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Enhancing Performance of Farm-Raised Brook Trout (*Salvelinus fontinalis*) with Natural and Artificial Diets

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Summary

1) Intent of Project

- Determine the feasibility and impact of a natural diet of baitfish on the growth of brook trout raised under five thermal regimes. Compare the growth and performance of brook trout raised on a natural diet with the growth of trout raised on an artificial, pellet food diet. Determine if an improved discrete culturing protocol can be applied to brook trout farming to enhance the growth and marketability of the trout to fee-based operations and private stocking clubs, while lowering the costs and environmental impact that such facilities must endure.

2) Work Conducted in this Project

- See attached report.
- Brook trout raised on a natural diet of baitfish showed enhanced growth at cold temperatures (<14°C) when compared to trout raised on an artificial diet.
- Brook trout raised on an artificial diet showed better growth at warmer temperatures (>14°C) when compared to trout fed a natural diet.
- A two-tier feeding strategy based on seasonal water temperatures where diet type is matched to water temperature would be the best culturing protocol for improved growth and performance of brook trout.

3) Meeting Original Expectations

- A recommendation as to the type of discrete culturing protocol that should be used to enhance brook trout growth was suggested.
- Results from Phase 2 of this project (1999-2000), where nitrogenous waste will be monitored, should be combined with Phase 1 results to better understand the impact of diet switching on brook trout aquaculture and any environmental impact this may have.

4) Information/Educational Material Developed

- See attached report.

5) Future Projections

- Phase 2 of this project will examine the environmental impact that the two diet types have on the effluent produced by trout farms and its influence on the surrounding freshwater environment.

6) Other Information

- See attached report.

Introduction

Intent of Project:

Brook trout (*Salvelinus fontinalis*) represent one of the principal fishes cultured in Wisconsin's commercial aquaculture facilities. Markets for farm produced trout include fish sold as food to wholesalers or retailers in the food industry, and catchable-size fish sold to fee-fishing businesses, private fishing organizations, municipalities and government agencies.

Though Wisconsin trout sold to the food industry represent \$1.9 million in sales annually, marketing has been hampered by concerns about poor flesh coloration and inferior taste, concerns traditionally associated with farm-raised trout. This may be attributable to composition of the artificial diet the trout are fed at commercial facilities.

When trout feed on natural food items, such as baitfish, their body composition maintains its rich coloration and superior taste. Farm-raised trout that are fed natural food items, particularly later in the culturing processes, have the potential to adapt behaviorally to a more natural feeding regime and suffer less from the "look-up syndrome". This could simultaneously result in the production of a better performing brook trout for both food and fee-fishing markets. This would make farm-reared trout more attractive to fee-fishing operations and encourage private-fishing organizations to purchase commercially raised brook trout.

For this project, information on growth rates, temperature preferences, and diet (food type and quantity), will be used to modify techniques and develop an improved discrete culturing protocol. By determining the feasibility and impact of baitfish in the diets of brook trout, and ultimately the performance of the brook trout, trout rearing dealers may be able to enhance the marketability of the trout to fee-based operations and private stocking clubs, while lowering the costs and environmental impact that such facilities must endure. Combining culture operations for baitfish and trout could not only be cost effective but allow for shifts in production to meet natural-market demand cycles. This could provide increased profitability in combination culture operations.

Perceived Benefit to Wisconsin Agriculture:

This study examined the scientific feasibility to the aquaculture industry of enhancing brook trout performance and marketability by the addition of natural food type (baitfish) during trout production. Both brook trout and baitfish aquaculture operations may experience increased demand in production and trout facilities would be able to offer greater choices to customers, with standard artificially fed trout and enhanced, naturally fed trout, that may provide increased angler challenge and improved behavior.

Overall, recommendations regarding the best commercial rearing techniques, as influenced by food type, will be made for optimal temperature requirements and growth rates. Additionally, in year two of the project, recommendations as to the impact that natural and artificial feeds have on the surrounding freshwater systems will be made, with reference to possibly decreasing nutrient input from naturally fed trout.

Protocol

Farm-raised brook trout were acquired from Silver Moon Springs Trout Farm and baitfish (fathead minnows) were obtained from Gollon Brothers Wholesale Live Bait. Brook trout were reared in indoor, flow-through 300-gallon tanks at 9°C. An experimental tank system was constructed so that individual trout could be fed and growth could be monitored. Experiments were conducted to evaluate the optimal growth conditions by testing temperatures (7, 9, 11, 15, 19°C) and food types (natural/artificial).

Artificial rations (pellet trout food) were supplied twice daily until trout were satiated, commonly referred to as the maximum daily consumption or on-demand feeding levels. Natural rations (baitfish) were supplied based on the maximum amount observed to be consumed during 30 minute feeding periods. Again, trout were fed twice per day, a value considered to be optimum for most trout species. Experiments lasted 30 days during which trout wet weight, water temperature, oxygen concentration, and light conditions (12 light :12 dark) were monitored.

Comparisons were made between growth rates of brook trout raised on natural and artificial diets, growth as a function of initial trout weight, and temperature regimes. These evaluations were used to determine the optimal rearing conditions and food types for greater performance in farm-raised trout.

Subjective Results

Brook trout fed a natural diet of baitfish exhibited a classic bell-shaped response to thermal influence on feeding and growth. Trout grew best at 11°C, with decreased performance at higher temperatures (15 and 19°C). Poorest growth occurred at 9°C with a slight improvement at the coldest temperature of 7°C. Brook trout fed a typical artificial, pellet diet showed a linear growth response to temperature. Poorest growth occurred at the lowest temperatures and growth increased as temperature increased. This study showed that brook trout reared at colder temperatures would benefit from a more natural diet of baitfish, with a two-fold increase in growth at temperatures between 10 and 14°C. As water temperatures increase (>15°C), brook trout would benefit from a more artificial diet of pellet trout food, with a modest increase in growth over trout fed a natural diet at higher temperatures.

Objective Results

Brook trout raised on an artificial diet (Figure 1):

- Overall, trout showed decreasing growth rates with increasing weight in the fish.
- Growth rates dropped sharply for trout at higher temperatures, with less dramatic decreases in growth for larger trout raised at colder temperatures.

Brook trout raised on natural diet (Figure 2):

- Overall, trout showed decreasing growth rates with increasing weight in the fish.
- Growth rates were similar for trout raised at all temperatures, with the sharpest decline in growth observed for large trout raised at the coldest temperature (7°C).

Significantly greater ($p < 0.05$, ANOVA, $F = 9.24$, $df = 4$) average growth was observed for brook trout raised at warmer temperatures (15 and 19°C) than at colder temperatures (7 and 9°C) when fed an artificial diet. Brook trout raised at 11°C and fed a natural diet of baitfish displayed significantly greater ($p < 0.01$, ANOVA, $F = 23.28$, $df = 4$) growth than at any other temperature. Growth by brook trout fed a natural diet was significantly less ($p < 0.05$, ANOVA, $F = 23.28$, $df = 4$) at warmer temperatures (15 and 19°C) than at colder (<12°C). Brook trout showed a slight increase in growth at the coldest temperature (7°C).

Overall (Figure 3), brook trout raised at 7°C grew significantly better ($p < 0.01$, t-test, $t = 5.17$, $df = 14$) when raised on a natural diet of baitfish. Trout raised at 9°C did not show any significant difference ($p > 0.05$) in growth when fed either natural or artificial diets. Trout fed a natural diet grew significantly greater ($p < 0.01$, t-test, $t = 6.99$, $df = 14$) at 11°C when compared to trout fed an artificial pellet diet. No significant difference ($p > 0.05$) in growth was observed at 15°C for trout raised on natural or artificial diets. Trout fed an artificial pelleted diet grew significantly greater ($p < 0.01$, t-test, $t = 4.02$, $df = 14$) at the warmest temperature of 19°C, when compared to trout fed a natural diet at the same temperature.

Assessment

This study examined the scientific feasibility of raising brook trout on a natural diet of baitfish instead of the standard pellet trout food, which is composed of plant matter, enhanced vitamins and processed fish meal. The goal was to better understand the growth patterns and influences of a modified diet on trout performance when the trout were raised under a five-tier thermal regime. We speculated that brook trout fed a natural diet would adapt behaviorally to a more

natural feeding regime and would exhibit enhanced growth under all thermal treatments. This could result in the production of a better performing brook trout for both food and fee-fishing markets.

Results from this study showed that brook trout fed a natural diet of baitfish did display enhanced growth at colder temperatures, with a two-fold increase in growth at 11°C, when compared to brook trout fed an artificial diet. Brook trout fed a natural diet at 11, 9, and 7°C either matched or exceeded the growth shown by brook trout raised under the same thermal conditions, but fed an artificial diet of pellet trout food. Brook trout raised at warmer temperatures, of 15 and 19°C, and fed a natural diet grew less than trout raised under identical conditions, which were fed an artificial diet.

Inversely, brook trout raised on a typical artificial, pelleted food diet grew poorly at colder temperatures ($\leq 11^\circ\text{C}$), when compared to the brook trout fed a natural diet. Brook trout fed an artificial diet grew better at warmer temperatures (15 and 19°C) than trout fed a natural diet. The brook trout raised at the warmest temperature of 19°C and fed an artificial diet grew significantly greater than the trout raised under the same conditions but fed a natural diet.

These results suggest that the aquaculture industry may wish to adopt a two-tier feeding strategy when raising brook trout for food or fee-fishing operations. The two feeding strategies would be based on the thermal environment that the brook trout are reared in.

Feeding strategy one:

If water temperatures are at or below 14°C brook trout fed a natural diet of baitfish may show enhanced growth and performance. Results from this study indicate that a two-fold increase in growth may be observed when trout are raised and fed in a thermal environment around 11°C. Results also showed that with decreasing water temperatures trout growth declined slightly, but remained greater when fed a natural diet than when fed an artificial diet.

Feeding strategy two:

If water temperatures exceed 14°C brook trout should be fed an artificial, pellet food diet to maintain optimal growth and performance. As water temperatures approach the lethal limit for brook trout (at 21°C brook trout typically cease feeding due to thermal stress) an artificial diet appears to supply the necessary caloric content and diet that brook trout need to continue growing.

The original goal of this study was to improve upon the discrete culturing protocol used by brook trout aquaculture operations to enhance the growth and marketability of brook trout in Wisconsin. The results show that if a two-tier feeding strategy is adopted by a brook trout farm, improved growth may be

observed if diet types are synchronized with water temperatures or seasonal thermal changes in the rearing ponds. By combining culture operations for baitfish and brook trout during colder temperatures greater growth by trout could be achieved with lower feed costs and production could be synchronized with natural-market demand cycles. This could provide increased profitability in combination culture operations. During warmer seasonal periods, brook trout fed an artificial, pellet food diet show better growth and continued use of an artificial diet would maximize production during thermally stressful periods.

Feeding brook trout a natural (baitfish) diet during colder seasonal periods has the additional benefit of increasing the production demand for the baitfish aquaculture operation and improving the growth of the brook trout during winter and spring periods. This may result in the availability of larger size brook trout earlier in the spring and increases the choices that trout facilities would be able to offer to customers, with standard artificially fed trout and enhanced, naturally fed trout, that may provide increased angler challenge and improved behavior.

Future Projections

During 1999-2000, phase 2 of this project will examine the environmental impact that the two diets (natural and artificial) have on effluent discharge and eutrophication of surrounding freshwater systems. Nitrogenous waste components (ammonia, nitrate, nitrite, and total nitrogen) will be monitored while the trout are reared on diets of baitfish (natural) and artificial pellets at the five temperatures examined in phase 1 of the project. A final report summarizing the two phases of the project will be completed in the Fall 2000.

Table 1. Conversion values for water temperature from Celsius to Fahrenheit.

<i>Celsius</i>	<i>Fahrenheit</i>
7	44.6
9	48.2
11	51.8
15	59.0
19	66.2

Figure 1

Growth as a function of brook trout initial weight
for trout fed an artificial diet (pelleted)
(Rearing temperatures of 7, 9, 11, 15, 19°C)

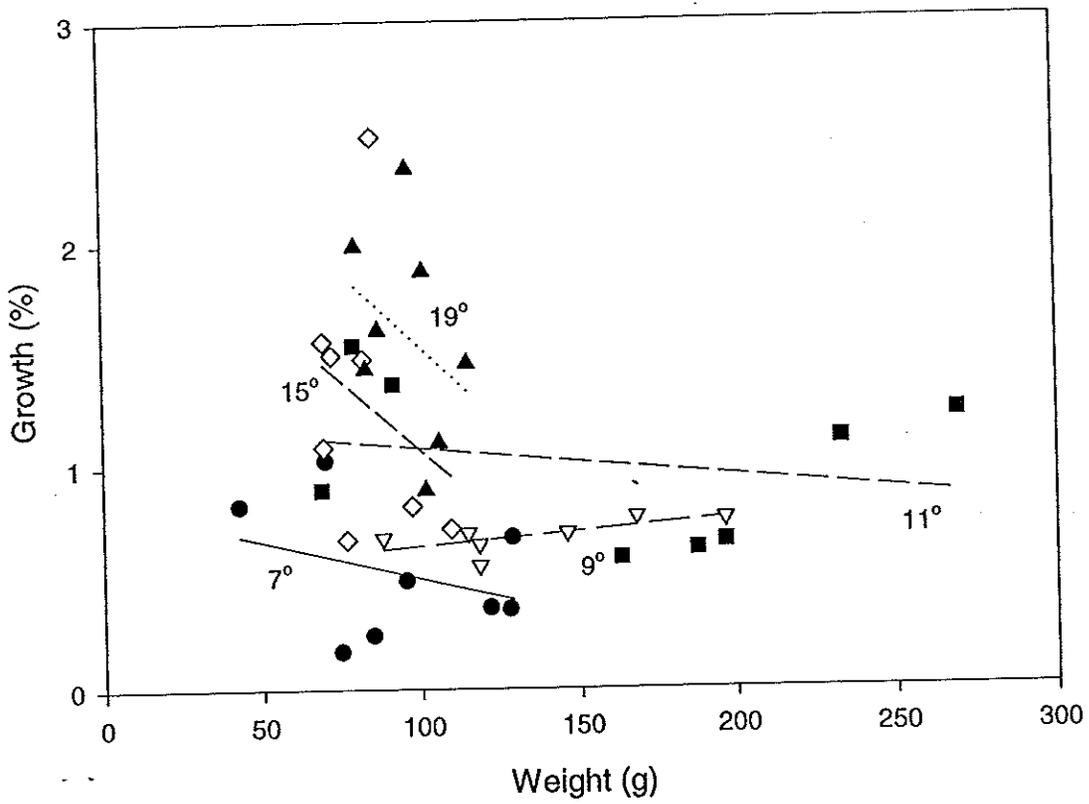


Figure 2

Growth as a function of brook trout initial weight
for trout fed a natural diet of minnows
(Rearing temperatures of 7, 9, 11, 15, 19°C)

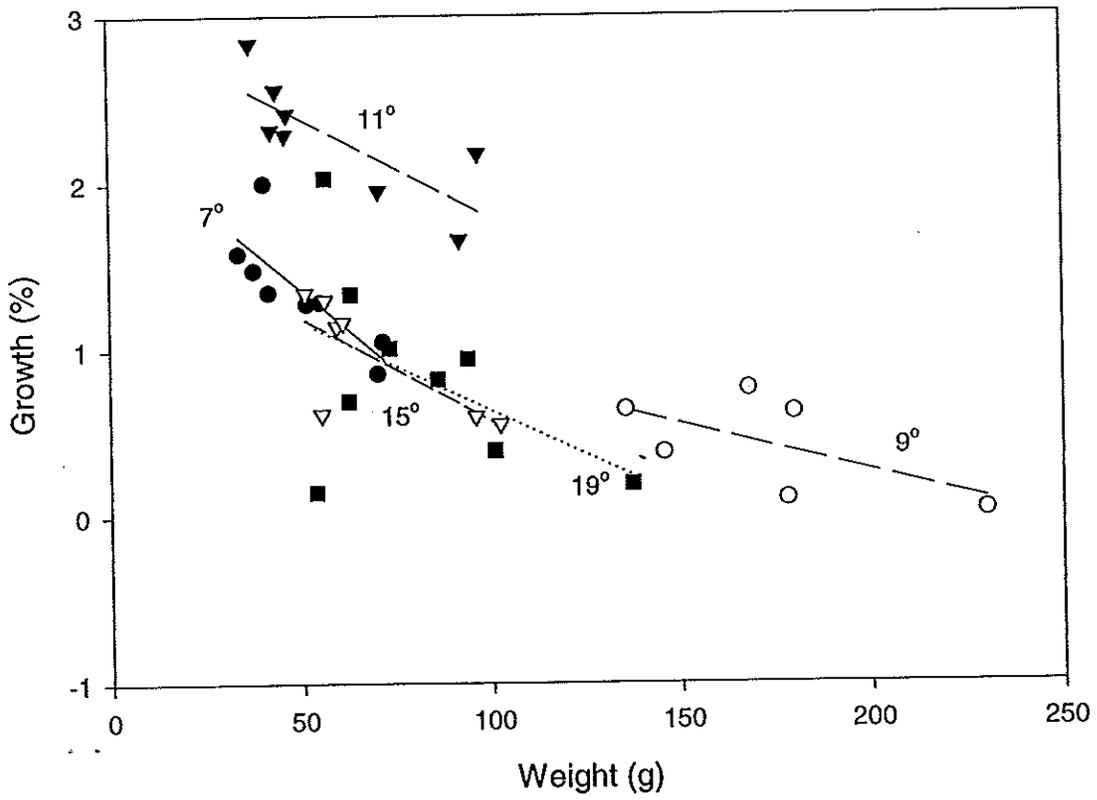


Figure 3

Growth of Brook Trout fed Natural (baitfish)
and Artificial (pelleted) Diets Over a 30
Day Period at Five Temperatures

