Recent Progress in Experimental Saltwater Tilapia Culture in the Bahamas

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ABSTRACT

The objective of this paper is to describe recent progress in experimental rearing of Florida red tilapia for saltwater culture at the Caribbean Marine Research Center, Bahamas.

Salinity tolerance was studied in Florida red tilapia in relation to early salinity exposure and to ontogenetic development. The results provide a basis for the development of methods of salinity adaptation that minimize reliance on low-salinity water during the hatchery phase of production and that improve survival and growth in seawater.

The operation of a commercial-scale saltwater tilapia hatchery on Lee Stocking Island (Exuma Cays) is described, including seed quality and rates of production under different methods of broodstock management.

Production of Florida red tilapia in 1 m^3 floating cages has been studied at a marine site on Great Exuma. Survival and growth remained high for 84 days, but declined with declining in-cage dissolved oxygen, suggesting that alternative cage designs are required to improve circulation.

Studies on growth in seawater pools have demonstrated the feasibility of lowering feed costs by utilizing prepared diets of relatively low protein content.

DEVELOPMENT OF METHODS FOR ADAPTATION TO SEAWATER

Since 1984, the Caribbean Marine Research Center (CMRC) has conducted research on intensive saltwater culture of Florida red tilapia for application to Caribbean Islands and similar regions where freshwater resources are often limiting (Watanabe *et al.*, 1991; 1989). While the suitability of the Florida red

tilapia strain for seawater (36-37 ppt) growout has been demonstrated by high growth rates and food conversion efficiencies (Watanabe *et al.*, 1988; Ernst *et al.*, in manuscript), the hatchery phase of production restricted to water of lower salinities. Methods for seawater adaptation have been developed that minimize reliance on low-salinity water during the hatchery phase of production and that maximize survival and growth following transfer to seawater.

Production of seedstock in brackishwater

Whereas broodstock were formerly maintained in low-salinity (2-6 ppt) groundwater (Watanabe *et al.*, 1991), studies have suggested the feasibility of utilizing water of higher salinities for seed production. Reproductive performance of Florida red tilapia broodstock was compared at salinities ranging from 1 to 36 ppt, under controlled laboratory conditions. Fry production per unit female weight was not impaired under salinities as high as 18 ppt, indicating that hatchery production in brackishwater would be practical (Watanabe *et al.*, in manuscript a).

Influence of spawning salinity on survival and growth in brackish- and seawater

To assess the influence of spawning salinity on survival and growth in brackish- or seawater, growth of juveniles, spawned at salinities of 4 and 18 ppt, were compared at rearing salinities of 18 and 36 ppt, under controlled photoperiod and temperature. Under both rearing salinities, growth was significantly higher for progeny spawned at 18 ppt than those spawned at 4 ppt, suggesting that progeny spawned under elevated salinities are better adapted for growth in brackish- and seawater (Watanabe *et al.*, in press). Progeny spawned at 18 ppt also exhibited higher resistance to cold-stress than those spawned in freshwater during culture in outdoor seawater tanks.

Influence of age at seawater transfer on culture performance

Salinity tolerance was determined in Florida red tilapia, spawned under 5 ppt, at 10, 25, 40, 55 and 70 days post-hatching, using the 96-hour median lethal salinity (MLS-96) index. A trend toward increased tolerance with age was observed, with tolerance improving markedly from 40 days post-hatching (Watanabe *et al.*, in manuscript b). To assess the influence of age at which transfer to seawater (37 ppt) is initiated on culture performance, survival of progeny acclimated to seawater beginning at 10, 25 and 39 days post-hatching was compared. Survival to 48 days post-hatching improved as transfer was delayed, from 20.0% in progeny beginning acclimation at 10 days post-hatching, to 55.9% in progeny beginning acclimation at 39 days post-hatching. The results demonstrate that premature transfer to seawater can impair survival, and that

selection of proper transfer time, based on knowledge of ontogenetic variation in salinity tolerance, can improve survival.

COMMERCIAL-SCALE HATCHERY FOR SALTWATER TILAPIA CULTURE

At the CMRC tilapia hatchery (Ernst, 1988), broodstock are maintained at a ration of 180 females to 60 males in 34 m^3 tanks, where spawning occurs naturally during the reproductive period of March through September. Based on the results of laboratory studies in which successful reproduction in brackishwater and improved seawater survival and growth of brackishwater-spawned progeny were observed, brood tank salinities have been increased in 1988 to 12 ppt by mixing groundwater with seawater.

Seed production rates and quality under the natural mouthbrooding and egg removal methods of broodstock management

Rates of seed (eggs, yolksac fry and free-swimming fry) production were compared under the egg removal and natural mouthbrooding methods of broodstock management. In the egg removal method, females were individually examined every 16 days, and eggs as well as yolksac fry removed from mouthbrooding fish for artificial incubation. In the natural mouthbrooding method, free-swimming fry were periodically netted from the brood tanks as they developed beyond the mother-dependent stage. While egg removal theoretically increases the spawning frequency (Lee, 1979) and, therefore, total seed production for individual females, natural-mouthbrooding eliminates handling of brood fish and artificial incubation systems. Data for the period March-May 1988 showed that each brood tank produced a mean of 188,000 eggs and yolksac fry, and 79,808 free-swimming fry (3188 seed/day or 93.8 seed/m^2 /day) under conditions of egg removal. In contrast, each brood tank produced a mean of 9,250 free-swimming fry (103.9/day or 3.1/m^2/day) under conditions of natural mouthbrooding (Watanabe *et al.*, unpublished data). Cannibalism of young fry by adults appeared to be the primary cause of poor fry production in natural mouthbrooding tanks.

To assess relative viability of artificially- and naturally-hatched fry, survival of fry produced under natural mouthbrooding and egg removal were compared for 28 days during sex-reversal in hatchery tanks. Survival was significantly higher among artificially- (73.9%) than naturally-hatched (49.7%) fry, supporting the feasibility of the egg removal method of broodstock management and for commercial-scale production of Florida red tilapia fry using brackishwater.

REARING EXPERIMENTS IN FLOATING MARINE CAGES

In 1987, an experiment was conducted to investigate the effects of feed rate on growth, survival and food conversion of Florida red tilapia reared in floating marine cages when fed a prepared diet under different feed rates (Clark *et al.*, in manuscript a). Twenty-four floating cages (1 m^3) were anchored in a sea pass (34-41 ppt; 26-33°C) on Great Exuma, Bahamas. Each cage was stocked with 300 juvenile, monosex-males with a mean weight of 10 g. Fish were fed daily a commercially prepared diet (32% protein) under 6 different rates: 4 programmed rates representing 50, 70, 90 and 110% of a prescribed satiation rate, *ad libitum*, and by demand feeders.

After 84 days, mean weights ranged from 94 to 156 g among treatment groups, while survival ranged from 94.7 to 99.7%. Mean specific growth rate was significantly lower under the 50% programmed feeding rate (2.42%/day) than for all other treatments (range = 3.15-3.46%/day), while food conversion ratios (dry wt./wet wt.) were significantly lower under the 50% (1.57) and 70% (1.68) programmed feeding rates than under all other treatments (range = 1.98-2.26). The results suggest that optimal growth and food conversion may be obtained by feeding at a 70% satiation rate. Feed rate under demand feeding exceeded those under programmed and *ad libitum* feeding, providing growth and food conversion comparable to that of fish fed at near-satiation rates, but with reduced labor.

Cage growout studies have continued in 1988 at Barraterre, where the effects of stocking density (100, 200 and 300 fish/m^3) and dietary protein level (28 and 32%) have been assessed. Fish have been grown from a mean initial weight of 8.8 g to a mean weight of 171.6 g over 83 days with survival ranging from 88 to 98% among treatment groups (Watanabe *et al.*, unpublished data). After this, survival declined as in-cage dissolved oxygen declined, indicating that cage carrying capacities were reached. Heavy rainfall and associated fluxes in salinity and temperature may have also adversely affected survival. Alternative cage designs are required to improve circulation and production. Controlled laboratory studies are needed to determine the interactive effects of salinity, temperature and photoperiod on survival and growth.

DEVELOPMENT OF COST-EFFECTIVE FEEDS

Feed costs represent from 58-67% of production costs during culture of Florida red tilapias in floating marine cages (Brass *et al.*, in manuscript), with protein accounting for a large part of the cost of prepared feeds. While there is a considerable amount of information of dietary protein requirements of tilapia during the early fingerling stages, little information is available on protein requirements from the fingerling through market stages (see Jauncey and Ross, 1982 for review). To reduce feed costs, the efficacies of diets containing protein levels of 20, 25 and 30% were compared. Fish were grown in 10m^3.

flow-through seawater pools (36-37 ppt, 32-38°C) stocked at a density of 25 fish/m^3, from a mean weight of 10.6 g to a mean weight of 291.4 g in 90 days, with no significant differences observed among diets during this period (Clark *et al.*, in manuscript b). Food conversion ratios ranged from 2.1 to 2.3. The feasibility of reducing feed costs by utilizing diets with relatively low protein level was demonstrated. Further studies are required to establish the minimum protein level under which optimal growth and survival are maintained.

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