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Dung beetle communities as biological indicators of riparian forest widths in southern Brazil

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ABSTRACT

Riparian forests provide important habitat for many wildlife species and are sensitive to landscape change. Among terrestrial invertebrates, dung beetles have been used to investigate the effects of environmental disturbances on forest structure and diversity. Since many studies demonstrated a negative response of dung beetle communities to increasing forest fragmentation, and that most dung beetle species had a more pronounced occurrence during warmest seasons, three hypotheses were tested: (1) Scarabaeinae richness, abundance, diversity and evenness are lower in thinner riparian zone widths than in wider widths during the warmest seasons; (2) Scarabaeinae richness and abundance are positively influenced by leaf litter coverage and height and canopy cover; and (3) Scarabaeinae composition varies with the reduction in riparian vegetation and among annual seasons. We selected four fragments with different riparian zone widths in three secondary streams in southern Brazil. In each fragment, four sampling periods were carried out seasonally between spring 2010 and winter 2011. We collected dung beetles using pitfall traps with two types of bait. We collected 1289 specimens distributed among 29 species. In spring and summer, dung beetle richness was higher in fragments with the widest riparian zone than in those with a thinner riparian zone, and it did not vary between fragments in fall and winter seasons. Dung beetle abundance did not differ among fragments with different riparian zone widths, but it was higher in spring and summer than fall and winter. Richness and abundance were positively influenced by leaf litter. While dung beetle diversity was higher in fragments with wider riparian zone widths than in those with thinner widths, the evenness was similar among fragments. Dung beetle composition differed between the fragments with the widest and thinnest riparian zones, and it also varied among the seasons. Our results suggest that decreased riparian zones affect negatively to dung beetle community structure in southern Brazil. Fragments with thinner riparian zones had lower beetle richness in warmest seasons and an altered community composition. In this sense, the dung beetles are potentially good indicators of riparian forest fragmentation since some species were indicators of a particular riparian zone width. From a conservation perspective, our results demonstrate that the new Brazilian Forest Code will greatly jeopardize not only the terrestrial and aquatic biodiversity of these ecosystems, but also countless other ecological functions.

1. Introduction

The world's rainforests have been disappearing at an alarming rate and the fragmentation of these systems is a genuine threat to biodiversity (Andresen, 2003; Sinclair et al., 2006). High rates of deforestation have caused a great loss in biodiversity in rainforests (Hassan et al., 2005), and nowadays the biodiversity conservation has become a challenge for humankind (Viana and Pinheiro, 1988). Consequently, many studies have analyzed the effect of landscape change on the richness and distribution of forest species in various regions of the world (Moreno and Halffter, 2001).

Riparian forests provide important habitat for many wildlife species (National Research Council, 2002) and are sensitive to landscape change (Marczak et al., 2010). Landscape attributes of riparian forests (proximity to water, structure, microclimate, etc.) are essential to the persistence of many wildlife species (National Research Council, 2002; Richardson and Danehy, 2007). Furthermore, riparian forests not only aid in the dispersal and movement of terrestrial organisms (Naiman et al., 2005), they also provide foraging habitat for many terrestrial and aquatic species (Marczak

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et al., 2010). These ecosystems increase the stability of stream and river margins and control the flow of nutrients and sediments into these bodies of water (Owens et al., 1996; Trimble and Mendel, 1995).

Riparian zone width is an important parameter for biodiversity conservation policies (Marczak et al., 2010). Keller et al. (1993) suggest that a buffer width of 100 m is necessary to protect the ecological functions of riparian forests (e.g., controlling erosion and sedimentation, moderating stream temperature and light, inputting fine and large organic debris). However, a width of 30 m has become standard in many jurisdictions of Canada and the United States (Lee et al., 2004). Furthermore, riparian zones established to protect aquatic resources may not be appropriate to maintain terrestrial riparian species at levels comparable to undisturbed sites (FEMAT, 1993). In general, widths recommended for protection of terrestrial riparian components were wider (100–200 m) than those recommended for aquatic ones (Lee et al., 2004). Many studies show that a width < 50 m is not enough to maintain viable populations of various terrestrial species, especially interior-habitat-preferring riparian fauna, particularly amphibians and birds (Marczak et al., 2010).

In Brazil, the New Forest Law (Código Florestal, 2012) has reduced the legal riparian zone of small farms from 30 m to 15 m or less (5 m). The critical point of this new law is that the conservation of riparian zones for small properties will not vary according to the width of the river, but according to the size of the rural property, causing great disagreement between farmers, ranchers and conservation biologists. The new legislation places the floodplains of large rivers at risk, included the many aquatic and terrestrial species that need these ecosystems to survive.

Identifying indicator species is a tool that contributes to conservation activities and natural area management (Dufrene and Legendre, 1997). Terrestrial arthropods are sensitive to environmental changes and good indicators of the ecosystem health due to their high diversity of species and interactions with plants and vertebrates (herbivore host-plant specificity, seed predation, seed dispersal, vertebrate parasite suppression) (Godfray et al., 1999; Kremen et al., 1993; Wall and Moore, 1999; Watts and Didham, 2006).

Among terrestrial invertebrates, dung beetles (Coleoptera: Scarabaeidae: Scarabaeinae) actively participate in nutrient cycling (Halffter and Arellano, 2002; Nichols et al., 2008), help control vertebrate parasites and aid in secondary seed dispersal (Halffter and Edmonds, 1982). The distribution of dung beetles is strongly influenced by microclimatic factors as temperature, light intensity or humidity (Hanski and Cambefort, 1991; Nichols et al., 2008), vegetation coverage and soil type (Davis et al., 2001; Gardner et al., 2008), and the availability of feces as a food source (Davis and Philips, 2009). Because of their dependence on the feces of vertebrates, this beetle community is influenced both by changes in the mammal community (Estrada et al., 1999) and by the loss and fragmentation of tropical forests (Nichols et al., 2007).

Dung beetles have been used in several studies to evaluate the impact of habitat modification and landscape fragmentation on forest diversity and structure (Davis, 2000; Halffter et al., 1992; Hill, 1995; Klein, 1989). Dung beetles are good biological indicators of structural habitat changes caused by disturbance on forests (Davis et al., 2001; Gardner et al., 2008; Nichols et al., 2007; Nyeko, 2009; Qie et al., 2011). The decline of dung beetle species richness and abundance with increasing habitat modification and forest fragmentation has been documented in many studies (Andresen, 2003; Estrada et al., 1999; Larsen et al., 2005).

Since many studies demonstrated a negative response of dung beetle communities to increasing forest fragmentation (Didham et al., 1996; Nichols et al., 2007), and that most dung beetle species had a more pronounced occurrence during warmest seasons (Hernández and Vaz-De-Mello, 2009; Lopes et al., 2011), three hypotheses were tested: 1. Scarabaeinae richness, abundance, diversity and evenness are lower in thinner riparian zone widths than in wider widths during the warmest seasons; 2. Scarabaeinae richness and abundance are positively influenced by leaf litter coverage and height and canopy cover; and 3. Scarabaeinae composition varies with the reduction in riparian vegetation and among annual seasons.

2. Materials and methods

2.1. Study area

The study took place in the Sinos River watershed, in the northeast of southern Brazil between 29° and 30° S. This watershed is one of the main basins of southern Brazil, has an area of approximately 4000 km^2 and includes 32 municipalities. The climate of this region is subtropical humid and the average annual rainfall varies from 1200 to 2000 mm. The Sinos River is approximately 190 km long, and while its headwaters are at an elevation of 900 m, its mouth is 5 m above sea level (Rolon et al., 2003).

We selected four fragments with different riparian zone widths in three secondary streams, for a total of twelve 100 m long fragments. We classified the fragments according to the width of the riparian zone: (1) fragments wider than 40 m on both stream margins (area > 40 m); (2) fragments of riparian vegetation with a width of 15–30 m on both stream margins (area < 30 m); (3) fragments of riparian vegetation with a width of 5–15 m on both stream margins (area < 15 m); and (4) fragments of riparian vegetation less than 5 m wide on both stream margins (area < 5 m) (Fig. 1).

In the fragments wider than 40 m on both stream margins (area > 40 m), the riparian vegetation extends up to 1000 m wide on one stream margin, varying from 210 to 440 m wide on the other stream margin. The fragments chosen for this study were non-contiguous, and the minimum distance between them was 1 km to increase the independence of the sampled areas. The land use type in all adjacent areas outside of the vegetation fragments has the same purpose, represented by small fields used for subsistence agriculture (crops and animals needed by the family to feed themselves during the year).

2.2. Sampling and Scarabaeinae identification

In each fragment, four sampling periods were carried out seasonally between spring 2010 and winter 2011. Dung beetles were collected using baited pitfall traps that were active for 72 h. The baited pitfall traps are considered the most efficient sampling method for collecting the majority of dung beetle species (Lobo et al., 1988; Halffter and Favila, 1993). The traps consisted of plastic containers with a diameter of 30 cm and depth of 20 cm, and they were buried in the soil up to the top edge and protected by a plastic dome that was suspended by 10 cm sticks. The traps were set 15 days before the first sampling period (spring 2010) to avoid the effects of disturbance caused by establishment of the traps, and remained at the study site during entire study period.

Two types of bait were placed in the traps: human feces (30 g) and decomposing pig meat (30 g). Human feces were chosen to attract coprophagous invertebrates (Gardner et al., 2008), and decomposing pig meat was used to attract necrophagous species. These bait types (feces and meat) attract the two major trophic guilds of dung beetles: coprophagy and necrophagy (Simmons and Ridsdill-Smith, 2011). Many studies showed that different bait types were used to attract distinct dung beetle species such as carrion (rotten fish or chicken), mammal excrement and decaying fruits (fermented banana) (Halffter and Halffter, 2009; Klein, 1989;