# Stress-mortality Differences between Intensively- and Extensively-Reared Largemouth Bass

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*Abstract:* Stress due to confinement in a net caused higher mortalities in largemouth bass *Micropterus salmoides salmoides* which were extensively-reared in ponds on zooplankton and other invertebrates than in those which were intensively-reared in raceways on pelleted food. Fish that were intensively-reared weighed more than the fish reared in ponds, although both groups were sorted with the same bar-grader. Intensively-reared fish exhibited 3% and 9% mortalities after 13- and 16-hour net confinements, respectively, compared to 34% and 38% for those fish reared in ponds. Fish reared intensively may be better able to tolerate the stress of harvest, handling, and transportation than extensively-reared fish.

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The fitness of fish produced in hatcheries has important implications concerning the success of management programs which involve stocked fish. Fitness may be defined as the summation of processes or characteristics of fish that influence survival, growth, and ultimately reproduction. Viability, growth, fecundity, predator avoidance, and resistance to stress and disease are often considered partial measures of fitness. Implicit in the fitness of hatchery-reared fishes is the ability of a fish to survive stocking (Hynes et al. 1981). Fish response to such stress, particularly mortality, is one measure of relative fitness (Strange 1980, Tomasso et al. 1980, Carmichael et al. 1984*a*).

Regardless of the fish culture method employed, fish will be crowded, handled, and transported at some point during production and distribution. These conditions have been associated with stress in black basses and typically occur during pond harvest, holding, and transportation (Carmichael et al. 1983, Carmichael 1984, Carmichael et al. 1984*a, b*). This study was designed to compare the responses to a stress challenge test of largemouth bass *Micropterus salmoides salmoides* that had been reared extensively in ponds on natural food with those fish reared intensively in raceways on pelleted food. Comparison of intensive and extensive methods is necessary as fish culturists now tend toward the more economical intensive methods, as suggested by Neal (1973).

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## Methods

Northern largemouth bass fry were produced using traditional techniques (Williamson 1979, Simco et al. 1986). They were spawned in a 0.04-ha earthern pond. When about 2 weeks old, fry were transferred from the spawning pond to a 0.04-ha rearing pond where they consumed zooplankton and other invertebrates. After 4 more weeks, fingerlings (0.8 g ± 0.2, Mean ± SE) were removed from the rearing pond and were divided into 2 groups. One group was trained to consume pelleted food using intensive methodology (Snow 1975, Williamson 1979). The training ration was Biodiet Grower,[1] a semi-moist pelleted food manufactured by Bioproducts, Inc. (Warrenton, Ore.). The other group was placed in a 0.04-ha pond and reared extensively on natural food (Snow 1975, Williamson 1979). The intensive methodology required size grading and crowding during a 2-week training period. Following training, the fish were held in a concrete raceway and were fed Biodiet Grower.

After a 6-week grow-out period, the 2 groups of fish were harvested and placed into fiberglass tanks containing well water. At harvest, water quality was similar in the raceway, pond, and fiberglass tanks (22°C, 300 mg/liter hardness, 5.0–7.0 mg/liter dissolved oxygen). Fish from the pond were harvested with a seine and then hauled in water containing salts and Furacin to holding tanks (Carmichael and Tomasso 1985). The fish in the raceway were harvested with dipnets after crowding with raceway-dividers. These fish were similarly hauled in water containing salts and Furacin to holding tanks. Both harvesting methods took about 30 minutes. Both groups of fish remained undisturbed and unfed in holding tanks for 24 hours. The next day, both groups were sorted using bar-graders to obtain fish of similar size. Approximately 300 fish from each group were anestheticized with 50 mg/liter tricain methane sulfonate and marked with pelvic fin clips. No fish were weighed at this time.

Fish from each group were counted into 2 76 × 76 cm dipnets—net A and net B—so that both intensively-reared fish ($N$ = 150 per net) and extensively-reared fish ($N$ = 150 per net) were represented in each net. The nets were placed in fiberglass tanks near a water inlet to provide oxygenated water (5.0–7.0 mg/liter dissolved oxygen). About 50 intensively-reared and 50 extensively-reared fish were released from each net into fiberglass recovery tanks after 13 hours of net-con-

[1]Mention of commercial products or firms does not imply endorsement by the U.S. Fish and Wildlife Service.

finement. The remaining fish, approximately 100 fish/treatment, were released from the nets to recovery tanks after 16 hours of net-confinement. For 7 days, dead fish were periodically collected and identified by fin clip. Time of death and weight of each fish were recorded. All fish surviving after 7 days appeared to have recovered. The intensively-reared fish were eating pelleted food. Chi-square and Student's *t*-test analyses ($P \leq 0.05$) were used as appropriate (Alder and Roessler 1972).

## Results and Discussion

The intensively-reared largemouth bass were heavier than extensively-reared fish (mean 1.89 g and 1.64 g, respectively; Student's *t*-test). The difference in weight apparently was due to fish shape or condition. Within treatment groups, there was no difference in size between dead fish and those alive at the end of the study (Student's *t*-test). Size was not a factor in stress responses of larger, dissimilar-sized largemouth bass (Carmichael et al. 1984*b*).

Intensively-reared fish survived the net-confinements of 13 and 16 hours better than did the extensively-reared fish. Among intensively-reared fish, cumulative mortalities following 7 days of recovery from 13 and 16 hours of net-confinement, 3% and 9% respectively, were significantly lower than the 34% and 38% respective mortalities for the extensively-reared fish (Chi-square analyses performed on frequency values; Table 1). Although most mortalities occurred during the recovery period, 11% of the extensively-reared fish were dead immediately after 16 hours of net-confinement. The mortalities in both groups diminished after 18 hours of recov-

**Table 1.** Cumulative mortalities of intensively and extensively-reared largemouth bass during a 7-day (168-hour) recovery period following 13 and 16 hours of net-confinement. Within-treatment replicate data (nets A and B) were combined for each of the 13- and 16-hour confinement periods. Actual number of dead fish are reported as they were collected over time. Percent cumulative mortality is given in parentheses. The first mortalities were recorded at 0 hours immediately following release of the fish from net-confinement into recovery tanks. Number of individual fish (dead and alive) is represented by *N*.

| Treatment | 0h | 6h | 18h | 48h | 72h | 96h | 168h |
|---|---|---|---|---|---|---|---|
| Intensive | | | | | | | |
| 13h | | | | | | | |
| $N = 98$ | 0 (0) | 0 (0) | 3 (3) | 3 (3) | 3 (3) | 3 (3) | 3 (3) |
| 16h | | | | | | | |
| $N = 203$ | 1 (1) | 1 (1) | 7 (3) | 11 (5) | 14 (7) | 15 (7) | 18 (9) |
| Total | | | | | | | |
| $N = 301$ | 1 (1) | 1 (1) | 10 (3) | 14 (5) | 17 (6) | 18 (6) | 21 (7) |
| Extensive | | | | | | | |
| 13h | | | | | | | |
| $N = 99$ | 3 (3) | 19 (19) | 27 (27) | 31 (31) | 33 (33) | 34 (34) | 34 (34) |
| 16th | | | | | | | |
| $N = 194$ | 29 (15) | 42 (22) | 60 (31) | 68 (35) | 72 (37) | 73 (38) | 74 (38) |
| Total | | | | | | | |
| $N = 293$ | 32 (11) | 61 (21) | 87 (30) | 99 (34) | 105 (36) | 107 (37) | 108 (37) |

ery, stabilized, and ceased after 6 days of recovery. The dynamics of the stress response, as measured here by mortality, appeared similar to those observed during and after hauling largemouth bass (Carmichael et al. 1984*a*). Hearn (1977) showed that largemouth bass acclimated to intensive culture survived better than extensively-reared fish when both were reared in ponds on natural prey.

We had no definitive ideas about the stress response due to net-confinement in largemouth bass of this size. Therefore, we initially designed the stress trial based on previous experience with larger fish. For example, we originally planned sequential fish releases from net-confinement at 18, 24, and 36 hours. At 13 hours of net confinement, fish began showing signs of severe stress, i.e. loss of equilibrium, much earlier than anticipated. In order to maintain the overall integrity of the study, the original release schedule was altered to release fish at 13 and 16 hours. Thirty-three percent of the fish were released after 13 hours of net confinement. At 16 hours, fish remaining in the net were in such a state of distress that we decided to release the remaining fish into recovery tanks to prevent complete mortality within this group. We decided this approach was preferable to attempts to reduce the stressor (crowding) while maintaining the initial design. We also decided on a 7 day recovery period rather than the 14 to 21 day recovery period suggested by Carmichael et al. (1984*a*). If not fed, we felt the smaller fish would not have the energy reserves to sustain them for a lengthy recovery period. In addition, most of the mortality occurred within 18 hours following release from the net, particularly among the extensively-reared fish (Table 1). We were interested in stress response associated with handling and crowding uncomplicated by starvation. Finally, we decided to use mortality as the stress response to measure instead of sublethal blood chemistry indicators reported by Carmichael et al. (1984*b*). Fish used in this study were too small for us to obtain adequate blood samples.

Possible explanations for the different survival values are numerous. Combined physical stressors of pond-harvest and net-confinement may have been factors that increased mortality in extensively-reared fish. Intensively-reared fish may have been accustomed to handling and crowding and thus were better able to withstand the stress challenge test. The recovery period following a stressor in largemouth bass has been shown to be quite lengthy in some cases—up to three weeks after severe hauling stress (Carmichael et al. 1984*a*). Thus, it is probable that the extensively-reared fish were more disturbed, or at least had not recovered from the stress of pond-harvest, at the time of net-confinement.

Additional studies will be required to identify or define specific factors or combinations of factors involved in each culture method which might explain the differential results obtained in this study. Investigation of the physical aspects of the respective culture environments would be an obvious avenue of study. Another area which might prove fruitful is the relationship of fish condition, as quantitatively defined by a length/weight relationship, and expected performance.

Regardless of the reasons proposed for the differential response to stress, all were functions of routine extensive and intensive fish culture methodology. Although the results of this study do not prove that intensively-reared fish are more likely to survive after stocking than extensively-reared fish, they do suggest that intensively-reared fish better sustain common hatchery stressors and arrive at the stocking site in less stressed condition.

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