Behavior and microhabitat competition of brown trout and greenback cutthroat trout in an artificial stream
by Lizhu Wang

A thesis submitted in partial fulfillment of the requirements for the degree o f Master of Science 1 n Biological Science
Montana State University

Abstract:
Behavior and competition of yearling greenback cutthroat trout (Salmo clarki stomias) and brown trout (S. trutta) were tested in an indoor stream aquarium during June-September 1987 and January-May 1988. Brown trout were, more aggressive than equal-sized greenback cutthroat trout. Brown trout initiated 92% of 2050. attacks in four sympatric experiments. Attack involvement of cutthroat trout was significantly higher in sympatry than in allopatry, but that of brown trout was almost the same in sympatry as in allopatry. Brown trout showed better ability in competing for energetically profitable stream positions. Brown trout occupied 72% of the 207 pool positions in sympatry with equal-sized cutthroat trout. The distance of cutthroat trout from food source was significantly greater in sympatry than in allopatry, but that of brown trout was almost the same in sympatry as in allopatry. In sympatry, food-source distance of cutthroat trout was significantly greater than that of brown trout. Cutthroat trout lost more weight than brown trout in sympatry. Brown trout could outcompete greenback cutthroat trout that were 1.27 times longer and 1.69 times heavier. The behavior of greenback cutthroat trout was the same under two different light intensities and two different water velocities. However, slow current combined with dim light significantly increased attack frequency of brown trout.

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citation, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

Behavior and competition of yearling greenback cutthroat trout (*Salmo clarki stomias*) and brown trout (*S. trutta*) were tested in an indoor stream aquarium during June-September 1987 and January-May 1988. Brown trout were more aggressive than equal-sized greenback cutthroat trout. Brown trout initiated 92% of 2050 attacks in four sympatric experiments. Attack involvement of cutthroat trout was significantly higher in sympatry than in allopatry, but that of brown trout was almost the same in sympatry as in allopatry. Brown trout showed better ability in competing for energetically profitable stream positions. Brown trout occupied 72% of the 207 pool positions in sympatry with equal-sized cutthroat trout. The distance of cutthroat trout from food source was significantly greater in sympatry than in allopatry, but that of brown trout was almost the same in sympatry as in allopatry. In sympatry, food-source distance of cutthroat trout was significantly greater than that of brown trout. Cutthroat trout lost more weight than brown trout in sympatry. Brown trout could outcompete greenback cutthroat trout that were 1.27 times longer and 1.69 times heavier. The behavior of greenback cutthroat trout was the same under two different light intensities and two different water volocities. However, slow current combined with dim light significantly increased attack frequency of brown trout.

INTRODUCTION

Indigenous cutthroat trout (*Salmo clarki*) have declined in abundance so drastically that many subspecies are extinct or nearly so (Behnke 1979). Behnke (1972) believed that at least 99% of the original populations of interior cutthroat trout have been lost in the last 100 years. One of the factors responsible in the decline is thought to be interspecific competition (Hanzel 1959; Behnke 1979; Liknes 1984).

The competition between cutthroat trout and some other salmonids, such as brook trout (Griffith 1972), steelhead (Hartman and Gill 1968), and rainbow trout (Nilsson 1981), as well as coho salmon (Glova 1984, 1986), and Dolly Varden (Andrusak and Northcote 1971; Schutz and Northcote 1972; Henderson and Northcote 1985; Hinder et al. 1988), has been well recorded. However, competition between cutthroat trout and brown trout (*S. trutta*) has not been carefully studied.

The autecologies of cutthroat trout and brown trout are well known, but not their synecology. They have similar food and habitat preferences (Miller 1957; Hartman and Gill 1968; Jenkins 1969; Brown 1971; Bustard and Narver 1975; Bachman 1984; Javorsky 1984; Scarnecchia and Bergersen 1986; Gatz et al. 1987). Therefore, interspecific competition probably happened when brown trout were first introduced into cutthroat trout streams, and may still be happening where these species are sympatric and food or habitat is in short supply.

When species with similar ecological requirements first mix together, particularly intense competition between them may ensue. Subsequently, one or both species may adapt morphologically, physiologically, or behaviorally to coexistence, or the competitively less successful species may die out locally or retreat to marginal habitats and no longer significantly overlap its competitor's spatial distribution or resource use (Nilsson 1967). Unlike the interactive segregation of cutthroat trout with Dolly Varden (Andrusak and Northcote 1971; Schutz and Northcote 1972; Hindar et al. 1988), and with coho salmon (Bustard and Narver 1975; Glova 1984, 1986), which are probably coevolutionary, interaction between cutthroat trout and brown trout, a result of recent artificial sympatry, would be expected to take the form of competitive exclusion.

The existence of competition between cutthroat and brown trout can be tested in an artificial stream, and various characteristics of the interaction could be examined. Trophic or habitat shift of one species when in the presence of another species is evidence for interspecific competition (Werner and Hall 1976). Overlap in resource use alone does not necessarily mean that two species are competing (Sale 1979), but resource overlap together with niche shift in sympatry is considered evidence of competition (Diamond 1978; Gatz et al. 1987). Therefore, the possibility of active displacement of cutthroat trout by brown trout and the behavioral advantage of one over the other could be evaluated by examining aggressive behavior and microhabitat use in allopatry and sympatry.

The broad objectives in this study were to determine whether interspecific competition exists between yearlings of greenback cutthroat trout (Salmo clarki stomias) and of brown trout, whether intraspecific competition exists within groups of these kinds of fish, and what may be the characteristics of such inter- and intraspecific competition. Specific objectives (if competition exists between these species) were to determine (1) the dominant species, (2) the role that body size may play in competition, (3) how the competition may be affected by light intensity, and (4) how the competition may be affected by water velocity.

MATERIALS AND METHODS

Experimental Animals

Yearling wild brown trout were obtained by electrofishing from Darlington Ditch, Gallatin County, Montana, in March and December 1987. Greenback cutthroat trout were obtained from the U.S. Fish and Wildlife Service's Fisheries Technology Center (BFTC) in Bozeman, where a brood stock of these fish is maintained. Female brood stock descended from females brought from Como Creek, Colorado, to Bozeman in 1977, but male gametes are brought each year from Hunters Creek, Colorado, both streams being in the South Platte River drainage.

The brown and cutthroat trout were raised separately in 2 2,000-liter flow-through circular tanks for 2 to 3 months under hatchery-operation conditions of lighting (primarily window light) and water temperature (12-15 C). Then they were held separately in a 1,000-liter flow-through tank, divided into sections by screens. Water temperature was held at 15 C. The photoperiod cycle was 12 hours light (0700-1900 h MDT) and 12 hours dark (1900-0700 h MDT). The tank was covered with screen to prevent fish from leaping out. The fish were fed Rangen trout pellets 2 to 3 times during each light period at a daily rate of 10% of the biomass of fish held in the tank.

The Stream Aquarium

The observations were made in an indoor stream aquarium at the BFTC. The aquarium was in the form of a hollow, rectangular "doughnut" circuit channel (Fig. 1) that was level (Fig. 2), that had cross-sectional dimensions of 60 cm wide and 40 cm deep (Fig. 3), and that had its current generated by an electric outboard motor. The long sides of the rectangle were screened at each end to form individual straight channels 4.5 m long (Fig. 1). The inner sides of the stream aquarium were plate glass, allowing unobstructed view above or below the water surface. The bottom and outside walls were plywood painted with black epoxy.

Inner volume of the channel circuit was about 3,172 liters. The "open water" (pools, riffles and traps) was about 1,336 liters, and the volume of gravel and interstitial water was about 1,593 liters.

The aquarium chamber that lay just downstream from the current-generating motor was designated as section I, the other chamber as section II. The downstream end of each section had a trap to catch fish that moved downstream (Fig. 1). The channel bed was gravel of 2-3 cm diameter. The bed surface was shaped to simulate riffles of 15-17 cm water depth and pools of 32 cm maximum water depth (Fig.