HATCHERY-REARING DOES NOT AFFECT HEART MORPHOLOGY OR *IN SITU* CARDIAC PERFORMANCE IN Oncorhynchus mykiss sp.

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EXTENDED ABSTRACT ONLY – DO NOT CITE

Introduction

Hatchery-reared salmonids have a low survivorship when released into the wild, and numerous studies have indicated that the inferior swimming performance (stamina) of these fish may be a major contributing factor (e.g. McDonald *et al*., 1998). In view of the positive relationship between swimming performance and cardiac variables (Kolok *et al*., 1993), it is probable that the poor swimming performance of hatchery-reared salmonids is at least partly related to aspects of their cardiac morphophysiology.

To investigate whether cardiac morphology and performance are different between adult hatchery-reared and wild *Oncorhynchus mykiss*, we measured maximum cardiac function, anoxia tolerance and cardiac morphology in two groups of hatchery-reared rainbow trout and two groups of wild steelhead trout (completely wild, and those reared in hatcheries until smolts) (size range 300 – 800g).

Methods

Steelhead trout were seined from the Rogue River by Oregon Dept. of Fish and Wildlife personnel in August 2000. These fish consisted of completely wild fish and those that were raised until smolts in an Oregon State hatchery (no adipose fins), and were captured in 21°C water approx. 8 miles upstream from the river's mouth. Rainbow trout were obtained from commercial fish farms in Oregon and

Washington State in the fall of 2000, where they were kept in earthen canals or ponds. These ponds were supplied with well water and/or surface water from local streams, and water temperatures at the time of collection were approx. 18 ^{o}C. All fish were transported back to Portland State University (PSU), and were held in 1000L tanks at 18 $\pm$ 1^{o}C for a minimum of 10 days prior to experiments. None of the fish were fed while at PSU because the wild fish refused to eat in captivity.

Experimental Procedures
An *in situ* heart preparation (Farrell et al., 1986) was obtained from each animal, and the heart was allowed to recover from surgery for approx. 20 min. [temperature 18^{o}C, cardiac output (Q) 22 ml min^{-1} kg^{-1}, output pressure (P_{out}) 50 cm H_2O]. Thereafter, the heart was exposed to a series of experimental manipulations: 1) an initial assessment of maximum cardiac output (Q_{max}) and power output (P_{max}); 2) 15 min. of anoxia or normoxia (P_{out} maintained at 50 cm H_20); and 3) a 2nd assessment of Q_{max} and P_{max} after 15 min. of recovery.

After experiments were complete, the fish's heart was removed, weighed, and the ventricle was placed into buffered 10% formalin. Thereafter, the compact and spongy myocardium were separated, weighed, and the proportion of the ventricle that was composed of compact muscle was calculated.

Results

Relative ventricular mass (RVM) and % compact myocardium were significantly higher in the rainbow trout from Washington (0.109 $\pm$ 0.003 and 32.9 $\pm$ 2.7) as compared with the completely wild steelhead trout (0.094 $\pm$ 0.004 and 26.5 $\pm$ 1.8). However, this was the only difference between the groups, and probably reflected the high proportion (5 out of 8) of males in the former group. Despite the differences in RVM and % compact myocardium, there were no initial differences in mass-specific cardiac performance between the groups (Table 1).

Fifteen min. of anoxia caused a significant reduction in maximum cardiac output (Q_{max}) and stroke volume (SV_{max}) in all the groups (range 11 – 17%), as compared to hearts from Oregon rainbow trout that were only exposed to normoxia (5%). However, there were no significant differences between the anoxic groups, and anoxic exposure appeared to have little effect on maximum power output (P_{max}). The reduction in P_{max} in the normoxic trout was not significantly different from that of any of the groups exposed to anoxia (Table 2).

Table 1. Maximum cardiovascular variables in hearts of wild and hatchery-reared *Oncorhynchus mykiss* prior to anoxia. No significant differences were found between groups.

Group	**Cardiac Output (ml min^{-1} g ventricle^{-1})**	**Stroke Volume (ml min^{-1} g ventricle^{-1})**	**Power (mW g ventricle^{-1})**
Normoxia Only			
Oregon Hatchery Rainbows (N = 6)	77.8 ± 1.9	1.10 ± 0.05	7.11 ± 0.45
Anoxia Exposed			
Wild-Wild Steelhead (N = 8)	73.2 ± 3.2	1.02 ± 0.05	7.34 ± 0.19
Hatchery-Wild Steelhead (N = 8)	68.0 ± 3.1	0.97 ± 0.04	7.16 ± 0.21
Oregon Hatchery Rainbows (N = 6)	76.6 ± 3.4	1.08 ± 0.06	7.00 ± 0.27
Washington Hatchery Rainbows (N = 8)	76.9 ± 5.0	1.08 ± 0.05	7.43 ± 0.45

Discussion/Conclusions

We found no evidence that heart size and the percentage of compact myocardium differed between wild *Oncorhynchus mykiss* and those cultured in earthen ponds or canals. These results are in contrast to those of Graham and Farrell (1992) who report that adult rainbow trout held in relatively pristine conditions and stable temperatures (8-11^{o}C) can be distinguished from wild anadromous conspecifics based on heart morphometrics.

In this study, cardiac morphometrics, maximum cardiac function and hypoxia tolerance were not different between wild and cultured *Oncorhynchus mykiss*. These results strongly suggest that cardiac function does not differ between adult wild and pond-reared trout, and thus that any differences in swimming performance between these two groups is due to other factors.

Leonard and McCormick (2001) showed that stream-reared Atlantic Salmon smolts had larger hearts as compared with hatchery-reared conspecifics. However, our results suggest that such differences are unlikely to persist in adult fish.

Table 2. Effect of 15 min. of anoxia on maximum cardiac variables in rainbow and steelhead trout. All values represent the ratio of performance after anoxia (2): that before anoxia (1). Groups with dissimilar letters are significantly different ($P < 0.05$; one-way ANOVA).

Group	**$Q_{max}2/Q_{max}1$**	**$SV_{max}2/SV_{max}1$**	**$P_{max}2/P_{max}1$**
Normoxia Only			
Oregon Hatchery Rainbows (N = 6)	0.98 ± 0.04 [b]	0.95 ± 0.02[b]	0.86 ± 0.02[ab]
Anoxia Exposed			
Wild-Wild Steelhead (N = 8)	0.89 ± 0.021[a]	0.86 ± 0.03[a]	0.86 ± 0.03[ab]
Hatchery-Wild Steelhead (N = 8)	0.88 ± 0.031[a]	0.83 ± 0.03[a]	0.83 ± 0.04 [a]
Oregon Hatchery Rainbows (N = 6)	0.89 ± 0.13 [a]	0.87 ± 0.02[a]	0.94 ± 0.04 [b]
Washington Hatchery Rainbows (N = 8)	0.87 ± 0.02[a]	0.85 ± 0.03[a]	0.89 ± 0.03 [ab]

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