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Fin Condition and Health Profiles of Albino Rainbow Trout Reared in Concrete Raceways with and without a Cobble Substrate

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Abstract.—Fingerlings of albino rainbow trout *Oncorhynchus mykiss* were reared for 200 d in concrete raceways with either concrete (controls) or cobblestone bottoms. Health and condition profiles were performed on 20 fish/treatment on four occasions. For fish in cobble-bottom raceways, there was no fin erosion as measured by fin indices (ranked from 0 to 2) applied to the fish as a whole or relative fin lengths (% of body length) of individual fins. For control fish, however, considerable erosion was evident for caudal, dorsal, anal, both pectoral, and both ventral fins. Condition factor, fat levels, and total length were reduced in cobbled raceways. Results are compared with previous experiments with normally pigmented rainbow and cutthroat trout *O. clarki*. Overall, cobble substrates markedly reduced fin erosion, which suggests that cobble-bottom raceways are especially suitable for rearing albino rainbow trout, if a slight reduction in growth is acceptable.

Fin erosion is a common problem in Utah trout hatcheries (Bosakowski and Wagner 1994). Microbial infection or hemorrhage or both is frequently associated with eroded fins (Schneider and Nicholson 1980; Khan et al. 1981). Fin loss can potentially compromise swimming ability and survival in the wild (Saunders and Allen 1967; Nicola and Cordone 1973). Fin erosion is also aesthetically unappealing to some anglers (Sternberg 1988).

Fin erosion has been attributed to a variety of causes, some environmental (Mahoney et al. 1973; Reash and Berra 1989) and some behavioral (Abbott and Dill 1985; Kindschi et al. 1991). The use of natural substrates during rearing has been associated with better fin condition (McVicar and White 1982; Bosakowski and Wagner 1994). Bosakowski and Wagner (1995) reported that Bonneville cutthroat trout *Oncorhynchus clarki utah* and rainbow trout *O. mykiss* reared in cobblestone bottom raceways had significantly better fin condition than fish in concrete bottom raceways.

This study was conducted to determine if albino rainbow trout respond similarly to cobble substrates. We examined fin condition, hatchery performance, and general health.

Methods

Methods we used were similar to those of Bosakowski and Wagner (1995); the floors of two outdoor concrete raceways were lined with cobblestone (2–4 cm) and pea gravel; two other raceways were randomly selected as controls. Bird netting covered the series of raceways used in the study, and plywood sheets covered a portion of each raceway to provide shade. The water depth was 0.28 m. Other differences in methodology from the Bosakowski and Wagner (1995) study are given below.

On 15 April 1994, we hand-counted 1,000 albino rainbow trout fingerlings (mean weight, 2.0 g) into each raceway; fish were reared for 200 d. Final fish counts were based on total weight. The density index (Piper et al. 1982) ranged from 0.13 at initiation to 0.37–0.52 at the study end. The flow rate of artesian well water varied from 39 to 78 L/min (flow index of 0.13–1.15; Piper et al. 1982), increasing over the course of the study. Final water quality values were dissolved oxygen, 6.0–6.2 mg/L inflow and 3.7–4.4 mg/L outflow; total gas saturation, 109–112%; temperature, 17°C; total alkalinity, 171–222 mg/L as $CaCO_3$; effluent pH, 7.3–7.4; carbon dioxide, 15–24 mg/L; and un-ionized ammonia nitrogen, 0.0017–0.0038 mg/L.

Health and condition profiles (HCP; Goede and Barton 1990) were conducted on experiment days 76, 108, 167, and 192, with 20 fish/treatment. The HCP fin index is a summary of all fins of a fish. It was recorded in such a manner that if one fin was a '2', the index for that individual was a '2'. The fin index in this study was modified from Goede and Barton (1990) and ranged from 0 (perfect fin) to 2 (severely eroded) instead of from 0 to 3. Also, severity was based on fin length as well as hemorrhaging.

Fish were fed a commercial trout diet (Silver-cup) by hand. Initially, the fish were fed 5.27% of body weight, six times a day. Feeding frequency was reduced to four times a day when the fish reached 5 g. Ration levels decreased as the fish grew, changing to 4.5% of body weight at 4.5 g, 3.4% at 12 g, 2.7% at 24 g, 2.1% at 39 g, and 1.9% at 62 g.

Raceways were cleaned once a week. The cement raceways were cleaned throughout with a metal broom, and the standpipe was pulled to flush the suspended solids. The cobbled raceways were similarly flushed after the substrate was lightly brushed. It was impractical to remove the waste feed and fecal material from between the rocks.

Statistical analysis.—All data were analyzed with SAS software for the personal computer (SAS Institute 1989). Body weight, total length, condition factor, fin index, bile index, fat index, hematocrit, leucocrit, and plasma protein were analyzed for normality (Wilk–Shapiro test) prior to statistical tests. Relative fin lengths (arcsine-transformed), total length, body weight, plasma protein, hematocrit, and condition factor were all normally distributed, so these variables were analyzed using Student's *t*-test for independent samples. Leucocrit, fin index, thymus index, fat index, and bile index data could not be normalized by transformation so these data were compared by using a Mann–Whitney *U*-test. Categorical data (eye, gill, pseudobranch, spleen, kidney, and liver) were analyzed by using a chi-square test, comparing frequencies of observations among category levels between treatments. Since the hypothesis was that fin erosion would be reduced over cobble bottoms, one-tailed significance levels ($P \leq 0.05$) were used for statistical testing of fin parameters. Two-tailed tests ($P \leq 0.05$) were used for all other variables.

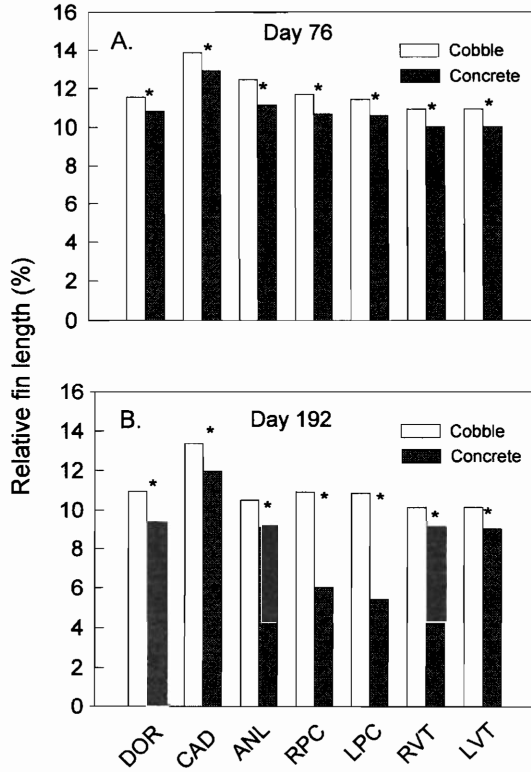

FIGURE 1.—Mean (N = 20) relative fin lengths (% of total length) for albino rainbow trout reared in concrete-bottom and cobble-bottom raceways and sampled on **(A)** day 76 and **(B)** day 192. An asterisk indicates a significant difference between bars ($P \leq 0.05$). Abbreviations are DOR = dorsal, CAD = caudal, ANL = anal, RPC = right pectoral, LPC = left pectoral, RVT = right ventral, and LVT = left ventral.

Results and Discussion

Fin erosion was significantly reduced (greater relative fin length) for the dorsal, caudal, anal, ventral, and pectoral fins in cobble treatments (Figure 1). The improvement was first observed on day 76 and was consistent thereafter. Fin index values were significantly higher (i.e., fins were more eroded) in concrete raceways only in the last two samples (days 167, 192; Table 1). The difference between the two methods of evaluating fin erosion indicated that relative fin length measurements (Kindschi 1987) are more sensitive to changes in fin wear than visual fin index estimates (Goede and Barton 1990).

Cobbled raceways had some drawbacks. In the last two samples, fat index and condition factor values were significantly greater in control fish than fish in cobbled raceways (Table 1). Mean lengths were also greater for control fish (196 mm ± 27.7 SD) than test fish (177 mm ± 22.7) in the last sample. The average final mean weight for the two raceways was greater for controls (91.6 ± 25.4 g) than for fish in cobble-lined raceways (67.3 ± 0.8 g), but the difference was not significant. Crowding fish for sampling and loading was more difficult in the cobbled raceways because of the uneven bottom, and fish escaped behind the screen. Cobbled raceways tended to have more algae, but it was not a problem.

The reduction in mean fat indices, total length, and condition factor in the cobble treatments versus the controls was also observed in Bonneville cutthroat trout (Bosakowski and Wagner 1995). Food pellets were probably more difficult to find in the cobble than on the flat cement bottom of control raceways. Floating pellets and demand feeders may be appropriate alternatives for cut-

TABLE 1.—Mean health and condition profiles (N = 20) of albino rainbow trout held in concrete raceways with or without a cobble substrate. Asterisk indicates significant difference in profile estimate between treatments ($P \leq 0.05$).

Variable and substrate	Experiment day 76	108	167	192
Fin index				
Control	0.00	0.00	0.95	1.65
Cobble	0.00	0.00	0.00*	0.00*
Condition factor[a]				
Control	1.18	1.15	1.25	1.29
Cobble	1.15	1.78	1.20*	1.14*
Fat index				
Control	3.00	3.00	3.35	3.70
Cobble	3.00	3.00	3.00*	3.40*
Thymus index				
Control	0.80	0.75	0.70	1.40
Cobble	0.50	0.70	1.05	0.70*
Bile index				
Control	0.10	0.55	0.65	2.45
Cobble	0.15	1.15*	0.70	2.25
Eye (% normal)				
Control	100	100	100	100
Cobble	100	100	95	80*
Plasma protein (g/dL)				
Control	6.06	4.62	5.35	5.25
Cobble	5.74	5.11	5.83	5.31
Hematocrit (%)				
Control	50.1	48.3	51.0	46.6
Cobble	49.5	46.5	50.2	45.1
Leucocrit (%)				
Control	0.24	0.45	0.10	0.60
Cobble	0.05	0.78*	0.18	0.38

[a] Condition factor = [(weight, g)/(total length, mm)^3] × 10^5.

throat and albino rainbow trout reared in cobbled raceways.

There were sporadic significant differences in the thymus index, bile index, and the eye (fish from cobbled raceways had a greater incidence of exophthalmia in the last sample, P = 0.050; Table 1). The hatchery is certified pathogen free, so the eye pathology was probably related to the high gas saturation in the incoming water (Stroud et al. 1975). However, total gas saturation did not differ significantly between cobbled and control raceways, and further sampling would likely find exophthalmia in controls as well.

There was no significant difference in feed conversion (control, 0.98; cobble, 1.15) or mortality (control, 10.4%; cobble, 10.6%). Some HCP parameters (kidney, pseudobranch, spleen, gut index, gill, and opercle) were normal and did not differ between treatments or among samples. Blood parameters (hematocrit, plasma protein, and leucocrit; Table 1) were within normal ranges (Snieszko 1961; Barnhart 1969).

Fin erosion of the albino rainbow trout differed somewhat from that of normally pigmented Bonneville cutthroat trout and rainbow trout (Bosakowski and Wagner 1995). The albino rainbow trout in cobbled raceways had perfect (uneroded) fins (0 fin index) at the end of our experiment, whereas normally pigmented fish had increasingly greater fin erosion, although it was reduced in cobbled raceways. Behavior may account for the difference because environmental conditions and rearing variables such as density were similar for both studies. Aggressive behaviors such as fin nipping of the dorsal and pectoral fins have been documented for juvenile steelhead, anodromous rainbow trout (Abbott and Dill 1985). Kindschi et al. (1991) demonstrated the influence of aggressive interactions when steelhead fingerlings reared in isolation did not develop dorsal fin erosion, whereas fin erosion appeared on fish reared in production tanks.

The difference in fin wear between albino and normally pigmented rainbow trout reared in cobblestone raceways raises some interesting questions. If fins are uneroded in cobbled raceways for albino rainbow trout, does this indicate that aggressive behavioral interactions are nil? Does this apply to fish reared in concrete-bottomed raceways as well? If so, does this mean that the erosion observed is entirely from abrasion and bacterial infection? Does the difference between albino and pigmented rainbow trout in concrete-bottomed raceways represent the contribution of agonistic behavior to fin erosion (i.e., pigmented rainbow trout display both environmental and behavioral effects, while albino rainbow trout display only the environmental effects)? If aggressive behavior is still present in albino rainbow trout, is the clear color of the fins a factor? For example, the initiation of erosion may form a white necrotic area that contrasts with a dark fin, providing a target for attack that may not be as visible on albino fins. To lend insight into these questions, further studies rearing mixed populations of albino and normal rainbow trout in cobbled and concrete raceways, as well as observations of aggressive behavior among albinos are needed.

Blindness due to degeneration of the retina in albino rainbow trout exposed to full sunlight has been noted (D. Allen and T. Hallows, University of Texas of the Permian Basin and Utah Division of Wildlife, unpublished data) and may obviate any aggressive behavior. However, fish actively fed and responded to the presence of a person, which indicated that the fish could see.

There were slight, but nonsignificant, differences in water quality between the two types of raceways. Effluent oxygen levels were below that recommended by Piper et al. (1982) and were lower in the two cobblestone raceways (3.7, 3.9 mg/L) than in controls (4.0, 4.4 mg/L). Un-ionized ammonia nitrogen levels were slightly lower in cobblestone raceways (0.0017, 0.0025 mg/L) than in controls (0.0034, 0.0038 mg/L). The accumulation of organic waste in the interstitial spaces of the cobble would be expected to increase the biological oxygen demand, reducing the available oxygen. The rocks may provide a greater surface area for colonization by nitrifying bacteria, which would reduce ammonia concentrations through conversion to nitrate, assuming aerobic conditions (Stickney 1979). These differences may be more pronounced on a larger scale.

This study demonstrated that the use of gravel substrates can significantly improve the fin condition of hatchery-reared albino rainbow trout. The benefits of cobbled raceways may outweigh the difficulties of crowding fish and cleaning raceways, which may be overcome by using innovations, such as baffles, to increase water flow through the gravel (Boersen and Westers 1986). Reduction in fin erosion may improve survival, but this still needs to be tested. The reductions in condition factor, fat levels, and size may counter the benefits to the fins. However, these negative effects may also be overcome with further experimentation.

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