Stressed Fish Produce Gametes of Poorer Quality

Stress is an unavoidable and ubiquitous feature of life and reproduction is one physiological process that is particularly sensitive to its disruptive effects. The deleterious effects of stress on fish reproduction have important implications in aquaculture.

This Aquaculture Update is based on results obtained by the author in studies on rainbow (Oncorhynchus mykiss) and brown (Salmo trutta) trout in the U.K.

In the fish farming industry it has long been recognized that batches of eggs collected from different fish can have survival rates that vary widely. For example, in U.K. rainbow trout hatcheries, egg losses to the eyed stage of development average ~18%; however, considerable individual variation is observed, with some batches of eggs having survival rates, up to 4-month-old fry, in excess of 85%, whereas others experience 100% mortality at fertilization (Bromage et al. 1992). As a consequence, the factors that determine gamete quality, particularly egg quality, have been subjected to much research on behalf of the aquaculture industry. Yet, apart from overripening (a change which is determined primarily by the time of stripping/spawning), no specific factors have been identified that directly correlate with gamete quality and offspring survival. The chemical composition and physical dimensions of the egg, the density and motility of the sperm, the nutrition of the parent fish and husbandry practices used for the maintenance of the broodstock and incubation of the eggs are all factors implicated in determining progeny survival; however, there is little hard evidence linking any of these parameters with fertility or subsequent survival of the offspring.

Previous studies have shown that fish subjected to stress have reduced blood levels of sex steroids. These sex steroids co-ordinate the reproductive process stimulating sperm production in males, egg production in females, and, ultimately, in mature fish, the sexual behaviour that results in spawning and fertilization. The following experiments were conducted to establish the consequences of this stress-induced hormonal disruption on gamete quantity and quality.

Two groups of maturing female rainbow trout and two groups of maturing males were subjected to repeated acute stress during the 9 months prior to spawning. (The fish were stressed by exposure to a brief period of emersion; this involved allowing the water to drain completely from the tanks, leaving the fish exposed to air for 3 minutes before the tanks were allowed to refill slowly.) A similar number of control fish were maintained in identical tanks but were not subjected to stress. The regimen of repeated acute stress used in this experiment mimics conditions on rainbow trout farms in the U.K., where trout are irregularly, but fairly frequently, disturbed by the various fish farming procedures.

Time of ovulation, fecundity, and egg size were recorded in mature females, and sperm counts were estimated for mature males. The eggs obtained from stressed females were fertilized with milt obtained from stressed males and the eggs from control females were...
fertilized with milt from control males. It was found that exposure of rainbow trout to incidents of stress during reproductive development resulted in delayed ovulation and reduced egg size in females, significantly lower sperm counts in males, and, perhaps most importantly, significantly lower survival rates for progeny of stressed fish compared to progeny of unstressed control fish (Campbell et al. 1992). There was no significant difference in survival rates between the eggs from the stressed and control crosses up to the eyed stage of development, when the eyes of the developing embryo are visible through the chorion. Over 90% of the eggs from both the stressed and control crosses became eyed, indicating a very good fertilization rate. A significant difference in survival rates between the progeny from the stressed and control crosses was, however, detected by the time the eggs hatched (% survival of progeny from stressed crosses to hatch = 76.5 ± 5.6% compared to 94.3 ± 1.41% for progeny from controls). At the end of the monitoring period, 28 days post-hatch, 63.4 ± 7.3% of the progeny from the stressed crosses were still alive, compared to 84.8 ± 2.5% of the progeny from the controls. In a similar experiment, groups of brown and rainbow trout were subjected to a single period of chronic crowding stress (2 weeks duration) in the later stages of reproductive development (1 or 2 months prior to spawning). It was found that exposure of brown and rainbow trout to episodes of chronic stress (which mimics the chronic overcrowding that can occur on some fish farms) in the few months before spawning also results in significantly lower survival rates for progeny of stressed fish of both species, compared to progeny of unstressed controls (Campbell et al. 1993).

In this study, the reduced survival of the progeny from the stressed fish compared to the controls attests to the fact that exposure to repeated acute stress reduces the quality of gametes produced. In addition, it was shown that overcrowding fish in the few months prior to spawning may also result in a stress-induced reduction in gamete quality. Hence, the conditions to which fish farm broodstock are subjected during sexual maturation will be an important factor in determining the quality of the gametes, and this will be reflected in the subsequent survival rate of the offspring.

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References

