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The use of fluctuating asymmetry as a measure of farming practice effects in rodents: A species-specific response

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ABSTRACT

The effects of agricultural intensification on vertebrate populations could vary depending on whether species are habitat specialists or habitat generalists. Organic farming practices are generally considered to be less intensive and more environmental friendly than conventional farming practices and, as a result, these two managements may impact on habitat specialists and habitat generalists in different ways. The effect of environmental and/or genetic stress on populations can be assessed using fluctuating asymmetry (FA) and body condition of animals. We predicted that populations of a specialist species, the Pampean grassland mouse (*Akodon azarae*) would have higher levels of FA and poorer body condition on conventional farms compared to populations of *A. azarae* on organic farms. In contrast, we predicted that populations of generalist species, the corn mouse (*Calomys musculinus*) and the small vesper mouse (*Calomys laucha*) would not show differences in FA or body condition between conventional and organic farms. We examined the expression of FA in the hind foot and used the scaled mass index as a surrogate for body condition. As predicted, we found higher FA in the habitat specialist (*A. azarae*) on conventional farms compared to organic farms, and found no differences in FA among the two generalist species (*C. musculinus* and *C. laucha*). However, we found no differences in body condition for the three studied species between the two managements. Our results suggest that the effect of farming practices on small mammals varies between habitat specialists and habitat generalists. The results of this study provide important insights for the study of asymmetries, both from biological and methodological perspectives. Our results support the idea that the level of FA may be used as an index to assess the effects of farming practices on vertebrate populations.

1. Introduction

The conversion of natural landscapes in croplands and pastures constitutes the main land cover change worldwide (Foley et al., 2005), and affects habitat quality and suitability at both local and landscape scales. Intensive use of chemical inputs, such as pesticides and fertilizers, and increased levels of disturbances at a local scale not only affects biodiversity on intensively used agroecosystems (Tscharntke et al., 2005) but also on natural landscapes (Geiger et al., 2010; Marchand et al., 2003). Contrarily, extensive farming practices, that exclude synthetic inputs, and maintain un-cropped border habitats (i.e., organic farming) provide suitable habitats for farmland biodiversity (Benton et al., 2003; Tuck et al., 2014), including plants (Roschewitz et al., 2005), insects (Holzschuh et al., 2007), birds (Beecher et al., 2002) and mammals (Fischer et al., 2011a,b; Macdonald et al., 2007). Thus, these farming practices can counteract the negative effects of agriculture intensification.

The effects of agriculture intensification on populations could vary with the degree of species' habitat specialization. Habitat specialists rely on local habitat quality and are more affected by habitat disturbance than generalist species, which are able to exploit a wider array of habitats and resources (Filippi-Codaccioni et al., 2010; Fischer and Schröder, 2014). Indeed, organic farms and their border habitats support a higher abundance of habitat-specialist small mammals (e.g., *Akodon azarae)* than conventional farms while having little influence on the abundance of habitat generalist

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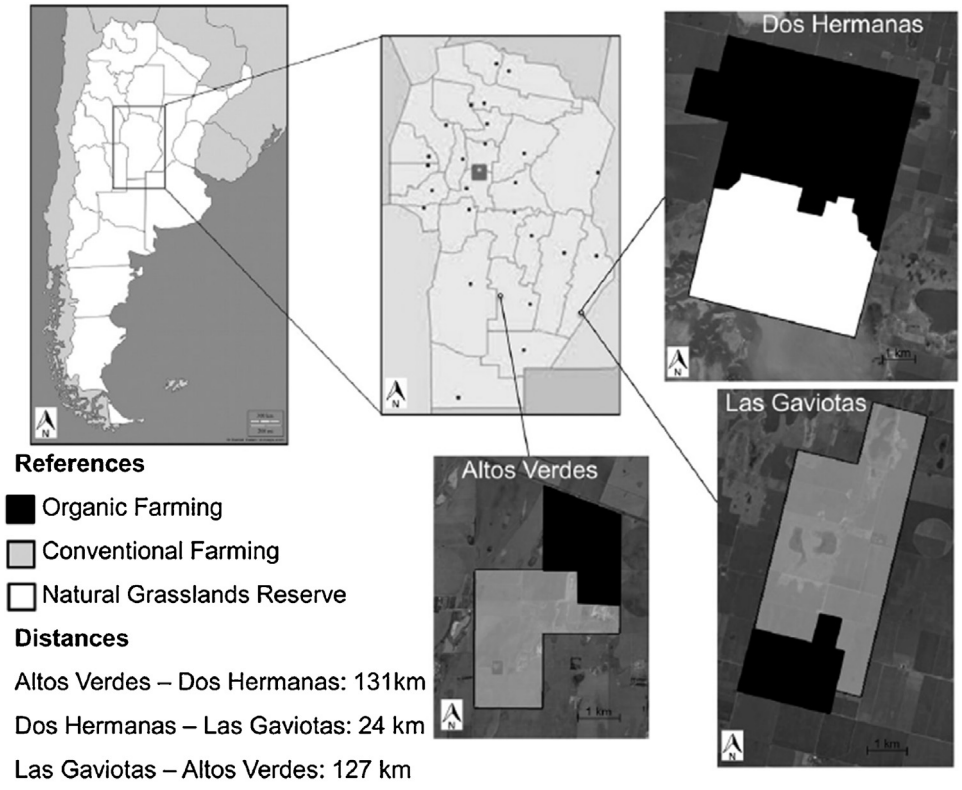

Fig. 1. Study area, agricultural systems of south-eastern Córdoba province with the three study sites (Dos Hermanas, Las Gaviotas and Altos Verdes) that include organic and conventional managements, with distances between them.

species, such as *Calomys musculinus* and *Calomys laucha* (Coda et al., 2015). Moreover, organic farms support higher female reproductive activity than conventional farms by offering high availability of shelter and food (Coda et al., 2014). Different farming practices, then, affect population parameters of small mammals.

Stress caused by agricultural processes can have detrimental effects on vertebrate populations (Marchand et al., 2003). Since developmental precision is negatively affected by a wide range of environmental and/or genetic stressors, the degree of developmental instability – an individual's inability to produce a consistent phenotype in a given environment (Zakharov, 1992) – has been suggested as a reliable indicator of population health (Cuervo and Restrepo, 2007; Lazić et al., 2013; Leary and Allendorf, 1989; Marchand et al., 2003). A frequently used metric of developmental instability is fluctuating asymmetry (FA), which is considered as the only form of asymmetry that can serve as a useful indicator of individuals exposed to environmental/genetic stress (Leary and Allendorf, 1989; Palmer and Strobeck, 1986). Fluctuating asymmetry is defined as small and random deviations from perfect bilaterally symmetrical traits (Ludwig, 1932; Palmer and Strobeck, 1986), and has been widely used to study both environmental and genetic stress (Beasley et al., 2013; Lazić et al., 2013; Leung and Forbes, 1997; Palmer, 1994; Polak and Taylor, 2007). In wild small mammals, high levels of FA are associated with habitat fragmentation (Marchand et al., 2003; Teixeira et al., 2006; Wauters et al., 1996), natural disasters (Hopton et al., 2009) and vegetation removal (Badyaev et al., 2000). Body condition of animals measured as body weight and length can also be used as individual indicators of environmental stress (Peig and Green, 2010, 2009).

In the present study we examined the degree of FA in right and left hind feet and body condition on populations of *C. musculinus*, *C. laucha* and *A. azarae*. We aim to find a reliable tool to infer local disturbance due to human activities in small mammal populations. We predicted that populations of habitat-specialists on organic farms will show lower level of developmental instability and better body condition compared to populations on conventional farms. Populations of generalist species will not show differences in FA and body condition between organic and conventional farms.

2. Materials and methods

2.1. Study area and design

This study was carried out in an agricultural landscape of south-eastern Córdoba province, Argentina (Fig. 1). Here, original flora is restricted to un-cropped border habitats that support both native and invasive herbaceous species. The most frequent crop sequences are wheat–soybean or soybean–maize (as alternate single summer crops per year with a winter fallow) although soybean monoculture as a single yearly summer crop is also a common practice (Puricelli and Tuesca, 2005; Satorre, 2005).

In this region, the small mammal assemblage is mainly represented by the Cricetidae rodents *C. musculinus*, *Calomys venustus*, *C. laucha*, *A. azarae*, *Akodon dolores*, *Oxymycterus rufus* and *Oligoryzomys flavescens* (Simone et al., 2010). Rodent species were ranked from generalists to specialists considering species-specific habitat specialization; ranging from habitat generalist (species that occur in almost all habitats within the agriculture landscape) to habitat specialist (species that occur in habitats with high vegetation cover): *C. musculinus*, *C. laucha*, *A. azarae*, *O. flavescens*, *C. venustus*, *A. dolores* and *O. rufus* (Martínez et al., 2014).

Three farms were sampled: Las Gaviotas (Postel S.A., 33°50′ S, 62°39′ W), Dos Hermanas (Rachel and Pamela Schiele Foundation, 33°39′S, 62°30′W) and Altos Verdes (Huanqui S.A., 33°18′S,