

Patterns and processes of adaptation and tolerance to low pH of freshwater plankton**(1.7.2007-31.3.2001) - Summary**

The pH is a major environmental factor of freshwater aquatic ecosystems, ranging from <2 to 12. Biodiversity is greatly reduced in highly acidic environments (pH <3) such as acid mining lakes (AML). For instance, neither fish nor cladocerans ('water fleas') dwell in such lakes (Moser & Weisse 2011c). Although the reduction of species numbers with decreasing pH has been described in several protist and metazoan phyla, the patterns and processes of adaptation and tolerance to low pH were little understood for planktonic organisms (Weisse & Stadler 2006, Weisse et al. 2007). Within this project, we could experimentally demonstrate that, on the one hand, acid tolerant species benefit from the reduced pressure of predation and competition under conditions of acid stress (Moser & Weisse 2011a). On the other hand, we found specifically adapted, acidophil species, which cannot survive under circumneutral conditions (Weisse et al. 2013a, b). We described the new rotifer species *Cephalodella acidophila* (Jersabek et al. 2011) and the ciliate *Oxytricha acidotolerans* (Weisse et al. 2013a) that were hitherto unknown. Furthermore, we investigated the as yet unknown combined effect of temperature and pH stress at different food supply with planktonic flagellates, ciliates and rotifers (Moser & Weisse 2011b, Weisse et al. 2013b). The combination of these 3 key environmental variables narrows the realised (=actual) pH niche of all our study organisms. These results presumably can be applied to other habitats as well.

We wanted to discriminate between genetically fixed, general physiological adaptations to acid conditions (at the species level) and locality-specific features in similar habitats, which result from small scale genetic changes of the organisms below the species level (microevolution). To this end, we investigated the biomass size spectrum and the dominant organisms using molecular methods in three acid mining lakes and one neutralised reference lake located in Austria (at Langau, Lower Austria) and East Germany (Lusatia). These four lakes differ with respect to their pH, age and/or geographic position. We tested experimentally the hypothesis that dispersal of microorganisms (in acid mining lakes) does not require a historical explanation, i.e. that the habitat acts as a filter that only preadapted organisms can pass. We found intraspecific genetic and physiological differences, as well as significant interactions between the organisms and their habitats, in which the organisms actually dwell or may exist (Weisse et al. 2011). In other words, different strains of the same (microbial) species may behave differently in the same habitat; respectively the same strain can have a different fitness in similar (but not identical) habitats. We, therefore, reject the hypothesis that the distribution of free living microorganisms can be understood solely in terms of habitat properties. This conclusion is of general ecological relevance.

Publications related to this project:

Peer-reviewed:

- Weisse, T., Laufenstein, N. & Weithoff, G. (2013b). Multiple environmental stressors confine the ecological niche of the rotifer *Cephalodella acidophila*. *Freshwater Biol.* 58: 1008-1015 [doi:10.1111/fwb.12104].
- Weisse, T., Moser, M., Scheffel, U., Stadler, P., Berendonk, T., Weithoff, G. & Berger, H. (2013a). Systematics and species-specific response to pH of *Oxytricha acidotolerans* sp. nov. and *Urosomoida* sp. (Ciliophora, Hypotricha) from acid mining lakes. *Eur. J. Protistol.* 49, 255-271, [doi: 10.1016/j.ejop.2012.08.001].
- Weisse, T., Berendonk, T., Kamjunke, N., Moser, M., Scheffel, U., Stadler, P. & Weithoff, G. (2011). Significant habitat effects influence protist fitness: evidence for local adaptation from acidic mining lakes. *Ecosphere* 2: art134 [doi:http:// dx.doi.org/10.1890/ES11-00157.1].
- Jersabek, C., Weithoff, G. & Weisse, T. (2011). *Cephalodella acidophila* n. sp. (Monogononta: Notommatidae), a new rotifer species from highly acidic mining lakes. *Zootaxa* 2939: 50-58.
- Moser, M. & Weisse, T. (2011c). The most acidified Austrian lake in comparison to a neutralized mining lake. *Limnologica* doi:10.1016/j.limno.2011.01.002.
- Moser, M. & Weisse, T. (2011b). Combined stress effect of pH and temperature narrows the niche width of flagellates in acid mining lakes. *J. Plankton Res.* 33: 1023-1032..
- Moser, M. & Weisse, T. (2011a). The outcome of competition between the two chrysoomonads *Ochromonas* sp. and *Poterioochromonas malhamensis* depends on pH. *Eur. J. Protistol.* 47: 79-85.
- Weithoff, G., Moser, M.; Kamjunke, N., Gaedke, U. & Weisse, T. (2010): Lake morphometry strongly shapes the plankton community structure in acidic mining lakes. *Limnologica* 40: 161-166.
- Weisse, T., Scheffel, U., Stadler, P. & Foissner, W. (2007). Local adaptation among geographically distant clones of the cosmopolitan freshwater ciliate *Meseres corlissi*. II. Response to pH. *Aquat. Microb. Ecol.* 47: 289-297.
- Weisse, T. & Stadler, P. (2006) Effect of pH on growth, cell volume, and production of freshwater ciliates, and implications for their distribution. *Limnol. Oceanogr.* 51: 1708-1715.

Publications for the general public:

- Gruber, E.-M. (2011) Sauer, oder was? Anpassung von Mikroorganismen an saure Gewässer. UNIVERSUM Heft 6, p. 78
- Niel, W. (2011) Mikroorganismen in sauren Seen: an der Aufgabe wachsen. ÖAW Thema des Monats 7/2011 (http://www.oeaw.ac.at/home/thema/thema_201107_2.html)

Collaboration partners:

Guntram Weithoff and Ursula Gaedke
University of Potsdam , Institute for Biochemistry & Biology, Dept. Ecology & Ecosystem Modelling,
Am Neuen Palais 10, D-14469 Potsdam, Germany, e-mail: weithoff@rz.uni-potsdam.de

Thomas Berendonk
Technical University Dresden, Institute for Hydrobiology, 01062 Dresden, Germany
e-mail: Thomas.Berendonk@TU-Dresden.de

Helmut Berger
Consulting Engineering Office for Ecology, Radetzkystrasse 10, 5020 Salzburg,
Austria, e-mail: office@protozoology.com