UNIVERSIDADE FEDERAL DE LAVRAS

RENAN DA SILVA MACEDO

DUNG BEETLE COMMUNITY RESPONSES TO THE
LAND USE CHANGES AND DUNG TYPES IN THE
BRAZILIAN SAVANNAS (CERRADO)

LAVRAS – MG

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> Dissertação apresentada à Universidade Federal de Lavras, como parte das exigências do Programa de Pós-Graduação em Agronomia, área de concentração em Entomologia, para a obtenção do título de Mestre.

Orientador

Dr. Júlio Neil Cassa Louzada

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DUNG BEETLE COMMUNITY RESPONSES TO THE LAND USE CHANGES AND DUNG TYPES IN THE BRAZILIAN SAVANNAS (CERRADO) (RESPOSTAS DA COMUNIDADE DE ESCARABEÍNEOS A MUDANÇAS DO USO DA PAISAGEM E TIPOS DE FEZES EM SAVANAS BRASILEIRAS (CERRADO))

Dissertação apresentada à Universidade Federal de Lavras, como parte das exigências do Programa de Pós-Graduação em Agronomia, área de concentração em Entomologia, para a obtenção do título de Mestre.

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LAVRAS – MG
2013

A Deus que sempre está comigo,
DEDICO

AGRADECIMENTOS

"Nada nasce dos diamantes, do estrume nascem flores"

(Fabrizio de André).

RESUMO

O Cerrado é o segundo maior bioma do Brasil e uma das savanas mais diversas do mundo. Ele está localizado entre três grandes biomas: Floresta Amazônica, Floresta Atlântica e a Caatinga, estendendo-se por uma grande região com várias fitosionomias peculiares, dentre elas, o cerrado *sensu stricto,* amplamente distribuído. Nas últimas décadas, grande parte do seu território está sendo transformado em campo de produção de diversas culturas como a soja e em imensas áreas de pastagens introduzidas para produção de carne e leite. Assim, muitas áreas nativas foram perdidas, além de muitas se encontrem degradadas e grande parte da paisagem fragmentada pela mudança de usos do solo. Frente a esta situação, pouco se conhece da perda de biodiversidade neste bioma. Nesse sentido, esta dissertação teve o objetivo de verificar as diferenças entre usos da paisagem em meso-escala, savana nativa (cerrado *sensu strictu*) e pastagens exóticas, utilizando os besouros da subfamília Scarabaeine como indicadores biológicos. Além disso, foi verificado o efeito da mudança de usos sobre a comunidade de escarabeíneos e o efeito da mudança do tipo de recurso alimentar, fezes humanas e fezes bovinas, a fim de compreender a dinâmica da ocorrência das espécies na transformação do cerrado na paisagem. As amostragens foram realizadas no noroeste de Minas Gerais. Foram amostradas dez janelas da paisagem em cada tipo de uso da paisagem, savana nativa e pastagem introduzida. Os escarabeíneos foram coletados através de armadilhas do tipo *pitfall* iscados com fezes humanas e com fezes bovinas. No geral, foi observado que os valores de riqueza, abundância e a equitabilidade das comunidades de escarabeíneos diminuíram com a mudança de savana nativa para pastagens exóticas, mesmo sendo em proporções diferentes nas janelas da paisagem, principalmente com fezes humanas. A comunidade de escarabeíneos em pastagem atraídas por fezes bovinas mostrou-se simplificada e com dominância de algumas espécies. Em relação à estrutura, as comunidades foram diferentes significativamente entre tipo de uso da paisagem e entre tipos de fezes nos usos. As diferenças da complexidade estrutural da vegetação em savanas nativas foi um fator decisivo para separar as comunidades de escarabeíneos das pastagens introduzidas, sendo importante para espécies que não ocorrem em pastagens. Para outras espécies, o tipo de fezes torna-se um fator importante na sua ocorrência em usos da paisagem, como as fezes bovinas, recurso abundante em pastagens. Os resultados mostram também que a riqueza das pastagens é influenciada pelas espécies que ocorrem no Cerrado regional, o que ressalta mais uma vez a importância da conservação do Bioma como um todo. Por fim, é preciso estabelecer medidas conservacionistas para que o restante do bioma seja mantido. Assim, será capaz ainda de fornecer espécies e com elas uma melhor qualidade dos usos das paisagens antropizadas, como as pastagens introduzidas.

Palavras-chave: Savanas neotropicais. Complexidade da vegetação. Paisagem. Pastagens introduzidas.

ABSTRACT

Cerrado is the second major Brazilian Biome and one of the most diverse savannas of the world. It located between the other large Brazilian biomes: the Amazon Forest, the Atlantic forest and "Caaatinga" (Dry lands). The Biome extends over two degrees of latitude spreading by one great region with diverse specific physiognomies, like the cerrado *sensu stricto* (native savanna), largely distributed in the landscape of the Cerrado. Over the last few decades, a large part of the Cerrado region has been transformed into crop production of several plants, especially soybean, and into large areas of exotic pastures for both beef and dairy cattle. Thus, many areas of native savannas have been lost creating a fragmented heterogeneous landscape. The aim of this study was to analyse the differences between land uses at the meso-scale (native savannas and exotic pastures), utilizing dung beetles as biological indicators. Moreover, we analysed the effect of land use changes and of dung types (human faeces and cattle dung), in order to understand the dynamics of the occurrence of dung beetles in the landscape. Sampling was carried out in the Northeast of Minas Gerais state, Brazil. Ten landscape windows in each land use type were sampled using *pitfall* traps baited with cattle dung and faeces human. Overall, richness, abundance and evenness of the dung beetle community decrease with the change of native savannas into exotic pastures. The dung beetle community in exotic pastures was simplified and showed some dominant species. The structure of the dung beetle community of exotic pastures was different compared native savannas. Thus, environmental factors and dung types were determinants of species occurrence. For some species, vegetation structural complexity was a decisive factor in separating the dung beetle communities between land uses, applicable for the species that do not occur in exotic pastures. For the other species, dung type was an important factor explaining the occurrence of the species in different land uses, since cattle dung is an abundant resource in exotic pastures. The results show that richness of pastures is influenced by the species recorded in the Cerrado region, which highlights the importance of conservation of Cerrado Biome. Finally, there is a need to establish conservation policies for the protection of the biome.

Key-words: Neotropical savannas. Vegetation Complexity. .Landscape. Exotic pasture.

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1 INTRODUCTION

The Cerrado biome is a high-priority region for conservation, with high biodiversity and endemism (MYERS et al., 2000). The biome is considered one of the richest and most diverse savannas in the world, contributing substantially to water and economic resources in Brazil (KLINK; MACHADO, 2005). However, despite this importance, only 30 % of the natural vegetation remains (MYERS et al., 2000). Thus, the conservation of the biome and its ecosystems has been neglected by the small apparent economic value attributed wrongly and little knowledge of the biome´s biodiversity (CAVALCANTI; JOLY, 2002; RATTER; RIBEIRO, 1997).

The Cerrado presents high habitat diversity. In this way landscape is made up by grassland, savanna and forest physiognomies. These forests can occur on the well-drained interfluves, with gallery forests or other moist vegetation. Forest physiognomies of the Cerrado Biome are often present in areas with richer soils. In contrast, open and dense grasslands formations can be more or less recognizable stages of the continuum in several types of soil and several other factors (OLIVEIRA-FILHO; RATTER, 2002; RIBEIRO; WALTER, 1998). There are several factors that determine the physiognomies, among which the natural fire dynamics strongly influences the types of vegetation in areas of cerrado (MIRANDA; BUSTAMANTE; MIRANDA, 2002).

The existence of large areas of native grasslands and savannas was attractive for human occupation of the Cerrado and the development of agriculture and pastures (KLINK; MOREIRA, 2002). Livestock growth and agricultural development had important implications for Cerrado land use. Land use changes occurred in response to technological innovations, capital investments, energy sources, and knowledge applied with the aim of intensifying

agriculture, in particular for soybean productions, and increasing the livestock production (KLINK; MACHADO, 2005; KLINK; MOREIRA, 2002).

The Cerrado is an important cattle ranching region, mainly on extensive pastures. The increase in the bovine herd is a direct consequence of the increase in the area of exotic pastures (HORGAN, 2001), representing 67% of the total cleared land of the biome. Often, the native savannas are replaced by exotic pastures, mainly by African grasses (SANO; BARCELLOS; BEZERRA, 1999).

Brazil has the second largest bovine herd in the world (FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS - FAO, 2011) and degraded exotic pastures represent a major problem due to the inadequate management of livestock (overgrazing and high-stocking rates), often resulting in great difficulty on the reestablishment of native vegetation (COSTA; REHMAN, 2005; KLINK; MACHADO, 2005).

Land uses changes can have many consequences on the community of species in the Cerrado Biome. The effects of the loss or the transformation of habitats can be analyzed by the changes in diversity that occur at different spatial scales (DUMBRELL et al., 2008). The loss of the habitat does not always entail the loss of biodiversity. There are landscape-dependent factors, like the type and frequency of disturbance, the configuration of fragments, habitat quality (resources and conditions) and the interaction between species that are important for understanding the effects of land use changes on biological communities (TSCHARNTKE et al., 2012).

Plant and mammal diversity are well known to be affected by habitat loss and fragmentation, reducing the number of species or favoring some species (VYNNE et al., 2011). The transformation of native savannas into disturbed landscapes by the establishment of crops and livestock can alter species composition. Structural changes in the vegetation and changes in species

interactions between species can affect the community negatively (KLINK; MOREIRA, 2002; MARINHO-FILHO; RODRIGUES; JUAREZ, 2002).

Tropical grassy biomes can suffer losses or alterations of the biodiversity by human disturbance. This is major problem due to the lack understanding about diversity patterns (BOND; PARR, 2010) and poor taxonomic information for many groups in the Cerrado (CAVALCANTI; JOLY, 2002). In the Cerrado biome, many development policies have neglected conservation, directly affecting biodiversity (KLINK; MACHADO, 2005). Due to the great importance of biodiversity responses to disturbance, there is an urgent need to understand diversity patterns for conservation of natural areas of the Cerrado at the regional scale (DUMBRELL et al., 2008).

Alternatively, a way to understanding how this process of land use change affects biodiversity is the use of bioindicators that can provide quick and representative responses to disturbance and can therefore be important tools in biodiversity conservation. Some insect groups, such as the dung beetles can be utilized for this purpose, since their abundance, richness and composition change in response to environmental changes (DAVIS; SCHOLTZ; SWEMMER, 2012), with a high performance/ cost-effectiveness in their response to disturbances (GARDNER et al., 2008; NICHOLS et al., 2007; NICHOLS; GARDNER, 2011). They are therefore considered effective indicators with high degree of the habitat specificity in the Cerrado (ALMEIDA et al., 2009).

The dung beetles (Coleoptera, Scarabaeidae) are a diverse taxonomic group, with nearly 4,500 species (HALFFTER; EDMONDS, 1982). In Brazil, the latest study showed about 618 species (VAZ-DE-MELLO, 2000). These beetles are detritivores and generally utilize dung of mammals for provision of food and nesting with different resource allocation strategies (HALFFTER; EDMONDS, 1982; HALFFTER; MATTHEWS, 1966).

Due to their importance in nutrient cycling, bioturbation and secondary seed dispersal, these beetles are recorded as a key species in the ecosystem. In the dung, beetles perform several ecological services for maintenance of the soil and suppression of parasites in livestock (NICHOLS et al., 2008).

Land use changes, mainly those that change native savannas into exotic pastures, are reported worldwide, with several consequences on the community of dung beetles which have a high degree of habitat specificity in Cerrado (ALMEIDA et al., 2011; BLAUM et al., 2009; DAVIS et al., 2010; DAVIS; SCHOLTZ; SWEMMER, 2012; JACOBS et al., 2010; NUMA et al., 2012).

There is lack of studies include two important effects on the composition and structure of the dung beetles: the effect of the land use change and the effect of the food resource change. Thus, it is necessary to understand the importance of local environmental factors (BARBERO et al., 1999; GITTINGS; GILLER, 1998), dung type, land use type (DAVIS et al., 2010; DAVIS; SCHOLTZ; SWEMMER, 2012; JACOBS et al., 2010), and the influence of savanna landscape with exotic pastures on dung beetle communities (LOBO; CABRERO-SAÑUDO, 2006).

The critical point is understanding the patterns of species occurrence in dung beetle communities in native savannas and in areas where native savannas have been replaced by exotic pastures, as well as the source of the species of dung beetles that colonize exotic pastures (LOUZADA; SILVA, 2009).

The aim of this study was to identify how the dung beetle community is affected by the change of native savanna into exotic pastures in the Brazilian Cerrado. The following hypotheses were tested:

(I) The replacement of Brazilian native savanna by exotic pastures decreases the richness, abundance and evenness of the dung beetle community.

(II) The vegetation structure determines the community structure of dung beetles.

(III) The richness of dung beetles in exotic pastures is increase by shared dung beetles species of the local Brazilian native savannas

2 THEORETICAL BACKGROUND

2.2 The Brazilian Cerrado

The Cerrado Biome covers approximately 2 million km² bordered by the Amazonian forest, the "Caatinga", and the Atlantic forest. The distribution of the Cerrado corresponds to the plateaux of central Brazil, which separate three of the largest South American water basins: the Amazon basin, the River Plate /Paraná basin and the São Francisco basin (OLIVEIRA-FILHO; RATTER, 2002).

The cerrado biome encopasses a range of vegetation types, including grasslands, savannas and forests. The vegetation tends to be replaced by forest physiognomies in sites with increased water availability or soil fertility, while grasslands appear in areas where periods of water deficit and waterlogging alternate (OLIVEIRA-FILHO; RATTER, 2002).

The physiognomies of the Cerrado Biome are well discussed, but it is possible to classify them as: dry grassland without shrubs or trees, called "campo limpo"; grasslands with a scattering of shrubs and small trees, called "campo sujo"; grasslands with scattered trees and shrubs called "campo cerrado"; vegetation dominated by trees and shrubs often 3-8 m tall and giving more than 30% crown cover but with a fair amount of herbaceous vegetation known as cerrado *sensu stricto*, and, finally, closed woodland with crown cover 50% to 90%, often with trees of 8-12m or even taller.; called "cerradão" (OLIVEIRA-FILHO; RATTER, 2002).

The "cerradão" occurs on soils of intermediate fertility in the cerrado landscape. This is a forest formation that is often associated with transition to mesophytic forest, the climax vegetation of the Cerrado Biome. The soils of

mesophytic forests are good for agriculture and the vegetation has been devastated.

Another forest formation that occurs in Cerrado is the riverine forests or "gallery forests". This denomination is explained because these forests form a "gallery" over water-courses. They are narrow forest strips, found along streams and flanked by grasslands, cerrado *sensu stricto* and "campos de cerrado". This forest is determined by soil moisture and variation of topography. When they border wider rivers, riverine forests are often called of "matas ciliares" (OLIVEIRA-FILHO; RATTER, 2002).

Some physiognomies of the Cerrado Biome occur when there are a periods with water excess, such as the "Veredas" and Floodplain grasslands. "Veredas" are valley-side marshes where the water table reaches or almost reaches the suface during the reainy season, found in the midle of topographic sequences , between gallery forests and others physiognomies of the Cerrado Biome. Floodplain grasslands are found in areas of even topography, liable to periods of inundation, usually restricted to the vicinity large rivers. In areas subjected to water deficit some physiognomies, like rock grasslands ("campo rupestre and campo de altitude"), mostly restricted to the tops of plateaux and mountain ridges, in soils that are shallow or confined to cracks betweeen rocks, can be found (OLIVEIRA-FILHO; RATTER, 2002).

Among the factors that affect vegetation distribution, fire is an important natural phenomenon that influences the density of the woody layer (trees and large shrubs) of the cerrado vegetation. Although most woody species are strongly fire adapted, but can be damage, favouring the vegetation in the ground layer, thus producing more open physiognomies, like grasslands and cerrado *sensu stricto* (OLIVEIRA-FILHO; RATTER, 2002).

2.3 Conservation of Brazilian native savannas

The Brazilian Cerrado is included in the world's 25 most important "hotspots" of biodiversity and endemism, and has less than 30 % of its natural vegetation remaining (MYERS et al., 2000). However, the conservation of the Cerrado biome has not been effective. The region was colonized by Europeans in the 18th century, and towns were founded at strategic points by prospectors seeking gold and diamonds. In the countryside, many large farms focused on extensive cattle ranching using native pastures (KLINK; MOREIRA, 2002; OLIVEIRA-FILHO; RATTER, 2002).

After 1950, the human impact on the Cerrado landscape was intensified by the mechanization of agriculture and the construction of major highways across Central Brazil (CAVALCANTI; JOLY, 2002; KLINK; MOREIRA, 2002). The use of new fertilization techniques associated with the development of resistant crop varieties - mainly, rice, corn and soybean varieties – helped open the Cerrado as a new Brazilian agricultural frontier.

The low cost of land, deep soils and abundant rainfall during the growing season were important factors in the development of large scale agriculture (CAVALCANTI; JOLY, 2002). By the early 1990s, at least 67% of the Cerrado Biome had been converted to intensive human activity (MYERS et al., 2000).

The Cerrado biome is also an important cattle ranching region, representing 33% of the national herd in 2002. Often, in a region without infrastructure, ranching is done on extensive native pastures. However, cattle activities in the Cerrado have grown extensively due to the increase in planted pasture. For the establishment of planted pastures, the native savannas are clear-cut and burned, after which African grasses, such as *Brachiaria brizantha*, *B. decumbens*, *Melinis minutiflora*, *Hyparrhenia rufa* and *Andropagon gayanus*,

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are sown (KLINK; MOREIRA, 2002; SANO; BARCELLOS; BEZERRA, 1999).

The eastern and southeastern regions of the Cerrado Biome, in Minas Gerais and São Paulo state, are the most fragmented and occupied for agriculture, cattle ranching, and urban expansion. In these regions the native savannas were reduced to small remnants, often not exceeding 100 hectares. There is a great necessity of conservation of the Cerrado Biome, though the priority and effort for conservation are low (CAVALCANTI; JOLY, 2002).

2.4 Dung beetles

According to Hanski and Cambeforti (1991), the subfamily Scarabaeinae has nearly 6 000 species distributed in the tropical regions of the world. In South America there are nearly1250 recorded species, and in Brazil, according to Vaz-de-Mello (2000), 618 species distributed along six tribes (Ateuchini, Canthonini,Coprini, Euristenini, Onthophagini e Phanaeini).

Most dung beetles species are coprophagous, but there are other food resources utilized by dung beetles, like carrion (necrophagy), decaying fruit (carpophagy), fungi (micetophagy), and plants in decomposition (saprophagy). Often, predation of some ants and millipedes has been observed (HALFFTER; MATTHEWS, 1966). In this way, these groups of species of dung beetles use different strategies for food resource allocation. The following strategies of allocation can be termed as functional guilds relating to their nesting behavior: rollers; tunnellers; and dwellers (HANSKI; CAMBEFORTI, 1991).

Dung beetles are important elements for several ecological processes and are recorded as key species in the ecosystem due to their participation in nutrient cycling, bioturbation and secondary seed dispersal. Dung beetles also

perform several ecological services for soil maintenance and suppression of parasites in livestock (NICHOLS et al., 2008).

Due to changes in the abundance, richness and composition of dung beetles in response to environmental changes it is possible to use them as bioindicators (DAVIS; SCHOLTZ; SWEMMER, 2012), with a high performance/ cost-effectiveness in response to disturbances (GARDNER et al., 2008; NICHOLS et al., 2007; NICHOLS; GARDNER, 2011).

2.6 Land use changes and dung types

The land use type of and food resource utilized by dung beetles should be treated together for the understanding of the influence of land use change, mainly in changes in vegetation structure and diversity of available food resources (BARBERO et al., 1999; GITTINGS; GILLER, 2008).

The source of food of coprophagous dung beetles is dung of wild mammals. Around the world, the population of mammals suffers with habitat loss or transformation and fragmentation. Some mammals, like *Bos taurus*, were introduced in Brazil with the purpose of beef and milk production. Thus, there is a high availability of cattle dung in pastures that favors dung beetles specific to large mammalian herbivores and causes environmental disturbers, like the increasing of parasites of the livestock (HANSKI; CAMBEFORTI, 1991).

Therefore, the conservation of the Cerrado Biome, in the context of agricultural landscapes, needs more attention in relation to the modifications of natural landscape human intervention, as occurs with the introduction of exotic pastures and domestic mammals. Some actions can be important for increasing the biological value of the pastures, like livestock diversification, with horse and cattle or other domestic animals (LOUZADA; SILVA, 2009).

3 METHODS

3.1 Study area

The study was carried out in native savannas (cerrado *sensu stricto*) in Northeast Minas Gerais state, Brazil. This region is covered extensively by native savannas.The native savannas of Brazil encompasse a series of vegetation physiognomies from open grasslands to dense woodlands, and recognizable stages of this continuum are given specific names. The dominant families of plants of the Biome Cerrado in the nonarboreal category are: *Fabaceae, Compositae, Poaceae and Orchidaceae*. In forest formations, the cerrado *sensu stricto* and "campo sujo" are dominated by species of the genera *Axonopus, Chamaecrista, Croton, Hyptis, Mimosa, and Oxalis* (FILGUEIRAS, 2002).

The climate of the Biome Cerrado varies considerably, but it is typical of the rather moister savanna regions. There is variation across the region in the average annual temperature, ranging from 18° to 28°C, and rainfall, from 800 to 2.000 mm, with a very strong dry season during the southern winter (April-September). Overall, the biome is characterized according to classification Koppen of Aw (rainy tropical) (OLIVEIRA-FILHO; RATTER, 2002; RIBEIRO; WALTER, 1998).

Most soils of the Cerrado Biome are distrophic, with low pH and availability of calcium and magnesium and high aluminium content. The soil in cerrado *sensu stricto* is strongly drained with a deep water table and seasonal water deficit at the topsoil level (OLIVEIRA-FILHO; RATTER, 2002).

The Cerrado is an important cattle ranching region and the bovine herd has been increasing since the 1980´s. The increase in the number of cattle has direct consequence of increasing land covered by exotic pasture, the most important land use in this Biome. These exotic pastures usually planted on

native savanna that has been, clear-cut and burned, and then often seeded with grasses of African, such as the *Brachiaria decumbens*, one of the most widespread species that tolerates soils of cerrado *sensu scricto*. Frequently, pastures with this species cover great areas of Brazilian native savanna that then become degraded-exotic pastures due to inadequate management (CAVALCANTI; JOLY, 2002).

3.2 Distribution of sampling effort

We sampled two types of land use in this study: areas of cerrado *sensu stricto* and exotic pasture (*Brachiaria* spp) in ten landscape windows (at least 20 km apart) in Minas Gerais (MG) state. We sampled areas in Pitangui, Martinho Campos, Pompéu, Felixlândia, Curvelo, Pirapora, Buritizeiro, Montes Claros/ Santa Rosa Montes Claros/ Morro Agudo and Claro das Poções (Figure 1). At each landscape window, we sampled three sites of each land use type. Each sampling site received five sampling points, 50 metres apart, placed along a transect. The sampling point was composed of the two pitfall traps (three metres apart), one using human dung and another cow dung as bait (Figure 2). Our sampling effort was 300 sampling points by land use types (native savanna and exotic pasture), totalling 600 pitfall traps in ten landscape windows.
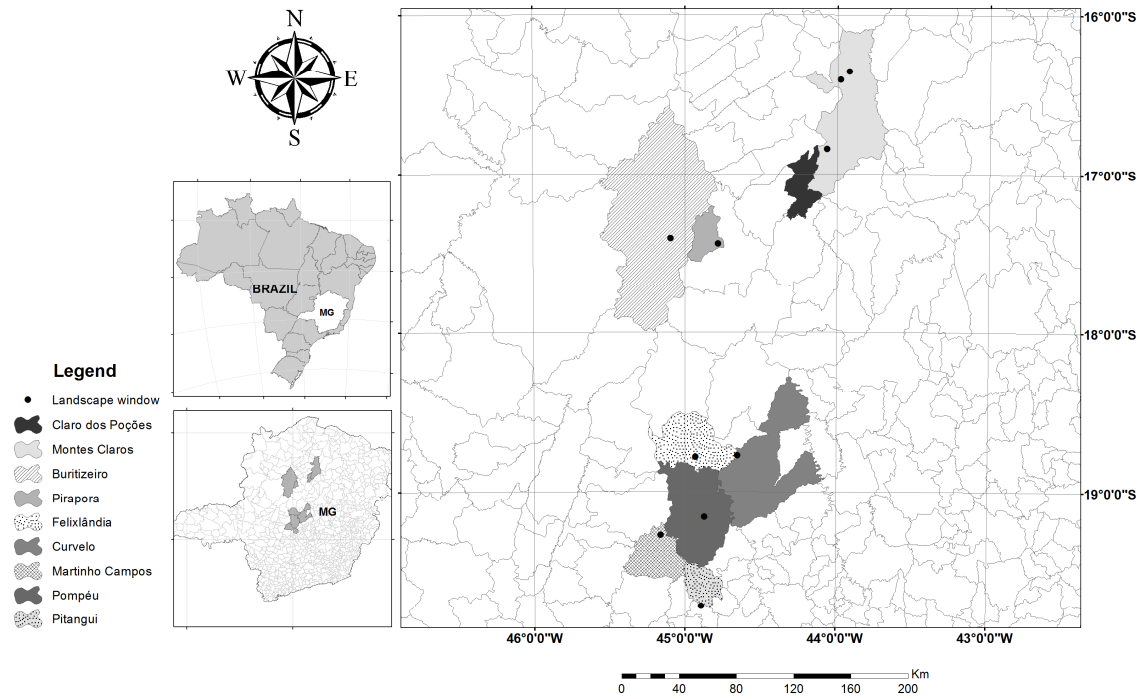
Figure 1   The ten sampled landscape window and location in Minas Gerais state, Brazil. The grid represents Universal Transverse Mercator (UTM) coordinates in UTM zone 23S – SAD69

The human faeces baited pitfall was composed of a plastic container (diameter 19 cm; depth 11 cm), buried in the ground, so that its opening at ground level and a plastic lid used as a rain cover. The trap container was half-filled with a solution of water, salt and liquid detergent. A small plastic cup containing the bait was suspended above the trap using a wire.

The cattle dung baited pitfall was composed of a plastic container (diameter 19 cm; depth 11 cm), buried on the ground, so that its opening at ground level. The trap container was half-filled with a solution of water, salt and liquid detergent. A steel rod was stuck in the ground with a twine tied to its upper end, which suspended the bait above the trap. The bait consisted of 500g of cattle dung wrapped in nylon.

The pitfall traps were baited and left for 48 hours, after which the insects were collected and placed in 70% alcohol solution for further sorting and identification at the Invertebrate Ecology and Conservation Laboratory of the Universidade Federal de Lavras (UFLA).We identified the dung beetles to genus and species, with the help of Dr. Fernando Z. Vaz-de-Mello of the Universidade Federal do Mato Grosso (UFMT) and Dr. Fernando Augusto Barbosa Silva of the Universidade Federal do Pará (UFPA). Vouchers were specimens were deposited at each of the three universities.

Sampling was carried out from the 17th January to 12th of February 2012. This period corresponds to the rainy season, during which dung beetles are active while in the dry season their abundance is decreasing (MILHOMEM; ZAGURY; MELLO, 2003).
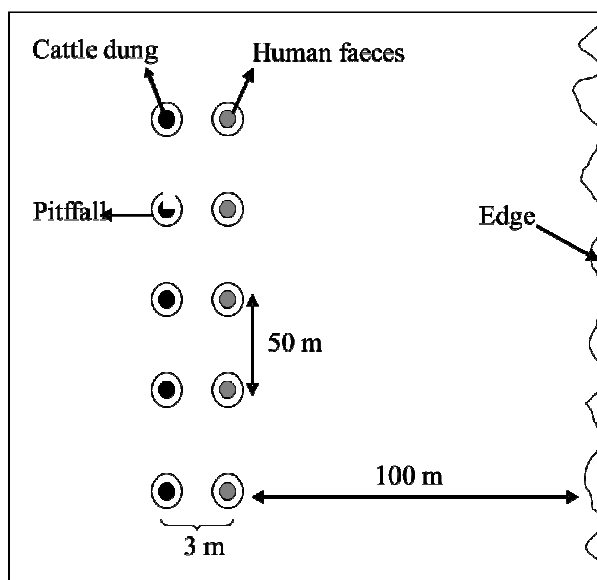
Figure 2   Sample design of each transect in native savanna and exotic pasture within sampling site

3.3 Vegetation measurements

3.3.1 Vertical structure of the herbaceous vegetation

In order to record the herbaceous vegetation growing between the two traps of each sampling point, a100 x 100 cm black panel, placed vertically 10 cm above the ground, was photographed utilizing a Nikon D40. The panel was photographed four times, once in each cardinal direction (Figure 3).

The pictures were analysed using the software Sidelook 1.1.01 (NOBIS, 2013). This software allows to calculate the vegetation density and fractal dimension of herbaceous vegetation, through the percentage of black pixels and white pixels from a dichromatic picture. The vegetation density was calculated

by the equation: VD= Ap. (BP/WP) / Wp. Where, VD = vegetation density; Ap = area of the panel; BP = black pixel; WP = white pixel; Wp = width of the panel. The fractal dimension of the herbaceous vegetation was used as a proxy of the local structural vegetation complexity (vegetation complexity).
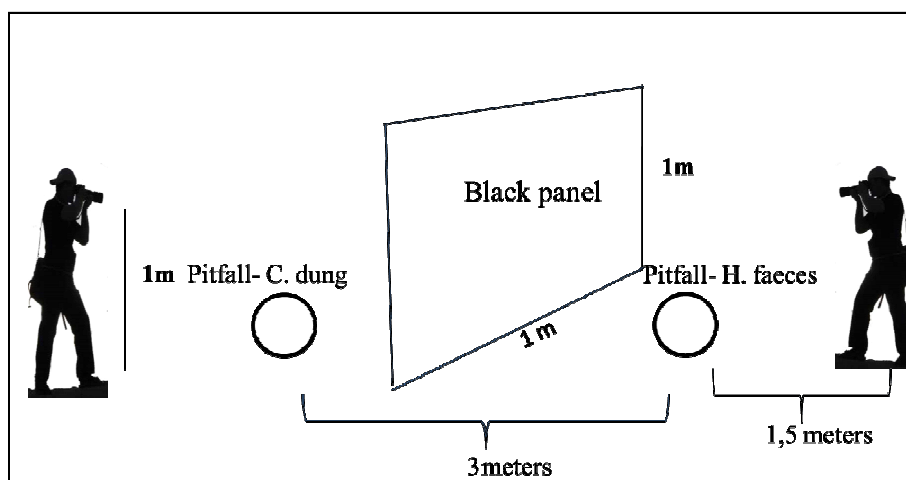
Figure 3   Methods used to record the herbaceous vegetation density and fractal dimension

3.3.2 Canopy openness

We took five pictures of the canopy above the transect, one in each sampling point, in order to record the mean percentage of canopy openness of each land use. The pictures were taken using a digital camera Nikon D40 coupled with a fish-eye lens (8mm) placed one metre above the ground and oriented towards the sky. The pictures were analyzed using the software Gap Light Analyser package version 2 (FRAZER; CANHAM; LERTZMAN, 1999), which represents an indirect method to measure the canopy openness (ratio of black pixel – canopy cover- and white pixel – openness).

3.4 Statistical analyses

3.4.1 Hypothesis (I)

We used individual-based accumulation curves to compare response patterns of species richness to sampling effort increasing in each land use (native savanna and exotic pasture) and landscape windows. Comparisons were made by visual assessment of overlapping 95% CI of the curves implemented in EstimateS.8.0 (COLWELL, 2009).

Rank-abundance plots were made by bait types in each land use in order to evaluate the patterns of species dominance. The species dominance patterns of the abundance of species were evaluated for baits within native savannas and exotic pastures. In addition, a Simpson index was calculated to evaluate the equitability of the dung beetle community between land uses. This index was calculated performed in the VEGAN of the R enviroment, version 2.15.2 (R DEVELOPMENT CORE TEAM, 2013).

The community parameters, structure and composition of species, were analyzed using non-metric multidimensional scaling (NMDS) in two ways. First, we evaluated the community between land uses, native savannas and exotic pastures, considering each bait type. Second, we evaluated the community differences for each bait types, cattle dung and human faeces, within each land use type.

The NMDS was based on a similarity matrix constructed using the Bray-Curtis index calculated on standardized, square-root transformed data. Statistical differences in community structure and composition between land uses and baits were measured using permutational multivariate analysis of variance (PERMANOVA). In addition, we tested the multivariate homogeneity between land use and bait groups by multivariate dispersion analysis (PERMDISP).

These analyses were performed using the Primer v.6 software with PERMANOVA+ (ANDERSON; GORLEY; CLARKE, 2008).

3.4.2 Hypothesis (II)

To evaluate the influence vegetation structure on the dung beetle community and which variables best predict the variation of the structure in each land use we performed a distance–based linear model (DISTLM) and a distance-based redundancy analysis (dbRDA) to model the relation between similarity resemblance matrix, built using dung beetle community structure data set and predictor variables (canopy openness, herbaceous vegetation density and vegetation complexity).

The purpose of DISTLM is to perform a permutational test for the multivariate null hypothesis of no relationship between matrix predictors and response variables on the basis of a chosen resemblance measure, using permutation of the samples to obtain a P-value. The total variation of the community structure matrix is portioned into a portion that is explained by each the predictor variable and a portion that unexplained (residual) (ANDERSON; GORLEY; CLARKE, 2008).

The approach implemented by DISTLM termed distance-based redundancy analysis (dbRDA), is a multivariate multiple regression on predictor variables that find linear combinations of the environmental variables which explain the variation of the structure or composition of the dung beetle community. These analyses were performed in the Primer v.6 software with PERMANOVA+ (ANDERSON; GORLEY; CLARKE, 2008).

The selection criterion was the adjusted R squared, which provides a more useful criterion than R squared for model selection. Thus, it was possible to include only predictor variables that explain the variation of the dung beetle

community without redundancy. This is the concept of *parsimony,* with which we obtain a simple model having good explanatory power with the fewest possible predictor variables. The procedure which examines the value of the selection criterion for all possible combinations of predictor variables is called the Best procedure (ANDERSON; GORLEY; CLARKE, 2008).

Lastly, to evaluate if there was a cause-effect relationship between variables, we performed a test of variance inflation factor (VIF) to calculate the value of collinearity (these variables are collinear if VIF is higher than ten). The VIF is defined in terms R^2 of model based on the variance of the predictor variable around its mean that is explained by other predictor variables in the model (O'BRIEN, 2007). This analysis was performed in the VEGAN package of the R environment, version 2.15.2 (R DEVELOPMENT CORE TEAM, 2013).

3.4.3 Hypothesis (III)

The percentage and absolute contribution of the native savannas to the species composition of exotic pastures was evaluated in two ways. First, we plotted a graph showing how many species attracted by cattle dung in a local exotic pastures were shared with local native savanna (located in the same landscape window as the exotic pasture) and with all native savannas in the same bait. Second, we plotted a graph showing how many species attracted by human faeces in a local exotic pastures were shared with local native savanna and with all native savannas (Cerrado region) in the same bait. Thus, it was possible to observe the percentage and the number of species recorded in exotic pastures that were not recorded in local native savannas, but were recorded in

other native savannas. In addition, we plotted Venn diagram for observing the number of species shared between land uses, between bait types.

4 RESULTS

4.1 Richness and abundance

We sampled 11, 252 dung beetles from 98 species, across two land uses in ten landscape windows (Table 1). Overall, in native savannas we collected 7,785 dung beetles from 92 species. In exotic pastures we collected 3,467 dung beetles from 55 species. The native savannas showed a high abundance and richness. Cattle dung attracted 6,522 dung beetles from 64 species while the human faeces attracted 4,730 dung beetles from 92 species.

Table 1   Number of individuals sampled and number of species in each landscape window for the land use types

Landscape windows	Number of individuals		Number of species	
	N. savanna	E. pasture	N. savanna	E. pasture
Curvelo (1)	147	49	38	8
Montes Claros-Mg/ Santa Rosa(2)	176	287	31	12
Claro das Poções(3)	292	219	36	27
Felixlândia (4)	30	262	13	16
Martinho Campos(5)	600	1043	34	20
Pirapora(6)	1128	525	55	19
Pitangui(7)	335	123	42	10
Pompéu(8)	743	264	43	9
Montes Claros-Mg/ Morro Agudo(9)	91	138	19	19
Buritizeiro(10)	4243	557	61	29

The number of the individuals collected was unequal in all landscape windows between baits and landscape windows with the same bait. The largest number of individuals captured with cow dung and human faeces bait was found

in native savanna of the Buritizeiro landscape window while in exotic pasture, the Martinho Campos-landscape window showed the largest number of individuals captured with cattle dung (see figure 4A and 4B).

The number of species was higher in native savanna, especially in traps baited with human faeces. Landscape windows: Buritizeiro, Pirapora and Pompéu, showed the largest numbers of species of dung beetles (see figure 4C and 1D).
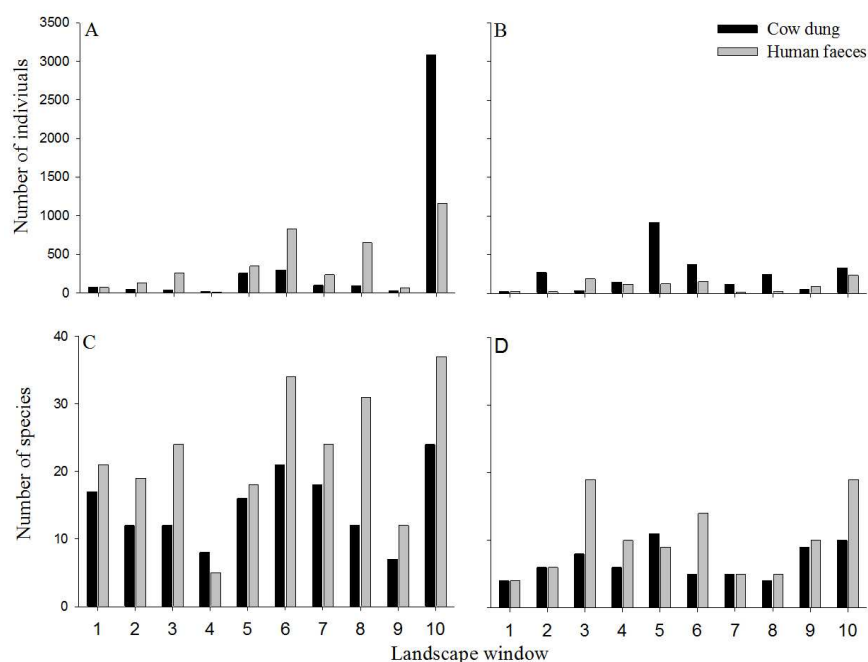
Figure 4 Patterns of the abundance and richness of dung beetles per landscape window (each number is a landscape window) in two land uses and with two bait types (cattle dung and faeces human): (a) and (b) show abundance of dung beetles in native savannas and exotic pastures, respectively; (c) and (d) show richness of dung beetles in native savannas and exotic pastures, respectively. The landscape windows are: (1) Curvelo (2) Montes Claros/ Santa Rosa (3) Claro das poções, (4) Felixlândia (5) Martinho Campos (6) Pirapora (7) Pitangui (8) Pompeu (9) Montes Claros/ Morro Agudo (10) Buritizeiro.

4.2 Sampling effort

The species accumulation curves between habitats indicated a significant difference in species richness of native savanna and exotic pasture, with native savanna having a larger number of species (Figure5A). For each land use, the species accumulation showed a different number of species collected as the number of individuals collected increased. Some landscape windows showed few species collected while others showed a large number of species (figure 5B and 5C).
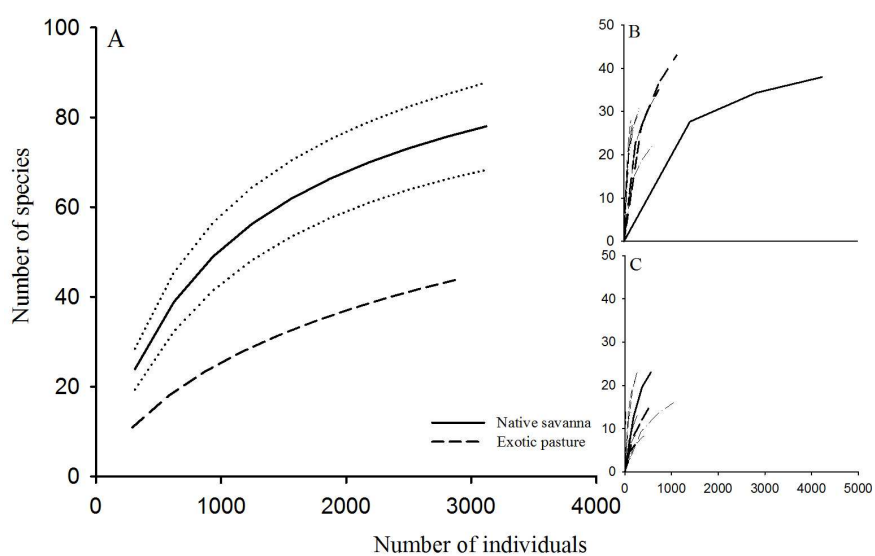
Figure 5   Individual-based species accumulation curves for dung beetles in (a) native savanna and exotic pastures; (b) only native savannas of landscape windows; (c) only exotic pastures of landscape windows. The dotted lines are 95% CI. In (a) there was as significant difference between native savanna and exotic pasture.

4.3 Structure and composition of the community

Native savannas were not dominated by few species neither of the two baits .The dung beetle community in native savannas was more equitable than the dung beetle community in exotic pastures. The combination of dominant species was different in each habitat, as well as in each bait type. According to the Simpson indices, the dung beetle community in native savanna (S= 68,50) was more diverse and showed lower dominance than the community in exotic pastures (S= 30,40). Segregation of food resources within the community was suggested by different captures between bait types.

Among the species captured in cattle dung in both land use types, *Dichotomius bos* was one of the most abundant species. *Digitonthophagus gazella*, an exotic species, was recorded in low abundance in the native savannas and in high abundance in exotic pastures in the traps baited with cattle dung. *Onthophagus hirculus* also was captured in cattle dung in high abundance. On the other hand, species captured in human faeces showed more equitability compared to cattle dung, *Canthon fortemaginatus* was the most abundant species (recorded in six landscape windows) in native savanna captured with human faeces and *Trichillum externepunctatum* the most abundant in exotic pastures (Figure 6).
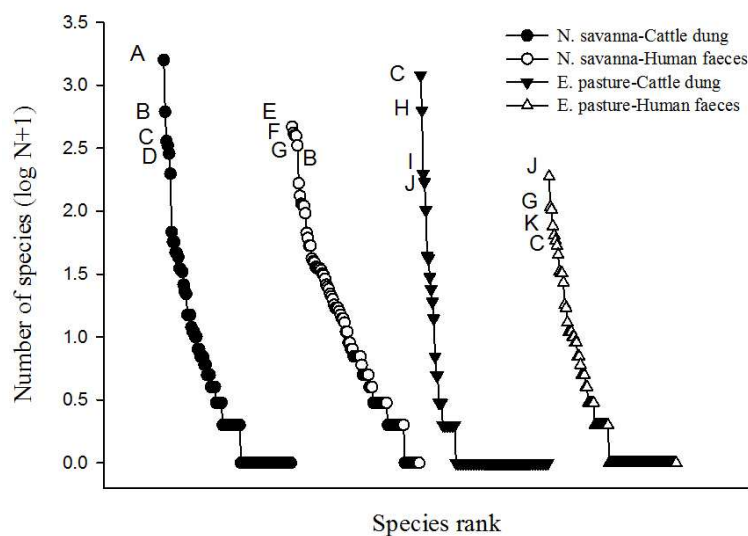
Figure 6   Rank abundance of the dung beetle community in native savanna (N. savanna) and exotic pasture (E. pasture) both with cattle dung and human faeces Letters represent the following species: (A) *Ateuchus aff. pauperatus*; (B) *Ontherus appendiculatus;* (C) *Dichotomius bos*; (D) *Agamopus viridis*; (E) *Canthon fortemaginatus*; (F) *Uroxis sp.C;* (G) *Canthon simulans;* (H) *Digitonthophagus gazelle;* (I) *Onthophagus hirculus* ; (J) *Trichillum externepunctatum*; (K) *Canthon aff. Podacricus.*

Dung beetle community composition and structure showed the same results in all statistical analyses. Dung beetle community structure in native savanna shows 45% similarity between dung types. In exotic pastures, 47% of the community was similar between dung types. The dung beetle community captured with human faeces showed 41% similarity between land use types. In cattle dung, 41% of the community was similar between land use types.

In native savanna the dung beetles caught in the different baits formed distinct clusters. The clusters of bait type were also scattered in native savannas (Fig.7A. PERMANOVA, pseudo-F= 3.2429, P >0.05; PERMDISP, F= 1.7987, P>0.05). In exotic pasture, the dung beetle community also formed distinct

clusters according to bait type, with more scattering in the cluster of species captured in human faeces (Fig.7B. PERMANOVA, pseudo-F= 4.917, P <0.05; PERMDISP, F= 7.479, P <0.05).

Considering dung types in different land uses, the dung beetle community captured in human faeces within native savanna and within exotic pastures was distinct. The clusters of the two land uses were also scattered (Fig. 7C. PERMANOVA, pseudo F=2.8521, P < 0.05; PERMDISP, F=0.21279, P >0.05) and dung beetle communities captured in cattle dung also differed between land uses (Fig. 7D, PERMANOVA, pseudo F=3.5008, P <0.05). The cluster of the two land uses were also scattered (Fig. 7D, PERMDISP, F= 4.9192, P>0.05).
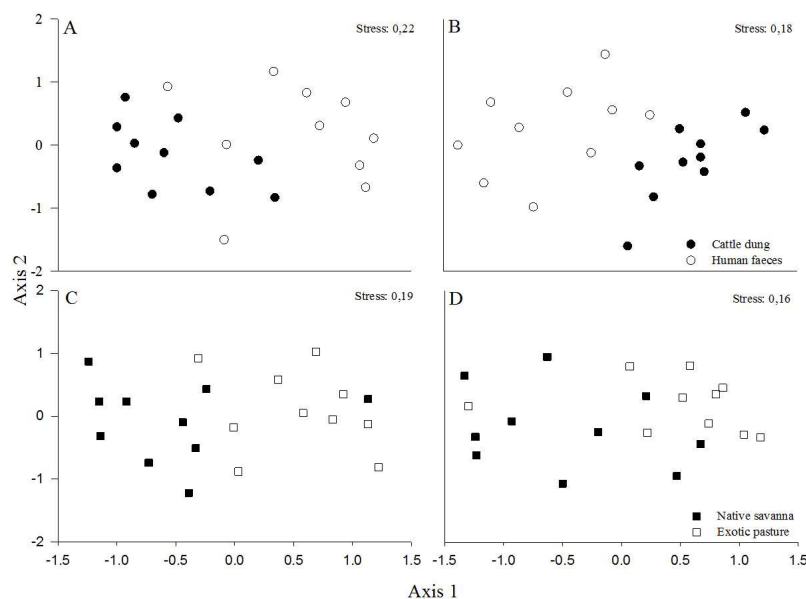
Figure 7   Nonmetric multidimensional scaling (NMDS) ordination based on a distance matrix computed with Bray-Curtis similarity index between land use types and bait typesNMDS (A) and (B) shows the difference in community structure of dung beetle between baits within native savanna and exotic pasture, respectively; NMDS (C) and (D) shows the difference in community structure of dung beetle between land use within human faeces and cattle dung, respectively.

4.4 Influence of native savannas in exotic pastures

Among all species collected, six species recorded in exotic pastures were not found in the native savanna. Of these six species, only five were captured in human faeces and one was captured in cattle dung (see Table. 2). In native savannas, 43 species were recorded only in this land use. Of these 43 species, 20 species were shared between baits; of these 20 species exclusively four species were recorded in cattle dung and 19 species were recorded only in human faeces.

Table 2   Landscape window, bait type and abundance of species not recorded in native savanna

Species	Landscape window	Bait	Abundance
Anomiopus sp.A	Claro da poções	H. faeces	1
Anomiopus sp. B	Montes Claros/ Sta. Rosa	H. faeces	1
Canthidium aff. viride	Buritizeiro	H. faeces	1
Canthon sp.	Montes Claros/ Sta. Rosa and Morro Agudo	H. faeces	9
Eutrichillum hirsutum	Felixlândia	H. faeces	1
Gromphas lacordairei	Felixlândia	Cattle dung	2

The number of shared species between native savannas and human faeces compared with pastures exotic and/or cattle dung are the most number of the combination between type baits, land uses and land uses with bait types. While in land use changes showed 48% of shared species and few species (15%) were shared between land uses and bait types. In exotic pasture, no species was captured in both cattle dung and human faeces. The exotic species *Digitonthophagus gazella* was found in native savanna and exotic pasture attracted only by cattle dung (Figure 8).
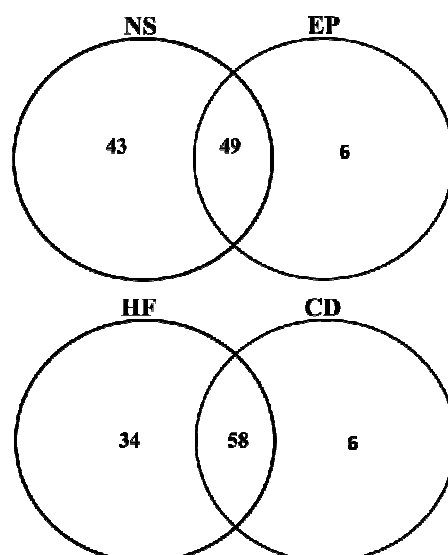
Figure 8   Venn diagram showing the number of shared species of dung beetles
in: two baits and two land uses HF= Human faeces; CD= Cattle dung,
NS= Native savanna, EP= Exotic pasture

Some species that were recorded in exotic pastures were not found in local native savanna, but occurred in native savannas of other landscape windows, in either cattle dung or human faeces. Some exotic pastures were strongly influenced by the species composition of the dung beetle community in local native savanna, while in other exotic pastures the influence was less pronounced (Figure 9A).

The influence of local native savannas in composition species of exotic pastures, captured with human faeces, in two landscape windows (Curvelo and Pompéu) was full; all species that occurred in exotic pastures were recorded in local native savannas. However, these landscape windows with the same composition between land uses, showed a low number of species (Figure 9A).In other exotic pastures, there was a higher number of local shared species in

human faeces (reaching almost 80 % and 90%). In the other exotic pastures the influence of local native savanna was lower (Figure 9A).

Overall, the number of shared species that occurred with cattle dung in exotic pastures compared to local native savanna was lower compared with species in human faeces shared between exotic pastures and local native savanna. Among the species that were captured in cattle dung, Pirapora-MG landscape window showed the same species between local native savanna and exotic pasture (Figure 9B). The influence of the Cerrado region on richness of exotic pastures, with species captured in cattle dung, reached almost 70% in some landscape windows. The richness of the local native savannas, with species captured in cattle dung, was less pronounced in some landscape windows than in species captured with human faeces. The richness of exotic pastures was complemented by species of Cerrado region, while the local native savannas were not complemented by the richness of exotic pastures.
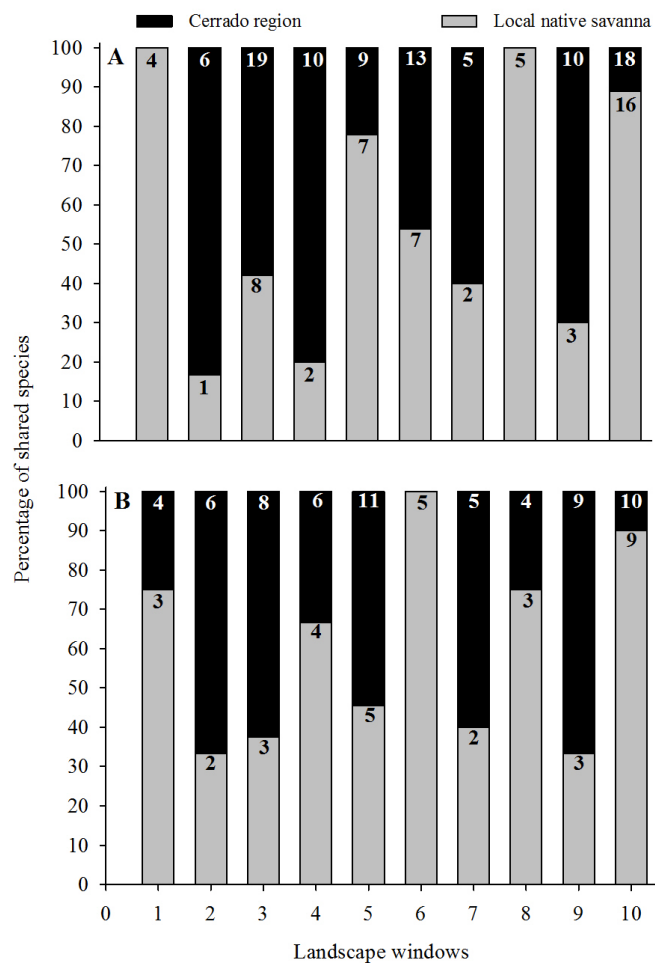
Figure 9   Percentage of shared species recorded in each exotic pasture
          compared with local native savanna and with native savannas overall
          (Cerrado region) in (A) human faeces and (B) cattle dung: (1)
          Curvelo (2) Montes Claros/ Sta Rosa (3) Claro das poções, (4)
          Felixlândia (5) Martinho Campos (6) Pirapora (7) Pitangui (8)
          Pompeu (9) Montes Claros/ Morro Agudo (10) Buritizeiro

4.5 Models with factors of the vegetation

The most influential variables structuring dung beetle communities, across native savanna and exotic pasture were land use type and vegetation complexity (DistLM., pseudo-F= 3.8285, P< 0,05; DistLM, pseudo-F=6.2601, P <0,05, respectively).Canopy openness and herbaceous vegetation density were not significant model variables with marginal test (DistLM, pseudo-F= 1.5724, P >0,05; DistLM, pseudo-F= 1.7517, P >0,05, respectively). However, the best solution for this model was to use all variables, since the variables did not show collinearity (see results in Table.3). In addition, the result of DistLM showed that this model explained 43.54% of the total variation of variance of the structure of the dung beetle community and db-RDA showed that this model explain the variation dung beetle community structure in native savannas.

Table 3   Results of the model with environment variable and values of Variance Inflation Factor

*Variables	R² adjusted	Variance Inflation Factor (VIF)
All	0.2849	< 10
CO, VC, LU	0.2688	< 10

Note: CO= Canopy openness; VC= Vegetation complexity; LU= Land Use

Vegetation complexity was different between land use types. Native savanna showed greater vegetation complexity than exotic pasture. Thus, the structural complexity is an important factor for evaluate difference in this land uses (F= 18.29, p<0,05; test T= -4.2776, p<0,005) (Figure 10).
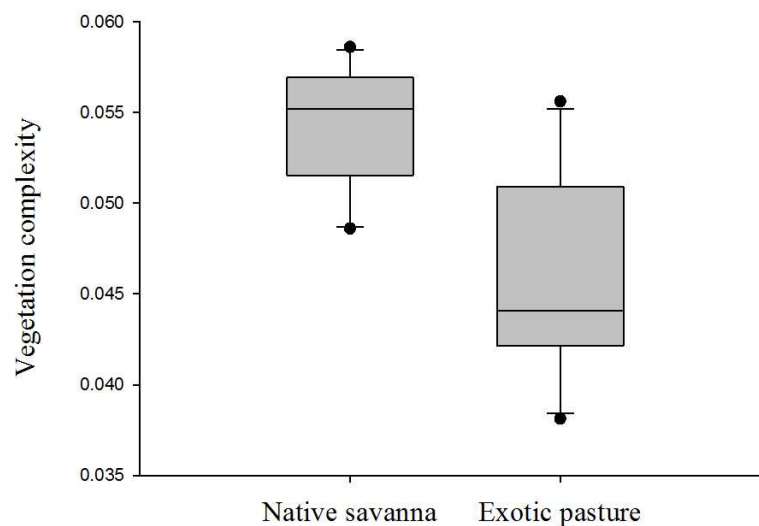
Figure 10 Distribution of the data of vegetation complexity in the two land uses: native savanna and exotic pastures. Data were standardized by total value and show normal distribution (W-statistic> 0,05, p> 0,05).

Within native savanna vegetation complexity was the most important variable for explaining the variance of the community structure of dung beetles (DistLM, pseudo-F= 1.8604, P< 0,05). The best model used in native savannas included canopy openness and vegetation complexity. In addition, the results of db-RDA showed that this model explained 32% of the total variation of variance of the community structure in native savannas. Within exotic pastures, the variables of the vegetation were not significant for explaining the variation of dung beetle community structure. Canopy openness, vegetation density and vegetation complexity weren't good predictors no model (DistLM, pseudo-F= 1.09, P> 0,05; DistLM, pseudo-F= 1.7147, P> 0,05; DistLM, pseudo-F= 1.346, P> 0,05, respectively).

5 DISCUSSION

We found that dung beetle community composition and structure were negatively influenced by land use change. The transformation of native savannas of the Brazilian Cerrado into exotic pastures altered the abundance and richness of dung beetles, resulting in a simplified-dung beetle community and decreasing the equitability in exotic pastures. On the other hand, the richness of exotic pastures was complemented by species that occurred within Cerrado region, and only not by the local native savannas. This difference in communities between land use types was explained by the availability of different dung types and differences in vegetation structure.

5.1 Dung beetle diversity

The number of species and individuals reported in this study were larger than other studies carried out in Brazilian native savanna. This may be due to larger sampling effort compared to following studies and the regional scale. For example, Almeida et al. (2011) collected 66 species and Gries et al. (2012) collected 4340 individuals from 55 species, both at 48h hours. Both these studies were carried out in grasslands of the Cerrado biome.

African savannas show a greater richness and abundance. For example, Davis et al. (2012) collected 76, 176 individuals of 113 species of dung beetles in African savannas and exotic pastures with a smaller sampling effort and 12 hours of trap exposure. This African savanna is composed of a similar habitat to the Brazilian native savannas, and lowveld, which is a habitat more open than Cerrado *sensu stricto*, allowing this comparison.

Some biogeographic issues can be raised for explaining the richness of these savannas. The high richness in African savannas may be attributed to the

presence of large mammals in Africa, while Australian savannas are probably less rich in species than African, American and Mediterranean savannas, but without many studies of the Australian native dung beetles (DOUBE; RIDSDILL-SMITH; WEIR, 1991). However, the extinction of the majority of large mammals on the South American continent could explain the low richness of the dung beetles compared to African (HANSKI; CAMBEFORTI, 1991). It is possible that American savannas, such as Brazilian savanna, can preserve a high diversity of dung beetles because many species did not go extinct, even after the extinction of large mammals, suggesting that the species that occur are the more generalist, and not those specialized on large mammal dungs.

5.2 Community structure and composition

These community-level changes in dung beetle composition and structure following conversion of native savannas into exotic pastures also occurs in other savannas in Africa and the Mediterranean, resulting in communities with less evenly distributed communities (DAVIS; SCHOLTZ; SWEMMER, 2012; NUMA et al., 2012). Overall, this is the same pattern found when other habitats, like tropical forests, with closed vegetation structure, are converted to pastures (QUINTERO; HALFFTER, 2009). For both tropical forest and native savannas transformed into pastures, the composition of the dung beetle community is altered, decreasing the richness and abundance of the dung beetles (ANDRESEN, 2003; HORGAN, 2008; NICHOLS et al., 2007).

In this context, the difference in the dung beetle community between land uses suggests different responses of species to conversion of native savannas. The exotic pasture species altered composition when compared with the native savanna (ALMEIDA et al., 2011; DAVIS et al., 2010; DAVIS; SCHOLTZ; SWEMMER, 2012; JACOBS et al., 2010) . For some species,

availability of food resources may be a more central driver of species occurrence than the overall land use types. For example, *Dichotomius bos* and *Onthophagus hirculus*, were widely distributed in cattle dung across landscape windows, suggesting that it is likely that species shifted to introduced cattle dung in open habitats (e. g. native savannas) a as occurred in eastern Madagascar with species of the genus *Onthophagus* (HANSKI et al., 2008).

These species likely are favored by foraging capacity in exotic pastures for cattle dung, resulting in a competitive advantage for some species on this novel food source (LOUZADA; SILVA, 2009), allowing them to persist in the hot, arid environmental conditions of pastures (QUINTERO; HALFFTER, 2009) and tolerate the higher compaction of soil caused by cattle (HALFFTER; FAVILA; HALFFTER, 1992).

Nearly 15% of the total of species of dung beetles was shared between dung and land uses types, suggesting that a small part of the total richness was able to switch food resource and land use types. Moreover, the species shared between cattle dung in land uses types was low, nearly 6% of total, suggesting that it is possible that many species are lost when native savannas are replaced by exotic pastures. Often, the effect of land use change and the effect of different dung types should be considered together for understanding the causes of the change in dung beetle community composition (DAVIS et al., 2010; DAVIS; SCHOLTZ; SWEMMER, 2012; JACOBS et al., 2010).

There is a dominance of species in cattle dung favored by human activities (HORGAN, 2007) and have maximally large geographic ranges across the landscape (RAHAGALALA et al., 2009). Domestic livestock have increase the abundance of these species due to their ability to manipulate dung of domestic mammals that were not present before, mainly *Bos taurus* (HORGAN, 2008). Dung quality and attractiveness are inherent to the physiology, digestion, and bacterial microflora present within the mammal, not a result of food type

alone (WHIPPLE; HOBACK, 2012) and filter feeders are important for dung beetles (HALFFTER; MATTHEWS, 1966). Some species like *Digitonthopahagus gazella,* an African dung beetle introduced into Brazil (MIRANDA; SANTOS; BIANCHIN, 2000), occurred in native savanna collected in cattle dung, suggesting that this species can invade native savannas if domestic livestock is established. This species also was recorded in intra-Amazonian savanna (MATAVELLI; LOUZADA, 2008).

There is some evidences that shifting mammal communities can indirectly influence dung beetle communities (NICHOLS et al., 2009), mainly, by large herbivorous mammals (VILJANEN; ESCOBAR; HANSKI, 2010). Thus, for other species, the evidence can suggest that environmental variables of different land uses (e.g. vegetation complexity) may be stronger determinants of occurrence than the availability of different types of dung (BLAUM et al., 2009; DAVIS; SCHOLTZ; SWEMMER, 2012). For example, *Canthon fortemaginatus*, was an abundant species only in native savannas, suggesting that it is sensible to land uses changes.

Native savanna conversion influenced the dung beetle community through availability of food types and environmental variables. The vulnerable species can be in decline along with native mammals (NICHOLS et al., 2009) since these mammals are affected by the replacement of the native savanna with exotic pastures; by changes in vegetation structure and composition of plant community (VIEIRA, 1999) and by the network of conservation land use in the form of forested rivers corridors and patches of Cerrado (TROLLE; BISSARO; PRADO, 2007; VYNNE et al., 2011).

5.3 Influence of native savannas on exotic pastures

The overall richness of dung beetles recorded in exotic pastures was complemented by species from both local native savannas and Cerrado region. Some landscape windows, the local native savanna showed not the same composition of dung beetles compared to local exotic pastures. Thus, when local native savanna shared not all species with pasture, the community was complemented by the species that occur in the Cerrado region.

The Cerrado Biome contributed species to exotic pastures that did not occur in local native savannas. Some environmental differences between landscape windows seem to be more influential than differences in the quantity of resource and their renovation rate at a regional scale (LOBO; CABRERO-SAÑUDO, 2006). Some species-specific adaptations suggest environmental tolerance or dispersal ability that could explain the regional presence of the dung beetles species (ROSLIN, 2000; ROSLIN; KOIVUNEN, 2001).

The influence of native savannas on the composition of species in exotic pastures was heterogeneous across landscape windows, sometimes, with species occurring in several local native savannas. These savannas can be rarer in Cerrado landscapes and the structure of the community in this land use types may be more disproportionately influenced by the spillover of generalist species from other land uses in the landscape, like pastures (ROSLIN et al., 2009; ROSLIN; KOIVUNEN, 2001; TSCHARNTKE et al., 2012).

Specifically, when one considers species shared on cattle dung between exotic pastures and Cerrado cattle dung-using species appear to have greater geographical ranges than habitat specialist species, because the shift to the currently abundant resource can relax interspecific competition (HANSKI et al., 2008; RAHAGALALA et al., 2009).

The environmental condition and conservation associated with each land use within the landscape windows was important for explaining the occurrence of the dung beetles, corroborated by other works (DAVIS; SCHOLTZ; SWEMMER, 2012; LABIDI; ERROUISSI; NOUIRA, 2012; LOBO; CABRERO-SAÑUDO, 2006).The exotic pastures show have factors that determine the composition of local dung beetles communities, like grazing history, number of livestock, distance between grazed localities and rate of dung renovation. These conditions could be explaining the variation local in dung beetles diversity in pastures (LOBO; CABRERO-SAÑUDO, 2006).

Microhabitat and microclimate requirements of each species (GITTINGS; GILLER, 1998) are also important for explaining their occurrence. The ability for choose herbivore dung can be according to their availability this dung in land use (DAVIS et al., 2010). The select land uses according own microclimate requirements may be in adverse environmental conditions (BARBERO et al., 1999).

5.4 Influence of vegetation structure

Despite evidence that local vegetation structure is a strong determinant of dung beetle community structure (BLAUM et al., 2009; DAVIS et al., 2010; DAVIS; SCHOLTZ; SWEMMER, 2012; HALFFTER; ARELLANO, 2002; HANSKI; CAMBEFORTI, 1991; JACOBS et al., 2010; VERDU et al., 2007), we found that canopy openness and herbaceous vegetation density were not determinant variables for explaining the differences in the structure of the dung beetle community in different land uses. Only vegetation complexity proved to be important in modifying the dung beetle community.

Canopy openness was important only for explaining the structure of the dung beetle community between native savannas. Canopy cover has been shown

to be important in structuring dung beetle communities (GRIES et al., 2012; HANSKI; CAMBEFORTI, 1991; NEITA; ESCOBAR, 2012). Canopy cover influences humidity as well as air and soil surface temperature, which might affect the survival and reproduction of dung beetles, also food availability and attractiveness (HANSKI; CAMBEFORTI, 1991). Dung placed under shade, can be important factor in maintenance of the quality of food resource (HORGAN, 2002).

Herbaceous vegetation density alone explained little of the differences in community structure, corroborating the results obtained by Gries et al. (2012). However, the combination with other environmental factors (e.g. canopy openness and vegetation complexity) can represent the vegetation structure and influences the dung beetle community under land use change, altering the composition of dung beetles (DAVIS et al., 2010; DAVIS; SCHOLTZ; SWEMMER, 2012; JACOBS et al., 2010; VERDU et al., 2007).

Among the environmental factors studied, vegetation complexity was important for explaining the difference in dung beetle communities, contrasting with Gries et al. (2012) who worked with afforestation of the Cerrado. Vegetation complexity can indirectly interact with dung beetle traits to produce changes in fitness of the species, in foraging strategies and in such as body sizes, reported in arthropods (DAVIS; SCHOLTZ; SWEMMER, 2012; MARSDEN et al., 2002; MORSE et al., 1985; NITTE; GUNNARSSON, 2006).

Vegetation complexity is also considered a factor that influences food resource detection by invertebrates (MORSE et al., 1985). The microhabitat can be modified by changes in vegetation complexity, so that more simplified vegetation structures exposes arthropods to higher light levels, to predators and changes in the food resource (GUNNARSSON, 1990).

6 CONCLUSIONS

Our results allow us to reach the following conclusions:

(I) The change of native savannas into exotic pastures simplified the community of dung beetles by altering both community structure and composition. These effects were often species specific and related to both land use change and food resource availability. For vulnerable species vegetation changes associated with land use change (e.g. vegetation complexity) were important determinants of species occurrences. For other species, availability of different dung resources provides an important factor for determining the occurrence of dung beetles in native savannas.

(II) Canopy openness and vegetation complexity were determinants of the structure of the dung beetle community in Brazilian native savannas. The vegetation structural complexity is important factor that distinguish the dung beetle community in land uses.

(III) There was a contribution of the richness of local native savannas and of the Biome Cerrado to the richness of exotic pastures. Overall, the conservation of the Cerrado Biome is important in order to maintain ecosystem functions and services in exotic pastures.

Some alternative practices for cattle management can be considered for the conservation of native savannas. The implementation of conservationist practices of livestock management, like rotational grazing, and with the use of silage, a form of conserved grass, will help to avoid grazing cattle within native savannas in dry seasons.

The farmers can make silage during the summer months when the grass supply is plentiful. This allows them to avoid using native savannas as pastures during the dry season and the resulting degradation. Thus, many native savannas would not be degraded and cattle dung would be confined to exotic pastures. Native savannas would also provide dung beetles species for pastures, improving the biotic quality of this land use. Another important aspect is the creation of public conservation policy for native savanna fragments, through incentives for the production of silage.

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