Biodiversity can promote ecosystem efficiency

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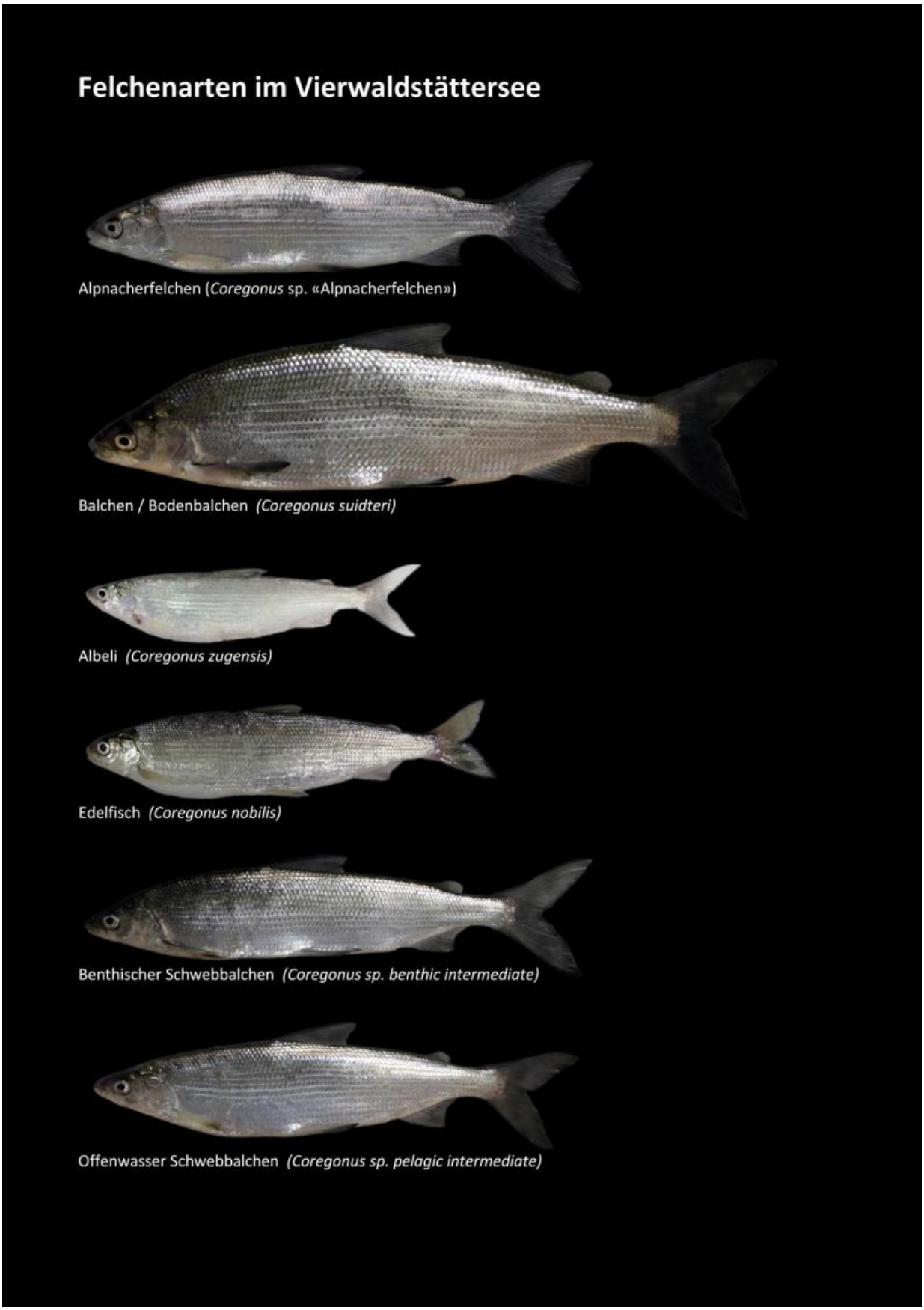

Felchenarten im Vierwaldstättersee
Alpnacherfelchen (Coregonus sp. «Alpnacherfelchen»)
Balchen / Bodenbalchen (Coregonus suidteri)
Albeli (Coregonus zugensis)
Edelfisch (Coregonus nobilis)
Benthischer Schwebbalchen (Coregonus sp. benthic intermediate)
Offenwasser Schwebbalchen (Coregonus sp. pelagic intermediate)

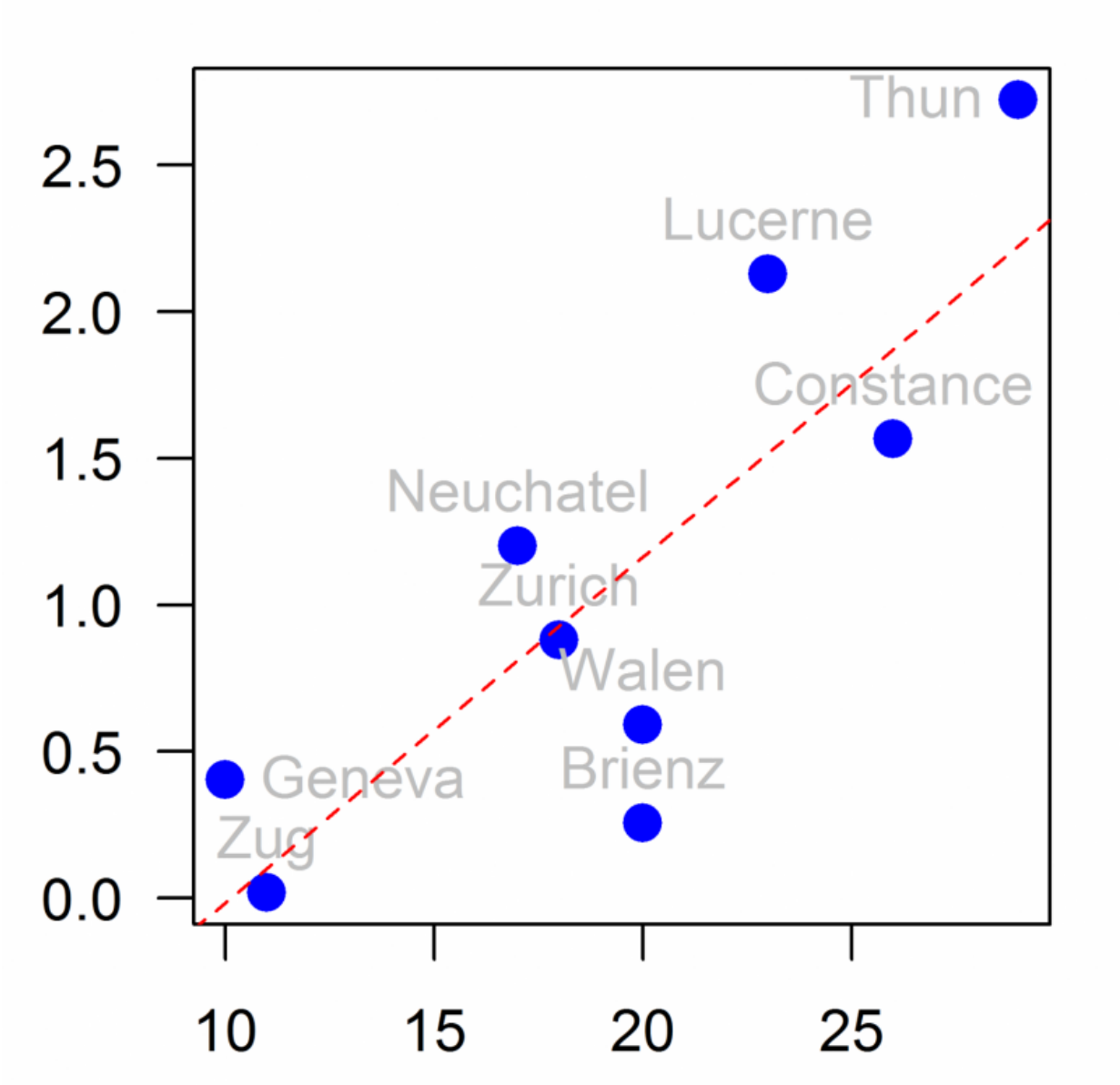
Six different whitefish species in Lake Lucerne. Credit: Swiss Federal Institute of Aquatic Science and Technology

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). Credit: Swiss Federal Institute of Aquatic Science and Technology

Six different whitefish species in Lake Lucerne

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.

More information: Alan G. Hudson et al. Managing cryptic biodiversity: Fine-scale intralacustrine speciation along a benthic gradient in Alpine whitefish (spp.), *Evolutionary Applications* (2016). DOI: 10.1111/eva.12446

Timothy J. Alexander et al. Does eutrophication-driven evolution change aquatic ecosystems?, *Philosophical Transactions of the Royal Society B: Biological Sciences* (2016). DOI: 10.1098/rstb.2016.0041