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Earthworm richness in land-use systems in Santa Catarina, Brazil

Marie Luise Carolina Bartz[a,*], George Gardner Brown[b], Marcio Gonçalves da Rosa[c], Osmar Klauberg Filho[c], Samuel Wooster James[d], Thibaud Decaëns[e], Dilmar Baretta[f]

[a] Universidade Positivo, Curitiba, Brazil
[b] EmbrapaFlorestas, Estrada da Ribeira Km. 111, C.P. 319, Colombo 83411-000, Brazil
[c] Universidade do Estado de Santa Catarina – Centro de Ciências Agroveterinárias, Lages, Brazil
[d] Univeristy of Iowa, Iowa City, United States
[e] ECODIV Laboratory, EA 1293, SFR SCALE, Université de Rouen, 76821 Mont Saint Aignan cedex, France
[f] Universidade do Estado de Santa Catarina – Centro de Educação Superior do Oeste, Chapecó, Brazil

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ABSTRACT

Brazil is a megadiverse country from which around 10% of all species are known. However, many areas in Brazil have not been adequately studied, particularly for soil animals. This includes the state of Santa Catarina, where only 18 of the approximately 300 known Brazilian earthworm species occur, and where very little is known of the impacts of land use management on earthworm populations (density and diversity). Therefore, the aim of this study was to evaluate earthworm species richness in five different land-use systems (LUS) with increasing anthropogenic impact: native forest (NF), eucalyptus plantation (EP), pasture (PA), integrated crop-livestock (ICL) and no-tillage cropping (NT), in six counties, three each from the Western and Plateau regions of the state. Nine monoliths of 25 cm × 25 cm × 20 cm depth were sampled at each site and worms hand sorted. Qualitative samples were also taken by digging at least 20 holes per site to improve the likelihood of collecting rare species. Samples were taken in the Winter and Summer months of 2011–2012 (July–August 2011, December 2011–January 2012). Contrary to expectations, species richness was higher in LUS with higher (ICL and NT = 15 and 17 spp.) vs. lower anthropogenic impacts (EP, PA, NF = 9–10 spp.), mainly due to the presence of exotic species in the cropping systems. Native species predominated in PA and NF, although natives were also found in highly disturbed ecosystems (NT, ICL) and in the West region all worms collected in NT were native. In total 24 species were identified in all LUS, with 19 native species, including several that were new to science. Several species were collected exclusively in each region, and overall qualitative samples yielded 24 species while quantitative samples only 16. Therefore, qualitative sampling appears to be more effective in determining earthworm species richness at regional levels, although quantitative samples are a useful addition when LUS are compared within a region, and if abundance and diversity index calculations are needed.

1. Introduction

Brazil is a megadiverse country that holds approximately 10% of all described species, although only about 10% of the estimated 1.8 million species have been described from the country (Lewinsohn and Prado, 2005). Of the 1013 known earthworm species in Latin America, Brazil hosts 336 (Brown et al., 2013), but large areas of the country still remain poorly known both in terms of biodiversity and the presence of species in different land use systems (LUS). One of these areas is the Araucaria forest region in Southern Brazil, particularly in the state of Santa Catarina (SC) (Brown and James, 2007). Until recently, very little work had been done on earthworms in SC, and only 18 species (of which only eight were native) were recorded for that state by Brown and James (2007), mainly due to the low number of sites sampled.

The state of SC occupies an area of around 95.7 thousand km^2, and is home to approximately 6.5 million persons (IBGE, 2010). Despite its small size (1% of Brazil's landmass), it contributes significantly to national economy and has the 6th largest gross domestic product in the country, being also an important agricultural

* Corresponding author. Tel.: +554399257521; fax: +55 4332562427.
E-mail addresses: bartzmarie@gmail.com (M.L.C. Bartz), george.brown@embrapa.br (G.G. Brown), tyler001@gmail.com (M.G. da Rosa), a2okf@cav.udesc.br (O.K. Filho), samuel-james@uiowa.edu (S.W. James), thibaud.decaens@univ-rouen.fr (T. Decaëns), dilmar.baretta@udesc.br (D. Baretta).

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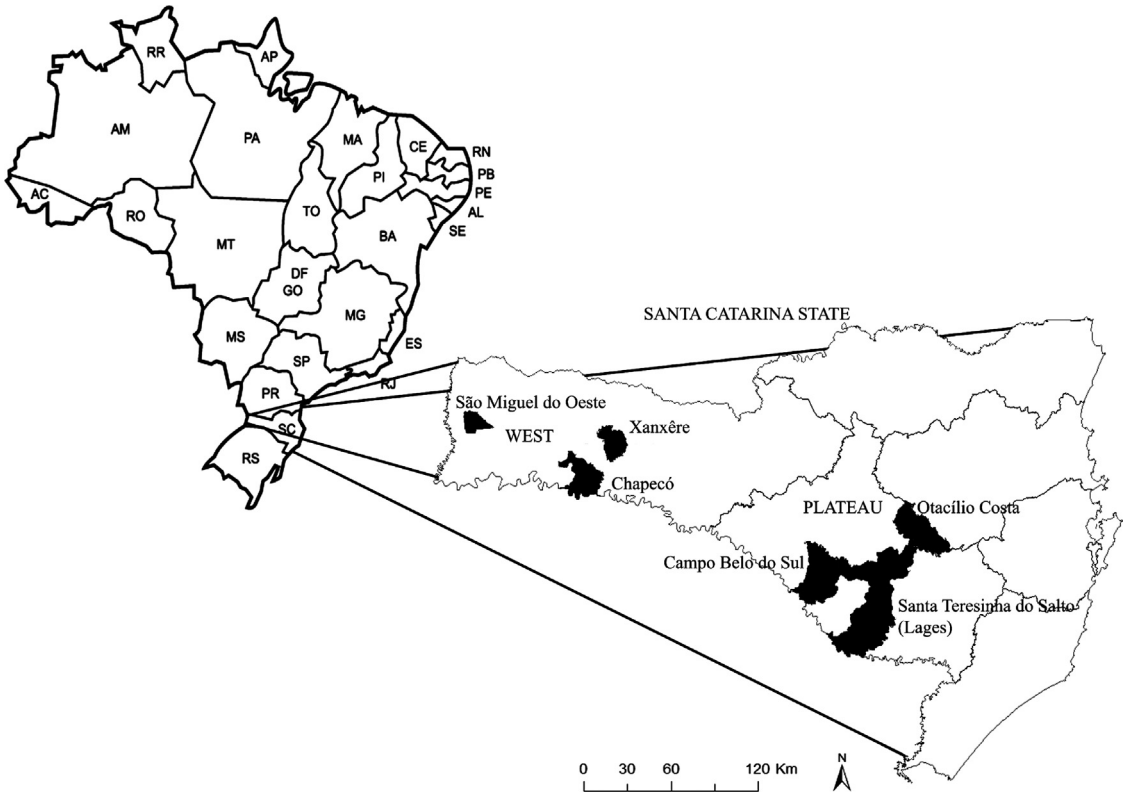

Fig. 1. Map showing the counties and regions in Santa Catarina State, Brazil, where earthworm sampling was performed.

producer, mainly of crops such as apples, onions, tobacco, rice, wheat, banana, garlic, maize and beans (CEPA, 2012). As in most of Brazil, the first European colonizers in SC arrived along the coast, making safe harbor in cities like São Francisco do Sul (established 1553), and then later made their way inland. The Plateau region (Fig. 1, "Plateau") was largely occupied in the 18th century by migrants from the state of São Paulo, who moved to SC to establish sawmills and cattle production. In the last 20–30 years old pasture lands have been progressively converted to annual cropping, mainly soybean and maize (Dufloth et al., 2005). The western most part of SC (Fig. 1, "West") was extensively colonized only recently (20th century) by immigrants of European origin coming from Rio Grande do Sul, who first established sawmills and then family farms with annual crops and animals (Waibel, 1955). Until 40 years ago, all cultivation practices were performed with conventional tillage (moldboard or soil inversion plows; ICEPA, 1999), but since then no-tillage has spread rapidly and most farmers in SC now employ this tillage practice (Veiga and Trombetta, 1997; Denardin et al., 2008) that generally promotes the maintenance and recovery of earthworm populations (Brown et al., 2003).

It is well known that land use intensification, mainly by agriculture, affects the composition of soil fauna and earthworm communities at various levels (Baretta et al., 2003, 2006; Decaëns, 2010; Postma-Blaauw et al., 2012). Intensification is generally accompanied by greater soil perturbation, greater proportion of annual cropping and use of external inputs such as fertilizers, insecticides, fungicides and herbicides that can affect the ability of soils to provide ecosystem services such as primary production, nutrient cycling, biological pest control and conservation of biodiversity (Giller et al., 1997). Among the organisms affected by intensification are the earthworms (Fragoso et al., 1997), considered important for soil function and the delivery of ecosystem services (Blouin et al., 2013). In most cases, intensification negatively affects earthworm communities (biomass, density, species richness; Decaëns and Jiménez, 2002; Decaëns et al., 2003; Feijoo et al., 2007; Smith et al., 2008; Ponge et al., 2013), but in some cases it may increase biomass and density and have no effect on species richness (Tondoh et al., 2007, 2011). Reasons for these differences may be related to the natural and anthropogenic history of the site, the extent of difference between the natural and disturbed ecosystems (e.g., native savanna vs. forest converted to pasture or crops), the biology of the species encountered, and the presence/absence of exotic or invasive species (Decaëns et al., 2004; Tondoh et al., 2011).

The whole of the state of Santa Catarina is within the Atlantic Rainforest biome, one of the 25 world hotspots of biodiversity, highly endangered and fragmented and in need of preservation (Myers et al., 2000). About 40% of the state was also originally covered by Araucaria forests, of which <1% remain intact (Alarcon et al., 2011). As very little is known of the soil biota in that state, and of the impact of land use practices on their populations, a large 3-year project (2010–2013) was undertaken by a consortium of universities and research institutes, to evaluate soil biodiversity along a land use intensification gradient (www.biotasc.com). In the present study, biodiversity of earthworms in SC was assessed comparing different regions (West and Plateau) and different land use systems. The efficiency of two different sampling schemes (qualitative and quantitative) for estimating species richness was tested, and earthworms communities were evaluated in order to assess their sensitivity to land use changes (Paoletti, 1999).

2. Materials and methods

2.1. Sites

The study was carried out in two regions (West and Plateau) of Santa Catarina (SC) state, Brazil. Study sites were randomly selected in both regions, with three counties per region: São Miguel do Oeste, Chapecó and Xanxerê in the West, and Lages (Santa