Conference Volume | 5th Symposium for Research in Protected Areas, 10 to 12 June 2013, Mittersill | pages 489 - 490

Changes in soil macrofauna composition in undisturbed areas: using altitudinal gradients as a proxy for climate change

Anton P. Mahringer, Martin Zimmer

Keywords

Climate change, soil food web, space-for-time approach

Abstract

In most terrestrial ecosystems, >80 % of the annually produced plant biomass is recycled through detrital breakdown (e.g., ZIMMER 2008, for an overview on detritus-processing). In addition to climatic conditions, numerous interactions of soil animals govern these decomposition processes, including potential top-down pressures from predators preying on detritivores (c.f., DUFFY et al. 2007; GESSNER et al. 2010). However, little is known on the importance of predator/detritivore interactions in the field, or on how their relevance depends on environmental conditions: In addition to horizontal biodiversity (e.g., within the guild of detritivores), vertical diversity (here: predators versus detritivores) may play a significant role in controlling decomposition processes and hence nutrient cycling.

In a space-for-time approach that used altitude as a proxy for changing climatic conditions, we aimed at shedding light on changes in soil food web structure along a climatic (altitudinal) gradient, in order to set the basis for detailed understanding of top-down effects of predators on decomposition processes. By making use of the natural change in climatic conditions (temperature, moisture) within spatially small scales along altitudinal gradients, we analysed the surface-dwelling soil macro-fauna in two replicate valleys at the south slope of Großglockner (Austria, National Park "Hohe Tauern") and their trophic interactions from subalpine (2000 m a.s.l.) to alpine (2800 m) altitudes. According to the well-accepted prediction of a shift of altitudinal levels by ca 500 m upon climate change (BLANKINSHIP et al. 2011; BOYERO et al. 2011), such a gradient allows for a first estimation of effects of climate change on soil food webs (and in further steps on decomposition and nutrient cycling) in the alpine environment. The particular status of a protected area appears particularly suited for such studies, owing to the lack of external influences (except for tourism and/or extensive land-use) on the soil system that might override (micro-)climatic effects.

For long-term capture of motile surface-dwelling soil invertebrates, we implemented a total of 54 pitfall traps, covering an altitudinal range from 2000 m to 2800 m in incremental steps of 100 m (3 replicate traps at each altitudinal station) at Ködnitztal and Teischnitztal, in July 2011 (during the "Tag der Artenvielfalt"). Traps were filled with 100 mL ethylene glycol. In August and September, catches were emptied and traps re-installed. In addition, hand-samplings of soil macro-invertebrates were performed at each other altitudinal station (2 persons, 15 min. each) for subsequent analysis of their tissue for stable isotope signatures (see below).

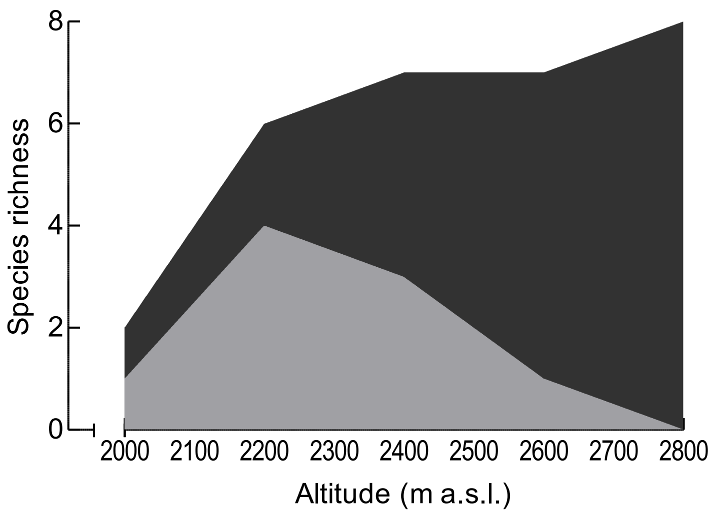

Figure 1: Altitudinal distribution of species richness of macro-detritivores (light grey) *versus* macro-predators (dark grey) along altitudinal gradients in Ködnitztal and Teischnitztal, Großglockner.

In the laboratory, captured invertebrates were determined to species level. Of representatives of common (present at at least 4 altitudes) and predacious soil invertebrates, the gut was dissected, and DNA extracted (QIAGEN DNeasy: ZARZOSO-LACOSTE et al. 2013; N = 3, for each altitude). Partial sequence of CO1 was amplified using universal invertebrate CO1-primers (FOLMER et al. 1994), before primers specific for potential prey taxa (e.g., Isopoda, Diplopoda, Diptera, Acari, Collembola, Nematoda; based on consensus sequences according to the BLAST database) were used to determine the prey spectrum of common predators.

In addition to this qualitative approach, a semi-quantitative approach aimed at estimating the relative contribution of different prey taxa to the nutrition of different predators at different altitudes. Gut-free tissues of hand-captured (see above) predators and their potential prey, having been stored frozen (-20 °C), were freeze-dried and ground for stable isotope analysis of $\delta^{13}C$ and $\delta^{15}N$.

Procedural details of PCR and stable isotope analysis will be published in an extended paper as soon as the final data will be available. The full set of data will be used for the estimation of above-ground soil food web structure at different altitudes (serving as proxy for changing climatic conditions).

None of the traps (having been implemented from July to September 2011) yielded more than a total of eight species of surface-dwelling predacious and detritivorous macro-invertebrates. The overall most common and abundant (predacious) species in our traps was the daddy-long-leg *Mitopus morio*, occurring at all altitudes (2000-2800 m a.s.l.) and being accompanied by its congeneric *M. glacialis* at 2600 and 2800 m. At lower altitudes (2000-2400 m), predators were represented mostly by lycosid spiders (e.g., *Acantholycosa pedestris*) and centipedes (e.g., *Lithobius erytrocephalus*), whereas carabid beetles (e.g., *Oreonebria atrata*, accompanied by *O. austriaca*) predominated at altitudes above 2400 m a.s.l. The most common and abundant macro-detritivore was the millipede *Allajulus fulviceps* that occurred from 2000 to 2600 m a.s.l. (albeit in decreasing numbers with increasing altitude), whereas the isopod *Trachelipus ratzeburgii* was restricted to 2000-2200 m a.s.l. The same altitudinal pattern was observed for the snails *Arianta arbustorum* and *Deroceras agreste*, respectively.

No macro-detritivores were captured at 2800 m, but the detritivorous surface-dwelling soil fauna at this altitude was solely represented by Collembola and Acari (meso-fauna). According to this finding, we hypothesize a shift in the food sources of macro-predators from macro-detritivores in the subalpine region to meso-detritivores in the alpine region. Until stable isotope data and PCR-results are available, however, we can but speculate on soil food web structure at different altitudes and potential consequences of climate change for soil food webs and ecosystem processes in the alpine environment.

Acknowledgements

We are grateful to the GROHAG Ökofonds for financial support. Stable isotope analyses are being carried out by the Faculty of Earth and Life Sciences (Dr. M.P. Berg), Vrije Universiteit Amsterdam.

Literature

BLANKINSHIP, J.C., NIKLAUS, P.A., HUGATE, B.A. 2011. A meta-analysis of responses of soil biota to global change. Oecologica, 165, 533-565.

BOYERO, L. et al. 2011. Global patterns of stream detritivore distribution: implications for biodiversity loss in changing climates. Global Ecology and Biogeography, DOI: 10.1111/j.1466-8238.2011.00673.x

DUFFY, J.E., CARDINALE, J.E., FRANCE, K.E., MCINTYRE, P.B., THÉBAULT, E. & M. LOREAU 2007. The functional role of biodiversity in ecosystems: incorporating trophic complexity. Ecology Letters, 10, 522-538.

FOLMER, O., BLACK, M., HOEH, W, LUTZ, R. & R. VRIJENHOEK 1994. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology, 3, 294-299.

GESSNER, M.O., SWAN, C.M., DANG, C.K., MC KIE, B.G., BARDGETT, R.D., WALL, D.H., HÄTTENSCHWILER, S. 2010. Diversity meets decomposition. Trends in Ecology & Evolution, 25, 372-380.

ZARZOSO-LACOSTE, D., CORSE, E. & E. VIDAL 2013. Improving PCR detection of prey in molecular diet studies: importance of group-specific primer set selection and extraction protocol performances. Molecular Ecology Resources, 13, 117-127.

ZIMMER, M. 2008. Detritus. In Jorgensen SE, Fath BD, Eds. Encyclopedia of Ecology. 903-911. Oxford: Elsevier.

Contact

Anton P. Mahringer

Martin Zimmer
Martin.zimmer@sbg.ac.at

Paris-Lodron-Universität
FB Organismische Biologie
Hellbrunner Str. 34
5020 Salzburg
Austria