Revista Brasileira de Entomologia 60 (2016) 73–81

REVISTA BRASILEIRA DE
Entomologia
A Journal on Insect Diversity and Evolution
www.rbentomologia.com

Biology, Ecology and Diversity

Spatial variation of dung beetle assemblages associated with forest structure in remnants of southern Brazilian Atlantic Forest

Pedro Giovâni da Silva*, Malva Isabel Medina Hernández

Programa de Pós-Graduação em Ecologia, Departamento de Ecologia e Zoologia, Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil

ARTICLE INFO

Article history:
Received 6 September 2015
Accepted 4 November 2015
Available online 30 November 2015
Associate Editor: Rodrigo Krüger

Keywords:
Beta diversity
Species composition
Species diversity
Spatial distribution
Tropical forest

ABSTRACT

The Brazilian Atlantic Forest is one of the world's biodiversity hotspots, and is currently highly fragmented and disturbed due to human activities. Variation in environmental conditions in the Atlantic Forest can influence the distribution of species, which may show associations with some environmental features. Dung beetles (Coleoptera: Scarabaeinae) are insects that act in nutrient cycling via organic matter decomposition and have been used for monitoring environmental changes. The aim of this study is to identify associations between the spatial distribution of dung beetle species and Atlantic Forest structure. The spatial distribution of some dung beetle species was associated with structural forest features. The number of species among the sampling sites ranged widely, and few species were found in all remnant areas. Principal coordinates analysis indicated that species composition, abundance and biomass showed a spatially structured distribution, and these results were corroborated by permutational multivariate analysis of variance. The indicator value index and redundancy analysis showed an association of several dung beetle species with some explanatory environmental variables related to Atlantic Forest structure. This work demonstrated the existence of a spatially structured distribution of dung beetles, with significant associations between several species and forest structure in Atlantic Forest remnants from Southern Brazil.

Introduction

Tropical forests host most of the earth's biodiversity, and provide several benefits to human beings through the provision of economic goods and ecosystem services (Gardner et al., 2009). In contrast, the maintenance of biodiversity and ecosystem processes associated with it depend on effective conservation initiatives, which are major challenges to conservationists and decision makers (Gardner et al., 2009; Rands et al., 2010; Tabarelli et al., 2010). There are many barriers to the creation of effective conservation policy decisions, including lack of established conservation practices tailored to different local conditions, a paucity of basic information on species abundance, distribution and conservation status, and perhaps most importantly, the potentially large number of unknown species (Pimm et al., 2014). Such shortcomings in our knowledge about species identity and local or regional distribution are referred to as Linnean and Wallacean shortfalls (Whittaker et al., 2005). Some of these gaps can be filled by connecting important issues such as the fulfillment of basic studies (e.g. associations between species and environmental conditions) in order to contribute to the knowledge on species distribution and also to the potential to discover new species. Furthermore, these studies can bring new information on spatial distribution of species associated with the variation in environmental conditions, which may be taken into consideration in planning conservation initiatives.

In Brazil, Atlantic Forest hosts a large part of the biodiversity of South American rainforests (Myers et al., 2000; Tabarelli et al., 2005) and was the second largest rainforest type in South America, covering about 150 million hectares of the Brazilian coast, northeastern Argentina and southeastern Paraguay (Tabarelli et al., 2005; Ribeiro et al., 2009; Vieira and Gardner, 2012). Historically, the Brazilian coast has always had the highest human population and industrial concentration and, thus, the Atlantic Forest has been affected by the growth and development of the country over the last five centuries (Dean, 1996), mainly in the last century. The Atlantic Forest is currently the most endangered Brazilian ecosystem in terms of biodiversity conservation (Myers et al., 2000). Recent studies indicate that only 12% of its original area remains, much of it fragmented with a high degree of isolation, and most in an intermediate state of regeneration (Ribeiro et al., 2009). Regardless, the fragments are usually of different sizes and exist in a heterogeneous matrix, consisting mainly of areas being

* Corresponding author.
E-mail: pedrogiovanidasilva@yahoo.com.br (P.G. da Silva).

http://dx.doi.org/10.1016/j.rbe.2015.11.001

used for various agriculture and forestry purposes. These features make the Atlantic Forest a very heterogeneous ecosystem, housing species with different environmental requirements (Aleixo, 1999).

The study of the diversity-environmental heterogeneity relationship of organisms that have key ecological functions and can be used as ecological indicators, such as dung beetles (Coleoptera: Scarabaeidae: Scarabaeinae), is a first step to support biodiversity conservation initiatives and management of ecosystem processes in tropical forests. Dung beetles are detritus-feeding insects that aid in organic matter decomposition and nutrient cycling (Halffter and Matthews, 1966; Hanski and Cambefort, 1991; Simmons and Ridsdill-Smith, 2011) by burying and consuming portions of feces, animal carcasses and rotting plant matter, thereby making the nutrients in these materials available to the ecosystem once again (Nichols et al., 2008). These insects construct tunnels in the soil, increasing aeration and water infiltration. They also bury eggs of cattle parasites (e.g., flies and nematodes) and secondarily disperse fruit seeds previously consumed by mammals on which they feed (Andresen and Feer, 2005; Nichols et al., 2008).

Dung beetles have been used as a tool for monitoring environmental changes in tropical forests because they are sensitive to fragmentation, disturbance and habitat loss (Klein, 1989; Halffter and Favila, 1993; Davis et al., 2001; Nichols et al., 2007; Gardner et al., 2008b; Korasaki et al., 2013; Viegas et al., 2014) and because they respond positively to increased restoration time in tropical forests (Davis et al., 2003; Audino et al., 2014; Bett et al., 2014; Hernández et al., 2014). However, few studies have identified important associations between dung beetle species and small changes in forest features (e.g. Hernández and Vaz-de-Mello, 2009; Campos and Hernández, 2013; da Silva and Hernández, 2014). Most studies investigate the Scarabaeinae community response when there is a clear environmental change, such as forest vs. open habitats (Lopes et al., 2011; Costa et al., 2013; Silva et al., 2014), forest vs. monocultures (Gardner et al., 2008b; Barlow et al., 2010), or distinct vegetation formations (Almeida and Louzada, 2009; da Silva et al., 2013).

Changes in environmental conditions in small spatial extents may be key drivers of compositional and structural differences in dung beetle communities in tropical forests (Feer, 2013; da Silva and Hernández, 2014, 2015a; Medina and Lopes, 2014). Changes in dung beetle communities affect their ecological functions, and hence proper ecosystem functioning (Vulinec, 2002; Andresen, 2003; Horgan, 2005; Slade et al., 2007; Gardner et al., 2008b; Kunz and Krell, 2011; Slade et al., 2011; Braga et al., 2012, 2013). In addition, these beetles are correlated with other taxa, particularly mammalian fauna (Barlow et al., 2007; Culot et al., 2013). Thus, the evaluation of the spatial distribution of dung beetle fauna, which combines ease of identification and low-cost and standardized sampling methods (Gardner et al., 2008a), may contribute to research concerning effectiveness of conservation management, especially in a heterogeneous environment as the Atlantic Forest.

The aim of this study was to determine whether small differences in forest structure affect the local distribution of Scarabaeinae dung beetles in remnants of Atlantic Forest in southern Brazil. We predict that dung beetle fauna will show spatial differences in relation to structural features of the Atlantic Forest.

Material and methods

Study area

The study was performed in four large, non-contiguous areas of Atlantic Forest in Santa Catarina state, southern Brazil (Fig. 1). Two areas are located on the Island of Santa Catarina: Peri Lagoon Municipal Park (PER, 27°42′ and 27°46′ S; 48°32′ and 48°30′ W, area of ca 75 km^2) and Permanent Protection Areas of Ratones (RAT, 27°30′ and 27°32′ S; 48°30′ and 48°27′ W, area of ca 73 km^2), both located in Florianópolis city. Other two areas are located on the mainland near the Brazilian Atlantic coast: Anhatomirim Environmental Protection Area (ANH, 27°22′ and 27°26′ S; 48°35′ and 48°33′ W, area of ca 56 km^2) located in Governador Celso Ramos city, and Permanent Protection Areas of Itapema (ITA, 27°02′ and 27°05′ S; 48°38′ and 48°35′ W, area of ca 175 km^2) located in Itapema city. The Island of Santa Catarina is approximately 54 km (north–south length) with a maximum width of 18 km, with a total area of 424.4 km^2. The distance between the island and mainland varies, with a minimum distance of 500 m and maximum around 10 km. Despite the conversion of forest for agricultural, livestock and forestry activities,

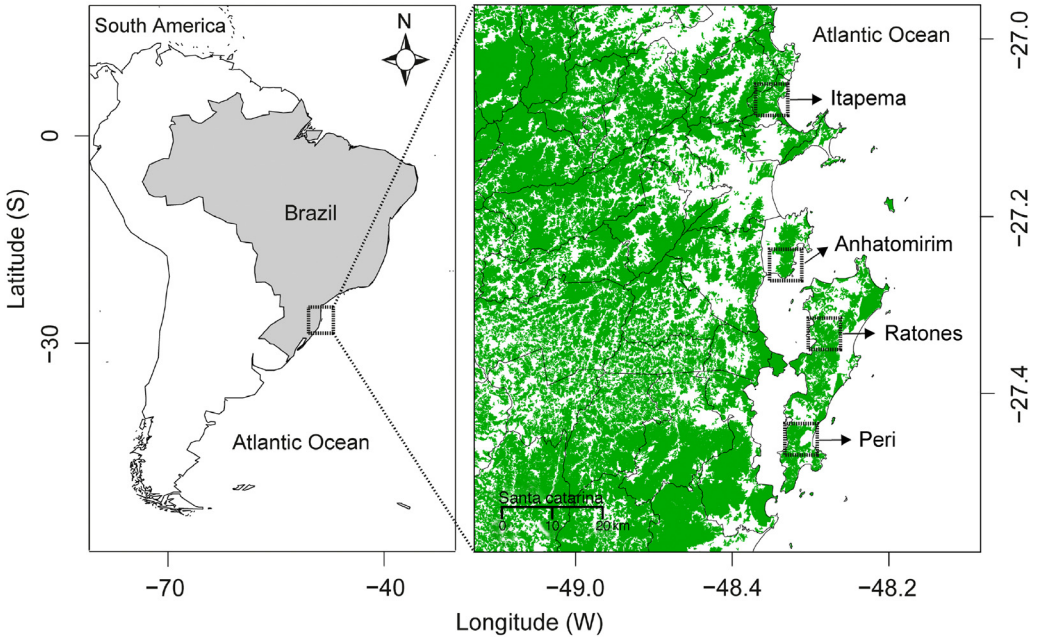

Fig. 1. Map of the Atlantic Forest remnants where dung beetles were sampled during January and February 2012. Anhatomirim Environmental Protection Area in Governador Celso Ramos city; Permanent Protection Areas of Itapema city; Peri Lagoon Municipal Park in Florianópolis city; Permanent Protection Areas of Ratones in Florianópolis city.