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GROWTH AND LONGEVITY OF RAINBOW TROUT IN TWO HEADWATER STREAMS IN NORTHEASTERN TENNESSEE

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Abstract

Rainbow trout in two headwater streams in northeastern Tennessee exhibited short life spans and slow growth. There was significant year–to–year variation in both age structure and growth rates within the two streams. In streams with a minimum size limit of nine inches for rainbow trout, very few of these fish entered the legal fishery before death. We believe such special regulations favor the success of rainbow trout over sympatric brook trout which can be harvested at six inches.

Introduction

In recent years a number of studies have documented the continuing loss of native brook trout (*Salvelinus fontinalis*) populations in the southern Appalachians. The most detailed information on this decline consists of a series of reports on the brook trout of the Great Smoky Mountains National Park (King, 1937; Lennon, 1967; Jones, 1978 and Kelly et al., 1980), but Bivens et al. (1985) demonstrated that this continuing loss has also occurred for eastern Tennessee populations in streams located outside the park. These authors generally agreed that the initial major losses of brook trout populations in the early 1900's were largely due to habitat destruction associated with widespread logging and forest fires. Since that period, habitat degradation has become less of a problem, but the loss of brook trout can be largely attributed to competitive replacement by the introduced rainbow trout (*Salmo gairdneri*). Moore et al. (1983) provided experimental support for this hypothesis by removing rainbow trout from streams containing sympatric populations of brook and rainbow trout. This manipulation resulted in an increase in brook trout density and biomass but the increase did not completely compensate for the numbers and biomass of removed rainbows. Neves et al. (1985) summarized the postulated characteristics of rainbows thought to be responsible for this competitive advantage: 1) lower vulnerability to angling and predation, 2) aggressive superiority in foraging, 3) greater tolerance of flooding and temperature variation, 4) higher growth rates and fecundity and 5) larger maximum size due to greater longevity; but they point out that most of these potential factors lack direct documentation. Much of the direct and indirect evidence in support of these proposed rainbow advantages is confounded by comparing characteristics of allopatric rainbows downstream from the areas of sympatry with characteristics of allopatric brook trout living upstream from areas of sympatry. Since brook trout are now confined to small headwater sreams, it would be of interest to examine the characteristics of allopatric rainbow populations under similar conditions. This study presents comparative information on growth and longevity from allopatric populations of rainbow trout in two small headwater streams in northeastern Tennessee.

Materials and Methods

Collection Sites. Fish collections and determinations of stream characteristics were taken in Briar and Ramsey Creeks, Washington County, Tennessee. These are second order streams which are tributaries of Dry Creek, a third order stream which empties into the Nolichucky River. For each stream, pH and conductivity were determined with portable electronic meters.

Width and depth were measured at 10-m intervals following procedures outlined in Armour et al. (1983). At each interval, depth was measured at points 1/4, 1/2 and 3/4 of the distance across the stream. All physical measurements and chemical determinations were made during periods of relatively low flow during the summer and fall. Average width, average depth, pH and conductivity were 3.32 m, 11.3 cm, 7.1 and 30μS/cm for Briar Creek and 2.59 m, 15.5 cm, 6.9 and 28μS/cm for Ramsey Creek. Depth and width measurements were based on 30 and 50 stations for Briar and Ramsey Creeks respectively. These same 300-m and 500-m sections were also used for the trout collections described below.

Neither of these two streams receives any significant fishing pressure. Briar Creek is on Cherokee National Forest Service lands and has been visited frequently by the senior author during the period covered in this report. During this period only one fisherman was encountered. Ramsey Creek is on land owned by the Buffalo Mountain Methodist Camp and the resident managers of the camp stated that fishing is practically non–existant on this stream.

Trout Collections. Fish were collected by means of backpack electrofishing units with voltages ranging from 120 to 500 AC or DC depending on water conditions and the unit available at the time. Each specimen was identified, measured for total length (TL) to the nearest mm and released. If the fish was >100 mm TL, a scale sample was taken from just below the dorsal fin. Fish <100 mm TL were assumed to be young–of–the–year. All fish were collected in late summer to early fall after they had completed the major spring growth period (Whitworth and Strange, 1983) to avoid the need to use back–calculated sizes in making size comparisons. Scale annuli were counted under a compound microscope to determine the age of fish >100 mm TL.

Table 1. Age/frequency distributions of rainbow trout collected in two headwater streams in northeastern Tennessee.

Stream and Year	Age 0+	Age I+	Age II+	Age III+
Briar Creek 1979	44	8	3	0
Briar Creek 1980	3	13	2	0
Briar Creek 1981	7	8	3	0
Briar Creek 1983	24	37	3	0
Briar Creek 1984	5	32	11	1
Briar Creek 1985	10	2	6	0
Briar Creek 1987	5	19	3	1
Subtotal	98	119	31	2
Ramsey Creek 1979	80	44	3	1
Ramsey Creek 1984	0	26	14	4
Ramsey Creek 1986	67	27	5	5
Ramsey Creek 1987	4	26	5	1
Subtotal	151	123	27	11
Total	249	242	58	13

RESULTS

Population structure and longevity. Information on age class composition is summarized in Table 1. No fish older than III+ were taken during this study and III+ fish were extremely rare. Chi square test of homogeneity indicate significant year–to–year variation in age class composition for both streams. Chi square values and associated probabilities for Briar and Ramsey Creek age/frequency distributions were 83.5, $p<0.001$, $df=12$ and 100.9, $p<0.001$, $df=6$ respectively. The III+ age categories were not included in these analyses due to the low expected frequencies. At least part of this heterogeneity can be attributed to large fluctuations in the relative abundance of the 0+ age classes. In 1984 and 1987 both streams experienced spates shortly after

Table 2. Average total length (mm) by age class of rainbow trout in two headwater streams in northeastern Tennessee.

Stream and Year	Age 0+	Age I+	Age II+	Age III+
Briar Creek 1979	98.5 (2.7)	169.5 (8.0)	223.0 (10.0)	- (-)
Briar Creek 1980	58.3 (1.7)	146.5 (6.7)	209.5 (25.5)	- (-)
Briar Creek 1981	77.7 (2.2)	137.0 (6.5)	190.0 (17.6)	- (-)
Briar Creek 1983	75.5 (1.4)	161.3 (2.9)	206.0 (12.9)	- (-)
Briar Creek 1984	78.0 (3.1)	145.8 (2.7)	210.1 (7.7)	273.0 (-)
Briar Creek 1985	72.0 (2.1)	158.0 (7.0)	206.8 (7.1)	- (-)
Briar Creek 1987	77.0 (1.9)	136.9 (2.2)	181.7 (7.3)	232.0 (-)
Ramsey Creek 1979	81.7 (0.9)	164.8 (2.9)	222.3 (17.8)	370.0 (-)
Ramsey Creek 1984	- (-)	150.8 (3.0)	206.1 (7.2)	236.3 (10.1)
Ramsey Creek 1986	63.0 (0.9)	157.8 (2.5)	218.6 (12.7)	236.8 (3.5)
Ramsey Creek 1987	82.3 (5.6)	140.7 (2.5)	185.6 (8.1)	231.0 (-)

Numbers in parentheses represent ±one standard error of the mean.

Sample sizes are represented by corresponding entries in Table 1.

completion of rainbow trout spawning in late March and early April. These spate episodes apparently resulted in heavy mortality of eggs or sac fry. The 1980 and 1981 0+ age classes in Briar Creek also appear weak but we do not have adequate field records for this period which would support any causal speculations.

Growth. Table 2 contains mean length and standard error of the mean for each age class. Sample size for each entry can be determined from the corresponding numbers in Table 1. A series of Kruskal–Wallis nonparametric ANOVA's were used to test for significant year–to–year variation in the average total length for each age class within a particular stream. In both Briar Creek and Ramsey Creek the 0+ and I+ age classes showed significant year–to–year variation ($p<0.001$) but no significant difference was detectable for the II+ age class ($p>0.05$). Each of the three age class analyses for Briar Creek had six degrees of freedom. For Ramsey Creek, the I+ and II+ analyses had three degrees of freedom but the 0+ analysis had only two degrees of freedom due to the absence of any 0+ trout in the 1984 sample. The III+ age classes were not analyzed due to the relatively small sample sizes.

Discussion

Our study indicates that rainbow trout in small headwater streams have a relatively short life span. Fish in their fourth year (III+) were rare in both populations studied. Similar results for rainbow populations in other headwater streams have been reported by Coulston and Maughan (1981) for North Carolina and by Whitworth and Strange (1983) for Rocky Fork in northeastern Tennessee. All these studies revealed population structure and longevity which was similar to that reported for brook trout in a variety of streams in the southern Appalachians (Konopacky, 1978).

Our study of rainbow trout in headwaters streams indicates slow growth and relatively small maximum size. A 10–inch (254 mm) fish is truly exceptional and 8–inch (203 mm) individuals are rare. This is similar to findings by Coulston and Maughan (1981) for North Carolina and by Whitworth (1980) and Whitworth and Strange (1983) for Rocky Fork in northeastern Tennessee. Coulston and Maughan (1981) noted that very few rainbows in the streams they studied ever surpass the minimun size limit of 10 inches (254 mm) prior to natural mortality.

In Tennessee, the general regulation minimum size is six inches (154 mm) for brook trout and no limit for other species; however, a number of special regulation streams have a 6–inch minimum for brook trout and a 9–inch (229 mm) minimum for rainbow and brown trout (Tennessee Wildlife Resources Agency, 1987). In such streams, rainbow trout are essentially protected from harvest while brook trout are not. These special regulations may put declining brook trout populations at a competitive disadvantage.

Available information for growth of rainbow trout in small headwater streams does not provide adequate support for the hypothesis that rainbows grow faster than brook trout. In our study rainbow trout fell within the ranges reported for 30 different Appalachian brook trout populations (Konopacky, 1978). Even small growth rate differences which give rainbows a size advantage also may give them an advantage in competitive interactions with brook trout (Larson and Moore, 1985). Whitworth and Strange (1983) found that rainbow trout gain a size advantage over brook trout in their second year of life in Rocky Fork in northeastern Tennessee. Unfortunately, they were forced to compare rainbows from downstream reaches with brook trout from the upper portions of their study area (Rose, 1986). Their comparison is further confounded by the fact that Rocky Fork is under the special regulation which restricts harvest of brook trout to individuals greater than six inches and rainbow trout to nine inches. Larson and Moore (1985) showed that rainbow trout of high–gradient streams in the GSM National Park grow faster than brook trout and continue to encroach on the remaining brook trout populations. This comparison is also confounded by comparing rainbows from the downstream edge of the zone of sympatry with brook trout from the upstream edge of the zone of sympatry. They noted that in low–gradient streams in the GSM National Park brook trout resist invasion from downstream rainbow populations and they suggested complex biotic and abiotic interactions were influencing these two species differently in different situations.

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