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Feeding *Acipenser persicus* and *Huso huso* (Acipenseriformes) larvae with *Artemia urmiana* nauplii enriched with HUFA and vitamin C: II. Effect on tolerance to shock exposure of environmental factors

By F. Noori[1,2], G. A. Takami[3], M. Van Speybroeck[1], G. Van Stappen[1] and P. Sorgeloos[1]

[1]*Laboratory of Aquaculture & Artemia Reference Center, Ghent University, Gent, Belgium;* [2]*Artemia and Aquatic Animals Research Institute, Urmia University, Urmia, Iran;* [3]*Department of Aquatic Health, Faculty of Veterinary Medicine, Tehran University, Tehran, Iran*

Summary

The effects of feeding *Acipenser persicus* and *Huso huso* larvae with *Artemia* nauplii enriched with ascorbyl palmitate (AP) and lipid emulsions on inducing tolerance against abrupt changes in environmental conditions (such as elevated levels of salinity, temperature, nitrite and total ammonia) were investigated. The 10 days post-hatch fish larvae were fed with decapsulated cysts (DC) or newly hatched *Artemia urmiana* nauplii enriched with saturated lipids and HUFA emulsions containing 0, 10, and 20% AP. The control groups received non-enriched nauplii as source of food. Each feeding experiment was carried out for 15 days in four replicates under controlled laboratory culture conditions. Ten randomly collected *A. persicus* and *H. huso* larvae from each replicate were subjected to different salinities, nitrite, total ammonia concentrations and temperatures. The results showed that feeding with *Artemia* nauplii enriched with HUFA and higher concentrations of vitamin C induces significantly higher tolerance to shocks in abiotic conditions in fish larvae of both species, as shown by higher survival. Nevertheless the two fish species did not exhibit a similar pattern of response: *A. persicus* showed higher tolerance compared to *H. huso*. Enrichment with HUFA alone did not result in a significantly improved tolerance, indicating the importance of dietary vitamin C to cope with abrupt physico-chemical changes.

Introduction

Exposure to sudden changes in environmental conditions is an inescapable aspect of an aquatic organism's life. These conditions include temperature, pH, light, oxygen, salinity, pollutants, and so on. Among these, ammonia and nitrite are very toxic to aquatic animals and may cause serious damage. Ammonia is known to reach elevated levels under normal aquaculture conditions (Tomasso, 1994). Ammonia toxicity to fish includes gill damage to suffocation and osmoregulatory dysfunctions causing kidney failure. Ammonia accumulation can lead to neurological and cytological failure (Maede, 1985; Tomasso, 1994). The average of the mean acute toxicity values for 32 freshwater species is 2.79 mg NH_3 L^{-1} compared with 1.86 mg NH_3 L^{-1} for seawater species (USEPA reports, 1984), which indicates that in general seawater species are slightly more sensitive to ammonia toxicity than freshwater species.

Nitrite is actively taken up across fish gills in competition with chloride (Bath and Eddy, 1980; Eddy and Williams, 1987). Research findings have shown that the primary cause of nitrite toxicity may vary among different fish species, such as oxygen transport failure, circulatory and tissue effects. In rainbow trout *Oncorhynchus mykiss*, erythrocytes have the ability to detoxify nitrite by oxidation to nitrate, thus removing this compound from the blood. The Siberian sturgeon *A. baerii* can tolerate high concentrations of nitrite owing to the detoxifying function of the liver (Huertas et al., 2002).

Acipenser persicus lives in the Caspian Sea with salinity in the range 9–13 g L^{-1} and regularly experiences salinity variations during its life cycle. The osmotic regulation in different sturgeons like green sturgeon *Acipenser medirostris* and other species of Acipenserids has been studied by many researchers such as McEnroe and Cech (1985) and Krayushkina and Semenova (2006). Furthermore, several researchers have studied the positive effect of HUFA and vitamin C enrichment on salinity shock performance of fish larvae (Merchie et al., 1993; Kolkovski et al., 2000; Lim et al., 2002). Vitamin C is well known as a major water-soluble antioxidant, and it has been identified as a potent immune-stimulator suitable for use in aquaculture (Uma et al., 1996) particularly for larval stages (Dabrowski, 1992). Several functions (skeletal development, growth, tolerance to toxicants and immunoactivity) are affected by dietary vitamin C deficiency and result in increased fish mortality (Dabrowski, 1992). Elevation of vitamin C levels in live food via bioencapsulation has improved the commercial larviculture of several fish species (Merchie et al., 1993) and it has been reported that the requirement of vitamin C in fish is affected by size, age, feeding rate, metabolic rate, physiological state, nutrient interrelationship, health status and environmental factors (Lovell, 1994; Halver, 1995).

Based on these literature data, it was assumed that feeding larvae of *Huso huso* and *A. persicus* with *A. urmiana* nauplii, adequately enriched with highly unsaturated fatty acids and vitamin C, would have a beneficial effect on overall performance of the fish larvae. Both sturgeon species are of high economic importance. To test this hypothesis, a number of larviculture experiments with both sturgeon species were run. This paper reports on the effect of the enrichment strategy on the response of the fish larvae to different stressful conditions, particularly to altered temperature, salinity and elevated ammonia and nitrite, whereas the effect on growth and survival in normal rearing conditions is the subject of a separate study.