How mixing light with salt makes a smolt?

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For decades, researchers have tried to find out what regulates changes in salmon when they transform from being freshwater to saltwater fish. Now they have come a little closer to an answer.

"We have presumed that changes in thyroid hormones have been important for normal smolt development, but we have not known how the hormone is activated and it specific roles," says Lars Ebbesson. The researchers at Uni Research Environment have now found important clues that may provide an answer.

A new study shows that light - increases in day length in the spring - affects developmental processes in the fish's brain during smoltification. In a new study just published in *Current Biology* Ebbesson and his colleagues found that light increased the production of a special enzyme, type 2 deiodinase, activating the thyroid hormone in the smolt brain. This enzyme stimulates the fish to prepare itself before it wanders out into salt water.

They also found an important change in the type-2 deiodinase paralog in the gills. The gills are important for regulating the salt balance in the fish. In the study, they found that this deiodinase paralog that activates the thyroid hormone in the gills only increases when the fish reaches saltwater.

The present study may explain why previous work on thyroid hormones and gill development in smolts, which have focussed on the freshwater parr-smolt transformation, have found thyroid hormones to have a

minimal role.

Control changes

"Our findings increase our understanding of the organ-specific regulation and activation of hormones. This gives us a better understanding of how environmental signals, such as light and salt, control physiological changes," says Ebbesson. He is the group leader of the Integrative Fish Biology group at Uni Research Environment.

The recent work is a collaboration together with Senior Researchers Tom Ole Nilsen and Sigurd Handeland from his group, Professors David Hazlerigg from the University of Tromsø and Sam Martin at the University of Aberdeen. The group also collaborates on the FRIMEDBIO project "The smolt brain model: Unraveling nature´s regulation of neural plasticity. The three year project is funded by the Research Council of Norway.

"In this project, we are exploring how environment and genetics regulate midlife neural plasticity, says Ebbesson.

New insight

"Taken together, these results provide new insight into the ways in which the smoltification is regulated and the ways in which the environment affects this special transition from fresh water to salt water," says Ebbesson.

Ebbesson and his colleagues have now started up a new three-year FRIMEDBIO project "Light & Salt - Thyroid hormone deiodinase paralogues & the evolution of complex life-history strategy in salmonids" to learn more about the relationship between light, salt

regulation and the transformation where the fish become smolt.

Among other things, Integrative Fish Biology at Uni Research has previously found out that salmon can be bothered by chronic mild stress. They found out that chronic stress can be a contributing factor preventing salmon from finding their way back to their rivers.

This is true because the environment affects the fishes' ability to learn. If the environment is poor for en extended period, their learning ability declines. The researchers demonstrated that fish that were exposed to poor water quality had a higher risk of developing chronic mild stress and impaired neural responses when challenged. How mentally and physiologically robust the fish are provides important information about how the fish will tackle challenges in the future. This is a new example of the ways in which Ebbesson and his colleagues use integrative neurobiology to help clarify some of biology's mysteries.

Want to find more answers

The research group shall now strive to become a Centre of Excellence in Integrated Fish Neurobiology. The goal is to create an environment that will be an important pillar for researchers in fish biology and evolution, both nationally and internationally.

"The brain is the central regulator of most biological processes, yet only a few scattered research groups study how the fish brain works in Norway. In a country where fish plays such an important role in society, a centre that can give new insight to important fundamental questions on brain function will also impact how we manage wild fish populations and improve aquaculture practices," says Ebbesson.

The centre will make it possible for researchers to take a closer look at specific regulation and functions in fish brains. Through research here,

they will be able to arrive at important answers to help both those who work with fish and those who work with people. Here they will also expand and centralise technological resources and neuroanatomical-databases. The work to develop this is already under way.

"We do not necessarily believe that fish and humans are the same, but mechanisms in the brain occur in a similar way for fish as for humans. By understanding more of what happens in the fish's brain, we can also understand more about the human brain," says Ebbesson.

The smolt brain

Ebbesson also emphasises that knowledge about how the fishes' brains function will be important for the aquaculture industry. Among other things, they will be able to predict and regulate how the fish will be affected by environmental changes.

The research group in Bergen is unique because its work is so interdisciplinary. The new centre will offer researchers completely new knowledge and tools.

Cf. the following website for more about smolt:
www.uib.no/en/rg/mdb/58938/usi … ore-about-our-brains

Interdisciplinary approach

The Centre of Excellence on Integrated Fish Neurobiology (SIFN) will be headed by Ebbesson. He has been affiliated with the University of Bergen since he moved to Bergen as a post-doc fellow in 2000. In 2006, he was hired at Uni Research, and in 2009 he started up the research group Integrative Fish Biology and the Fish Neuroscience Network in Bergen.

This subsequently evolved into NORDFORSK Behavioural Fish Neuroscience Network (BeFiNe), which is now part of the EU's COPEWELL project. In the autumn of 2015, the research group will seek to become a Centre of Excellence.

The centre will study evolutionary and environmental mechanisms that control development and functional changes in the fish's brain. This is a joint initiative with the Universities of Bergen, Tromsø and Oslo in cooperation with the Norwegian Institute of Marine Research, the Sars International Centre for Marine Molecular Biology and international experts from Japan, the USA and Europe.

"Globally leading"

"The centre here in Bergen will become globally leading," says Ebbesson.

The key to success lies in the fact that the centre will combine expertise from various fields in neuroscience, functional neuroanatomy, behaviour, molecular biology, bio-informatics, ecology and fish physiology.

"This kind of integrative approach is important in order to solve challenges with regulation of life-history transitions, behavioural motivation and environmental and genetic modulation of adaptation. At present there are few researchers in the world who are capable of having this kind of integrative approach," says Ebbesson.

More information: "Functional Divergence of Type 2 Deiodinase Paralogs in the Atlantic Salmon." *Current Biology* 03/2015; DOI: 10.1016/j.cub.2015.01.074

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