Wound healing and the effect of chronic stress in post-smolt Atlantic salmon (*Salmo salar*)

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Introduction

The skin of Atlantic salmon (Salmo salar), is a coherent and dense barrier that protects the interior of the fish against the outer environment. The skin covers the entire outer surface, including the head, fins and eyes. Lesions in the skin are a major welfare issue for the fish.

Materials and methods

Atlantic salmon post-smolts (mean weight 120g) were divided into two identical tanks (500L), and two treatments were established. High production intensity, HPI (mean fish density 126 kg/m^3) and normal production intensity, NPI (mean fish density 16 kg/m^3) . Three cylinders of tissue were excised with a 5 mm biopsy punch. Samples (n=12 per treatment) for gene expression analyses (microarray), histology, immunohistochemistry and scanning electron microscopy were collected 1, 3, 7, 14, 36, 42 and 57 days post wounding (dpw).

Results

In general, the wounds from both HPI and NPI followed the normal progression of wound healing, with hemostasis, re-epithelialization, inflammation, tissue formation and tissue remodeling. The first 14 days of the healing process was dominated by acute inflammation and epidermal repair as shown through imaging, histological evaluation and transcriptomics. In the early inflammatory phase a more adherent mucus layer was observed, which further correlated with altered transcription of glycosyl transferases and mucin genes. This may indicate different properties and functions of the mucus during the acute inflammatory phase. Formation of scales and granulation tissue started approximately at 14 days post wounding. This was followed by wound contraction and formation of dermal structures.

At the transcriptomic level the greatest differences between NPI and HPI were found at 2-14 dpw, with more than > 500 DEG at each sampling point. In general, inflammation was enhanced in the HPI wounds, while cell proliferation and tissue regeneration was repressed. Histological examinations showed transient delays in the formation of epidermis, mucus response, scale mineralization, wound pigmentation and formation of dense connective tissue in HPI wounds. The overall wound morphology was also altered in fish reared at HPI. Wounds from NPI fish contracted in an elongated manner, while the wounds from HPI fish were more circular. The fish reared at HPI had significant higher cortisol levels compared to NPI fish, thus we suggest that cortisol are one of the main factors contributing to the delayed wound healing responses in fish reared at HPI .

Conclusion

The presented description of the wound healing processes in Atlantic salmon and the effect of HPI, gives insight into comparative ulcerative biology in fish and provides both novel and updated knowledge that can be applied for improved best operational practices for fish welfare in aquaculture.