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Covering Rearing Tanks Improves Brown Trout Growth and Feed Conversion

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Abstract

Although an important part of the natural environment of fish, overhead cover is usually absent during hatchery rearing. To evaluate the possible influence of overhead cover on juvenile brown trout *Salmo trutta* hatchery rearing performance, this study compared three different cover treatments: near-full (98%) cover, partial (65%) cover, and no cover (completely open). After 12 weeks of rearing in 1.8 m-diameter circular tanks, total tank weight gain was significantly greater and feed conversion ratios were significantly less in tanks of brown trout that were either partially or near-totally covered, in comparison to those tanks that were completely open. The viscerosomatic index, hepatosomatic index, and splenosomatic index values were not significantly different among any of the treatments. Fin condition indices were also not significantly different. The use of either partial or full covers is recommended to maximize brown trout rearing efficiencies, with full covers providing the additional benefit of preventing fish from jumping out of the tanks.

Keywords

Brown Trout, Overhead Cover, *Salmo trutta*, Circular Tanks

1. Introduction

Tanks used during hatchery rearing are typically uncovered to facilitate regular cleaning, allow for observations on fish growth, and discover possible fish health issues [1] [2] [3]. However, overhead cover is a normal part of the natural environment of wild fish, and brown trout *Salmo trutta* in particular is attracted to overhead cover [4] [5].

Because overhead cover is essential in natural habitats for numerous salmonids [6] [7] [8] [9] [10], studies have been conducted evaluating the use of partial covers during hatchery rearing. In some studies, partial overhead tank covers have improved the hatchery rearing performance of rainbow trout *Oncorhynchus mykiss* [11] [12] and brown trout [13]. However, the benefits of partial tank covers have not been universally reported, and may be species or strain specific [14] [15] [16] [17].

The concept of overhead cover was recently expanded to include covering nearly the entire top of the tank during the rearing of rainbow trout [12]. These nearly-full covers, with only a small open space to allow automatic feeders to dispense food to the fish, produced rainbow trout rearing performance superior to uncovered tanks and similar to that observed in partially-covered tanks [12]. In the only other study involving near-total tank covers during salmonid rearing, Roadhouse *et al.* observed that lake trout *Salvelinus namaycush* was significantly heavier when reared in covered troughs compared to those reared in uncovered troughs [18].

There have been no published studies examining the use of near-full covers during the hatchery rearing of brown trout. Thus, the objective of this study was to investigate the use of near-total tank covers on the growth and feeding efficiency of brown trout in comparison to those reared with partial covers or no overhead cover at all.

2. Materials and Methods

2.1. Hatchery Rearing

Experimentation occurred at McNenny State Fish Hatchery, rural Spearfish, South Dakota, USA using twelve circular fiberglass tanks (1.8 m in diameter, 0.8 m deep, 0.6 m operating depth). Each tank received approximately 45 L/min of aerated and degassed well water (11˚C; water hardness as $CaCO_3$-360 mg/L; alkalinity as $CaCO_3$-210 mg/L; pH-7.6; total dissolved solids-390 mg/L). Three overhead tank cover treatments were used (N = 4): open (no cover), partial cover over 65% of the tank, and near-full cover over 98% of the tank (with a small opening for the automatic feeder). Partial and near-total covers were made by riveting 6.35 mm corrugated black plastic sheeting (Coroplast, Vanceburg, Kentucky, USA), which was cut into a semi-circular shape to match the diameter of the open tops of the rearing tank, onto square aluminum tubing at the radius (**Figure 1**). The size of the partial cover was due to the use of one 1.22 × 2.44 m corrugated plastic sheet for each partial cover during construction. Ambient lighting occurred because of 0.5 m high translucent panels located just below the tank room ceiling, with daylight ranging from approximately 14.1 h at the start of the study to 15.2 h at the end. Overhead electric lights were only turned on once a day for approximately 15 min during daily tank cleaning and mortality removal.

The study began on April 29, 2015 and lasted for 12 weeks. At the start of the experiment, each of the twelve tanks received 10.23 kg (approximately 1650 fish) of juvenile Plymouth Rock strain brown trout [Mean (SE) weight and length of 6.17 (0.18) g and 80.8 (0.8) mm, respectively]. Fish were fed 1.5 mm extruded, floating pellets (Skretting, Tooele, Utah, USA) to satiation daily, which was based on a hatchery constant of 7.26 (0.065 mm/day) with an anticipated 1.1 feed conversion [19]. Feeding to satiation was visually verified at periodic intervals, and individual lengths and weights of fish from each tank were measured approximately every 30 days to evaluate feeding rates and growth projections (n = 5 on day 30 and 62). Each tank received 23.35 kg of feed during

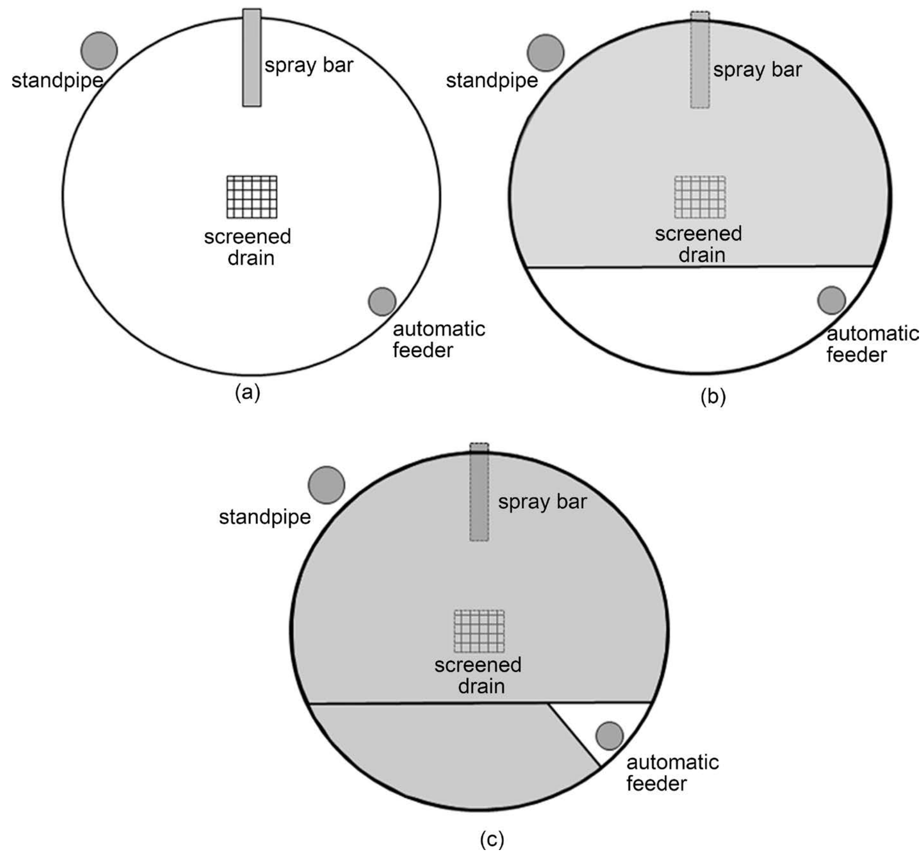

Figure 1. Schematics of an uncovered tank (a), partially covered tank (b), and near fully covered tank (c).

the experiment. Pellets were dispensed from EWOS 505 (Norco-last AS, Sweden) automatic feeders between 08:00 to 18:00 for 1 minute at 20-minute intervals. Feed rations, along with the number and weight (g) of mortalities, were recorded daily for each tank.

2.2. Data Collection

Total body weights to the nearest 0.1 g, and viscera, liver, and spleen weights to the nearest 0.001 g, were recorded at the beginning of the experiment from a common pool (n = 30) and at the end of the experiment from each tank using a model ER-120A A&D electronic balance (Tokyo, Japan). Digital calipers were used to record total lengths, and the lengths of the dorsal fin and one pectoral and pelvic fin to the nearest 0.01 mm. Additionally, total tank biomass (to the nearest 5 g) was measured at the beginning and end of the experiment for each tank using a Ohaus model T1XW scale (Parsippany, New Jersey, USA). At the end of the experiment, total body, liver, spleen and visceral weights were recorded from five randomly-selected individuals from each tank. Total, dorsal, pectoral and pelvic fin lengths were also recorded for the same individual fish.

The following equations were used:

1) Condition Factor (K) = [weight (g)/total length (cm)^3] × 100.

2) Fin index (%) = {[fin length (mm) ÷ total length (mm)] ×100}.

3) Viscerosomatic index (VSI) = {[weight of viscera (g) ÷ total fish weight (g)] × 100}.

4) Hepatosomatic index (HSI) = {[liver weight (g) ÷ total fish weight (g)] × 100}.

5) Splenosomatic index (SSI) = {[spleen weight (g) ÷ total fish weight (g)] × 100}.

6) Food conversion ratio (FCR) = feed fed (g)/weight gain (g).

2.3. Statistical Analysis

Data were analyzed using the SPSS (9.0) statistical analysis program (SPSS, Chicago, Illinois, USA) with significance predetermined at $P < 0.05$. Individual tanks were the replicates used for statistical analysis because they were the experimental unit, not the individual fish. At the end of the experiment when multiple fish were sampled from one tank, the mean of that sample was considered a replicate and used for analysis. One way analysis of variance (ANOVA) was conducted, and if the treatments were significantly different, pairwise mean comparisons were performed using the Tukey HSD test.

3. Results

Total tank weight gain and food conversion ratio were significantly improved in tanks that were either near-completely covered or partially covered, compared to uncovered tanks (Table 1). However, no significant differences in growth or food conversion ratio were found between the near-completely covered and partially covered tanks. Mortality was under 0.5% in all of the tanks and was not significantly different among the treatments.

No significant differences were observed among the treatments in individual fish lengths (Table 2). Mean individual fish weights were 18.3 g, 16.3 g, and 16.3 g in the near-completely covered, partially covered, and uncovered tanks, respectively, but were not significantly different. There was no significant difference in any of the internal organ indices. Mean SSI was 0.19 in the uncovered tanks compared to 0.10 and 0.09 in the covered tanks but, there was considerable variation. There was no significant difference in fin condition indices among the treatments as well.

Table 1. Mean (SE) rearing data for tanks of rainbow trout that were open at the top, partially-covered, or near-fully covered. Means in a row with different letters are significantly different ($N = 4$, $P < 0.05$).

	Rearing Tank Cover			
	None	Partial	Near-Full	P value
Start weight (kg)	10.23 ± 0.00	10.23 ± 0.00	10.23 ± 0.00	
Food fed (kg)	23.35 ± 0.00	23.35 ± 0.00	23.35 ± 0.00	
End weight (kg)	27.00 ± 0.43 z	28.54 ± 0.19 y	28.83 ± 0.09 y	0.002
Gain (kg)	16.77 ± 0.43 z	18.31 ± 0.19 y	18.61 ± 0.09 y	0.002
Food Conversion Ratio	1.40 ± 0.04 z	1.28 ± 0.13 y	1.26 ± 0.06 y	0.004
Mortality (%)	0.31 ± 0.07	0.16 ± 0.04	0.22 ± 0.07	0.258

Table 2. Ending mean (SE) length, weight, condition factor (K)[a], liver weight, hepatosomatic index (HSI)[b], viscera weight, viscerosomatic index (VSI)[c], spleen weight, splenosomatic index (SSI)[d], fin lengths, and fin indices[e] from rainbow trout reared in tanks that were open at the top, partially-covered, or near-fully covered ($N = 4$, $P < 0.05$).

	Rearing Tank Cover			
	None	Partial	Near-Full	P value
Length (mm)	115 ± 2	113 ± 3	118 ± 4	0.550
Weight (g)	16.3 ± 0.62	16.3 ± 1.3	18.3 ± 1.7	0.476
K[a]	1.05 ± 0.03	1.08 ± 0.02	1.07 ± 0.02	0.691
HSI[b]	1.79 ± 0.18	1.68 ± 0.07	1.89 ± 0.05	0.483
VSI[c]	8.90 ± 0.10	8.42 ± 0.77	8.65 ± 0.54	0.829
SSI[d]	0.19 ± 0.09	0.10 ± 0.01	0.09 ± 0.05	0.346
Pectoral fin index[e]	12.44 ± 0.15	13.10 ± 0.24	12.56 ± 0.30	0.174
Dorsal fin index[e]	11.62 ± 0.22	11.32 ± 0.92	10.52 ± 0.31	0.300
Pelvic fin index[e]	11.12 ± 0.38	11.49 ± 0.50	11.45 ± 0.40	0.807

[a]$K = 10^5 \times (\text{weight})/(\text{length}^3)$; [b]HSI = 100 × (liver weight/body weight); [c]VSI = 100 × (viscera weight/body weight); [d]SSI = 100 × (spleen weight/body weight); [e]Fin index = 100 × (fin length/total length).

4. Discussion

4.1. Cover

The significant improvements with the use of either partial or near-total overhead cover observed in this study with brown trout are similar to those reported for rainbow trout [12]. Partial covers have been previously shown to improve brown trout rearing performance in circular tanks [13], but this study is the first to document the positive effects of near-total tank overhead coverage. In contrast, Pickering *et al.* observed no increase in brown trout growth when reared under partial covers [14]. The discrepancy between these studies may be due to the genetic strain of brown trout used in these experiments. Pickering *et al.* used a very domesticated strain [14], while the Barnes *et al.* used a very wild strain [13]. Strain differences have also been suggested to cause differences in the reaction to overhead cover in rainbow trout [12].

In the wild, brown trout have been observed to spend a large amount of time under cover, and especially use overhead cover to avoid disturbances [20] [21]. The use of overhead cover during hatchery rearing is likely accommodating brown trout innate behavior [7] [22]. By providing an area of refuge in an otherwise relatively sterile hatchery environment, overhead cover may be increasing brown trout growth by reducing the expenditure of energy and stress that occurs in uncovered tanks as the trout search in futility for a place of refuge [14] [23] [24] [25].

4.2. Lighting

It is also possible that the location of the tanks may have influenced the results. Pickering *et al.* reared brown trout and other salmonids in outdoor tanks and noticed little positive effect from overhead cover [14], where-as this study and others [11] [12] [13] were conducted indoors under ambient light filtering inside through translucent panels. In this study, in the near-fully covered tanks, only 0.1 lux of light was able to enter the tank through the small opening for the feeder, but apparently this small amount of light either met or exceeded the amount needed for brown trout growth [26] [27].

4.3. Indices

The feeding rate used for this study was based on historical data to achieve satiation and maximum growth at McNenny Hatchery. The relatively high HSI values, similar to those of similarly-sized rainbow trout fed to satiation [28] and much greater than those of trout fed restricted rations [12] [28], appear to indicate that the brown trout in this study were fed close to, or at, satiation. HSI is an indicator of liver energy content [29] and is particularly indicative of nutritional status [30]. Both HSI and VSI are indicators of lipid deposition, and the lack of differences among the treatments suggests that nutrient partitioning was similar between the covered and uncovered tanks [31] [32] [33] [34], even though growth and feed conversion were improved through the use of overhead cover.

All of the SSI values were within normal limits as reported by Shimma *et al.*, Uyan *et al.*, and Wiens *et al.* [35] [36] [37]. However, the relatively large SSI mean, although not significantly different from the covered tanks, and increased SSI variation in from fish in the open tanks is none-the-less interesting. The spleen plays a major role in trout immune responses [38], and has been shown to increase in size as a result of stress or disease [39] [40]. SSI is an indirect measure of immune function [37], and the SSI means from fish in the covered tanks were similar to that reported for unstressed salmonids in other studies [12] [28] [40]. However, the mean SSI observed in the open tanks is similar to that reported from diseased or stressed rainbow trout [40] [41].

The fin index values were generally greater than that reported previously for hatchery-reared brown trout and slightly less than that observed in wild brown trout [42]. These values may also provide additional evidence that the fish were fed to satiation in this study, because satiated fish are less aggressive and aggression is linked to decreased fin lengths [43] [44].

4.4. Structural Advantages

The plastic covers with aluminum supports used in this study have several ad-vantages over the wooden covers used in other studies by Barnes *et al.* [13]. The plastic covers are very light weight, extremely sturdy, and virtually unaffected by water. These materials do not rot or rust, as compared to covers composed of either wood or steel. The plastic covers are also much easier to remove and re-install, making fish moving and tank cleaning much less laborious.

5. Conclusion

In conclusion, the use of either partial or near-total overhead cover is recommended during the indoor rearing of brown trout in circular tanks. The use of near-total covers provides an additional benefit of keeping the trout from jumping out of the tanks, but makes tank cleaning and fish observations more difficult. In situations where frequent tank cleaning or fish observations are required, partial tank covers may be more practical.

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