NOTES

GROWTH AND FOOD CONVERSION OF RAINBOW TROUT REARED IN BRACKISH AND FRESH WATER

Although brackish water culture of rainbow trout (*Salmo gairdneri* Richardson) has been practiced in other countries for years (Awakura, 1962; Awakura, Shibata, and Honma, 1962; Sato, 1965; Jensen, 1967), few attempts have been made to culture this euryhaline species in brackish water in the United States (Leon, 1970). The following study was designed to study the growth, food conversion, and survival rates of rainbow trout reared from fingerling to market size in brackish and fresh water.

Materials and Methods

Six 1.8-m diameter round fiber glass tanks with a water depth of 0.6 m were used as experimental culture tanks (Andrews et al., 1971). Fresh water from a deep well (22°C) or brackish water (25-30‰) from the Skidaway River, Savannah, Ga., was pumped into each tank through flow control nozzles at a rate of 19 liters/min (1.3 hr/exchange). Since the temperature of the brackish water varied and the experimental tanks were located out-of-doors, water temperatures were not controlled.

Four experimental tanks were stocked with rainbow trout averaging 60 g each at an initial density of 7.2 kg fish/m^3, and two were stocked at a density of 14.4 kg fish/m^3. Fish in two of the tanks containing 7.2 kg/m^3 and the tanks containing 14.4 kg/m^3 were acclimated to brackish water by gradually changing the fresh to brackish water ratio of incoming water. Figure 1 shows the changes in salinity during the 9-day acclimation period.

Each group was fed a commercial pelleted trout feed[1] twice daily according to Leitriz's feeding table (Oshima, 1968). The entire population of each tank was weighed and counted monthly. Temperatures, ammonia, salinity, and dissolved oxygen levels were determined biweekly. Ammonia levels were below 0.3 ppm and oxygen concentrations were above 7.0 ppm throughout the experimental period. After 16 weeks (December 4, 1970-March 26, 1971) the experiment was terminated. Growth data was tested for statistical significance by the method of Duncan (1955).

Results and Discussion

Acclimation to brackish water

A survival rate of 99.5% was obtained in the two groups acclimated to brackish water during the 9-day period and the following 10 days in which salinity was 30‰. These results are in contrast to a previous report that over 40% mortality was obtained when rainbow trout weighing approximately 60 g each were adapted to 30‰ salinity (Oshima, 1968).

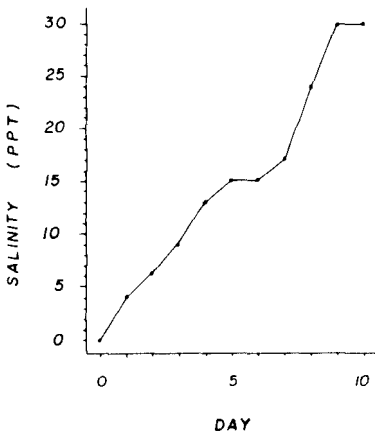

FIGURE 1.—Changes in salinity during the 10-day period in which the rainbow trout fingerlings were acclimated to brackish water.

[1] Donated by Agway, Inc., Syracuse, N.Y.

In a pre-experiment test, 60-g trout were gradually adapted from fresh water to 30‰ salinity within a 1-day period with a mortality of 5%.

These results indicate that a gradual change from 0 to 30‰ salinity over a 10-day period can be accomplished with low mortality. Since other studies have indicated that larger fish are more easily adapted to higher salinities than smaller fish (Awakura, 1962; Sato, 1965), this conclusion only holds for the 60-g fish.

Growth, survival, and food conversion data

Growth curves for the three experimental groups are shown in Figure 2 along with the average water temperatures for the corresponding period. During the first 5 weeks of this experiment when the growth rates of all groups were similar, temperature differences were not as large. Once temperature differences occurred, growth rates were affected. The final average individual weights (256 g) were significantly higher ($P < 0.05$) in the freshwater groups which were maintained at near constant temperature (averaging 21.3°C) than in the colder saltwater (13.5°C) groups (217 g in the low density group and 176 g in the high density group). The average final density (Table 1) was significantly greater ($P < 0.05$) from the highest stocking density tanks in brackish water (Group 2) than from the lower density brackish water (Group 1) and freshwater (Group 3) tanks.

Food effiiciency and survival were best in the lower stocking density brackish water tanks (Group 1) and poorest in the freshwater tanks (Group 3). A gradual mortality of one or two fish daily was observed in the freshwater group which was maintained at temperatures in excess of the optimum temperature for rainbow trout.

Temperature had a greater effect on growth, food conversion, and survival than did salinity. The freshwater group maintained at approximately 21°C grew faster than the brackish water group on the individual weight basis, but had

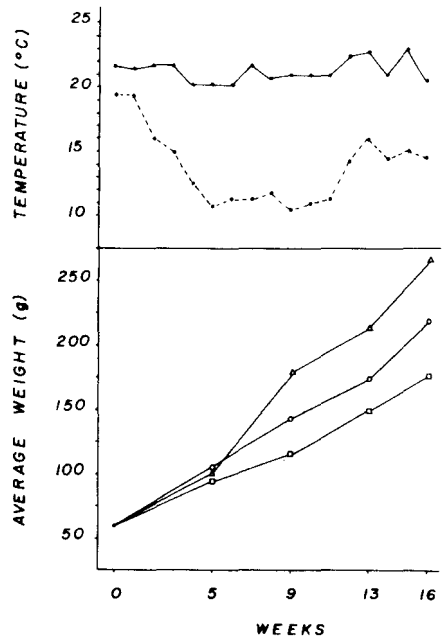

FIGURE 2.—Water temperatures and growth curves from an experiment in which rainbow trout were reared in fresh and brackish waters. The solid and broken lines represent temperatures for the freshwater and brackish water groups, respectively. The triangles represent average weights of the fish in the freshwater group, and the circles and squares represent average weights for the low and high density brackish water groups, respectively.

TABLE 1.—Experimental data from the entire 16-week growing period (December 4, 1970-March 26, 1971).

Group	Initial density	Average salinity	Average temperature[1]	Final density[2]	F.C.R.[3]	Percent survival
	kg/m³	‰	°C	kg/m³		
1	7.2	28 ± 0.6	13.5 ± 3.2	24.0 a	1.8	98
2	14.4	28 ± 0.6	13.5 ± 3.2	42.6 b	2.1	93
3	7.2	0	21.3 ± 1.3	27.2 a	2.3	87

[1] Brackish water (incoming) was pumped from Skidaway River which varied in temperature while fresh water was direct from a well and at a constant temperature (22°C).
[2] Values follow by the same letter are not statistically different ($P > 0.05$).
[3] Food conversion ratio (grams feed/gram gain).

a poorer food conversion efficiency and survival rate. The lower survival rate (87%) of this group resulted in a total production (final density) only slightly greater than the saltwater group stocked at the same density.

A faster growth rate, better survival, and better food conversion were obtained at the lower stocking density brackish group thus demonstrating the effects stocking density has on these variables. The fact that oxygen was over 7 ppm in all groups throughout this experiment indicates that stocking density and not oxygen stress accounted for this reduction in performance.

Conclusions

The fact that temperature was not constant in all groups precluded a conclusive comparison of the performance of rainbow trout in brackish and fresh water. Nevertheless, the following conclusions can be made from these experimental data:

1. Rainbow trout were converted from fresh to 30‰ salinity in a period of 9 days and were reared to market size at this salinity.
2. Trout fingerlings averaging 60 g each were reared to 266 g in 21°C fresh water with a rapid individual growth rate and an acceptable survival and food conversion rate.
3. Survival and growth rates and food efficiencies were excellent for trout reared in brackish water at an average temperature of 13.5°C.

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TAKASHI MURAI
JAMES W. ANDREWS

Skidaway Institute of Oceanography
55 West Bluff Road
Savannah, GA 31406

THE AMOUNT OF SPACE AVAILABLE FOR MARINE AND FRESHWATER FISHES

Cohen (1970) has presented rather careful estimates of the total number of fish species in the world and in each of eight ecological groupings. He found that an "astonishingly high percentage" of bony fishes live in freshwater habitats. According to Cohen's analysis, 41.2% (8,275 species) of all fish species live in fresh water (includes both primary and secondary freshwater fishes). He indicates that this high percentage must reflect the degree of isolation possible in freshwater environments and refers to the great variety of habitats and ecological niches in fresh water and also along tropical shores.

The great number of freshwater fish species becomes even more striking if the volume of fresh water in the world is compared to the volume of the oceans. Indeed, the mode of speciation and the structure of the niche appear highly divergent between the two environments. The oceans account for 97% of all the water in the