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Experimental use of cobble substrates in concrete raceways for improving fin condition of cutthroat (*Oncorhynchus clarki*) and rainbow trout (*O. mykiss*)

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Abstract

In two separate experiments, Bear Lake cutthroat trout (*Oncorhynchus clarki* Utah) fingerlings and domesticated rainbow trout (*O. mykiss*) fingerlings were reared for 10 and 6 months, respectively, in concrete raceways with or without (controls) cobblestone bottoms. Health/Condition Profiles (HCPs) were performed bi-monthly on 20 fish per treatment. Both species showed significantly reduced fin erosion in cobble bottom raceways using fin scores from all 8 fins of individual fish. Relative fin lengths (% of body length) showed that significant shortening of fins of control fish occurred on caudal and both pectoral fins for cutthroat trout and for right pectoral, both ventral, caudal, and anal fins of rainbow trout. Comparison of the two species for relative fin lengths and fin scores showed that fin erosion was much more severe in rainbow trout. Overall, cobble substrates reduced fin erosion for both species, suggesting that natural bottoms are better for rearing than concrete.

Keywords: Substrate; Cobble; Concrete; Raceways; Fin erosion; *Oncorhynchus clarki*; *Oncorhynchus mykiss*

1. Introduction

Fin erosion is a common problem at cold-water fish hatcheries where salmonids are intensively reared (reviewed in Kindschi et al., 1991). Hatchery fish with eroded fins are easily distinguished from wild trout and may be less desirable to discriminating anglers (Sternberg, 1988) and consumers. Eroded fins can also be accompanied by microbial infection and/or hemorrhage (Schneider and Nicholson, 1980; Goede and Barton, 1990)

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and may result in partial fin loss (Kindschi et al., 1991), both possibly affecting swimming ability and survival in the wild.

A recent survey of all 10 Utah state fish hatcheries indicated that better fin condition often occurred in trout that were reared in raceways and ponds which contained natural bottom substrates such as gravel or mud (Bosakowski and Wagner, 1994a). To further test this hypothesis, we conducted a controlled study comparing two trout species reared in raceways with or without cobblestone bottoms.

2. Materials and methods

Experiment #1

Two outdoor raceways were lined with cobblestone (2–4 cm) bottoms and two normal raceways with concrete bottoms were selected as control raceways. Each raceway ($L=7.01\times W=0.91\times H=0.28$ m) was stocked with 1000 Bear Lake cutthroat trout (*Oncorhynchus clarki* Utah) fingerlings (F_1 progeny from wild broodstock). The fingerlings were stocked into the raceways at 55 mm in total length (TL) on 20 July 1992 and were reared under normal production scale for 10 months. The density index (Piper et al., 1982) ranged from 0.08 at initiation to 0.52–0.73 at the end of the study, when they reached 13 months of age and 180 mm TL. Flow rate was held constant at 0.88 l/s. Water quality determinations were performed in each raceway every 2 months using standard methods (APHA, 1989). At the end of this study values were: dissolved oxygen, 8.0 mg/l inflow and 4.9–7.0 mg/l outflow; total gas saturation, 105.5%; temperature, 12.9°C; total alkalinity, 188 mg/l; pH, 7.5–7.6; carbon dioxide, 10.5–13.2 mg/l; and total ammonia nitrogen, 0.22–0.32 mg/l.

Every 2 months, necropsies were conducted from 20 fish per treatment using the Health/Condition Profile (HCP) system (Goede, 1991). Most of the parameters used in this system are also discussed in further detail in Goede and Barton (1990). Fish were crowded to the head of raceways to obtain random grab samples with dip nets (Piper et al., 1982). As part of the HCP, fish were anesthetized with 100 mg/l of MS-222 (tricaine methane sulfonate), weighed to nearest 0.1 g, measured to the nearest mm for TL, and condition factor (K_{TL}) was calculated. In addition to the HCP fin procedures, we used a modification of Goede's (1991) HCP fin index (Bosakowski and Wagner, 1994a), in that we considered fins to be eroded with or without active infection and hemorrhaging, and each fin received a separate score instead of a single value for the fish. Thus, a perfect fin received a ''0'' score, 1 = slight erosion, and 2 = severe erosion. The sum of scores for all fins was totaled for each fish (representing individual fin scores). In addition, cutthroat trout in this study also showed occasional split and frayed fins which were not necessarily eroded or shortened in length. So, we also kept a record of the frequency of the number of fins which showed fraying (fin fraying frequency). On the last necropsy, fin lengths were also measured to the nearest mm and fin length ratios with total length were calculated (fin length/TL × 100) (Kindschi, 1987). These percents are termed ''relative fin lengths'' and were shown to be stable, linear relationships for trout ranging in size from 100 to 300 mm TL (Bosakowski and Wagner, 1994b).

Experiment #2

This experiment was conducted with a domesticated strain (Ten Sleep) of rainbow trout (*O. mykiss*), using the same raceways as in Experiment #1. However, water depth was doubled to 56 cm and smaller pea gravel was added to help fill-in the interstitial spaces between cobblestones. Each raceway was stocked on 9 June 93 with approximately 1300 fingerlings which were reared in the raceways for 6 months (until 9 months of age) when they reached approximately the same length as the cutthroat trout. This resulted in a density index ranging from 0.09 at the start of the experiment to 0.47–0.51 at the end. Flow rate was held constant at 121 l/s. Water quality determinations were performed in each raceway, every 2 months and at the end of this study were: dissolved oxygen, 6.9–7.2 mg/l inflow and 4.6–5.4 mg/l outflow; total gas saturation, 108%; temperature, 17.3°C; total alkalinity, 192 mg/l; pH, 7.2–7.3; carbon dioxide, 19.6–27.1 mg/l; and total ammonia nitrogen, 0.12–0.22 mg/l.

Statistical analysis

All data were analyzed on a personal computer using the Number Cruncher Statistical System (NCSS), Version 5.03, Kaysville, UT. Parametric data (body weight, total length, condition factor, hematocrit, leukocrit and plasma protein) were analyzed for normality (D'Agostino, 1990) prior to statistical tests. Relative fin lengths (arc-sine transformed), total length, and condition factor were normally distributed, so they were analyzed using Student's *t*-test. Leukocrit, hematocrit, and plasma protein data could not be normalized using a variety of transformations, so these data were compared using a Mann-Whitney U-test. Non-parametric ordinal data (bile, fin, opercle, thymus, fat, and hindgut index) were also analyzed using a Mann-Whitney U-test. Categorical classification data (eye, gill, pseudobranch, spleen, kidney, and liver) were analyzed with Fisher's Exact Test by comparing proportions which made up the "percent normals" (see Goede, 1991) for each organ or tissue. Since our hypothesis was that cobble bottoms might improve fin condition, one-tailed significance levels ($P < 0.05$) were used for statistical testing of fin parameters. Two-tailed tests were used to determine significance levels ($P < 0.05$) for all other variables.

3. Results and discussion

Individual fin scores showed a significant reduction in fin erosion in cobble treatments only on the last necropsy for both species (Fig. 1). At the end of the study, fin lengths were also measured and showed reduced relative fin length for dorsal and pectoral fins of control cutthroat trout (Fig. 2A) and reduced right pectoral, ventral, anal, and caudal fins for control rainbow trout (Fig. 2B). Both experiments showed the same result that fin condition was improved with cobble substrates (Table 1).

In comparing species, rainbow trout fin erosion was noticeably more severe than in cutthroat trout (Figs. 1 and 2). Interestingly, rainbow trout already displayed severe shortening of the dorsal fin prior to the start of treatment (65 mm TL) and essentially remained the same by the end of the study (180 mm TL) while Bear Lake cutthroat trout showed very little erosion of this fin. It is likely that dorsal fin erosion in rainbow trout is due to a species-specific behavior called "fin-nipping" which has been documented to occur exten-

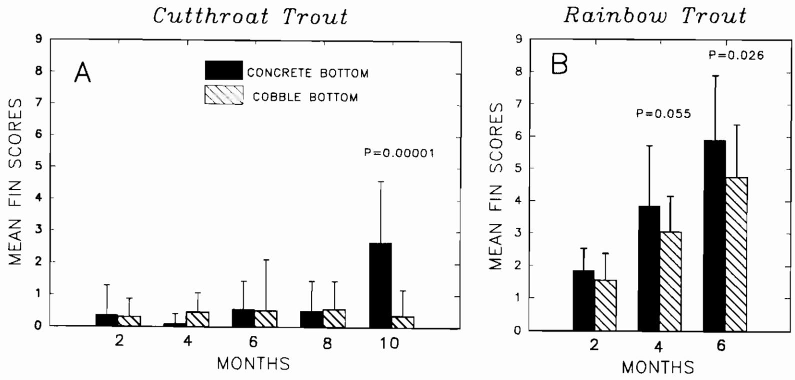

Fig. 1. Fin scores for individual fish at 2-month intervals after beginning treatment with or without cobble bottoms for cutthroat (A) and rainbow trout (B). Data represent means ± s.d. ($n = 20$).

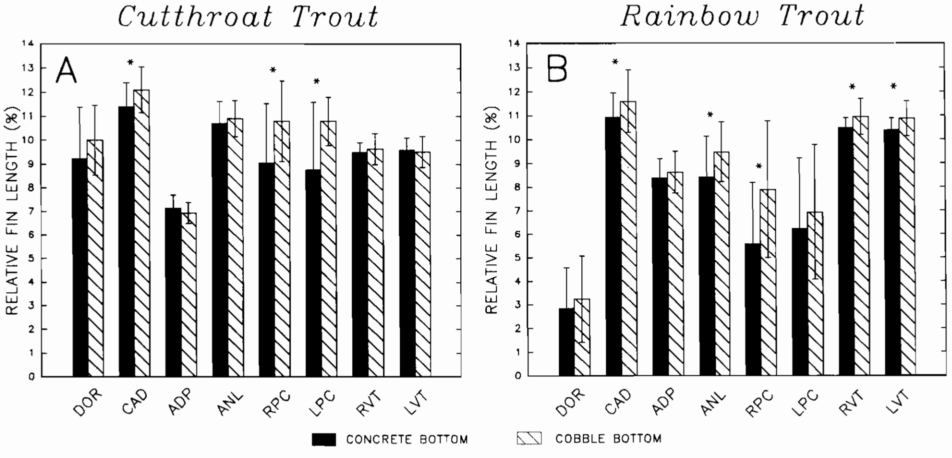

Fig. 2. Relative fin length (% of body length) of cutthroat trout (A) and rainbow trout (B) reared in concrete bottom and cobble bottom raceways. Data represent means ± s.d. ($n = 20$). Asterisks indicate significant difference between bars ($P < 0.05$). DOR = dorsal; CAD = caudal; ADP = adipose; ANL = anal; RPC = right pectoral; LPC = left pectoral; RVT = right ventral; LVT = left ventral.

sively on the dorsal fin of juvenile steelhead trout, *O. mykiss* (Abott and Dill, 1985). Kindschi et al. (1991) showed that steelhead fingerlings reared in isolation did not develop dorsal fin erosion, compared to counterparts reared in production nursery tanks.

In addition to fin erosion, fin fraying was also noted only for cutthroat trout. The frequency of fin-fraying tended to be higher (Mann-Whitney U-test, $P = 0.058$) in the control group compared to the cobble treatment at the end of the study, but not at the previous four necropsies.

Analysis of fin condition of cutthroat trout using the HCP fin index showed that fins remained in good condition in both groups until the last necropsy (at 10 mos.) where there was significantly ($P = 0.009$) greater fin erosion in the control group (1.1 versus 0.3 in the cobble group). For rainbow trout, no difference in the HCP fin index was detected between

Table 1
Fin erosion and fraying indices for Bear Lake cutthroat trout reared in concrete (control) and cobblestone raceways ($n=20$)

Necropsy month	HCP fin index mean		Individual fin score sum		Fin fraying frequency sum	
	Cobble	Control	Cobble	Control	Cobble	Control
2	0.35	0.15	6	7	10	4
4	0.40	0.40	9	2	3	9
6	0.25	0.50	10	11	15	23
8	0.35	0.30	11	10	21	29
10	0.30	1.10*	7	53*	71	90**

Months refer to treatment duration, not age of fish.
*$P<0.05$; **$P<0.058$.

groups because of frequent severe erosion of dorsal fins which tended to mask the effects observed for other fins. The drawback of the HCP fin index is that only one fin needs to be eroded to get a score, thus it is not sensitive to effects on multiple fins. Overall, several different fin indices clearly showed that the cobble substrate improved fin condition of both species compared to conspecific controls in typical concrete raceways.

Unfortunately, a side effect of the cobble treatment occurred in the cutthroat trout study. It was observed that length (−9.8%) and weight (−26.4%) were significantly reduced ($P=0.02$ and 0.04, respectively) compared to fish from control raceways (Fig. 3). Fat levels of fish from the cobble treatment (mean fat index = 1.1) were also significantly lower than control treatment (mean = 2.0, $P=0.014$). The reason for this substantial difference in growth and fat levels was apparently due to the fact that food pellets quickly sank through the 28 cm water column and were lost between the stones in the cobble treatment, whereas in control raceways, fish were apparently feeding on the bottom. These results corresponded to the better feed conversion values found in control fish (1.18 ± 0.156) compared to cobble treatment (1.33 ± 0.184). No such effects on growth, fat level, or feed conversion occurred with cobble treatments in the rainbow trout experiment. This is probably because smaller ''pea'' gravel was added and the water depth was doubled, apparently alleviating the problem of pellets sinking quickly between the crevices of the cobblestones. The use of demand feeders or floating pellets would also eliminate the problem regardless of cobble size or water depth.

Looking at other health parameters, no significant difference was observed for mortality levels between cutthroat trout from control (7.3%) and cobble treatments (7.0%), or among rainbow trout from control (4.3%) and cobble treatments (3.2%). Excepting fin and fat index, only a few minor shifts in HCP parameters were noted. These were a slight, but significant, difference ($P<0.05$) in hematocrit of cutthroat trout at the final necropsy (controls 45.3 ± 3.81 versus cobble 41.9 ± 3.39), although both treatments were within normal limits for trout (Snieszko, 1961). There was also a slight, but significant, difference in plasma protein at the end of the study for rainbow trout (controls 4.4 ± 1.44 versus cobble 3.4 ± 1.17). In looking at water quality, there were no significant differences between the two types of raceways in either study. Thus, the difference in growth rate of cutthroat trout was likely due to food availability and not to a decline in health associated with the cobble treatment.

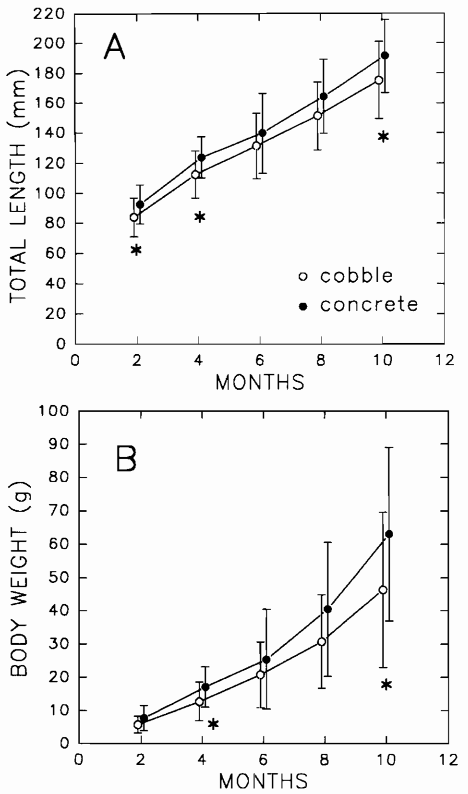

Fig. 3. Total length (A) and body weight (B) of cutthroat trout reared in control and cobble bottom raceways. Data represent means ± s.d. ($n = 20$). Asterisks indicates pairs that are significantly different ($P < 0.05$). No significant differences were noted in the rainbow trout experiment (data not shown, see text).

In conclusion, the results demonstrate that natural bottom substrates during rearing can significantly improve fin condition of hatchery-reared trout. The reason for such improvement is probably related somehow to a reduction in abrasion to fin margins. Such smoother surfaces may also quicken healing after fin nipping injury. While the absolute decrease in fin erosion was relatively small (< 15%) for both species using cobble substrates, it should be realized that the walls in cobble raceways were also concrete. Thus, additional prevention of fin erosion may be expected if trout are reared in more natural gravel and earthen systems. These experiments corroborate the old, but untested, hypothesis that concrete raceways are at least partially responsible for fin erosion.

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