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Litter decomposition and soil organisms within and outside of *Camponotus punctulatus* nests in sown pasture in Northeastern Argentina

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ABSTRACT

Camponotus punctulatus builds big nests, up to 1.20 m high and 2 m in diameter, containing more organic matter and nutrients than the surrounding soil. The aim of this study was to relate litter decomposition in *C. punctulatus* nests with soil organisms. We expected a greater level of decomposition and more soil organisms within than outside the nests. The study site was a field of *Setaria sphacelata*, a common sown pasture in Northeastern Argentina, with 180 nests of *C. punctulatus* per hectare. To estimate decomposition rates we buried litterbags within and outside the nest (microsite type) at the beginning of each season and recovered those from the previous season. We used litterbags of different mesh size (7 mm, 2 mm, 100 μm and 1 μm) filled with 8 g of *S. sphacelata* litter. At the same time, we sampled the soil surrounding litterbags to estimate microbial dehydrogenase activity and the abundance of nematodes and mesofauna. Soil microbial activity was greater outside the nests, mesofauna were significantly more abundant inside the nests, and nematodes had similar abundance inside and outside the nests. Throughout all seasons, there was a greater proportion of Prostigmata and Mesostigmata in the nests, whereas Oribatida and Collembola were more abundant outside. Oribatid species composition differed between microsites. In the nests, there were two periods of higher decomposition (spring and summer) while outside the maximum occurred in spring, but only in litterbags of 7 and 2 mm mesh. The lack of macro and mesofauna (litterbags with 100-μm mesh) decreased organic matter decomposition in the nests in summer and induced phosphorus immobilization in winter. Ant activity and feeding preference, nest architecture and the plant community on *C. punctulatus* nests are suggested as plausible factors that modify soil organism abundance and decomposition.

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1. Introduction

Ecosystem engineers were defined by Jones et al. (1994) as organisms that indirectly or directly affect the availably of resources to other organisms through modifications of the physical environment. Within soil organisms, earthworms, termites and ants have been identified as the most important soil engineers (Lavelle et al., 1997; Folgarait, 1998). These organisms create biogenic structures (casts, pellets, galleries, chambers and nests) that determine specific pathways for decomposition at scales of time and space that exceed their life-span.

Decomposition has been commonly used as a parameter of ecosystem functioning. It is regulated by a combination of hierarchical factors operating at different scales (Lavelle et al., 1993; Andrén et al., 1994) and varying in space and time (Moore and De Ruiter, 1991; Beare et al., 1995). This process is performed mainly by soil microorganisms because only they have the exoenzymes required to degrade organic matter (Paul and Clark, 1989). However other, soil organisms that participate in the mechanical breakdown of litter (Brussaard et al., 1997) may also degrade organic matter through their metabolism. Microfauna, mainly comprising free-living nematodes, can regulate decomposition processes (Yeates and Coleman, 1982; Robertson and Freckman, 1995) and nitrogen mineralization (Seastedt et al., 1987; Sohlenius et al., 1988), and have a key place in the soil food web (Ingham et al., 1985; Sohlenius et al., 1988). Mesofauna, which includes mites and collembolans, alter the microbial community because of their selective feeding, dispersal, and activation of microorganisms (Mitchele and Parkinson, 1976; Parkinson et al., 1979; Rusek, 1998). They can be responsible for up to 23% of organic matter decomposition (Seastedt, 1984) and tend to accelerate phosphorus mineralization, even in cases where there is no loss of plant mass. Also, the composition or richness of the mesofaunal community can affect nitrogen fluxes (Mebes and Filser, 1998; Osler et al., 2004). Finally, macrofauna, mainly earthworms, termites and ants, also affect decomposition either directly through digestion or indirectly by their effects on microbial activities and through the alteration of physical and chemical properties of the soil (Lavelle et al., 1997; Folgarait, 1998; Ndiaye et al., 2004).

Changes in land use modify soil environmental conditions and alter the community of ecosystem engineers (Lavelle et al., 1994; Senapati et al., 1994; Folgarait, 1998). Within the Espinal Phytogeographical Region of Argentina (Carnevali, 1994), in Corrientes Province, natural grasslands have been used for traditional cattle ranching since the 19th century. In recent decades, ranchers began sowing pastures for livestock. The omnivorous ant *Camponotus punctulatus* (Mayr) has unexpectedly increased its abundance in these new agroecosystems, from ~20 nests/ha in natural areas to 180 nests/ha in sown pastures (Folgarait et al., 2007). The causes of the increase in anthill density are still under study but most probably are related to soil disequilibrium (Folgarait et al., 2003). Although *C. punctulatus* may build either small belowground nests under grass tussocks or large conspicuous nests (Kusnezov, 1951), in flooded areas and fields disturbed by agricultural practices it constructs larger aboveground nests (Folgarait et al., 2007), characterized by a specific plant community growing on them (Folgarait et al., 2002). At the beginning of the construction of these large nests workers take soil from the upper 10 cm of the soil surface. In older nests (>6 years old), though, they excavate below the ploughed horizon as well as around the periphery of the nest making a ditch, the presumable origin of the soil used to build the mound above ground. Accordingly, the nest structure gets bigger (up to 1 m in height and 1.5 m in diameter) and more complex, with many galleries and chambers in the upper central part (Gorosito et al., 2006). These mounds are extremely tough and the soil has higher concentrations of organic matter and nutrients (N, Ca, Mg, P, K) in comparison to the soil away from their influence (Folgarait et al., 2002). In greenhouse experiments, the common sown pasture *Setaria sphacelata* (Schumach) acquired more biomass and better foliar quality when grown in soils from *C. punctulatus* nests than in control adjacent soils (Folgarait et al., unpublished).

Most studies of ant nests have considered the effects on individual components of the soil such as soil chemistry (Nkem et al., 2000; Wagner et al., 2004), soil physical structure (Dostál et al., 2005), diversity of soil organisms (Laakso, 1999; Dauber and Wolters, 2000; Boulton et al., 2003; Lenoir et al., 2003) or changes in the structure of the detrital food web (Laakso and Setälä, 1998). The main goal of this study was to determine the effects of *C. punctulatus* nests on the whole decomposition process and on the abundance and activity of soil organisms. We hypothesized that enhanced soil quality is caused by increased decomposition levels, related to a greater abundance or particular activities or interactions of the soil organisms present in the nest. To test this hypothesis, we sampled soil organisms and measured decomposition rates inside and outside nests over the course of a year, burying litterbags of different mesh sizes to evaluate how different soil organisms affect decomposition rates in different seasons.

2. Materials and methods

2.1. Study site

This study was carried out at INTA Mercedes Experimental Station, in the city of Mercedes, Corrientes province, Argentina (29°S, 58°W). The climate is subtropical humid with a mean annual temperature of 20.1 °C and annual precipitation of 1270 mm (Fernández et al., 1993). Soils have developed on Triassic basalt and sandstone, with a large contribution of Pliocene fluvial clays (Purnell and Hein, 1969). The study site had been sown with *S. sphacelata* ten years before the initiation of this work.

2.2. Soil organisms

Before burying litterbags, four soil samples of 900 ± 20 g (mean ± S.E., dry weight) were collected with a shovel from two microsite types: anthills and pasture outside the anthills. Samples were placed immediately in plastic bags and taken to the laboratory to extract mesofauna and nematodes within the next 48 h. In the case of soil samples for microbial analyses, bags were held for longer in a refrigerator at 4 °C. To analyze microbial activity outside of the anthill subsamples of