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Effects of Agriculture on Bee Community (Hymenoptera: Apoidea) Structure in a Mixed Orchard in Central Mexico

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Abstract: The structure of the bee community was studied at a mixed fruit orchard in the central Plateau of Mexico. The species richness found for the community was low. The bee species abundance has a log normal truncated distribution, when all flower visitors are taken into account. The low diversity of bee pollinators sampled from a fruit orchard in the Central Plateau of Mexico is the direct effect of agricultural practices that has occurred in the region for the last 2,000 years. The reasons for these patterns are discussed and recommendations for future research are given.

Key words: Bees, pollination, diversity, mixed orchards, central Mexico

INTRODUCTION

Traditional Mexican fruit orchards are special types of agroforestal systems characterized by high biodiversity and richness, similar to that of natural ecosystems[1].

A particular type of fruit orchard is found in the Central Plateau of Mexico. In these orchards fruit tree species of Eurasian origin, such as apples, pears and peaches are planted intermingled with annual native crops, such as pumpkin, squash, gourds and several species of beans.

There is no information on the pollinators of these fruit orchards, except for the study of Búrquez and Sarukhán[2] on the pollinators of wild and cultivated populations of scarlet beans (*Phaseolus coccineus*). Dramatic declines in managed and feral honey bees have been reported for the US., Mexico and Canada[3], but data on the status of wild invertebrate pollinators are lacking[4]. This fact precludes the assessment of a suspected pollinator loss, which has been documented in other parts of the world.

Biodiversity measures have been used to assess the effects of habitat perturbation on different animal communities. For example, Nestel *et al.*[5] found that the diversity of soil Coleoptera belonging to nine families was greater in shaded than in unshaded coffee agroecosystems in Veracruz (Mexico) and that scarabeid beetles were strongly affected by the degree of forest perturbation. Kevan *et al.*[6] found that blueberry fields in New Brunswick, Canada, unaffected by the pesticide feniotrothion fitted well to the log-normal model of species diversity and abundance, whereas affected fields did not fit the same model.

MATERIALS AND METHODS

Study site: The study was carried out in a mixed orchard located in Huejotzingo, Puebla at N19°10′02′′ W98° 23′27′. The climate in the study area is transitional between the semialpine climate prevalent in the Sierra Nevada (Popocatepetl-Ixtaccihuatl volcanoes) and the temperate climate of the Valley of Puebla, with summer (May-October of every year) rains, cool summers, an average annual temperature of 15.7°C and annual rain fall of de 868.2 mm[7,8].

Plants: The plants observed during the study are grouped under three categories:

Fruit trees: Criollo varieties of *Prunus domestica* (plum), *Prunus persica* (peach), *Pyrus malus* (apple), *Pyrus communis* (pear) which are introduced species and the native *Prunus serotina* (capulín).

Native cultivated annuals: *Phaseolus vulgaris* (Common bean), *Phaseolus coccineus* (scarlet runner bean) and *Cucurbita pepo* (squash).

Native weeds: *Simsia amplexicaulis* (), *Bidens odorata* (acahual blanco), *Lopezia racemosa* (perita), *Dalea leporina*, *Sycyos deppei* (chayotillo) and *Viguiera* sp. (acahual).

Bee censuses: Bee censuses were performed on all plant species during 1995 and 1996, according to the following protocols:

Table 1: Bee counts for all plant species

Family	Subfamily	Species	Total of bees	Trees total	Annuals total	Weeds total
Colletidae	Colletinae	*Colletes bombiformis*	20			20
		Colletes compactus	2			2
Andrenidae	Andreninae	*Andrena (Callandrena) zerifera*	2			2
		Andrena (Celetandrena) vinnula	3			3
		Andrena sp.	7	1		6
		Megandrena sp.	4			4
	Panurginae	*Heterosarus (Pterosarus)* sp. 1	3			3
		Heterosarus (Pterosarus) sp. 2	1			1
		Heterosarus (Pterosarus) sp. 3	3			3
		Heterosarus (Pterosarus) sp. 4	1			1
		Perdita sp.	4			4
		Protandrena sp.	3			3
Halictidae	Halictinae	*Lasioglossum (Lasioglossum)* sp.	1		1	
		Lasioglossum (Dialictus) sp.	1		1	
		Paragapostemon coelestinus	20	4		16
		Halictus ligatus	1	1		
Melittidae	Dasypodinae	*Hesperapis (Disparapis) n.* sp.	90			90
Megachilidae	Megachilinae	*Megachile* sp.	7			7
Apidae	Anthophorinae	*Anthophora marginata*	11			11
		Peponapis pruinosa	1147		1147	
		Thygater sp. 1	281		281	
		Thygater sp. 2	709		709	
		Thygater sp. 3	27			27
		Xenoglossa fulva	41		41	
		Centris sp.	10		10	
	Apinae	*Apis mellifera*	1680	859	804	17
	Bombinae	*Bombus ephippiatus*	6			6
		Bombus pennsylvanicus	7		4	3
		Total	4092	865	2998	229
		Number of species	28	4	9	20
		H'	1.55	0.047	1.37	2.21

Introduced fruit trees: Once a week, during the blooming season of each species 10 min censuses were carried out every hour from 9:00 through 18:00, on observation quadrants of 0.4 x 0.7 m.

Census dates for each of the tree species were as follows:

***Prunus domestica* (plum):** March 7-March 28 (4 censuses)

***Prunus persica* (peach):** October 19-March 19 (23 censuses)

***Pyrus malus* (apple):** March 7-April 10 (6 censuses)

***Pyrus communis* (pear):** March 7-March 19 (3 censuses)

***Prunus serotina* (capulín):** December 7-February 12 (11 censuses)

Native cultivated annuals: Phaseolus vulgaris: Ten minute censuses were carried out every hour from 8:30 to 15:30 on 6 groups of 4 plants each, selected at random. The observations were performed twice a week during 5-weeks from June 18 to July 23.

***Phaseolus coccineus*:** The same methodology described above for *P. vulgaris* was used. Censuses were performed between June 11 and July 23.

***Cucurbita pepo*:** Censuses were carried out on 12 plants selected at random, twice a week during 7 weeks form June 21 to August 13. Ten minute censuses were repeated every hour from 8:30-12:30, when the flowers closed.

Weeds: Ten censuses were carried out on weeds: Three on October 15, 19 and 31, 1995 and seven on October 13, 16, 19, 22, 25, 28 and 31. On each of the dates indicated above all five weed species were surveyed. Ten minute censuses were carried out every hour on 0.7 x 0.7 m quadrants. Every quadrant contained flowers of only one weed species.

Voucher specimens of the bees observed as flower visitors were collected, pinned and deposited at the Entomological Collection of the Universidad de las Américas-Puebla. These specimens were determined to species by R. W. Brooks, Natural History Museum, University of Kansas. Bees of the genus *Hesperapis* were determined by Roy R. Snelling, Department of Entomology, Natural History Museum of Los Angeles Country.

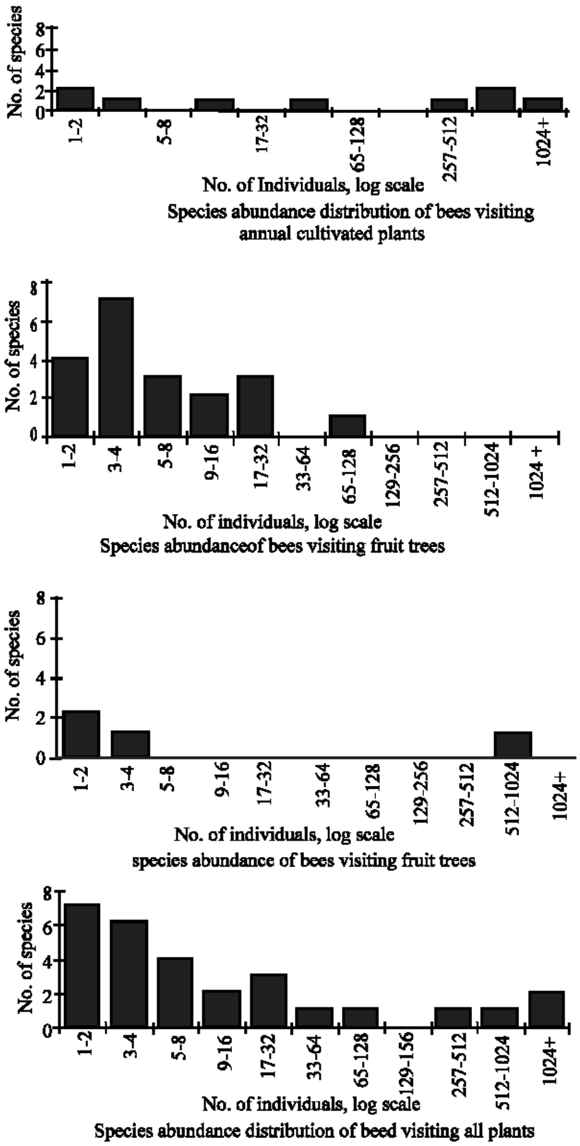

Fig. 1: Species abundance distribution histograms for each of the plant categories and for all plants pooled

Data analysis: A list of species was compiled and together with the number of individuals surveyed, used for further calculation of Shannon diversity indexes at three levels: general, for bees found on all plants; by plant category (trees, cultivated annuals and weeds) and by plant species.

The Shannon Index (H′) was calculated using Eq. 1:

$$H' = -\sum p_i \ln p_i \qquad (1)$$

Where, pi is the proportion of individuals found in the ith species.

Species abundance and diversity: Species abundance data, expressed as octaves, were plotted against number of species per octave to describe graphically the distribution of the abundance of species. The overall distribution of species abundance was fitted to a truncated log normal model, following Magurran[9].

RESULTS AND DISCUSSION

Table 1 presents the number of each of the 28 bee species found as floral visitors of the 14 plant species surveyed during the study. For each bee species, the numbers of individuals observed visiting each plant species is given, as well as the total number of bees and the number of bee visitors for each category of plant (trees, annuals and weeds). Also, Table 1 gives the total number of bee species and the number of bee species for each plant category.

Only the species abundance distribution for all plants pooled fits a truncated log normal and is described by this model at a probability of $P \simeq 0.75$ (χ^2 =4.96; 8d.f.) (Fig. 1).

The species richness (number of species) found for the orchard studied here, could be regarded as low, since the site is located within the altiplano sur region, considered as the second most diverse area in Mexico, after the xeric regions of the Mexican deserts[10]. This apparent lack of diversity may be explained by the fact that agriculture has been practiced in the region for at least the last 2,000 years and there are no remnants of the original vegetation in a very extensive area around the study site.

Deforestation and agricultural practices such as tillage, probably limit the availability of nesting sites both for soil nesting and plant nesting bees. Expected soil nesting genera are either underrepresented, as are the cases of the genera *Colletes*, which is represented only by two species in the sample and *Andrena*, represented by 3 species, or absent like *Mexalictus*, *Deltoptila* and *Hylaeus*, The same situation occurs with the plant nesting species, with only one species of *Megachile* and Osmiinae and *Anthidium* not represented. On the other hand, *Paragapostemon*, which is an endemic monotypic genus, is well represented and contrary to previous conceptions[11], females of *P. coelestinus* visit and collect pollen from a variety of plants, including plum and three species of weeds. Also, females are active during the daytime and not infrequently found, at least in the study area. Although the nesting biology of *P. coelestinus* is unknown, it is likely a soil nesting species.

An undetermined number of bee species could have been overlooked during the censuses due to several reasons. Different species of small bees, especially *Lasioglossum*, *Heterosarus* and to some extent, *Perdita*, are very difficult to tell apart, even upon examination of dead pinned specimens under the microscope.

Also, the survey was carried out during daytime and no matinal or crepuscular species were recorded.

Despite all the limitations of the methodology used, even if the total number of species recorded were to double the actual number recorded the diversity is not as high as that of other studies carried out in small areas in Mexico[12,13].

When all the bee species are taken together, the species abundance distribution fits a truncated log normal distribution. Bearing in mind that the results presented here represent sampling of only one season, obtaining this type of distribution was expected. The interesting observation is that when bee species abundance distribution is split into three components, according to the type of plants visited, none of the components can be fitted to a particular type of abundance distribution. These facts suggest that the bee community found in the orchard studied functions as a unit only when all the flowering plants present in the area are considered. Since most of the bee diversity (20 species in total, 16 of which exclusively visit weeds) was found visiting the weeds the role of these plants in maintaining the diversity in this type of agroecosystem is extremely important.

Long term comparisons between the bee fauna of orchards as the one studied here, abandoned orchards and areas of preserved vegetation in the same area will provide information on the potential bee species richness of a given landscape and on the decline in diversity associated with the agricultural practices common in that area.

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