Relationship Between Rearing Conditions and Health in Chum Salmon (Oncorhynchus keta) Fry

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Abstract: We examined relationships between rearing conditions and health parameters, carcass adenosine triphosphate (ATP) content and ATP synthase transcript (AST) level, using chum salmon fry in two hatcheries to demonstrate appropriate rearing conditions. The standard values of ATP content (<21.0 pmol/g LW) and AST level (>4.34 pmol competitor/μ g total RNA), which reflect health, were in the range of <30 kg/m3 at rearing density and >8 mg/l at dissolved oxygen concentration (DO). Our results suggest that physiologically appropriate rearing conditions for culture of chum salmon fry were <30 kg/m3 at rearing density and >8 mg/l at DO.

Key words: Chum salmon; Rearing density; Dissolved oxygen concentration; Physiology

Chum salmon (Oncorhynchus keta) fry that are artificially fertilized and intensively cultured are released into streams for enhancement of coastal stocks in Hokkaido, northern Japan (Kobayashi 1980). Our research group has suggested that by analysis of carcass adenosine triphosphate (ATP) content and ATP synthase transcript (AST) level it is possible to identify crowded culture conditions that cause aggravation of health in chum salmon fry (Mizuno et al. 2010). The Japanese standards of rearing conditions for chum salmon fry are generally accepted as <20 kg/m3 at rearing density and >6 mg/l at dissolved oxygen concentration (DO) (Nogawa and Yagisawa 1994). However, the health of chum salmon fry has not been examined in detail and the relationship between practical rearing conditions and the health of the fry has not been shown in the hatcheries. In the present study, relationships among rearing density, DO and health were examined using chum salmon fry cultured in two hatcheries in order to determine appropriate rearing conditions for practical chum salmon fry culture.

On April 7, 14 and 21, 2008, two to five ponds were chosen in one hatchery in northern Hokkaido. In addition, seven ponds were selected in another hatchery in southern Hokkaido on April 26, 2010. In each outflow of the ponds, water temperature, pH and DO were measured using water quality meters (YSI85/50FT, YSI, Yellow Springs, OH, USA) and total ammonium concentrations were examined with commercial ammonium test kits (Kyoritsu Chemical, Tokyo, Japan). Un-ionized ammonia concentration (UIA) was estimated using the ammonium dissociation constant (Trussell 1972), which is dependent on temperature and pH, multiplied by total ammonium concentration. Fifteen fry were randomly caught from each pond and immediately anesthetized by 1.0 g/l 2-phenoxyethanol. After measurement of body weight (BW), blood was removed by caudal cutting. Rearing density was estimated as fry number multiplied by the mean BW of sampled fry/pond volume and expressed as kg/m3. The carcasses were frozen under −80°C for two physiological analyses. Analyses of carcass ATP content and AST level were performed according to Mizuno et al. (2010).

In the present study, the water temperature and pH of the ponds ranged between 5.2 and 9.0°C and between 6.50 and 6.83, respectively (Table 1). The UIA concentration was <0.1 μg/l in all ponds and the mean BW of the fry ranged from 0.86 to 2.36 g. Prior to this study, we demonstrated that there were no effects of differences in water temperature between 5 and 10°C and in fry BW between 0.7 and 3.0 g on the two health parameters analyzed in this study (Mizuno et al. unpublished data). In chum salmon fry, negative physiological effects (unbalanced ion regulation) of acid water have been first found at pH 5.0 (Watanabe et al. 1995). The UIA, which showed the lowest concentration of all previous papers to report negative physiological impacts of UIA was 4 μg/l in salmonid (Maede 1985). Therefore, this information suggests that there were no effects...
of differences in water temperature, pH, UIA and fry body size on the two health parameters in the present study. The means of carcass ATP content and AST levels ranged between 8.00 and 1,245 pmol/g BW and between 3.52 and 14.2 pmol competitor/μg total RNA, respectively (Table 1). Mizuno et al. (2010) demonstrated that increased ATP content and decreased AST levels are signs of initiation of health aggravation resulting from high density and suggested that the parameter border lines between healthiness and unhealthiness are in 8.16 to 21.0 pmol/g BW in the ATP content and in 4.34 to 5.04 pmol competitor/μg total RNA in the AST level. If these border lines of health parameters are applied to the present results, a hatchery-fry are regarded as in poor health in Ponds A, B and C on April 7 and in Ponds C, D, E and F on April 21 and in as good health in Pond B on April 14 and 21. The fry in Pond C on April 14 were considered in impaired health, since the AST value was out of the range of good health, while the ATP value was in the range of good health. This finding suggests that declined AST precedes increased ATP during aggravation of health in chum salmon fry. On the other hand, β hatchery-fry are considered healthy in all ponds.

Figure 1 shows the relationship among each of the two health parameters, rearing density and DO using Graph-R ver. 2.17 based on the copyright of Dr. Tohru Ito. The area, which was regarded as good health in the carcass ATP content (< 21.0 pmol/g BW; Fig. 1A) and in the AST level (> 4.34 pmol competitor/μg total RNA; Fig. 1B), was mainly found in < 30 kg/m³ at rearing density and in > 8 mg/l at DO. These results suggest that appropriate rearing conditions for culture of chum salmon fry were < 30 kg/m³ at rearing density and > 8 mg/l at DO in terms of health.

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References


Fig. 1. Relationship among rearing density, dissolved oxygen concentration (DO) and carcass ATP content (A) and among rearing density, DO and carcass ATP synthase transcript level (B). X- and Y-axes show rearing density and DO in the 2 graphs, respectively. Contours represent carcass ATP content in the A graph and carcass ATP synthase transcript level in the B graph.