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Influence of a badger carcass on soil chemistry and Collembola

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Abstract. In June 2009 a badger carcass was exposed on the former Soviet military training area of Lieberose in Brandenburg, Germany. Two months later, soil samples were taken on the former carcass site by a cross-shaped sampling design including 61 samples. Parameters tested were pH, water content, organic matter content, NO_3^-, NH_4^+, PO_4^{3-} and conductivity. During a second sampling campaign in June 2010, the same parameters were tested again as well as collembolans. One year after decomposition, NO_3^- and PO_4^{3-} was still significantly increased, whereas NH_4^+, conductivity and water showed a significant increase only in the first sampling campaign. Organic matter content and pH showed no significant changes. 7,606 collembolan individuals belonging to 13 species were extracted. 94.6% were *Hypogastrura vernalis* Carl, 1901. Most collembolans were found directly where the carcass decomposed.

Key words. Carcass, nitrogen, Collembola, *Hypogastrura vernalis*, soil parameters.

INTRODUCTION

Researches in the field of carcass ecology became popular in the last 20 years. Quite a lot of investigations dealt with the topic of scavenger communities of larger animals (e.g. Selva & Fortuna 2007) or carrion-attendant insects (e.g. Braack 1987, Ratcliffe 1996). But only few focused on changes in soil chemistry (Towne 2000, Danell et al. 2002, Melis et al. 2007) and hardly anything is known about Collembola communities under carcasses. As other arthropod groups at carcasses are better known (Gu et al. 2014), this article focuses on Collembola.

MATERIALS AND METHODS

Study site is the former military training area Lieberose, situated about 30 km north of Cottbus in Brandenburg, Germany. The sampling area is the former Soviet disposal site, which had been restored and covered with the local sandy soil.

In June 2009 a carcass of the badger (*Meles meles*) was exposed. After the complete skeletonization in August we used a cross-shaped sampling design to take soil samples. The supposed center of the carcass was 0. The four transects facing northeast, southeast, southwest and northwest consisted of 14 consecutive samples and one external one meter away from the others (Fig. 1). The outer sampling points should be a reference of uninfluenced soil as the extend of influence on the soil was unknown. The top 5 cm of soil was sampled by a metal soil corer (6 cm in diameter) and parameters tested on pH, water content, organic matter content, NH_4^+, NO_3^-, PO_4^{3-} and conductivity. In June 2010, soil samples were taken again. This time, the transects faced north, east, south and west. Further a second row was taken to investigate the soil mesofauna. The extraction of collembolans followed the concept of Macfayden (1961). All specimens were bleached in lactic acid for 24 hours and then determined to species level.

The pH was determined by photometry, the water content gravimetrically and the organic matter content by dry incineration. The investigation of the nutrient concentrations of NO_3^-, NH_4^+ and PO_4^{3-} were done in a photometer at different wavelengths and of conductivity in a special measuring cell.

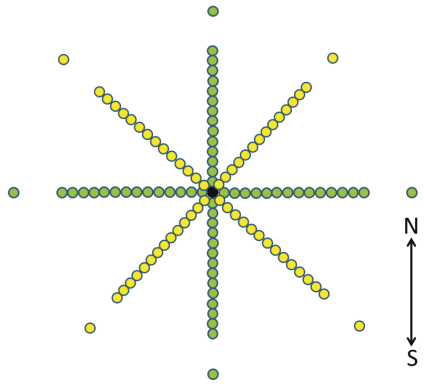

Fig. 1. Sampling design, yellow = transects in August 2009, green = transects in June 2010.

RESULTS

Neither 2009 nor 2010 were significant changes in pH or organic matter content along the transects (Figs 2 and 3). However, there is a tendency for a decrease in pH in the first year. Conductivity was significantly increased in 2009, but in 2010 the values decreased to a normal level (Fig. 4). In the center, water content was also significantly higher in 2009, whereas in 2010 it was lower in the center (Fig. 5). Significantly high values of NH_4^+ were detected in 2009 (Fig. 6). NO_3^- instead showed a significant increase in 2009, and higher values were still found in 2010. In 2010, NO_3^- was increased further away from the carcass (Fig. 7). In the center there was a significant increase in PO_4^{3-} in both years although more pronounced in 2009 (Fig. 8).

In total 7,606 collembolan individuals were determined belonging to 13 species. 94.6% of them were *Hypogastrura vernalis* Carl, 1901. The other species were *Entomobrya multifasciata* Tullberg, 1871, *Entomobrya* spec. juv., *Friesea* cf. *afurcata* Denis, 1926, *H. manubrialis* Tullberg, 1869, *Isotomodes productus* Axelson, 1906, *Lepidocyrtus cyaneus* Tullberg, 1871, *Mesaphorura macrochaeta* Rusek, 1976, *Parisotoma notabilis* Schaeffer, 1896, *Proisotoma ripicola* Linnanie-

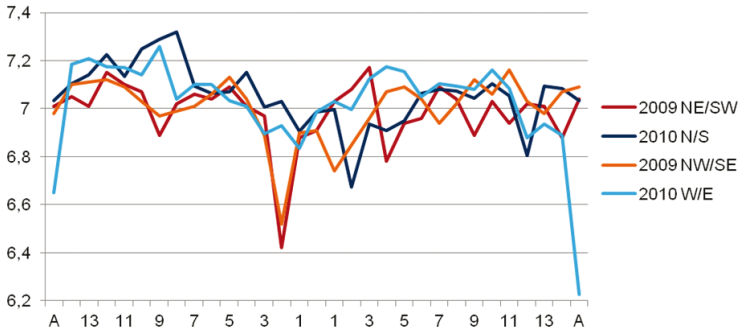

Fig. 2. The pH values along the transects; NE/SW – northeast to southwest, N/S – north to south, NW/SE – northwest to southeast, W/E – west to east.

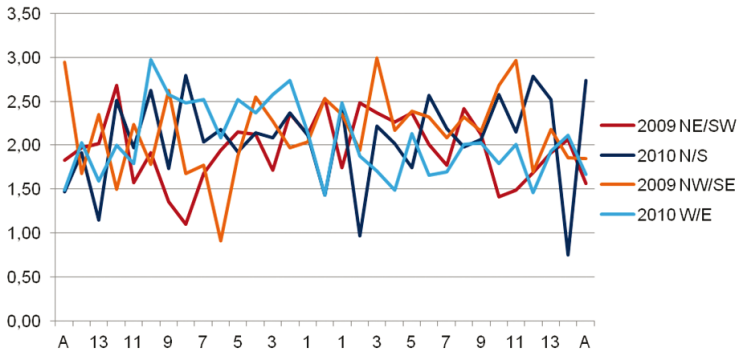

Fig. 3. Organic matter content (%) along the transects; NE/SW – northeast to southwest, N/S – north to south, NW/SE – northwest to southeast, W/E – west to east.

mi, 1912, *Pseudachorutes* spec. juv., *Sminthurus nigromaculatus* Tullberg, 1871 and *Sphaeridia pumilis* Krausbauer, 1898. The highest number of individuals was near the center of the carcass area (Fig. 9), almost all of them were represented by *H. vernalis*. This species was significantly correlated to nitrate (r=0.434; ρ=0.000) and phosphate (r=0.419; ρ=0.001).

DISCUSSION

The pH neither showed 2009 or 2010 significant higher or lower values in the center of the carcass. Melis et al. (2007) measured significant lower pH values in the center, but they used European bison as study objects. Towne (2000) instead found increasing pH when studying carcasses of American bison. Original soil pH might determine changes induced by carcasses.

Water content was significantly higher in 2009. Body fluids moisturize the soil. Gu & Krawczynski (2012) support this theory in their study. The carcass also provided cover, so the soil was

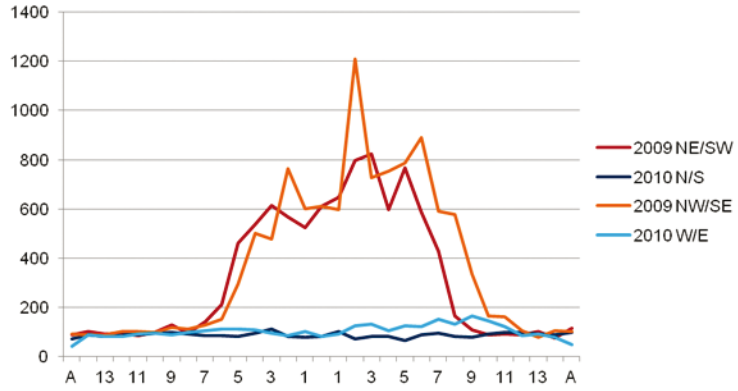

Fig. 4. Conductivity (µS/cm) along the transects; NE/SW – northeast to southwest, N/S – north to south, NW/SE – northwest to southeast, W/E – west to east.

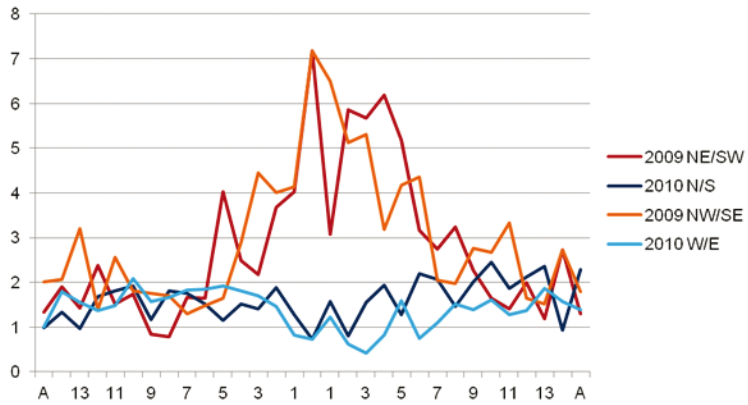

Fig. 5. Water content (%) along the transects; NE/SW – northeast to southwest, N/S – north to south, NW/SE – northwest to southeast, W/E – west to east.

protected against evaporation. In 2010, water content showed a decrease in the center. At the former carcass site, vegetation was mainly gone by decomposition, so the soil was no longer covered and rain water evaporated easily.

Organic matter content showed no significant changes. The formation of humus is slow-moving process (Blume 2010). So it is possible that higher concentrations of organic matter could be detected later, but regarding the facts of the small size and scavengers taking away parts of the carcass it is not likely.

In 2009, NH_4^+ was significantly higher around the carcass. Aerobic processes in the soil could also prove a rapid conversion from NH_4^+ to NO_3^-. NO_3^- had significant higher values near the center of the carcass in 2009, but in 2010 it was only few higher than the surrounding area. Ni-

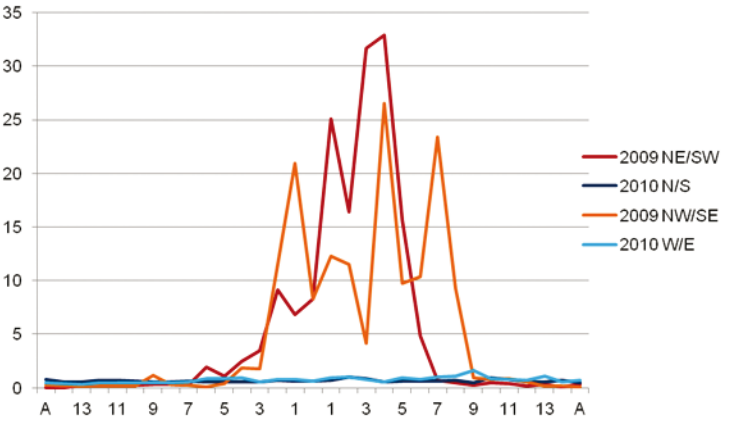

Fig. 6. Ammonium (µg/g dry substance) along the transects; NE/SW – northeast to southwest, N/S – north to south, NW/SE – northwest to southeast, W/E – west to east.

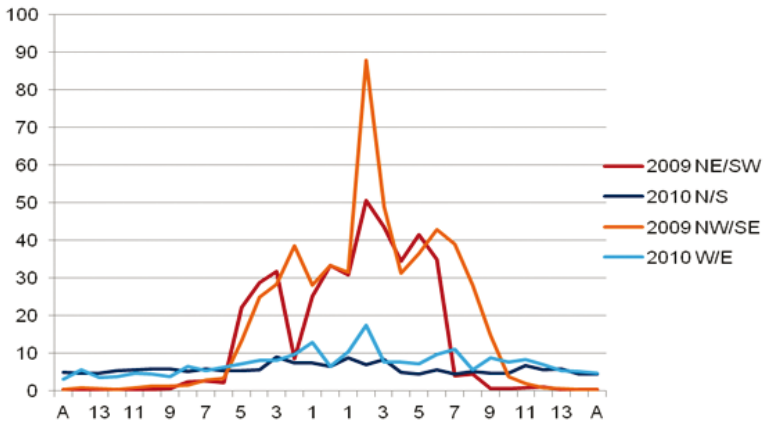

Fig. 7. Nitrate (µg/g dry substance) along the transects; NE/SW – northeast to southwest, N/S – north to south, NW/SE – northwest to southeast, W/E – west to east.

trate is as well as ammonium easily washable, but maybe it became not as low as ammonium, because of the continuous conversion of NH_4^+ to NO_3^-. Towne (2000) announced that the amount of nutrient transport depends on size, time and distance from the carcass. He could prove higher nitrate concentrations for less than three years and Melis et al. (2007) even measured significant higher values for only one year. Nitrate may convert fast because of degassing to atmosphere or incorporation by vegetation (Trolldenier 1971). In 2010, nitrate concentration increased conspicuously away from the center of the carcass. It is possible that thousands of flies developing in the soil transported themselves as nutrient sources to the outer section, leaving puparia behind as source for nitrate.

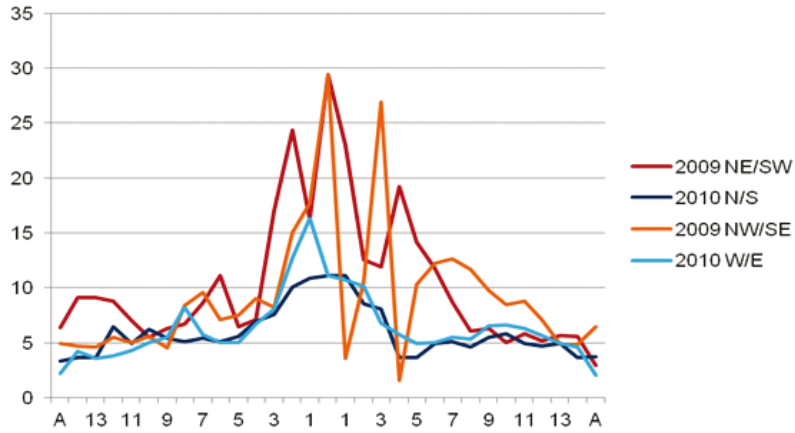

Fig. 8. Phosphate (mg/g dry substance) along the transects; NE/SW – northeast to southwest, N/S – north to south, NW/SE – northwest to southeast, W/E – west to east.

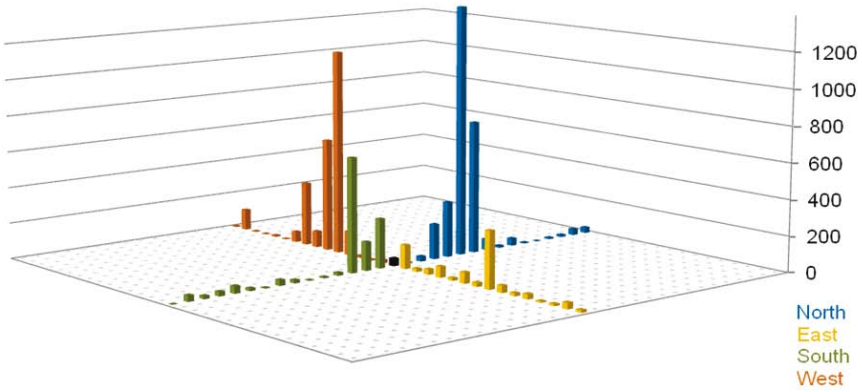

Fig. 9. Distribution of collembolans (total numbers of specimens) along the transects.

PO_4^{3-} showed a significant increase in both years. It seems to be rather stable in soils (Augustin 1992, Blume 2010), and moves with the erosion of soil material (Kuntze et al. 1994). Melis et al. (2007) also found higher phosphate concentrations near carcasses and Towne (2000) recorded this pattern even after three years of decomposition. Conductivity was significantly increased in 2009, but not in 2010. This parameter is strongly dependent on other nutrients.

The coenosis of Collembola was highly dominated by *Hypogastrura vernalis*. This species had its highest densities near the center of the carcass, so it is likely that this was the only species to benefit from the presence of larger carrion. Carcasses may lead to a massive reproduction of this species. *H. vernalis* is rarely mentioned in literature. This could be an evidence of not being present in "normal" habitats, but in special ones like carcasses. The correlation of *H. vernalis* to nitrate and phosphate proves the connection to the carcass. Yet is remains unclear, why this species benefits massively from carcasses.

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