

Morphology of the eyeball, orbit and retina of atlantic salmon (*Salmo salar*) alevins under hypoxic conditions [Morfología del bulbo ocular, Órbita y retina de alevines del salmón del atlántico (*Salmo salar*) bajo condiciones hipóxicas]

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It has been demonstrated that hypoxia retards the growth of fish, reduces the survival of their larvae, deforms their vertebral column, but despite this teleost fish have the ability to completely regenerate many of their tissues, particularly the retina. As we do not have enough information about the effects of hypoxia on the eyeball, orbit and retina of Atlantic salmon (*Salmo salar*), we propose the following objectives: 1) Compare the morphological changes of the eyeball of fish subject to hypoxia and normoxia. 2) Determine changes in the orbit structure. 3) Describe the retina of salmon alevins. 4). Recognize hypoxic cells using the anti-Hif1 α antibody in the retina of alevins as a sensor. 5) Determine the Shh morphogenic expression in alevins exposed to different times of hypoxia. Around 1,000 *Salmo salar* alevins were placed in a continuous water flow of 9 °C at 100% SatO₂ and alevins maintained at a hypoxia of 60% SatO₂. The latter were transferred to normoxia (at days two, four, and eight after hatching). A control group maintained at continuous normoxia and another at continuous hypoxia was also considered. All the alevins were euthanized at 950 UTAs (\pm 2 months after hatching). Diaphonization (double-stain) according to the Hanken & Wassersug technique was undertaken to describe the morphology of the periorbital cartilage and to measure the ocular diameter. The HIF-1 α factor antibody 1:50, and the anti-Shh antibody dilution of 1:100 were used. The alevins after hatching had large eyeballs with the optic cup having an embryonic shape, even a choroidal fissure. The greatest thickness was observed in the nasal ventral zone which corresponds to a zone of pluripotent cells. The optic cup aspect with embryonic characteristics has only been

reported in salmonids. The central retina of the alevins those were cultivated with a 60% saturation of O₂ for two, four or eight days had positive immunostaining when analyzed with the anti-HIF1 α antibody hypoxia sensor. The inner ganglion and nuclear layers had immunopositive cells, with the highest in the alevins that were two days in hypoxia and the lowest when the hypoxia was chronic. Nevertheless, in the latter case the alevins had anatomical deformation of the eyeball and periocular cartilage. The anti-Shh antibody clearly shows a gradient that is expressed in the germinative zone and in the cells of the inner ganglion and nuclear layers. The eyeball and particularly the retina in salmon alevins are an example of neuronal plasticity and neurogenesis. © 2016, Universidad de la Frontera. All rights reserved.

Eyeball

HIF1 α

Hypoxia

Orbit

Retina

Salmo salar

Shh