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Response of lepidopteran herbivore communities to crop management in coffee plantations

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ABSTRACT

Although the conservation potential of low input coffee plantations has been widely proved, the effect of management intensity on insect herbivores and particularly caterpillar communities has been scarcely studied. We used a management intensity quantitative index to assess changes in leaf damage, abundance of all herbivores and caterpillar species richness, abundance, evenness and community species composition along a management intensity gradient in coffee plantations.

There was no correlation between management intensity and the abundance of all herbivore guilds, but there was a negative relationship between management intensity and caterpillar abundance and species richness. Management intensity was positively related to caterpillar species evenness but did not influence species composition, which was rather influenced by climatic seasonality. We found 202 lepidopteran morphospecies, of which 128 fed on coffee plants. Despite a greater caterpillar abundance and richness, mean leaf damage to coffee plants was lower in plantations with a low management intensity index. Overall, we suggest that low and intermediate management intensity and the preservation of a diverse shade canopy can contribute to the conservation of Lepidoptera, without representing significant amounts of leaf damage to coffee plants.

1. Introduction

Conventional intensified agriculture is ecologically unstable and represents a threat to biodiversity (Altieri, 1999). In contrast, low input management and alternative practices maintain certain ecological processes necessary for biodiversity conservation (Altieri, 1999). This kind of agriculture is especially important for conservation in fragmented landscapes (Perfecto and Vandermeer, 2002). In this context, coffee is a relevant crop for biodiversity conservation in the Neotropics, because many of the rustic polyculture systems of coffee production preserve a great diversity of tropical forest species. In particular, their conservation potential increases as the canopy cover resembles the original forest (Méndez et al., 2010).

There is a continuous spectrum of management practices and intensity in coffee plantations, from rustic polycultures to sun coffee monocultures (Moguel and Toledo, 1999). Management practices include the use of external inputs such as fertilizers, insecticides and fungicides of both inorganic and organic origin. In addition, management of shade trees ranges from conservation of the original canopy cover, selective pruning and the introduction of commercial shade species, to the complete removal of native vegetation, exposing coffee plants directly to the sun. The use of external inputs and the degree of vegetation structure modification, however, do not necessarily covary, and thus management intensity is difficult to assess (Hernández-Martínez et al., 2009). The original classification proposed by Moguel and Toledo (1999) establishes five categories based on management

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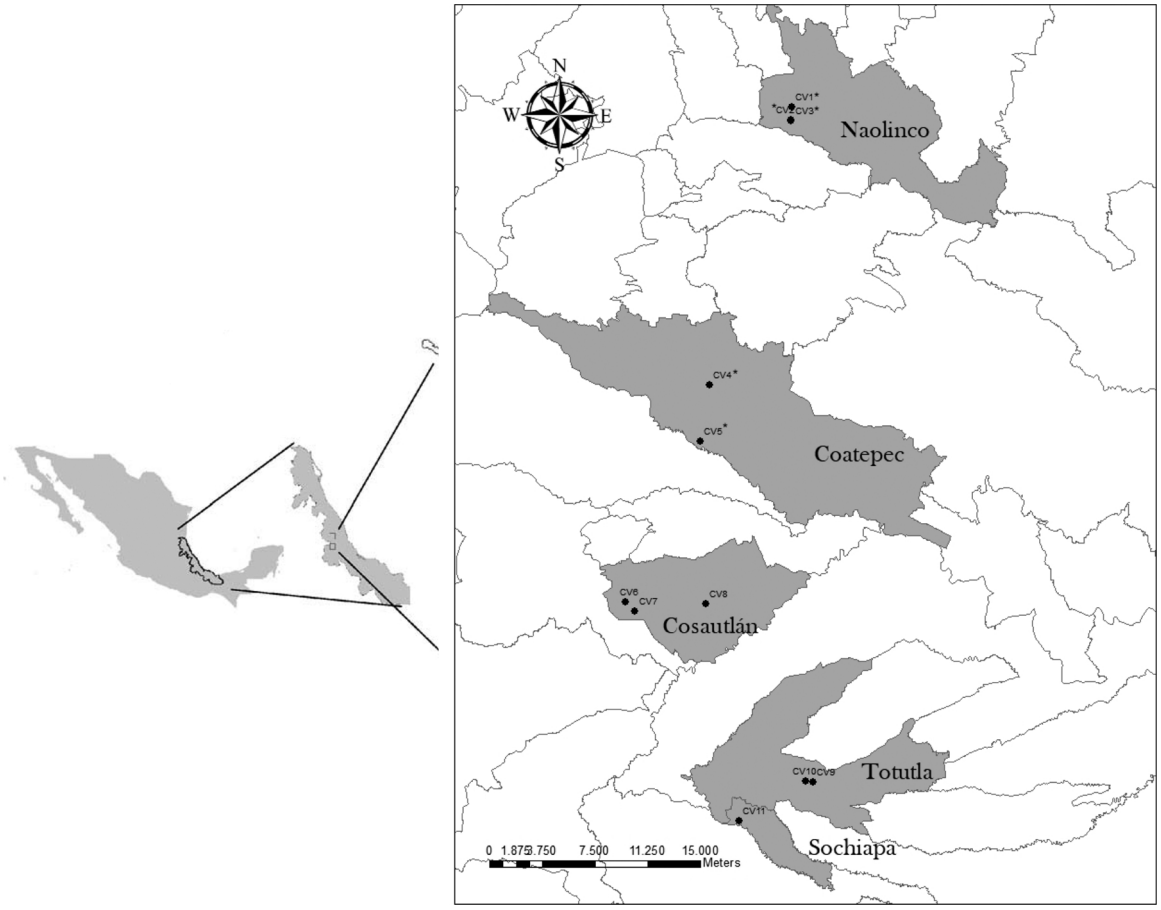

Fig. 1. Location of the 11 coffee plantations (dots) within the five municipalities in Veracruz, Mexico, where the study was carried out. * Indicates plantations selected for the study of caterpillar communities. Totutla and Sochiapa conform the Huatusco region.

level and vegetation structure complexity: two categories include traditional shaded agroforests with native trees, the third includes shaded crops with commercial species and the last two consider shaded and unshaded monocultures (Moguel and Toledo, 1999). However, this classification uses only qualitative methods to determine the category of the productive system, is based on the assumption of a correlation between external inputs and the degree of vegetation modification and is not consistent in the selection of indicators (Hernández-Martínez et al., 2009). Alternatively, Hernández-Martínez et al. (2009) proposed to assess management intensity with a quantitative index including vegetation structure variables (percent canopy cover, mean height and richness, shade tree abundance, among ohers) and other management practices such as conventional or alternative fertilization, as well as pest and weed control. Hence, it represents a better alternative to the qualitative classification of Moguel and Toledo (1999).

In coffee cropping systems, like in any other agroecosystem, management practices influence biotic interactions and ecological processes that are linked to productivity, soil fertility, pest control and the conservation of local biodiversity (Moguel and Toledo, 1999; Thébault and Fontaine, 2010). For example, arthropod communities are commonly affected by the use of pesticides and also by the reduction of vegetation structure complexity, leading to changes in plant-animal interactions such as pollination and herbivory (Isaacs et al., 2008). Herbivory is particularly important for agriculture and farmers because it can produce significant crop yield losses. In fact, it has been estimated that annually, herbivore damage causes the loss of one fifth of the worlds agricultural production (Sallam, 2005). Over 900 herbivores have been reported to feed on coffee crops, and 31 caterpillar species have been registered as significant coffee pest in the American continent (Barrera, 2008). However, in shaded coffee plantations, only few herbivores seem to represent serious pest problems, including the berry borer (*Hypothenemus hampeii*) and the coffee leaf miner (*Leucoptera coffeella*). In addition, crop management can also affect higher-level species interactions. For example, evidence supports that, in shaded coffee plantations bird predation effectively reduces herbivore populations and this could explain why there are few pest outbreaks (Greenberg et al., 2000; Johnson et al., 2009). Understanding how coffee management practices affect herbivore communities can help to design strategies to keep pests controlled while assuring the conservation of arthropod diversity of tropical wet and mountain forests.

The Lepidoptera is a particularly interesting group to study the effects of crop management in tropical ecosystems, as it represents an important component of biodiversity including both pollinators and herbivore guilds (Bawa, 1990; Dyer et al., 2007). Whereas the influence of different management practices has been assessed for pollinators (Klein et al., 2003; Ricketts, 2004; Vergara and Badano, 2009; Boreux et al., 2013), no information is available on how management intensity affects caterpillar communities and the damage they produce on coffee crops. The aim of this study was to evaluate changes in caterpillar community diversity and composition and the damage they cause to coffee leaves along a management intensity gradient. Based on what was found by Borkhataria et al. (2006) and Perfecto et al. (1997) we hypothesized that if agrochemicals and vegetation structure complexity affect insects like caterpillars, then their abundance and species richness should decrease with increasing management intensity. Second, if herbivores, and particularly caterpillar abundance is reduced with the use of external inputs and a decrease of vegetation structure complexity, then foliar damage should decrease along a management intensity gradient.