The Ichthyogram

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Performance and Behavior of Cutthroat Trout Reared in Covered Raceways

Cover is a critical part of the habitat of many fish, including salmonids. The use of covers for the intensive culture of fish has not been researched in too much depth, and the results have been contradictory. One study found that covers on concrete troughs did not affect growth or mortality of coho salmon (*Oncorhynchus kisutch*) alevins, but the combination of cover and substrate resulted in a higher mean weight than that of alevins in uncovered troughs with the plastic substrate. In another study, channel catfish (*Ictalurus punctatus*) cultured in circular tanks with or without covers did not differ in growth, feed conversion, or survival. Research with lake trout (*Salvelinus namaycush*), reared in covered or uncovered rearing troughs and fed by hand or demand feeders, indicated that fish in covered raceways and hand-fed were heavier and more active when startled. A recent study here at the Fisheries Experiment Station with rainbow trout (*Oncorhynchus mykiss*) indicated little benefit from the use of covers. Problems with sunburn lesions in Atlantic salmon (*Salmo salar)* were solved when circular pools were covered with saran cloth providing 90% shade. Hatchery manuals also advise against exposure of eggs and alevins to direct sunlight.

In this study, cutthroat trout (Bear Lake Bonneville strain, *Oncorhynchus clarki* utah) were reared in outdoor concrete raceways either with plywood covers or without.

Growth, feed conversion, and mortality were not significantly different between the covered and uncovered (control) treatments after 256 days. Autopsy-based health and condition parameters were generally not significantly different between the groups, but fish under cover had significantly better fin index values on two separate sampling times (P=0.001). Fat levels were significantly higher in covered fish during early rearing (P=0.002), but the benefit was not significant in the last sample. Hematocrit values were significantly higher in fish from covered raceways than uncovered raceways, although the difference was slight (<3% P<0.05). Covered raceways were noticeably cleaner, but cursory examina-

(Continued on page 3)

inside...

Whirling Disease Found in Porcupine and Causey Reservoirs in Northern Utah

The range of whirling disease continues to expand in northern Utah with the discovery of infected fish in Porcupine and Causey Reservoirs. In early June, a deformed rainbow trout was discovered in Porcupine Reservoir by Diane Driscoll, a graduate student at Utah State University. Subsequent testing showed the presence of *Myxobolus cerebralis* spores in both rainbow trout and fingerling kokanee salmon. This was the first discovery of the disease in kokanee salmon in Utah. Adult kokanee as well as brown trout and rainbow-cutthroat hybrids were negative for the parasite. In 1993, fish in the river below the reservoir and at a downstream private hatchery were found positive for the first time.

Later in the month, samples of fish obtained from Causey Reservoir in the Ogden River drainage also showed the presence of spores in rainbow trout and young kokanee salmon. Again, older members of other wild salmonid species showed no spores.

Histopathologic confirmation of whirling disease from head cartilage revealed damage in kokanee was surprisingly severe. Lesions in kokanee were equally severe as in the more susceptible rainbow trout. Biologists are especially concerned about the effect of the parasite on naturally reproducing wild kokanee, cutthroat and brown trout that will be exposed from birth.

The finding of the parasite in both reservoirs is in contrast to results of previous testing. Kokanee salmon from Porcupine reservoir were tested extensively for whirling disease from 1988 to 1993, and were certified as a brood source of eggs. Causey reservoir was tested in 1993 as part of a whirling disease survey and also found negative. In July 1994, the two state hatcheries which stock these reservoirs were tested and found free of the parasite, as they have always been. These findings have caused UDWR biologists to suspect a further very recent intentional spread of the disease.

Meanwhile, sentinel fish placed in Spring Creek in southern Utah have tested positive for WD. Pigmented and albino rainbow trout were placed either in a circular metal cage or allowed to swim free in a dirt raceway system. The location was the site on an abandoned aquaculture facility in the Fremont River drainage which was one of the original sites of whirling disease. The experiment was designed to test the the validity of sentinel fish testing, especially for fish placed in small cages with limited exposure to surface mud and tubifex worms. As estimated by spore counts, caged and free-ranging fish were equally infected. Additional caged rainbow trout have been placed in the lower Fremont River. Triploidbrake trout (brown trout x lake trout s) have been placed in cages alongside rainbow trout in Smithfield, Utah to test their susceptibility to WD.

Chris Wilson

PASSAGES at FES

* **Curtis Knight**, contract biologist for June sucker culture has left FES to pursue a graduate degree at USU. Replacing him is **Roger Mellenthine**.
* **Dave Ross**, research biologist ,has accepted the position of brine shrimp biologist in the northern region.
* **Russ Lee**, contract fish biologist, has left to accept a job as fish health specialist with the state Department of Agriculture.
* **Brian Shearer** will be returning to his previous position as wildlife technician at Loa Hatchery.

(Continued from page 1)

tion of gill tissues did not reveal any differences in gross appearance between treatments.

Maximum fin length was also measured on all fins and scaled to total length for comparison. On day 166, fin length measurements were not significantly different between covered and uncovered groups for the dorsal, caudal, adipose, and anal fins. However, both left and right pectoral fins from fish in covered raceways were significantly longer than in uncovered raceways. Both ventral fins were shorter in covered raceways at this time, but by day 225, were not significantly different.

Behavior Tests

In an outdoor tank, observations of cover preference were made for 4-fish groups over a 45 min period, either in the presence of a stuffed eagle or without it. The 45 min period was also broken down into three 15 min segments and analyzed separately. There was a significant tendency for all groups to seek cover, regardless of rearing environment. No significant differences in cover preference between treatments (cover/uncovered) or between the presence/absence of the predator model were noted during any of the 15-min periods or when all periods were pooled (Table 1). These results were contrary to previous tests with rainbow trout which showed a significant difference in the first 15 min period with the eagle present. The lower sample size in that test may account for the discrepancy.

The results indicate that cover does help reduce fin erosion and promote fat storage, particularly during the first few months outdoors. No differences in preference for cover were noted due to rearing in covered or uncovered raceways.

Eric Wagner

Table 1. Mean number of fish under cover, ± SD (N=10), observed in a tank covered at one end at 1 minute intervals for 45 minutes in the presence of a potential predator or without.

Minutes	Stuffed Eagle		Control	
	Covered	Uncovered	Covered	Uncovered
0-15	2.2 ± 0.91	2.6 ± 0.94	2.1 ± 0.96	2.2 ± 0.70
15-30	2.2 ± 0.92	2.6 ± 1.02	2.0 ± 1.12	2.5 ± 0.67
30-45	2.7 ± 0.87	3.0 ± 0.87	2.3 ± 1.09	2.9 ± 0.71
Total Period (0-45)	2.3 ± 1.05	2.7 ± 0.97	2.1 ± 1.06	2.5 ± 0.74

Hydrogen Peroxide Trials Fizzle

Preliminary trials conducted by the U.S. Fish and Wildlife Service evaluating the utility of hydrogen peroxide as a fungicide for fish eggs have been encouraging. The unpublished data reported success at 250 and 500 ppm for treatment of rainbow trout eggs at 12 C for 60 min. The LaCrosse National Fisheries Research Center suggested 15 min treatments in a distributed protocol .Hydrogen peroxide has recently been reported by Scottish researchers (*Aquaculture International* 2:10) to be useful for control of sea lice on Atlantic salmon.

Due to concerns about formalin, the carcinogen currently used to treat eggs, some preliminary tests were conducted at the Fisheries Experiment Station, Fountain Green Hatchery, and Mantua Hatchery. At Mantua Hatchery, two egg-tray stacks were treated every other day with formalin (1000 ppm) and two with hydrogen peroxide (250 ppm for 15 min). During the first three treatments, only 1% of the amount needed was applied due to problems in communication. After that time, 250 ppm were applied until the eggs eyed and were shipped. Fungus appeared by the time the fourth treatment of peroxide was applied and covered all the dead eggs by the time they were picked at the eyed stage. In contrast, none of the eggs treated with formalin had fungus on them.

Even at 500 ppm of hydrogen peroxide every day, the amount of fungus was still unacceptable for egg incubation.

At Fountain Green Hatchery, egg jars were used instead of trays for incubating cutthroat trout eggs taken from broodstock at Electric Lake. Fungus appeared between the 4th and 10th day in the peroxide treatment (250 ppm for 15 min, every other day) and not in the formalin treatment (1750 ppm every day).

After examining the results from the previous two tests, some cutthroat trout eggs were used to conduct a test at a higher concentration at the Fisheries Experiment Station. A shortage of stacks precluded replication of the treatments, but three stacks were available for a preliminary test. One stack was treated every other day with 500 ppm hydrogen peroxide, another treated with the same concentration every day, and the third left as an untreated control. Both peroxide treatments were 15 min drips. The percentage of fungused eggs was measured by determining the average number of eggs per unit weight of fungused eggs and relating that to the total weight of eggs. The percentage of fungused eggs was worst in the untreated control (69%), and progressively better in the every-other-day treatment (59%) and every-day treatment (41%). All of the eggs were eventually dumped.

Even at 500 ppm of hydrogen peroxide every day, the amount of fungus was still unacceptable for egg incubation. The discrepancy between the results of the work here in Utah and the U.S. Fish and Wildlife Service may be related to the instability of hydrogen peroxide over time. The peroxide in this test was not assayed to determine the actual percent active ingredient. The need for an assay may preclude its utility for treatment of fish eggs. It is possible that hydrogen peroxide may act as a preventative, but low doses may be ineffective for treating existing fungal infections. Higher concentrations, longer treatment times (e.g., 1 hour), or combinations thereof need to be tested.

Further tests will probably be conducted at the Fisheries Experiment Station before attempting to use hydrogen peroxide in the state production hatcheries.

Eric Wagner

Inbreeding Assessment of Utah Broodstocks

Inbreeding is simply the mating of related individuals, resulting in greater homozygosity, i.e, less variation in genes, Nature's blueprints. Greater homozygosity is desirable in some cases, such as linebreeding, where an outstanding individual is mated with a descendant to increase that individual's contribution (e.g., greater growth) to the gene pool. Inbred stocks of mice and fish have been useful for toxicology research where a reduction in individual variation was desirable to better compare results among laboratories.

Inbreeding can also be detrimental, increasing the incidence of deformities. Nils Ryman of the University of Stockholm has reported that the returns from the ocean of inbred Atlantic salmon (*Salmo salar*), were significantly lower than outbred fish. Work by Harold Kincaid of the U.S. Fish and Wildlife Service and others have demonstrated that inbreeding can reduce egg hatchability, formalin tolerance, fry survival, and growth.

The concern about possible inbreeding in state hatchery stocks have prompted at least one state wildlife agency--Wyoming-- to conduct an evaluation. This article summarizes a portion of an evaluation conducted by the author to determine the degree to which the species and strains of trout reared by the Utah Division of Wildlife Resources are inbred.

Fluctuating Asymmetry

To assess the degree of inbreeding, a number of researchers have monitored bilateral asymmetry, i.e., the difference in counts between the left and right side in characters such as the number of fin rays. This technique, known as fluctuating asymmetry, has been used in a number of different species from fruit flies to deer mice. Robb Leary of the University of Montana has demonstrated a negative correlation between asymmetry and enzyme heterozygosity in fish.

In this study, fluctuating asymmetry was assessed by counting five meristic characters on the left and right side of each of forty fish: gill rakers on the lower first branchial arches, gill rakers on the upper first branchial arches, mandibular pores, pectoral fin rays, and pelvic fin rays.

Fluctuating asymmetry was assessed in Sand Creek strain brown trout (*Salmo trutta* L.), Owhi strain brook trout and six strains of rainbow trout, *Oncorhynchus mykiss* (Sand Creek, Ten Sleep, Fish Lake-DeSmet, Shepherd of the Hills, Erwin, and Shasta). In addition, two stocks of Bonneville cutthroat trout (*Oncorhynchus clarki* utah) were evaluated, one from Mantua Hatchery Bear Lake stock and the other originating from Manning Meadow Reservoir broodstock. The reservoir is located in the Monroe Mountains south of Richfield, Utah. Cutthroat (N=40) and brown trout (N=20) from self-reproducing populations in the Logan River, Utah were sampled in September 1993 during the course of a fisheries survey and were examined for asymmetry as well.

The mean asymmetry for each of the stocks varied from 1.25 to 3.15 (Table 1). Cutthroat trout generally had higher mean asymmetry values than the other species examined, and ranged from 2.65 to 3.15. (Fig. 1) Cutthroat trout from the Logan River had a lower mean

(Continued on page 6)

(Continued from page 5)

asymmetry value than hatchery fish, but not significantly so (Wilcoxon test, $P>0.05$). Mean asymmetry of brown and brook trout were similar to rainbow trout. The Sand Creek strain of rainbow trout had the lowest mean asymmetry, being significantly different from all but the brown trout from the Logan River.

Hatching Records

In addition to asymmetry calculations, data from the state hatchery records for the last twenty years was summarized to evaluate possible trends in development to the eyed stage ("eye-up"), percent hatch, and percent cripple (Table 2).

In this study there was no increase in deformities over the last twenty-year period examined. In brown trout the percentage actually decreased significantly. Percent deformities (cripples) were relatively low (1.5% in kokanee to 6.6% in Strawberry Reservoir cutthroat trout) compared to percentages reported for inbred zebra danio, *Brachydanio rerio* (10 to 75% deformed fry), convict cichlid, *Cichlasoma nigrofasciatum* (84%), and rainbow trout (11 to 18%). In the convict cichlid, the deformities were not apparent until the fourth or fifth generation of brother-sister matings. Norwegian researchers D. Aulstad and A. Kittelsen however, noted lethal deformities averaging 12.6% in five inbred groups of rainbow trout after only a single generation of brother-sister mating.

The percent survival to the eyed egg stage ("eye-up") from 1972 to 1993 for most Utah hatchery stocks did not appear to follow any trend (correlation coefficients not significantly different from zero). The Owhi brook trout did have a negative regression slope that was significant ($P=0.03$; $r=-0.712$), but appears to be heavily influenced by the high eye-up in 1985 and 1986. Interestingly, the albino rainbow trout had a significant positive slope, influenced by the low eye-up in 1978 and 1979. The percentage of eggs that hatched was highly variable, and did not decrease over the time period examined . Eggs stripped from wild stocks (lake trout and kokanee) had significantly lower eye-up and hatching success than the hatchery brood stocks, except brook trout and albino rainbow trout.

The mean asymmetry results and the eyeup, percent hatch, and percent cripple results indicate that inbreeding is not a problem in Utah's broodstocks. However, a recent (1993) thesis by Charles Alexander (U. Wyoming) presented data indicating that enzyme homozygosity and fluctuating asymmetry in salmonids were not correlated, casting doubt on the utility of asymmetry for evaluation of inbreeding. Therefore, further research looking at enzyme heterozygosity and the proportion of polymorphic loci is planned for next year.

Eric Wagner

Fig. 1. Mean fluctuating asummetry of Utah broodstocks.

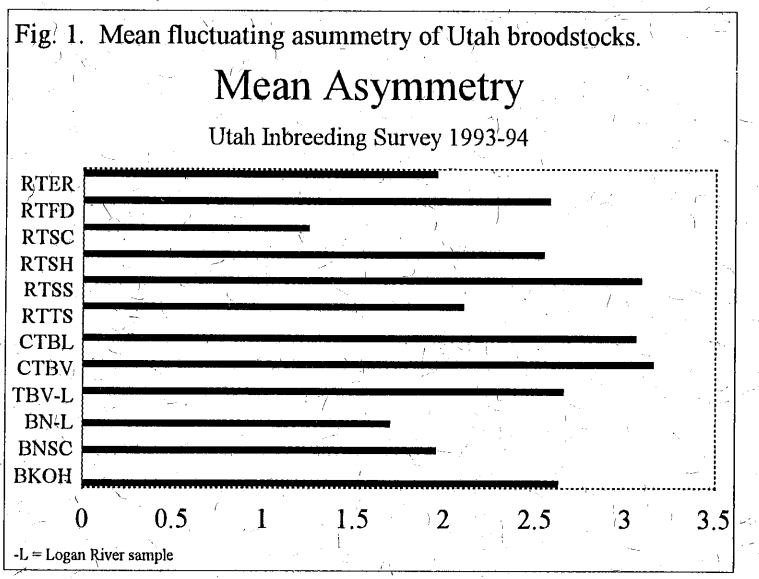

Table 1. Mean asymmetry (± SD) for species and strains of trout reared in Utah or sampled from self-reproducing populations. A sample size of 40 was used for each asymmetry evaluation unless otherwise noted. Means among species with a common letter subscript are not significantly different ($P > 0.05$).

Specie Strain[1]	Stock Origin	Mean Asymmetry ± SD
Rainbow trout		
RTER	Ennis Hatchery	$1.95 \pm 1.24_{bcdef}$
RTFD	Egan Hatchery	$2.57 \pm 1.55_{cdefgh}$
RTSC	Egan Hatchery	$1.25 \pm 1.02_{a}$
RTSH	Egan Hatchery	$2.54 \pm 1.50_{bcdefgh}$
RTSS	Ennis Hatchery	$3.08 \pm 2.28_{cdefgh}$
RTTS	Egan Hatchery	$2.10 \pm 1.28_{bcdefg}$
Cutthroat trout		
CTBL	Mantua Hatchery	$3.05 \pm 1.61_{cdefgh}$
CTBV	Manning Meadow, Monroe Mts., Utah	$3.15 \pm 1.64_{efgh}$
CTBV[2]	Logan River, Cache County, Utah	$2.65 \pm 1.61_{cdefgh}$
Brown Trout	Logan River, Cache County, Utah	
BN? (N=20)		$1.70 \pm 1.45_{abcde}$
BNSC	Egan Hatchery	$1.95 \pm 1.09_{bcdef}$
Brook Trout		
BKOH	Egan Hatchery	$2.62 \pm 1.26_{defgh}$

[1]Strain abbreviations: RTER=Erwin, RTFD=Fish Lake/DeSmet, RTSC=Sand Creek, RTSH=Shepherd of the Hills, RTSS=Shasta, RTTS=Ten Sleep, CTBL=Bear Lake, CTBV=Bonneville, BNSC=Sand Creek, BN?=unknown brown trout strain, BKOH=Owhi.
[2]The cutthroat trout in the sample for mean asymmetry were also used for counting meristic characters which most closely matched the Bonneville subspecie description.

Table 2. Mean egg survival (±SD) to the eyed stage (eye-up), hatching rate (%), and percent cripples for species and strains reared in Utah. The sample size is in parentheses. Means among species with a common letter subscript are not significantly different ($P > 0.05$).

Specie / strain	Eye-up (%)	Hatch (%)	Cripple (%)
Brook trout/ Owhi	$68.1 \pm 12.9_{cd}$ (11)	$81.7 \pm 11.8_{d}$ (35)	$2.6 \pm 1.3_{bcd}$ (33)
Brown trout /Sheep Creek	$83.5 \pm 8.1_{a}$ (18)	$83.2 \pm 16.2_{d}$ (23)	$3.8 \pm 4.0_{bc}$ (24)
Lake trout/ Jenny Lake	$66.2 \pm 6.5_{d}$ (04)	$61.1 \pm 23.8_{e}$ (13)	$4.4 \pm 1.8_{bc}$ (13)
Kokanee salmon/Sheep Creek	$66.0 \pm 1.4_{d}$ (02)	$52.4 \pm 19.7_{f}$ (07)	$1.5 \pm 0.4_{d}$ (07)
Cutthroat trout/ Bear Lake	$79.2 \pm 9.0_{a}$ (34)	$88.9 \pm 9.8_{bc}$ (261)	$4.0 \pm 5.2_{bc}$ (254)
Strawberry Reservoir[1]	$82.1 \pm 8.1_{a}$ (05)	$84.7 \pm 15.8_{cd}$ (61)	$6.6 \pm 5.2_{a}$ (55)
Rainbow trout/ Albino	$70.6 \pm 15.0_{bcd}$ (21)	$88.7 \pm 11.4_{bc}$ (18)	$3.9 \pm 2.8_{bc}$ (18)
Fish Lake- DeSmet	$77.6 \pm 7.7_{abc}$ (20)	$89.6 \pm 10.9_{ab}$ (126)	$2.9 \pm 2.5_{bcd}$ (120)
Sand Creek	$82.9 \pm 5.9_{a}$ (22)	$92.1 \pm 8.0_{ab}$ (86)	$3.2 \pm 3.0_{bcd}$ (82)
Shepherd of the Hills	$82.3 \pm 7.1_{a}$ (20)	$93.4 \pm 4.5_{a}$ (50)	$2.4 \pm 1.9_{cd}$ (48)
Ten Sleep	$78.6 \pm 6.4_{a}$ (19)	$91.5 \pm 5.4_{ab}$ (61)	$4.7 \pm 2.7_{ab}$ (55)

[1]Strawberry Reservoir cutthroat trout is a Yellowstone cutthroat x rainbow trout hybrid.

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