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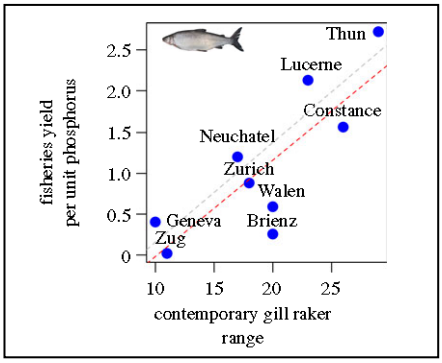
Press Release, Thursday, February 16th 2017

Biodiversity can promote ecosystem efficiency

Humans influence evolution. In the case of whitefish in Swiss lakes, one consequence of this is replacement of a diversity of specialised species by fewer generalists. A recent analysis now suggests that communities of diverse specialists utilise trophic resources more efficiently.

In a theme issue on “Human influences on evolution, and the ecological and societal consequences”, published by the Royal Society (UK), two review articles are devoted to fish: the first discusses adaptive capacities in fish exposed to pollution, while the second – an Eawag contribution – examines the effects of lake eutrophication on fish biodiversity. The authors show that the increase in primary production caused by eutrophication can lead to changes throughout the food web. Changes in productivity alter the physico-chemical environment, which has further effects – e.g. via selection processes – on lake fauna and flora. Such changes can also affect habitat availability, thus eroding differences in habits and behaviour which had previously contributed to the separation and genetic differentiation of species. Eutrophication thus commonly results in reduced ecological specialization and genetic and phenotypic homogenization of species, both among lakes and among niches within lakes.

Essentially, these findings reflect those of an earlier Eawag study of whitefish (published by Vonlanthen et. al. in *Nature* in 2012), as well as studies of other fish in other lakes. Here, however, the phenomenon of “eco-evolutionary feedback” has been further investigated. Taking the example of whitefish, the authors not only studied the effects of eutrophication on biodiversity but also, for the first time, analysed the relationship between current fishery yields, nutrient availability and functional diversity. The latter was measured in terms of the range of a key functional trait – the number of gill rakers: sparsely rakered fish are better adapted for sediment feeding but cannot filter plankton effectively, while for densely rakered fish the converse is true. Fishery yields relative to lake productivity were shown to be higher in lakes where whitefish diversity is higher. In Lakes Thun or Lucerne, for example, which were not subject to heavy eutrophication and which still harbour relatively diverse communities, the whitefish yield per unit phosphorus is higher than in, say, Lakes Zug or Geneva. According to the researchers, this indicates more efficient utilization of the trophic resources available in the lakes.



Correlation between whitefish yield per unit phosphorus (y axis) and the range of gill raker numbers, an index of functional diversity in whitefish species (x axis). The two lakes which do not fit this pattern – Brienz and Walen – are influenced by sediment-rich glacial meltwater: the resultant turbidity, with sunlight penetrating less deeply into the lake, leads to lower potential productivity.

Original article:
Alexander TJ, Vonlanthen P, Seehausen O (2017): Does eutrophication-driven evolution change aquatic ecosystems? Phil. Trans. R. Soc. B 372: 20160041. http://dx.doi.org/10.1098/rstb.2016.0041

Theme issue:
Philosophical Transactions of the Royal Society B: 19 January 2017; volume 372, issue 1712, «Human influences on evolution, and the ecological and societal consequences», compiled and edited by Kiyoko M. Gotanda, Andrew P. Hendry and Erik I. Svensson:
http://rstb.royalsocietypublishing.org/content/372/1712

New publication issued by the Federal Office for the Environment:
Vonlanthen P, Hefti D. 2016: Genetik und Fischerei. Zusammenfassung der genetischen Studien und Empfehlungen für die Bewirtschaftung. Bundesamt für Umwelt, Bern. Umwelt-Wissen Nr. 1637
Vonlanthen P, Hefti D. 2016: Génétique et Pêche. Synthèse des études génétiques et recommandations en matière de gestion piscicole. Office fédéral de l'environnement, Berne. Connaissance de l'environnement n° 1637 (includes English abstract)

PEAK course:
The applied course on "Genetics and fishery management" (in German) is planned to be held again in autumn 2017. For details see: http://www.eawag.ch/peak

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Six different whitefish species in Lake Lucerne (photos on www.eawag.ch)

Until recently, four species of whitefish were known to occur in Lake Lucerne, differing in size, shape and spawning depth/season: *Coregonus suidteri* ("Balchen/Bodenbalchen"), *C. zugensis* ("Albeli"), *C. nobilis* ("Edelfisch") and the so-called "Alpnacherfelchen". In 2009, Eawag scientists identified a fifth species, spawning at depths between the shallow-spawning *C. suidteri* (up to approx. 10 metres) and the deep-spawning *C. zugensis* (from approx. 40 metres). Because it spawns at intermediate depths, this species is known unofficially in German as the "Schwebbalchen". Now, a sixth species has been identified by the group led by Ole Seehausen, head of the Fish Ecology and Evolution department at Eawag and Professor of Aquatic Ecology at Bern University. The six whitefish species all differ not only genetically but also in growth rate and spawning behaviour; in most cases, they also differ in appearance and in gill-raker count. Surprisingly, the most recently identified species – which has yet to be named – spawns in close proximity to the "Schwebbalchen", but is found particularly in the open waters of the lake. According to Seehausen, the fact that another whitefish species has been identified in Lake Lucerne highlights the importance of unbiased sampling strategies using quantitative genetic and morphological methods. «These are essential if we are to understand the evolutionary mechanisms structuring biodiversity, and also to improve conservation and fisheries management», he says.

Original article:
Hudson AG, Lundsgaard-Hansen B, Lucek K, Vonlanthen P and Seehausen O (2016): Managing cryptic biodiversity: Fine-scale intralacustrine speciation along a benthic gradient in Alpine whitefish (*Coregonus* spp.). Evol Appl. http://dx.doi.org/10.1111/eva.12446