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Historical and ecological determinants of dung beetle assemblages in two arid zones of central Mexico

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ABSTRACT

This work focuses on coprophagous beetles (Scarabaeinae and Aphodiini) from two arid zones located in the center of Mexico: Barranca de Metztitlán, Hidalgo, and Zapotitlán-Salinas, in the high zone of the Tehuacán-Cuicatlán depression. The first site has a rich representation (in terms of species, individuals, and biomass) of beetle fauna from the dry Mexican Altiplano, whereas the beetles from Zapotitlán correspond to a reduced subset of the fauna from the Balsas and the middle and lower zones of the Tehuacán-Cuicatlán depression. Although flowering plants from both arid zones show the same biogeographical affinities, there is a significant contrast in the degree of endemism, with the highest plant endemism in the Tehuacán-Cuicatlán Valley, and no a single endemic species within beetles. In this work, we propose a biogeograpical-historical explanation for this contrasting phenomenon. Beetles assemblages from both zones included in this study are characterized by the marked dominance, both in terms of individuals and biomass, of one species of the genus *Canthon*. Success of the dominant *Canthon* species can be explained by their thermoregulation mechanisms, whereas dominance of other medium-sized species could be associated with the availability of trophic resources as a result of anthropic influence.

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1. Introduction

In central Mexico, arid zones originate from an "orographic shadow" effect produced by the Sierra Madre Oriental that prevents humidity from the Gulf of Mexico from reaching these areas. These environmental conditions coupled with the geographic isolation of the area have resulted in a flora that, although with strong Neotropical affinities, presents a high degree of endemism. In general, flowering plants in the Mexican xerophytic region (Rzedowski, 1978), including both arid zones studied in this work, have an endemism of 50–75% at the species level (Rzedowski, 1978, 1991, 1993). However the amount of endemic regional fauna does not follow the same pattern as in the plants, and cannot be generalized. The available literature examining levels of endemism for coprophagous beetles seems to indicate *a priori* a very different scenario from that of the flowering plants. Although the composition of the assemblages also has a strong Neotropical affinity, the number of endemics is practically zero.

It is worth noting that although throughout the Mexican Altiplano, including arid zones, there are a number of flowering plants and insect groups with Neotropical affinities. In addition, there are also older elements of Septentrional origin whose speciation has occurred in the Altiplano. This dual biogeographical association (Neotropical and Septentrional) is shared between the Altiplano and the wide contact and superposition zone found between the Nearctic and Neotropical regions described by Halffter as the Mexican Transition Zone (1964, 1976 and 1987).

The Biosphere Reserves of Barranca de Metztitlán (Hidalgo) and Tehuacán-Cuicatlán (Puebla-Oaxaca) (Fig. 1) share climatic conditions but have different biogeographic histories. Coprophagous beetles of Metztitlán comprise a rich representation of fauna from the Mexican Altiplano, especially the drier northern and western zones. On the other hand, the Reserve of Tehuacán-Cuicatlán (near Zapotitlán-Salinas) has a far lower diversity of beetles found in the Balsas and the medium and lower zones of the Tehuacán-Cuicatlán depression. The main difference between the assemblages of beetles from the Altiplano and those of the Balsas and Tehuacán-Cuicatlán depressions is the former (both of Neotropical and Septentrional affinities) is comprised of species evolved *in situ*, whereas the dominant species of the latter are Neotropical elements having

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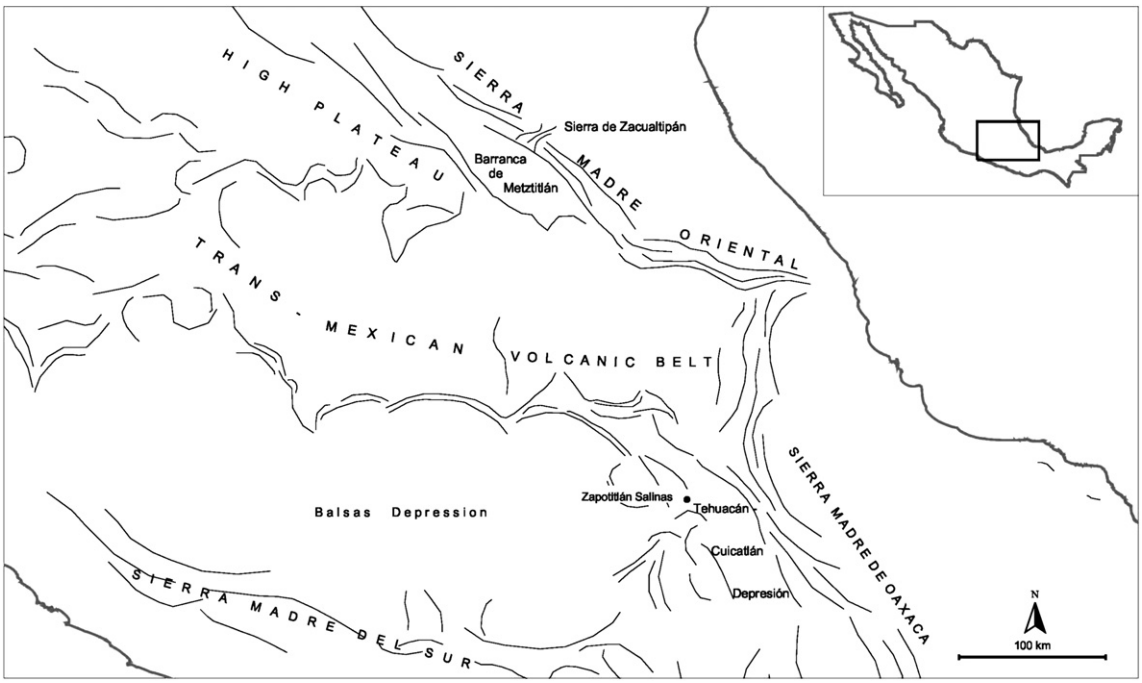

Fig. 1. Map with the locations of Metztitlán and Tehuacán (Zapotitlán-Salinas).

arrived more recently to the Mexican Transition Zone, and thus have closer affinities to Central and South American faunas.

Another potential explanation for the composition and structure of both beetle assemblages is the anthropic effect, as a high human density has characterized central Mexico since Precolombine times, with a further significant impact to the soil after European colonization (Cook, 1949). The higher zones of the Tehuacán-Cuicatlán depression are a prime example of this old anthropic effect, as it is documented that beginning at least 900 years ago, the incremental increase in agricultural activity (mainly of maize) resulted in a higher demographic density causing significant soil erosion (McAuliffe et al., 2001). Beginning with the European colonization and continuing to the present day, agricultural activities, mainly through the introduction of cattle, have continued to transform the arid and semiarid landscapes of central Mexico. Nowadays deforestation caused by carbon production, sheep overpopulation, and feralization of domestic animals such as donkeys, further modify the vegetation structure of both Biosphere Reserves, potentially leading to changes in the diversity of several groups of organisms.

This study compares both arid zones of Barranca de Metztitlán and Tehuacán-Cuicatlán in order to compile data to aid in understanding the mechanisms behind the formation and evolution of dung beetles assemblages. Thus, our objectives were to a) describe the richness and the composition of dung beetles assemblages in both arid zones; b) compare guild structure, as well as, species abundance and biomass; c) analyze similarities and differences between both assemblages in order to find the patterns behind the formation and evolution of faunas in the arid zones of central Mexico; d) discuss the possible anthropic factors influencing changes in the assemblages.

2. Material and methods

2.1. Description of the study areas

Barranca de Metztitlán (Fig. 1) forms part of the Altiplano province within the Mexican xerophytic region (Rzedowski, 1978). The Eastern boundary is delimited by the Sierra de Zacualtipán, forming a rain shadow that prevents humidity from the Gulf of Mexico from reaching this arid area. Barranca de Metztitlán opens to the NW extreme of the arid Mexican Altiplano, a fact that may explain the great influence this area has on the scarab fauna of Barranca de Metztitlán (Halffter et al., 2008).

Our study area lies between 1300 and 1800 m.a.s.l., and has an average annual precipitation of 500 mm, and an average annual temperature between 18 and 22 °C. The vegetation is characterized by two main shrub types: premontane shrubland (1600–1800 m.a.s.l.) and crassicaule scrubland (1300–1700 m.a.s.l.). Premontane shrubland is characterized by *Agave diformis, Agave striata, Agave lechuguilla*, and several species of the genera *Mimosa, Senna, Krameria, Neopringlea, Ipomoea, Cnidoscolus*, as well as isolated individuals of *Yucca filifera*. Cassicaule scrubland (1300–1700 m.a.s.l.) is dominated by *Isolatocereus dumortieri*, a tall columnar cactus endemic of Mexico, plus some other species such as *Fouquieria splendens*, *Agave xylonacanchta, A. striata*, *Y. filifera*, *Prosopis* sp., *Bursera* sp., *Opuntia leucotricha*, *Myrtillocactus geometrizans*, and *Acacia* sp. In the hotter, more humid areas it is also possible to find tropical deciduous forest, which as the name suggests, loses its leaves during the dry season (from November to March), and is dominated by *Bursera morelensis* and *Prosopis laevigata*, plus several species of cacti and succulents such as *Mirtillocactus geometrizans* (garambullo), *Cephalocereus senilis* (viejito), *I. dumortieri* (órgano cimarrón), *Opuntia* sp., *Marginatocereus marginatus*, and *Agave xylonacantha* (CONANP, 2003).

Within the Mexican xerophytic region, the Tehuacán-Cuicatlán depression (Fig. 1) represents a characteristic biogeographical province (Tehuacán-Cuicatlán floristic province, Rzedowski, 1978). The flora of this province has affinities to the Balsas depression, and together these two provinces constitute an arid region on the leeward slopes of the Sierra Madre Oriental and Sierra Madre de Oaxaca (Montaña and Valiente-Banuet, 1998). The Tehuacán-Cuicatlán depression is bordered to the east by the Sierra Mixteca, to the west by the Sierra de Zongolica, to the north and center by the Sierra Mazateca, and to the south by the Sierra de Juárez (Fig. 1). Our area of study lies between 1500 and 1830 m.a.s.l, with an annual average precipitation of 380 mm and an average annual temperature of 21 °C.

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