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Citizen scientists help unravel the nature of cattle impacts on native mammals and birds visiting fruiting trees in Brazil's southern Pantanal

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ABSTRACT

We used 2 years of camera-trap surveys conducted by citizen scientists to compare native mammal and bird visits to dominant fruiting-tree species in low and high cattle-impact areas of rarely-flooded “cordilheira” forests in the Brazilian Pantanal. Monthly fruit censuses showed greater diversity of fruiting-tree species in low cattle-impact areas. Citizen scientists documented 29 native mammal and bird species among 5639 photo records obtained at fruiting trees. Analyses of 3 sets of camera-trap samples comprising: (1) only *Attalea phalerata* palms, (2) all ten dominant fruiting-tree species, and (3) all except a species with a highly-valued fruit and an unusual distribution, showed that faunal composition in low cattle-impact areas was significantly different and more diverse compared to that in high cattle-impact areas. Long-term cattle-related alterations of forest vegetation and short-term fruit depletion and interference by cattle explained faunal differences. While 5 frugivores and 1 carnivore were consistent indicators of low cattle-impact conditions, the value of 2 other frugivores (*Tayassu pecari* and *Crax fasciolata*) as indicators of cattle impact varied depending on fruit-species nutritive value, timing, and distribution. Improved cattle management is needed to prevent additional loss of forest biodiversity.

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1. Introduction

Cattle rearing operations affect native fauna and flora, species interactions, and ecological communities across a wide range of climates, geographic regions, and environments (Bock and Bock, 1999; Chaikina and Ruckstuhl, 2006; Elliott and Barrett, 1985; Moser and Witmer, 2000; Shepherd and Ditgen, 2005). Negative impacts on native fauna can result from habitat and vegetation alterations, diet overlap with cattle, and alterations in behavior or habitat use associated with avoidance of cattle (Chaikina and Ruckstuhl, 2006; Elliott and Barrett, 1985; Moser and Witmer, 2000; Shepherd and Ditgen, 2005).

In the Brazilian tropics, cattle grazed in naturally-open rangelands or in areas that were deforested and converted to planted exotic, i.e., non-native, grass pastures (hereafter called planted pastures) also forage and seek shelter in nearby forests. Therefore, in addition to impacts on native grazers and browsers characteristic of open habitats, they potentially affect forest species, like ground-dwelling frugivores, which are the focus of this study. Frugivorous animals comprise a large part of vertebrate community biomass in tropical regions and are important seed

dispersal agents, contributing to the dynamics and structure of forests (Jordano, 2000; Silman et al., 2003; Terborgh, 1983, 1986). Similar to cattle impacts on grazers and browsers, short-term indirect and direct effects on native frugivorous animals potentially include overlap in use of fruit resources and/or alterations of behavior and habitat use, e.g., if native fauna avoid areas where cattle congregate, or shift their spatial or temporal feeding patterns in the presence of cattle. Long-term indirect impacts of cattle on frugivores potentially include vegetation and habitat alterations caused by foraging and trampling of forest understory and shifts in seed dispersal and predation (Johnson et al., 1997; Nunes et al., 2008; Santos, 2011; Shepherd and Ditgen, 2005; Tomas et al., 2009).

The Pantanal of Bolivia, Paraguay, and the Mato Grosso region of central-western Brazil is an England + Wales-sized alluvial plain (150,500 km²) that drains the upper Paraguay river basin and forms one of the largest seasonal tropical wetland systems in the world (Hamilton et al., 1996; Junk et al., 2006; Nunes da Cunha et al., 2014; Padovani, 2010). It supports a rich variety and abundance of wildlife, is recognized internationally as a region of conservation importance, and is an important production area that has supported extensive cattle ranching operations since the late 1800s (Junk et al., 2006; Mazza et al., 1994; Nunes da Cunha et al., 2014; Santos et al., 2002, 2008). The Pantanal is one of the few places in the American tropics where a wide variety of wildlife are easily observed. For this reason, ecotourism

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is popular in the Pantanal, and has been adopted by a number of property owners as an alternative economic activity to replace or supplement cattle ranching. North American and European tourists interested in citizen-scientist opportunities are drawn to the region, and as reported for other studies (e.g., McKinley et al., *this issue*) have been integral to the successful collection of field data described in this article.

Because >95% of the Brazilian Pantanal consists of privately-owned ranches called “fazendas”, the region has been (and continues to be) vulnerable to development trends initiated in the 1960s that decrease the environmental sustainability of ranch properties. These trends have included the introduction of harmful ranching practices, most significantly deforestation, conversion of natural habitat to planted pasture, and subsequent intensification of cattle operations (Santos et al., 2008; Silva et al., 1999). So, in addition to impacts and probable species losses from deforestation and conversions, the remaining native fauna and flora have been exposed to increased levels of cattle activity associated with the expansion of planted pasture. By 2008 (the period of this study), approximately 13% of the natural vegetation cover had been altered in the Pantanal (15% by 2014; Instituto SOS Pantanal and WWF-Brasil, 2015). Forest formations called “cordilheiras”, which were the focus of this study, have unfortunately been disproportionately targeted for deforestation and conversions in the Pantanal, because they occupy areas above typical peak flood levels and as a result are preferred locations for establishing the less flood-resistant exotic-grass monocultures (Silva et al., 1999).

Recent studies in the southern Pantanal, have shown that cattle-related impacts associated with both traditional and intensive (i.e., requiring deforestation and conversion to planted pasture) ranching practices may have negative consequences for forest flora and fauna, e.g., loss and simplification of forest understory vegetation (Nunes et al., 2008; Santos, 2011), alteration of forest structure and succession (Santos, 2011; Tomas et al., 2009), loss of insectivorous birds associated with forest litter (Nunes, 2009), loss of nesting cavity trees, *Sterculia apetala*, for threatened hyacinth macaws, *Anodorhynchus hyacinthinus* (Guedes et al., 2006), and altered range area and use by a wide-ranging prevalent frugivore, the white-lipped peccary, *Tayassu pecari* (Keuroghlian et al., 2015).

Our main objective was to determine whether native ground-dwelling mammalian and avian species visiting freshly-fallen fruits at trees in Pantanal forests were affected by cattle-related, or cattle-operation related, impacts. To that end, we relied on citizen scientists to conduct camera-trap surveys of forest fauna visiting fruiting trees in areas exposed to different levels of cattle activity. Using the data compiled from photo records by citizen scientists, we performed a range of analyses to evaluate impacts on faunal assemblages. Fruiting trees were ideal locations for monitoring the interactions between cattle and a wide range of native fauna, because they, like watering holes on dry savannas, are natural aggregation sites for fauna (Wemmer et al., 1996). A secondary objective of the study was to investigate the potential wider application of the procedures developed for citizen scientists as tools for evaluating and monitoring other types of environmental impacts in regional forests.

2. Materials and methods

2.1. Study area

We focused our investigation in the upper Rio Negro subregion of the southern Pantanal (Padovani, 2010), Município de Aquidauana, Mato Grosso do Sul, Brazil (Fig. 1). Native vegetation in the region, as is true for many parts of the Pantanal, is a complex mixture of aquatic, savanna, and forest formations that are strongly influenced by annual and multi-annual flood cycles, consequent moisture conditions, climatic and edaphic factors, and human alterations of the landscape (Nunes da Cunha et al., 2007; Pott and Pott, 2009). The woody vegetation in the study area, which combines species from bordering biomes, e.g., the

Cerrado, Atlantic Forest, Amazon, and Chaco (Nunes da Cunha et al., 2007; Pott and Pott, 2009), includes periodically-flooded semi-open scrublands, a gradient of riparian forest types (200 to 1000 m in width) on seasonally-flooded levees associated with the Rio Negro, and rarely-flooded forested regions called “cordilheiras”. The latter forest formations, which were the focus of the current study, are characteristic of long (tens of kilometers), narrow (50 to 500 m) paleo-levees that are 1 to 2 m above the average flood level and generally separate from present-day river levees (Nunes da Cunha et al., 2007; Salis et al., 2006; Santos, 2011). Bordering the “cordilheira” forests in the study area are flood-prone lower-lying grasslands and a range of aquatic environments that include seasonal and permanent wetlands and lakes and seasonal rainwater drainages called “vazantes” (Eaton, 2006). Based on GIS surveys of the “cordilheira” zone in the study area, 28% of the natural landscape was comprised of forest, while the remaining 72%, depending on season and extent of the annual flood, alternated between dry savanna and aquatic habitat. The climate is highly seasonal (Köppen-Geiger, tropical savanna, Aw) with annual rainfall in the study area from 1998 through 2009 averaging 1414 ± 196 mm (95% CI), and air temperatures during the hotter wet season (December to April) and cooler dry season (July through September) averaging 30 °C and 26 °C, respectively (D. P. Eaton and Fazenda Campo Lourdes, unpublished data).

The study area (S 19°29′–19°36′, W 55°32′–55°39′) encompassed three adjacent cattle ranches, i.e., 5700 ha Fazenda Campo Lourdes, 4400 ha Fazenda Santa Maria Pica Pau, and 2600 ha Fazenda Santa Emília. Largely related to management practices used on the ranches, the state of “cordilheira” forests (and other natural habitats) with respect to impacts from the cattle operations ranged from relatively undisturbed to highly disturbed, to absent. In the latter cases, “cordilheira” and riparian forests had been replaced recently (<10 years) with planted pastures. Within traditionally-managed sections of the ranches, where cattle were grazed on native pasture in large (typically >500 ha) enclosures for extended periods (3 months to year-round), uneven use of forage plants also caused a range of impacts by cattle herds in both pasture areas and adjacent forests and wetlands (Santos et al., 2004). In the “cordilheira” forests, cattle not only browsed and trampled understory vegetation, but also used particular sections for shade, latrines, and sleeping sites. The degree of these activities varied substantially among sections of “cordilheira” forest within the properties and within grazing enclosures, creating the array of low to high cattle-impact areas that were compared during this study.

2.2. Fruit census and choice of dominant fruiting species for camera-trap surveys

As part of a broader investigation of fruit availability for native frugivores, citizen scientists (from Global Ecotours and Earthwatch Institute) conducted monthly censuses of forest fruits from January 2006 to December 2008. They censused fruits along ten one-kilometer trails established to sample the range of forest types and conditions in the study region. Citizen scientists quantified fruit availability for ground-foraging animals by collecting fresh fruits from the forest floor within 20 randomly chosen 50 m² plots that were adjacent to census trails. All fruits from the plots were identified by project investigators and then counted and dried at 50 °C to a constant weight by citizen scientists. The census showed the monthly timing and abundance (dry mass, g m⁻²) of forest-floor fruits.

For the camera-trap surveys of forest animals, we used fruit census results to choose dominant fruiting-tree species, which we defined for each sampling period as the one or two species with the most abundant fruit fall. Camera-trap sampling periods lasted two to six weeks and occurred at intervals of two to three months over the study period from January 2007 to December 2008. After identifying dominant fruiting species for a camera-trap sampling period, we led citizen scientists on systematic searches of “cordilheira” forests to locate individual trees with an abundance of freshly fallen fruits. The areas searched were

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