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Early succession arthropod community changes on experimental passion fruit plant patches along a land-use gradient in Ecuador

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ABSTRACT

Many tropical landscapes are today characterized by small forest patches embedded in an agricultural mosaic matrix. In such highly fragmented landscapes, agroforests have already been recognized as refuges for biodiversity but few studies have investigated the potential of non-forested land-use types to contribute to overall biodiversity of functionally important taxa in the tropics. This study experimentally investigated species richness, abundance, and community similarity of arthropods on Yellow Passion fruit plants, planted in standardized patches in 30 sites along a land-use intensity gradient. The gradient comprised all major land-use types of the area: forest fragments, abandoned coffee agroforests, coffee agroforests managed under shade trees, pastures, and rice fields in Coastal Ecuador. We found a total of 2123 individuals belonging to 242 species. Overall arthropod species richness increased with light intensity and leaf-surface area and decreased with land-use intensity: forest fragments and abandoned coffee agroforests harboured significantly more species than rice or pastures. Overall diversity in managed coffee agroforests was intermediate between the intensively managed and more natural habitats. However, the three most abundant taxa of arthropods (ants, spiders, and beetles) had the highest number of species in managed coffee agroforests, while ant abundance was highest in abandoned coffee agroforests and spider abundance highest in managed coffee agroforests. Analyses of community similarity revealed that open (pasture, and rice) and shaded (forest, abandoned and managed coffee agroforests) land-use types had distinct arthropod communities. In conclusion, although open agricultural land-use types tend to have fewer species in lower numbers, all land-use types contribute to overall biodiversity of the agricultural matrix because of distinct communities in shaded vs. non-shaded land-use types.

1. Introduction

Forests constitute about 30% of the terrestrial surface (FAO, 2005) and tropical landscapes are frequently characterized by a mosaic of different managed ecosystems with patches of natural forest (Schelhas and Greenberg, 1996). Efforts to conserve biological diversity worldwide have mainly focused on remnants of natural forests (Perfecto and Vandermeer, 1996; Moguel and Toledo, 1999), overlooking the fact that agroecosystems can also contribute to preserving biodiversity in these highly fragmented landscapes (Moguel and Toledo, 1999; Klein et al., 2002; Perfecto et al., 2003; Tylianakis et al., 2005, 2006). Numerous studies also emphasize managed and abandoned coffee agroforests as important refugia for biodiversity within the agricultural landscape (Moguel and Toledo, 1999; Perfecto et al., 2003; Lozada et al., 2007; Richter et al., 2007; Philpott et al., 2008; Gordon et al., 2009; Teodoro et al., 2009), however few studies have investigated the contribution of more intensive agricultural land-uses such as pastures and rice fields for biodiversity conservation.

Arthropods account for more than half of the global biodiversity (Strong et al., 1984). Landscape structure and habitat fragmentation may influence the ecology of arthropods (Hunter, 2002), which may be used as indicators of habitat degradation or umbrella species (Kim, 1993; Carignan and Villard, 2002; Bockstaller et al., 2008). Arthropods are also key functional components of the ecosystem,

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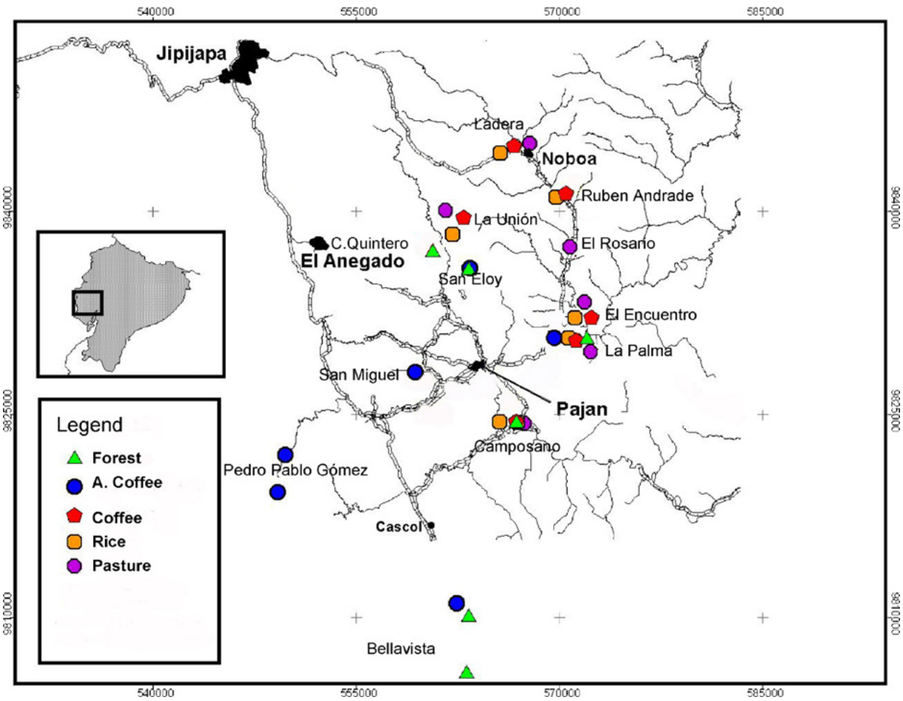

Fig. 1. Map of the study region showing location of all 30 study sites surrounding major towns. Double lines represent main highways, other lines represent roads.

acting for instance as pollinators, seed predators, natural enemies of pests, and decomposers of dung or litter (Didham et al., 1996; Nichols et al., 2008).

The western Ecuador Chocó-Darién biogeographical region is considered a global hotspot for biodiversity (Myers et al., 2000), but a large part of its original semi-deciduous forest has been converted to agriculture (mainly pastures, annual cultures, and coffee agroforests; de Koning et al., 1999). Remnants of secondary forest, which regenerated after abandonment of agricultural fields, are embedded in this agricultural landscape. Coffee agroforests were established by replacing some forest trees with fruit and timber species. Fruit tree species such as mango, orange, *citrus* sp, papaya, and avocado as well as the legume timber species *Inga* spp. and *Erythrina* spp. are the most common tree species used in the coffee agroforests. However, some forest trees may be kept by farms in coffee agroforests, which are characterized by a multilayered canopy structure (Lozada et al., 2007). Many coffee agroforests have been abandoned throughout the study region due to low economic revenues, and these abandoned agroforests currently resemble secondary forests.

Our research focuses on how arthropod communities on fruit plants, which are used by smallholders, are affected by anthropogenic habitat modification in tropical landscapes. Specifically, we examined how species richness, abundance, and community similarity of arthropods vary across a gradient of land-use intensity (natural forest, abandoned coffee agroforests, coffee agroforests, pasture, and rice). Additionally, we evaluated the influence of environmental variables on species richness and abundance, and determined changes in the composition of the arthropod community in relation to land use.

2. Materials and methods

2.1. Study region

The study was carried out on private farms located within three cantons: Jipijapa (1°19′60″ S, 80°34′60″ W), Paján (1°34′00″ S, 80°25′00″ W), and Noboa (1°24′00″ S, 80°23′00″ W), in Manabi province, Ecuador (Fig. 1). The study region was characterized by semi-deciduous forest vegetation with an annual rainfall ranging from 1500 to 2500 mm and an altitudinal range between 142 and 260 m a.s.l. The climate of the region is highly seasonal with marked rainy (June–November) and dry (December–May) seasons (Inamhi, 2002). The land in the region is mainly devoted to a range of agricultural activities, which are usually carried out in smallholder low input farms.

2.2. Land-use types

We selected five different land-use types comprising a gradient of increasing anthropogenic disturbance: 1. Forests (remnants of secondary forests with higher plant species richness in comparison to the other land-use types), 2. Abandoned coffee agroforests (former coffee agroforests abandoned for 10–15 years due low coffee prices, with few coffee shrubs remaining, and forest regeneration occurring), 3. Managed coffee agroforests (highland coffee *Coffea arabica* L. managed under a diverse canopy of shade trees), 4. Pastures (mostly saboya *Panicum maximum* Jacq as the dominant grass species), and 5. Rice fields (subsistence crop grown with relatively intensive management, including use of urea as fertilizer). Forest sites were used as a positive control for biodiversity.

2.3. Study site selection and resource plants

Six replicates of each land-use type were selected, totaling 30 study sites (Fig. 1). The study sites were usually clustered in groups of three or more land uses to avoid spatial autocorrelation within a single land-use type. We introduced Yellow Passion fruit plants *Passiflora edulis* Sims f. *flavicarpa* Degener, which was not already present in any of the sites, as a standardized resource for herbivores. Passion fruit is grown by smallholders and an experimental set up provides an opportunity to study arthropod communities assembled from the local pool of species with no history of contact with their new hosts (Novotny et al., 2003).

In each study site, we transplanted 15 seven-month old Yellow Passion fruit saplings within a rectangle of 1.5 m × 2.5 m, arranged