REARING WITH OVERHEAD COVER INFLUENCES RAINBOW TROUT BEHAVIOR

Kristen H. Becket and Michael E. Barnes*
South Dakota Department of Game, Fish and Parks
McNenny State Fish Hatchery
Spearfish, South Dakota 57783
*Corresponding author email: mike.barnes@state.sd.us

ABSTRACT

This study assessed the differences in the behavioral reactions of rainbow trout (*Oncorhynchus mykiss*) reared in tanks with or without overhead cover. Fish were reared for eight weeks in tanks either completely uncovered, or with either 33% or 66% overhead cover, prior to behavioral observation. In the initial experiment, a hand-waving stimulus applied over the tank for approximately five seconds resulted in a significantly different behavioral response between the fish in the uncovered and partially-covered tanks. The fish in the uncovered tanks randomly scattered, while the fish in the tanks with 66% overhead cover displayed retreating behavior from open to covered areas of the tanks. Fish in tanks with 33% cover responded by a mix of random scattering and retreating behavior. In a subsequent experiment, three fish per tank from the first experiment were removed from their original tanks and placed into tanks with a different cover treatment. After two hours, a hand-waving stimulus was applied. In this experiment, fish reared without cover maintained the same random scattering behavioral response to a hand-waving stimulus exhibited in the first experiment, even if overhead cover was available as a retreating location. Fish reared using either of the overhead cover treatments in the first experiment continued to respond to the stimulus by retreating, even if the amount of overhead cover was changed from 33% to 66% or vice-versa. This study may have implications regarding the use of tank covers during hatchery rearing to improve post-stocking survival.

Keywords

rainbow trout, *Oncorhynchus mykiss*, overhead cover, hatchery rearing, behavior

INTRODUCTION

Fish are typically placed in uncovered tanks during hatchery rearing to allow easy access for observation and periodic cleaning (Reisenbichler and Rubin 1999). Overhead cover is essential for juvenile salmonids in natural habitats (Swales et al. 1986; Smith and Griffith 1994; Keith et al. 1998). In a hatchery setting, the growth and feeding efficiency of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) was increased by partially covering circular rear-

ing tanks (Barnes and Durben 2003; Barnes et al. 2005). Devore and White (1978), and Hartzler (1983) suggested that partial cover accommodates the innate behavioral adaptations developed by trout in natural situations to respond to startle or antipredator stimuli. In the wild, trout spend a considerable amount of time under cover (Hartman 1963; O'Hara 1986) and are especially prone to use covered areas as refuge sites when disturbed (Bachman 1984). Because refuge sites are not usually available during hatchery rearing, trout would not be able to learn this behavioral response, which could potentially affect post-stocking survival.

The behavior of rainbow trout in response to a stimulus during hatchery rearing has not been reported, nor has rainbow trout behavior under different amounts of overhead cover (tank coverage). Behavioral responses to novel amounts of cover have also not been reported. Thus, the objectives of this study were to examine the behavior of rainbow trout during hatchery rearing in tanks with varying degrees of overhead cover, and to determine the response of trout reared under a set cover regime to a novel cover treatment.

METHODS

All experimentation occurred at McNenny State Fish Hatchery, Spearfish, South Dakota, USA, using well water at 11 °C (total hardness at $CaCO_3$, 360 mg/L; alkalinity as $CaCO_3$, 210 mg/L; pH 7.6; total dissolved solids, 390 mg/L). At initial feeding, twelve 100-L tanks each received 375 rainbow trout fry. Four tanks were uncovered, four tanks had overhead coverage of approximately 33% of the tank surface, and the remaining four tanks had overhead coverage of approximately 66%. The covers were constructed from 6.35 mm corrugated black plastic sheeting and sat on the lip of each tank, approximately 15 cm from the water surface. The fish were fed a commercial trout diet (Skretting, Tooele, Utah, USA) at a hatchery constant of 5.60 (Buterbaugh and Willoughby 1967), with feed weighed daily to the nearest 0.1g and dispensed via automatic feeders (Sweeney Enterprises, Inc., Boerne, Texas, USA) hourly from 08:00 to 16:00. Tanks were cleaned twice a week, but otherwise left undisturbed except for daily feeding. The fish were reared in these tanks for a total of eight weeks, reaching a mean (± S.D.) length of 40.4 ± 2.4 mm and mean weight of 0.72 ± 0.13 g, before behavioral data were collected in two experiments.

Experiment 1. An individual stood above one of the tanks for 30 seconds to allow the fish to acclimate to their presence. After 30 seconds, a digital image of the tank was recorded to capture the location of the fish before a stimulus was applied. After taking the digital image, the individual applied a stimulus (vigorous hand-waving across the top of the tank for five seconds), and recorded another digital image immediately after the stimulus ceased. One set of images was taken for each tank, with replication provided by the four tanks per treatment. The digital images were then transferred onto a computer where a numbered grid was superimposed over the tank surface, and fish location was quantified by grid location (Figures 1a, 1b, 1c). Grid location data were analyzed using one way analysis of variance and Tukey's mean comparison procedure with significance set

at $\alpha = 0.05$. In addition to the grid data, observational data were also recorded using the ethogram in Table 1.

Experiment 2. After experiment 1 was completed, three fish per tank from the first experiment were removed from their original tanks and placed into tanks with all three of the different cover treatments (uncovered, 33% cover, 66% cover). After two hours, a hand-waving stimulus was applied. Only visual observations of behavior were recorded; digital images were not taken. The visual observations were categorized by using the same ethogram as the first experiment. One observation was recorded for each tank, with replication provided by the four tanks per treatment.

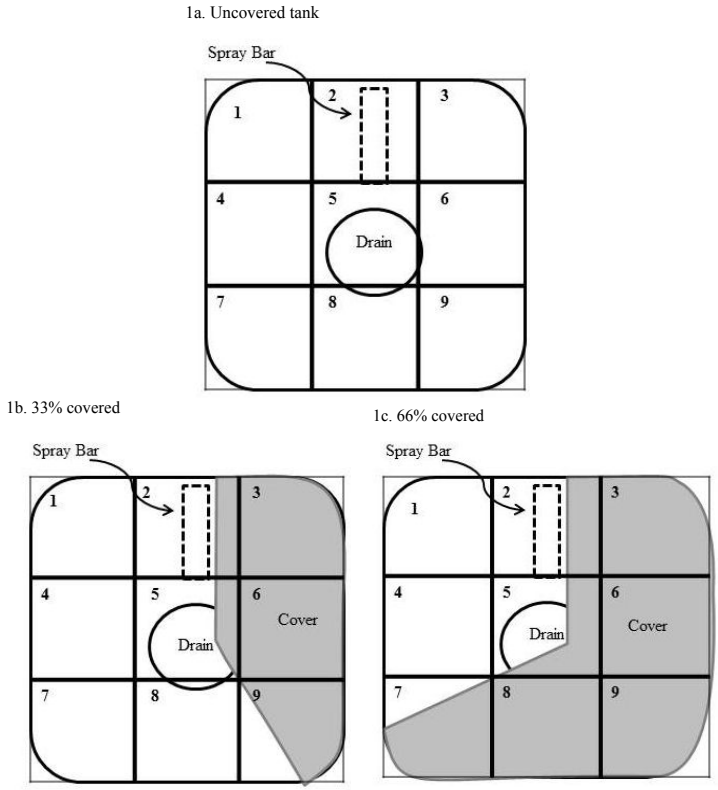

Figure 1. View of uncovered, 33% covered, and 66% covered tanks with the numeric grid superimposed.

Table 1. Ethogram used to describe the behavioral reaction to a stimulus of rainbow trout reared in tanks with varying amounts of overhead cover.

Behavior	Definition
No Reaction	No influence or difference in the behavior
Random Scatter	Swimming to no particular area
Retreat	Swimming to a particular area

RESULTS

Experiment 1. Observationally, the fish from the tanks with overhead cover reacted very differently to the handwaving stimulus in comparison to fish in the uncovered tanks. While all of the fish were randomly scattered before the stimulus, the fish in the partially-covered tanks exhibited clear retreat behavior after the stimulus was applied (Table 2). Significant differences in the number of fish per tank grid after the stimulus were detected among the overhead cover treatments (Table 3). Significantly fewer fish were observed in the uncovered parts of the tank in those tanks with 66% cover compared to both the uncovered and 33% covered tanks. A mean of only 33 fish, out of the 375 fish in each tank, were observed in the open areas of the 66% covered tanks, while in the same

Table 2. Behavioral responses to a hand-waving stimulus of rainbow trout reared in tanks with varying amounts of overhead cover.

Overhead cover	Pre-stimulus Behavior	Post-stimulus Behavior
None (uncovered)	Random Scatter	Random Scatter
33%	Random Scatter	Retreat
66%	Random Scatter	Retreat

Table 3. Mean (+ SE) number of rainbow trout observed in defined tank grid locations. Means across a row with different letters are significantly different (P < 0.05). Grid sections where fish could not be counted because the grid was covered are indicated in the table by covered.

		Overhead Cover		
Grid	Time	None	33%	66%
1	Pre-stimulus	0.00 + 0.00 z	0.00 + 0.00 z	0.00 + 0.00 z
	Post-stimulus	3.75 + 1.25 z	0.00 + 0.00 y	0.00 + 0.00 y
2	Pre-stimulus	0.00 + 0.00 z	5.00 + 0.00 z	0.00 + 0.00 z
	Post-stimulus	3.75 + 1.25 z	2.50 + 1.44 z	0.00 + 0.00 y
3	Pre-stimulus	0.00 + 0.00	covered	covered
	Post-stimulus	5.00 + 0.00		
4	Pre-stimulus	15.00 + 5.00 z	3.75 + 2.39 z	7.00 + 1.77 z
	Post-stimulus	55.00 + 15.00 z	3.75 + 2.39 y	4.25 + 0.75 y
5	Pre-stimulus	137.50 + 12.50 z	100.00 + 28.86 z	17.50 + 2.50 z
	Post-stimulus	100.00 + 0.00 z	75.00 + 14.43 z	4.00 + 1.00 y
6	Pre-stimulus	50.00 + 33.41	covered	covered
	Post-stimulus	42.50 + 19.73		
7	Pre-stimulus	28.75 + 9.21 z	12.50 + 4.78 z	covered
	Post-stimulus	27.50 + 10.30 z	12.50 + 4.79 z	
8	Pre-stimulus	25.00 + 5.00 z	60.00 + 23.45 z	covered
	Post-stimulus	10.00 + 0.00 z	58.75 + 24.35 z	
9	Pre-stimulus	12.50 + 2.50	covered	covered
	Post-stimulus	12.50 + 2.50		

grid locations, 82 fish were observed in the 33% covered tanks and 163 in the uncovered tanks.

Experiment 2. The behavioral response to a stimulus was influenced by the amount of overhead cover experienced during prior rearing (Table 4). When fish previously reared under either of the overhead cover regimes were placed in open (uncovered) tanks and a stimulus was applied, random scatter behavior was observed, similar to the response of fish reared previously in open tanks. When fish previously reared under either of the covered treatments were placed again in tanks with either 33% or 66% overhead cover and received a hand-waving stimulus, retreating behavior to under the covered areas of the tanks was observed. However, when fish reared in uncovered tanks were placed in tanks with either 33% or 66% overhead cover, they reacted to the stimulus by randomly scattering; their behavior was the same as if there was no overhead cover available.

Table 4. Behavioral response to a hand-waving stimulus of three rainbow trout originally reared in tanks that were uncovered, or had either 33% or 66% overhead cover and subsequently placed in different tanks that were either uncovered, or had either 33% or 66% overhead cover.

	Overhead Cover		
Original Rearing	**None**	**33%**	**66%**
None	Random Scatter	Random Scatter	Random Scatter
33%	Random Scatter	Retreat	Retreat
66%	Random Scatter	Retreat	Retreat

DISCUSSION

These results indicate that rainbow trout reared in tanks with overhead covers behave differently than those reared in uncovered tanks. These results are similar to the observations made by Devore and White (1978) and Hartzler (1983) who indicated that partial cover accommodates the innate behavioral adaptations developed in natural situations to respond to startle or antipredator stimuli. Our results support the conclusions of Bachman (1984), Hartman (1963), and O'Hara (1986) that trout spend a considerable amount of time under cover and seek refuge under overhead cover when they are disturbed. Similarly, Barnes et al. (2005) noted that when partial tank covers were available during hatchery rearing, brown trout concentrated under the cover and remained relatively motionless. It is possible that the use of tank covers could be simulating a nocturnal strategy described by Meyer and Gregory (2000) with larger salmonids in streams. However, nocturnalism is typically associated with colder water temperatures during the winter (Griffith and Smith 1993; Contor and Griffith 1995; Meyer and Gregory 2000) while the trout in this study were maintained at a constant 11 °C.

There are implications to hatchery rearing practices and post-stocking survival of hatchery-reared fish from this study. The benefits of overhead cover on the

hatchery rearing performance of juvenile salmonids have been described previously (Barnes and Durben 2003; Barnes et al. 2005), although results may be specific to unique strains or species (Pickering et al. 1987). More importantly, the lack of response to overhead cover of the trout reared in uncovered hatchery tanks may indicate an inability to adjust quickly to novel habitats after stocking. This in turn may make the stocked fish more vulnerable to both conspecific aggression and predation (Hossain et al. 1998). The inability of hatchery-reared fish to learn other adaptive behaviors for survival in the wild after stocking is well-documented (Shumway 1999; Huntingford 2004). In addition, using overhead cover during hatchery rearing has been shown to increase the likelihood of the use of overhead cover after stocking in salmonids (Roberts et al. 2011; Näslund et al. 2013), which may increase post-stocking survival (Johnsson et al. 2014). It would be beneficial for future studies to examine if the use of overhead cover during hatchery rearing has any impacts on the growth or survival of rainbow trout after stocking.

Based on the results of this study, the use of overhead cover during the hatchery rearing of rainbow trout is recommended, particularly if the trout are to be released into the wild for recreational use or for conservation.

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