Jim S. Gregory
J. S. Griffith

First-winter Survival of Caged Wild and Hatchery Cutthroat Trout in Allopatry and in Sympatry with Brook Trout

Abstract

Winter survival of wild and hatchery-reared cutthroat trout (Oncorhynchus clarki) *both alone and in sympatry with wild brook trout* (Salvelinus fontinalis) *was compared in cages in a second-order spring-influenced tributary to Henry's Lake Outlet, Idaho. Wild cutthroat trout were about half the length of the hatchery cutthroat and wild brook trout at the beginning of the experiment, and all groups of fish exhibited growth through winter. Survival was not size-dependent. Survival rates of groups containing hatchery cutthroat trout in sympatry with brook trout and hatchery cutthroat or wild cutthroat in allopatry were 84 to 94 percent. However, survival of wild cutthroat held in sympatry with brook trout was 6 percent. We attributed low survival of sympatric wild cutthroat trout to competitive effects of brook trout. These effects may have been exacerbated by confinement in the cages, cage stocking densities, or cage mesh-size that may have reduced food availability.*

Key words: cutthroat trout, *Oncorhynchus clarki*, brook trout, *Salvelinus fontinalis*, wild, hatchery, survival, competition, winter.

Introduction

Brook trout (*Salvelinus fontinalis*) introductions have typically led to the replacement of native cutthroat trout (*Oncorhynchus clarki*) populations in western streams (Young 1995). Surveys of 48 streams in the Henry's Fork watershed in 1996 and 1997 revealed that native Yellowstone cutthroat trout (*O. c. bouvieri*) existed in only five (Van Kirk *et al.* 1997). This replacement is a function of many factors including the vulnerability of cutthroat trout to angling (MacPhee 1966, Schill *et al.* 1986), predation by brook trout on cutthroat trout (Irving 1987), and behavioral differences between the two species (Griffith 1972). Interspecific interaction of these two species during winter has not been thoroughly examined.

Jim S. Gregory, Gregory Aquatics, 5306 Zollinger Road, Mackay, ID 83251
J. S. Griffith, Department of Biological Sciences, Idaho State University, Pocatello, ID 83209

Within a trout species, size entering the first winter is an important physiological factor affecting survival (Hunt 1969, Smith and Griffith 1994, Meyer and Griffith 1997). At the end of their first summer, wild brook trout often are 20 to 40 mm longer than their wild cutthroat trout counterparts (Griffith 1972; data from this study). Also, hatchery-reared age-0 cutthroat trout typically enter the winter at larger sizes than their wild counterparts in our study streams. Therefore, wild cutthroat trout might be expected to have lower winter survival rates than either hatchery cutthroat or wild brook trout. In addition, larger individuals more readily displace smaller fish from daytime concealment cover in winter (Gregory and Griffith 1996). Therefore, if wild cutthroat trout use the same winter cover as either hatchery cutthroat trout or wild brook trout, wild cutthroat trout may be additionally disadvantaged.

In this study, we held groups of juvenile fish in cage throughout winter. Our objectives were to: 1) assess size-specific survival of wild and hatchery cutthroat trout during their first winter, and 2) compare survival of cutthroat trout in allopatry and sympatry with brook trout.

Methods

Tests were conducted in second-order Stephens Creek about 300 m from where it enters Henry's Lake Outlet, 7 km below Henry's Lake (44° 32' N, 111° 17' W) in Fremont County, Idaho. Diffuse inflow of groundwater somewhat moderated water temperature at the site (1,954 m in elevation). No anchor ice formed during the study period, and surface ice formed to 5 cm in thickness everal times for a few days.

Age-0 brook and cutthroat trout were captured by electrofishing in late September from tributaries of Henry's Lake Outlet, and wild Yellowstone cutthroat trout averaging 46 mm long (range 30-65 mm) were collected from a tributary of Henry's Lake. Cutthroat trout that had been spawned in the Idaho Department of Fish and Game Henry's Lake Hatchery and then released as fry into streams in late summer also were captured. These fish averaged 81 mm (range 68-95 mm). Wild brook trout averaged 83 mm (range 51-105 mm).

Tests were conducted in eight cages, constructed of 6-mm mesh galvanized screen attached to 1.5-m long by 0.5-m wide by 0.6-m deep rectangular angle-iron frames. Wire mesh floors were present, but the tops were uncovered. Because wild cutthroat were small enough to pass through the mesh, the sides and floors of those cages in which wild cutthroat trout were held were lined with fiberglass window screen (1-mm mesh). To increase water flow through those cages, siphon ho es 2.5 cm in diameter were extended into each cage from a beaver pond immediately upstream. Cages were placed at locations where water velocity through the larger mesh cages was 12 to 15 cm/sec and water depth was 40-50 cm. Willow branches from a nearby beaver cache were added to each cage to simulate the cover provided by the cache. Cages were checked, and debris was removed from the outside of the wire mesh twice monthly throughout the winter. Stream temperature at the site was monitored with an Onset Instruments StowAway IT temperature recorder.

Fish were measured to the nearest millimeter (total length) and divided into groups of 16 on 30 September 1995. Each group was randomly assigned to a cage. No significant difference in average length of each type of fish existed among cages (ANOVA, $P \leq 0.05$). Four groups contained only 16 cutthroat trout (two cages with wild fish, two cages with hatchery fish), and four groups contained mixed species (eight brook trout and eight wild cutthroat in two cages, and eight brook trout and eight hatchery cutthroat trout in two cages). Fish density in each cage (21 fish/m^2) was higher than winter densities of wild cutthroat trout observed in previous studies on the South Fork of the Snake River, Idaho (Griffith and Smith 1993), but was similar to fish densities we observed during the study period in high-quality habitat immediately below the Stephens Creek beaver dam.

Fish survival was evaluated three times during the experiment (28 October and 29 December 1995, 19 February 1996) and at its conclusion on 30 March 1996. On these dates, fish were dip-netted from the cages, counted, and measured. Individual fish were not marked, but because of consistent correspondence in sizes of fish in a cage throughout the experiment, we believe we were able to correctly track individuals and thereby assess size-specific survival rates and estimate growth rates. Arcsin-transformed survival percentages were compared with a 2-way ANOVA, and a Least Significant Difference test was used to assess whether brook trout presence or cutthroat trout origin affected survival of cutthroat trout. A *t*-test was used to assess whether there was a significant difference between mean lengths of fish that died during the experiment and those that survived.

Results

Survival of wild cutthroat trout held in allopatry (both cages combined) was 84 percent compared to only 6 percent when held in sympatry with brook trout (Fig. 1); only one of 16 wild cutthroat trout survived in the two cages in which they were sympatric with brook trout. This difference in survival of wild cutthroat trout held in sympatry with brook trout and in allopatry was significant ($F = 11.51$, $P = 0.019$). Survival of hatchery cutthroat trout both in allopatry and with brook trout was 94 percent. There was no significant difference ($P > 0.05$) in survival among wild cutthroat trout held alone and hatchery cutthroat trout held either alone or with brook trout. Mean survival of brook trout was 81 percent when held with either hatchery or wild cutthroat trout. Mortality of wild cutthroat trout was highest during the first period (late September to late October, Fig. 1), whereas hatchery cutthroat trout mortality extended throughout the winter. Brook trout mortality was highest in the period from mid-February to late March.

We found no significant difference ($P > 0.05$) in initial size between fish that later died and those that survived the experiment within a treatment. Fish in all groups grew in length during winter (Table 1). Brook trout growth was

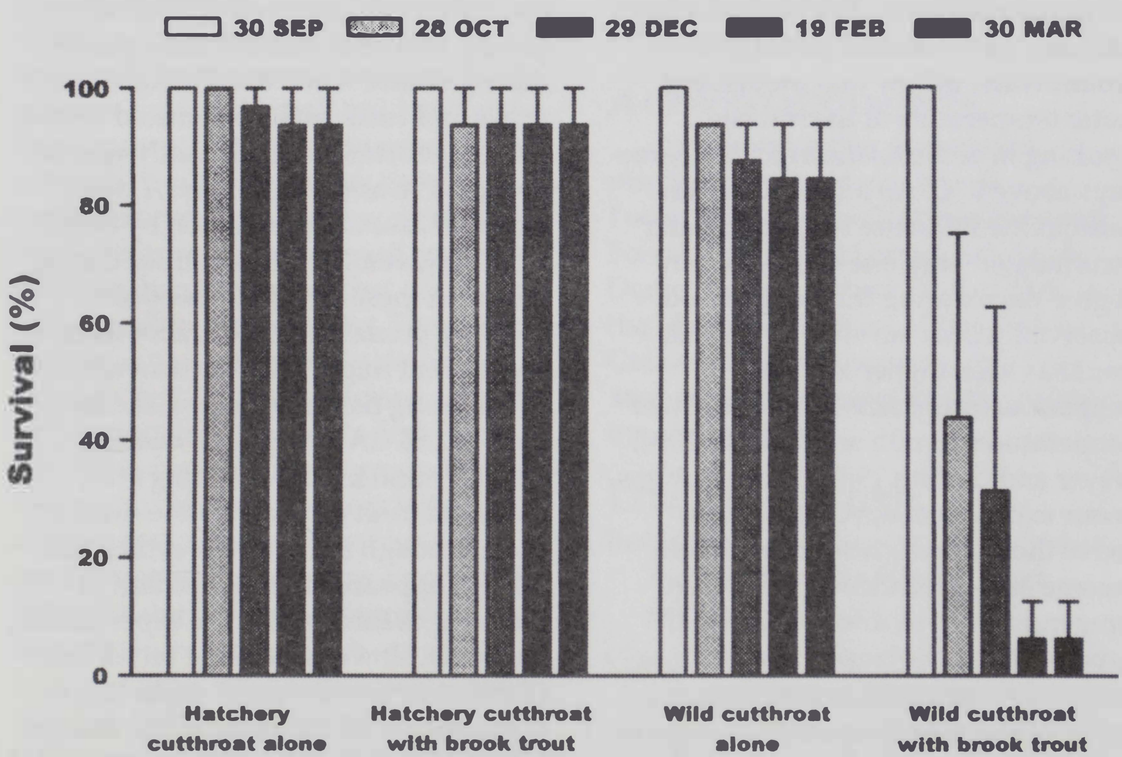

Figure 1. *Mean survival (% ± SE) of caged hatchery and wild cutthroat trout in allopatry and sympatry with brook trout in a tributary to Henry's Lake Outlet, Idaho, September 1995 to March 1996.*

Table 1. *Mean initial and final lengths (mm), and mean growth (mm) of age-0 brook and cutthroat trout that survived in cages from 30 September 1995 through 30 March 1996 in a tributary to Henry's Lake Outlet, Idaho.*

Species	Length (SE)		
Treatment (*N*)	Initial	Final	Growth (SE; %)
Wild cutthroat trout			
Alone (27)	47.0 (1.3)	49.2 (1.2)	2.2 (0.4; 4.7)
With brook trout (1)	61.0 (—)	65.0 (—)	4.0 (—; 6.6)
Hatchery cutthroat trout			
Alone (30)	80.6 (1.0)	85.3 (1.4)	4.7 (0.5; 5.8)
With brook trout (15)	81.8 (1.6)	86.9 (1.8)	5.1 (0.4; 6.2)
Brook trout			
With wild cutthroat (13)	84.3 (4.7)	87.1 (5.1)	2.8 (0.9; 3.3)
With hatchery cutthroat (13)	84.5 (2.3)	93.4 (2.7)	8.9 (0.7; 10.5)

slower in the fine-mesh cages containing wild cutthroat trout than in those containing hatchery cutthroat trout.

Discussion

Eighty-four percent of the wild cutthroat trout held in allopatry survived the 182-day experiment despite their small initial size, which suggested that size alone did not affect overwinter survival. The high survival rate may have resulted partially from groundwater inflow that moderated water temperature at the test site resulting in accumulation of 625 degree-days above 0 °C. An adjacent stream without the influence of groundwater accumulated only one-third as many degree-days during the same period. Observed winter survival of juvenile trout has been higher at higher temperatures and size-related at lower temperatures (Smith and Griffith 1994, Meyer and Griffith 1997). Temperatures in our experiment apparently were above those at which survival would become size-dependent. Had water temperatures been lower, we would have expected the larger hatchery cutthroat trout (68-95 mm at the beginning of the experiment) to survive at a higher rate than the smaller wild cutthroat trout (30-65 mm).

Survival of cutthroat trout in cages with brook trout was size-dependent, as survival of the larger hatchery fish exceeded that of the smaller wild fish. Predation by brook trout likely caused a portion of cutthroat mortality in cages that contained both wild cutthroat and brook trout. The only wild cutthroat trout that survived in the presence of brook trout was the largest individual at the beginning of the experiment. Predation of cutthroat trout by brook trout has been observed during summer (Irving 1987) but was not anticipated during winter when trout metabolism slows and food intake is reduced (Elliot 1976). Unfortunately, our study was not designed to assess piscivory. A study aimed at assessing predation by brook trout on juvenile cutthroat trout during winter in these streams is needed.

Any predation on cutthroat trout by brook trout might have been an artifact of confining fish, especially if the food supply and cover were sub-optimal. The smaller mesh in cages holding wild cutthroat trout excluded some drifting food although immature mayflies and midges appeared to be abundant in those cages throughout the experiment. However, slower growth of brook trout (Table 1) in the fine-mesh cages (cages containing wild cutthroat trout) than in large-mesh cages (cages containing hatchery cutthroat trout) indicated that food availability was reduced in the fine-mesh cages.

Effects of competition may have been exacerbated by confinement in the cages, by cage stocking densities, or by artificial food exclusion imposed by the cage mesh. Competition between cutthroat trout and brook trout may not occur in natural situations if the two species select different micro-habitats during winter. We observed juvenile brook trout and cutthroat trout in our test stream intermingling in a pool downstream from the beaver dam during nighttime snorkel surveys in winter. However, in the South Fork of the Snake River, Idaho, cutthroat trout concealed in boulder substrate (Griffith and Smith 1993) whereas brook trout use woody debris, vegetation, and undercut banks for concealment (Cunjak 1996). In streams where habitat types "preferred" by one species do not occur, both species may select the same habitats (Gibson 1978, Griffith and Smith 1993, Meyer and Griffith 1997), increasing the probability of competition.

The presence of groundwater inflows in streams, as in those from which we collected test fish, can accelerate development and growth of autumn-spawned brook trout and slow development of spring-spawned cutthroat trout. This occurs because water temperatures in these reaches remain warmer in winter and cooler in summer than in streams that are not influenced by groundwater. Therefore, eggs of autumn-spawned salmonids develop rapidly, often hatching as early as February in the Henry's Fork basin. Autumn-spawned fish in groundwater-influenced systems also rear initially at warmer temperatures than those available in streams lacking appreciable groundwater influence. Progeny of fish that spawn in spring hatch out much later and grow relatively slowly during summer in the cool groundwater-influenced streams. Autumn-spawned fish are therefore significantly larger than spring-spawned fish entering their first winter and are thereby conferred a competitive advantage (Glova 1986, Gregory and Griffith 1996). This effect is especially important in the Henry's Fork basin because it contains numerous springs (Whitehead 1978) and streams that are primarily spring-fed; about 75 percent of the base flow entering Island Park Dam originates from springs (Benjamin this issue).

Cutthroat trout have declined throughout their range (Duff 1996) but appear especially disadvantaged in the groundwater-influenced streams of the upper Henry's Fork basin because of competition with larger, autumn-spawned brook trout. In addition, rock concealment cover is unavailable in many of these streams (Gregory 1997), and age-0 cutthroat trout may therefore have to use winter habitat types, i.e., woody debris and undercut banks, better suited to, and occupied by, brook trout. Stocked hatchery cutthroat trout also may displace wild conspecifics in winter because of advantages conferred by their larger size; additional research is needed to assess the effects of hatchery fish on wild cutthroat trout.

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