ascertained by flow cytometry. Fish were anaesthetized with MS-222, an indwelling catheter was placed in the dorsal aorta, and fish were allowed to recover for 24 h in black perspex boxes. The cannulated fish were transferred to a 39L Brett-type swim tube respirometer and acclimatized overnight at a water velocity of 11 cm sec⁻¹.

Once resting O₂ consumption rate (MO₂) was assessed, swimming speed was gradually elevated by 0.5 body lengths (BL) sec⁻¹ at 30 min intervals until the fish could no longer maintain a given velocity. MO₂ was determined at each new speed and the maximum swimming speed and time to fatigue were recorded for the calculation of Ucrit. In each swimming trial, 3 blood samples were withdrawn from the dorsal aorta at set swimming speeds: (1) the acclimation velocity, (2) 2 BL sec⁻¹, and (3) Ucrit. Each blood sample was analyzed immediately for measurement of hematocrit (Hct), hemoglobin (Hb), red blood cell count (RBCC), arterial blood O₂ content (CaO₂), arterial blood CO₂ content (CaCO₂), arterial plasma pH (pHa), and plasma lactate. In addition, arterial blood partial pressure of O₂ (PaO₂), red cell pH (pHi), and methemoglobin (MetHb) were assessed at Ucrit. The arterial partial pressure of CO₂ (PaCO₂) and plasma HCO₃⁻ concentration were calculated from CaCO₂ and pHa by rearrangement of the Henderson-Hasselbalch equation.

Results and Discussion

Triploids in this study, as in previous haematological assessments (Benfey 1999), had lower RBCC, higher mean cell volume and mean cell Hb. In addition, there was no significant difference in Hct, Hb, and mean cellular Hb concentration between diploid and triploid fish at any of the swimming speeds. Similarly, there was no difference in MO₂, CaCO₂, PaCO₂, HCO₃⁻, pHa, and

plasma lactate between the two groups at all 3 sampling times, and no differences in Ucrit, MetHb, and PaO_2 at the end of the swimming trial. In contrast, CaO_2 was approximately 30% lower in triploids at all sampling times, and percent Hb O_2 saturation (% SO_2) and pHi were lower in triploids at Ucrit. Therefore, while the larger erythrocytes of triploids do not appear to limit CO_2 excretion during aerobic swimming and at Ucrit, the O_2 carrying capacity of triploids appears to be compromised. However, despite having a 30% difference in CaO_2 , diploid and triploid chinook salmon, as in other salmonids (Small and Randall 1989; Stillwell and Benfey 1996), have a similar Ucrit. Since only large reductions in O_2 capacity ($\geq 50\%$) significantly reduce swimming speeds in chinook salmon (Brauner *et al.* 1993), assessing swimming performance may not be a sensitive enough technique to detect the potential O_2 carrying capacity limitations of triploids. *In vitro* there is no difference in Hb- O_2 affinity, or in the magnitude of the Bohr and Root effects, between diploid and triploid Atlantic salmon blood (Sadler *et al.* 2000). Thus, our results indicate that the mechanisms regulating Hb O_2 transport and/or pHi *in vivo* in triploid chinook RBC may differ from those of diploids. While the reduced O_2 carrying capacity of triploid chinook salmon may not be severe enough to affect swimming performance, whether it reduces overall fitness under chronic sub-optimal conditions remains to be investigated.

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