BIOCHEMICAL CHARACTERISTICS OF SERUM AND STRIATED MUSCLE FROM HIGH DESERT REDBAND TROUT

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EXTENDED ABSTRACT ONLY- DO NOT CITE

Introduction

Arid-land redband trout (*Oncorhynchus mykiss* ssp.) occur in southern Oregon, southwestern Idaho and northern Nevada. The United States Fish and Wildlife Service is considering the redband trout for threatened species status, in large part due to habitat degradation and elevated stream temperatures. However, data exist which both support and contradict the suggestion that elevated stream temperatures are responsible for declining redband trout populations. We have recently demonstrated that juvenile redbands can swim in excess of 3 body lengths per sec and have values for metabolic scope above 600 mg O_2/kg/hr at 24°C. In addition, Rinne (1980) has shown that the critical thermal maximum of trout from southwestern arid regions exceeds 28° C. In contrast, both wild redband trout (Gamperl et al., unpublished data) and hatchery-reared rainbow trout (Peterson et al. 1979) have preferred temperatures below 15 ^{o}C.

The ability of redband trout to survive increased stream temperatures and harsh habitat conditions illustrates the remarkable plasticity of this salmonid and must be due to exceptional physiological and or biochemical adaptations. Before effective management plans for the redband trout can be developed, it is important to characterize the effects of elevated stream temperatures on this species and define the temperature optima for physiological function. Thus, the objective of this study was to examine whether habitat temperature influences biochemical indices of energy metabolism in serum, axial white muscle, and the ventricle of redband trout.

Methods

We focused on two stream populations of redband trout in southeastern Oregon during August of 1999. The Little Blitzen River, which rarely has maximum temperatures above 18°C, was designated as the "cold" stream. The second site, Bridge Creek, which is normally characterized by maximum temperatures above 24°C was selected as our "warm" stream. In both streams, the daily temperature fluctuation during summer can exceed 10°C. Fish were collected by hook and line, and allowed to recover in stream cages for at least 48 hrs. Fish were anesthetized, measured, weighed, and blood was collected from the caudal vein. Serum was isolated by centrifugation, the ventricle was excised, weighed, and a sample of white muscle was taken just ventral to the dorsal fin. All tissues were frozen rapidly in liquid nitrogen and transported to Idaho State University for biochemical analysis.

We measured serum osmolality using a vapor osmometer, and concentrations of triglycerides and free fatty acids by established spectrophotometric techniques. Maximal activities of citrate synthase (CS, a mitochondrial marker of aerobic metabolism) and lactate dehydrogenase (LDH, a marker of anaerobic glycolysis) in white muscle were determined for whole tissue homogenates at 5°, 15°, and 25°C. CS activity in cardiac muscle was measured at 15°C. Sample means were compared by a one-way ANOVA and Tukey's post hoc test. Statistical significance was established at $P < 0.05$. All values are expressed as mean ± S.D.

Results

Redband trout sampled from the Little Blitzen were significantly smaller than animals from Bridge Creek (Table 1). Relative ventricular mass was 28% greater in trout from the Little Blitzen, however, CS activity in cardiac muscle was not different between the two groups. Serum osmolality was significantly lower in trout from Bridge Creek. Concentrations of serum free fatty acids

	Length (cm)	Weight (g)	Relative Ventricle Mass (%)	Ventricle Citrate Synthase (U/g)	Serum Osmolality (mol/kg)	Serum FFA (mM)	Serum TG (mg/dl)
Blitzen (cold)	19.0 ± 2.3	74 ± 30	0.112 ± 0.019	19.6 ± 2.1	261 ± 14	1.1 ± 0.4	333 ± 63
Bridge (warm)	22.7 ± 4.2	144 ± 82	0.088 ± 0.012	18.6 ± 1.4	242 ± 23	0.8 ± 0.4	294 ± 73
P	0.007*	0.006*	<0.001*	0.261	0.014*	0.094	0.137

Table 1. Physical and biochemical characteristics of redband trout from the Little Blitzen River and Bridge Creek.

n = 14 for all variables except ventricle citrate synthase (N = 8). FFA = free fatty acids, TG = triglycerides. * Significant difference between groups.

(FFA) and triglycerides were similar between the two trout populations and comparable to plasma values reported previously for hatchery-reared rainbow trout (Rodnick and Williams 1999).

The activity of CS in white muscle was 1.6 to 2-fold higher in redband trout from the Little Blitzen at the temperatures examined. Conversely, LDH activity was 60% higher in white muscle of fishes from Bridge Creek. The corresponding thermal sensitivities (Q_{10} 5°-25°C) of both CS (1.5-1.7) and LDH (1.7) were comparable between the two groups of fishes, suggesting the expression of similar enzyme isozymes at different environmental temperatures.

Table 2. Biochemical characteristics of axial white muscle from redband trout.

	Citrate Synthase			Lactate Dehydrogenase		
	5°C	15°C	25°C	5°C	15°C	25°C
Blitzen (cold)	2.1 ± 0.5	3.2 ± 0.7	4.6 ± 1.4	258 ± 85	474 ± 161	779 ± 283
Bridge (warm)	1.0 ± 0.2	1.6 ± 0.3	2.9 ± 0.9	433 ± 45	802 ± 96	1374 ± 286

P	<0.001*	<0.001*	0.014*	<0.001*	<0.001*	<0.001*

n = 8 for all assays. Maximal enzyme activities are expressed as units (μmol of substrate)/min/g tissue. * Significant difference between groups.

Discussion and Conclusion

Our results suggest that thermal history can selectively influence the characteristics of ventricle size, serum osmolality and the maximal activities of metabolic enzymes in white muscle of redband trout. A warm-adapted redband trout appears more dilute and may utilize higher rates of anaerobic metabolism during swimming activity than a cold-adapted redband trout. Conversely, the cold adapted trout appears to have a higher potential for aerobic metabolism and better maintenance of stroke volume at cold environmental temperatures. Together, these differences may help explain our recent findings that thermal history influences swimming and metabolic performance of redband trout.

Acknowledgements

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