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Boundaries of Alfalfa Field and Their Function as Refuge for Butterfly (Lepidoptera: Rhopalocera) Communities

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Simple Summary: Protected areas are insufficient for preserving flora and fauna from danger. However, some agroecosystems can serve as alternative sites of refuge and conservation of species diversity, mainly for insects. Butterfly species are after bees, the second most important pollinators. Some environmental conditions in agricultural areas can favor butterfly abundance and diversity. So, we characterized the vegetation on the edges of *Medicago sativa* farms in central Mexico and identified the species of diurnals butterflies associated. We found a high diversity of butterflies and most than half of the plant species were native flora of central Mexico, with ethnobotanical use. Six butterfly species were migratory and four mexican endemic species. The high diversity of the native vegetation and the positive correlation between butterflies and plant species, despite intensive crop management system, are probably the factors that generate most of the resources needed for a rich butterfly community, which includes migratory and endemic species. The results of this study suggest crop fields can provide refuge for butterflies as well as other benefits derived from the use of edge plants.

Abstract: Farmland edge plants can support high butterfly richness. Our objective was determine if, even in farms under intensive cultivation, the diversity of plants (mostly native) in crop edges is enough to sustain a high species richness of butterfly. We characterized the vegetation on the edges of *Medicago sativa* farms in central Mexico and identified the species of diurnals butterflies (Rhopalocera) associated. Butterflies and plants were counted along transects at the edges of a cultivated field during 24 months. We found 2710 individuals of plants, belonging to 48 different species from 24 families; 1749 individuals of diurnal butterflies, belonging to 57 species from six families. Most than half of the plant species found were native flora of central Mexico and with ethnobotanical use. A similarity analysis test showed significant differences in floristic composition between transects. The Canonical Correspondence Analysis between butterfly species and plant families showed three groups. Six butterfly species were migratory and four mexican endemic species, most of them associated with a group formed by Amaranthaceae, Euphorbiaceae, Annonaceae Lamiaceae Apiaceae and Fabaceae families. The high diversity of plants in our agro-ecosystem plays an important role to sustain a high diversity of butterflies and could be useful as biological corridors.

Keywords: diurnals butterflies; farmland; edges flora; migratory butterflies

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1. Introduction

Some agro-ecosystems have a high diversity of insect species that take refuge in the edges of crop fields, which are formed by native vegetation or by an array of different crops [13,16,41]. Many studies [10,37,38,40,41,52] have reported that the structure and diversity of plants associated with farmland can support a high richness of butterfly species, which are, after Hymenoptera, the second most important pollinators [50]. Also, it have showed that the diversity of Lepidoptera was higher in transitional areas, located between agricultural and protected areas, because transitional areas have more flowering plants [6,23,32]. Furthermore, the heterogeneity of topographic conditions, and the richness and structural complexity of plant species provide many habitats, by protection for larvae

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and nectar for adult butterflies [41,52]. Other environmental conditions and cultivation techniques can have an influence on the abundance and diversity of Lepidoptera. Many works [1,47,52,56,59] have shown that an increase in soil moisture and the presence of crop field edges formed by native vegetation lead to a greater abundance and diversity of butterflies. Although some agricultural management systems rely on the use of chemical substances, intensive use of plough and closeness to urban areas can negatively affect the abundance and diversity of butterflies [4,36]. Another negative factor is the periodical cutting of crops [12,18,46], but its effect is diminished when the cutting is performed at the end of summer, when the life cycle of butterflies is complete [64].

The natural habitats of butterflies have been rapidly disappearing in recent years, while Alfalfa (*Medicago sativa* L.) crops occupy 32, 266, 605 ha in the world and 21.5% of the agricultural land in central Mexico [48]. Also, agricultural intensification through landscape homogenization is the main drivers of the butterflies diversity declines [19]. Therefore, the aim of this study is to determine that, even in farms under intensive cultivation, the diversity of plants (most of them native) in crop edges is enough to sustain high species richness and give refuge to endemic and migratory butterfly species.

2. Materials and Methods

Study site. The study was carried out in a *Medicago sativa* crop located in the state of Puebla (18°52′32′′ N and 98°25′51′′ W; 1686 m.a.s.l.) in Central Mexico. The climate is mainly temperate, with summer rainfall. The annual precipitation ranges from 700 to 1000 mm and the temperature ranges from 18° to 21° C. The soils are mostly Feozems and Fluvisols, which are good for agriculture. The original vegetation was dominated by woodlands in which *Pinus* species were associated with *Abies religiosa* (Kunth) Schltdl. & Cham or *Quercus* sp. [14]. Today, a high proportion of the land surface has been converted to farmland for growing corn, beans and lucerne. Small woodland areas remain in the northern and northwestern parts of the state, containing native vegetation.

Collection of butterflies and plants. Butterflies and plants were counted for five days every month, during 12 months, along four transects (300 m each one) in the edges of a cultivated field. Twenty-three Van Someren Rydon butterfly traps were set along each transect [61]. The traps were placed at 1.30 m from the ground, at 50 m from each other. We also collected butterflies manually using entomological nets. Temperature, relative humidity and wind speed were recorded using a pocket weather tracker (Kestrel 4000, Niels-Kellerman Co., Boothwyn). The butterflies were preserved in ethanol (70%). The plants surrounding each trap (an area of 1 m x 1 m) were counted, collected and dried at 35 °C. Butterflies and plants were identified using taxonomic keys.

Data analysis. A Simpson index [42] of diversity was calculated for both plants and butterflies, and the diversity and abundance between transects was compared using a Kruskal Wallis test. The similarity in the composition of plant species between transects was analyzed using a Jaccard index [33]. A similarity analysis test (ANOSIM [5]) was used to identify significant differences in floristic composition (software PAST v.1.15 [25]). A species accumulation curve was obtained by the nonparametric estimator Chao 1, to determine the sampling efficiency of butterflies [34], using EstimateS v. 9.1.0 [8]. Environmental variables (temperature, relative humidity and speed of wind) were compared between transects and during 12 months using a repeated-measures ANOVA [24]. A Canonical Correspondence Analysis (CCA [35]) was used to evaluate the effect of environmental variables on the butterfly community, and the relationship between different plant families and the butterfly species under study (software MVSP v. 3.12c [39]). The results were then subjected to a correlation analysis between plant and butterfly species (software NCSS 2001 [30]).

3. Results

3.1. Abundance and diversity

We found 2710 plant specimens belonging to 48 species and 24 families (Table 1). Most than half of the plant species found (58 %) are native flora of Central Mexico, and 91.66% of them have ethnobotanical use. The Simpson's diversity index showed no significant differences between transects, but the Jaccard index showed that the similarity in species composition was very low and

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the ANOSIM test showed significant differences in floristic composition (R= 0.042, p= 0.051, 9,999 permutations; α<0.10). Only 13 plant species were shared between transects.

Table 1. Abundance and ethnobotanical use [60] of plant taxa found in the edges of a Medicago sativa field in central Mexico. *Species native to Mexico [62,63]. (-)No ethnibotanical use registered.

Families	Taxa	Abundance	Ethnobotanical use
Apiaceae	*Foeniculum vulgare*, Mill., 1768	3	curative and comestible
Asteraceae	**Aldama dentata*, La Llave, 1824	19	forage
	**Bidens odorata*, L., 1753	32	curative, forage and comestible
	**Galinsoga parviflora*, Cav., 1796	4	forage
	**Sanvitalia procumbens*, Lam., 1792	13	curative and ornament
	Taraxacum officinale, F.H.Wigg., 1780	56	curative, forage, comestible, and melliferous
Brassicaceae	**Lepidium virginicum*, L., 1753	6	curative, forage and comestible
	Nasturtium officinale, W.T. Aiton, 1812	4	curative and comestible
Amaranthaceae	*Alternanthera* sp., Forssk, 1775	40	--
	Chenopodium album, L., 1753	4	Curative
Phytolaccaceae	**Phytolacca americana*, L., 1753	3	curative, comestible, ornament and to colour
Polygonaceae	**Persicaria hydropiperoides*, (Michx.) Small, 1903	2	curative, forage and to colour
	Rumex conglomeratus, Murray, 1770	8	curative and comestible
Commelinaceae	**Commelina diffusa*, Burm.f., 1768	60	curative, forage and ornament
Fabaceae	**Erythrina coralloides*, Moc. y Sessé ex DC., 1825	1	curative, comestible, ornament and artisan
	Melilotus albus, Medik, 1786	2	forage and melliferous
	Medicago lupulina, L., 1753	31	forage and melliferous
	**Vigna luteola*, (Jacq.) Benth., 1859	3	curative and comestible
	Trifolium repens, L., 1753	586	forage and comestible
Lamiaceae	*Leonotis nepetifolia*, (L.) R.Br.,1811	56	curative, ornament and melliferous
	**Salvia mexicana*, L., 1753	4	forage, comestible, ornament and melliferous
	**Salvia longistyla*, Benth, 1833	93	Curative
Lauraceae	**Persea americana*, Mill., 1768	5	curative and comestible
Annonaceae	*Annona cherimola*, Mill., 1768	2	comestible and combustible
Euphorbiaceae	**Euphorbia heterophylla*, L., 1753	2	curative
	Ricinus communis, L., 1753	74	curative
Malvaceae	**Anoda cristata*, (L.) Schltdl., 1837	6	curative, forage, comestible and ornament
	**Kearnemalvastrum lacteum*, (Ait.) D.M.Bates, 1967	2	curative, and forage
	Malva parviflora, L., 1753	9	curative, forage and comestible
	**Sida haenkeana*, C.Presl, 1835	32	--
Lythraceae	**Cuphea angustifolia*, Jacq. ex Koehne, 1877	8	curative
Myrtaceae	**Psidium guajava*, L., 1753	5	curative, forage, comestible, artisan, to colour and combustible
Onagraceae	**Oenothera rosea*, L´Hér. ex Ait., 1789	70	Curative and ornament
Oxalidaceae	**Oxalis corniculata*, L., 1753	98	curative, forage, comestible and ornament
Poaceae	*Arundo donax*, L., 1753	37	curative, forage, artisan and construction
	Bromus carinatus, Hook. & Arn., 1840	6	forage and comestible
	Chloris gayana, Kunth., 1829	1096	forage
	**Ixophorus unisetus*, (J.Presl) Schltdl.,1861	44	forage
	**Setaria parviflora*, (Poir.) Kerguélen, 1987	28	forage
Pteridaceae	*Adiantum sp*., L., 1753	10	-
Loranthaceae	**Psittacanthus calyculatus*, G.Don, 1834	1	curative and artisan
Anacardiaceae	*Schinus molle*, L., 1753	1	curative, forage, comestible, to colour, combustible and construction
Convolvulaceae	**Ipomoea purpurea*, (L.) Roth., 1787	28	curative and ornament
Solanaceae	**Physalis philadelphica*, Lam., 1786	2	curative, forage and comestible
	**Solanum americanum*, Mill., 1768	4	curative, comestible and melliferous
	**Solanum lanceolatum*, Cav., 1795	17	curative, forage, comestible, and melliferous
	Solanum sp., L., 1753	3	-
Cannaceae	*Canna indica, L., 1753*	90	comestible, ornament and artisan
24	**48**	**2710**	

We collected 1749 butterfly specimens belonging to 57 species and 6 families (Table 2). We found four Mexican endemic species Hamadryas atlantis Bates, Phyciodes pallescens Felder, Chlosyne ehrenbergii Geyer and Anthanassa sitalces Hall; six migratory species, Ascia monuste L., Smyrna blomfildia Fabricius, Eurema daira Godart, Eurema proterpia Fabricius, Vanessa atalanta Frühstorfer and Danaus plexippus L. and a species typical of woodland: Morpho polyphemus Westwood.

Table 2. Abundance and feeding guilds of the butterfly taxa (Lepidoptera: Rhopalocera) found in the edges of the Medicago sativa field. *Endemic species of Mexico [27,45]. ** Migratory species [20], (x) presence (-) absence.

Families	Species	Abundance	Nectar feeding	Yeast feeding	Mud-puddling
Pieridae	*Colias eurytheme* Boisduval, 1852	1035	x	-	-
	Colias cesonia (Stoll,1790)	5	x	-	-
	***Eurema mexicana* (Boisduval, 1836)	2	x	-	-
	Eurema salome (Reakirt, 1866)	2	x	-	-
	***Eurema daira* (Godart, 1819)	23	x	-	x
	***Eurema proterpia* (Fabricius, 1775)	11	x	x	x
	Eurema boisduvaliana (C. Felder & R. Felder, 1865)	3	x	-	-
	Leptophobia aripa (Boisduval, 1836)	99	x	-	-
	Catasticta nimibice (Boisduval, 1836)	1	x	-	-
	***Ascia monuste* (Linnaeus, 1764)	11	x	-	-
	Nathalis iole Boisduval, 1836	22	x	-	-
	Phoebis boisdusvalii (C. Felder & R. Felder, 1861)	1	x	-	-
	Phoebis agarithe (Boisduval, 1836)	2	x	x	x
Nymphalidae	*Chlosyne lacinia* (Geyer, 1837)	20	x	-	-
	**Chlosyne ehrenbergii* (Geyer, [1833])	64	x	-	-
	Vanessa atalanta (Frühstorfer, 1909)	16	x	x	-
	Vanessa annabella (Field, 1971)	8	x	-	-
	Anthanassa texana (W.H. Edwards, 1863)	16	x	-	-
	* *Phyciodes pallescens* (R. Felder, 1869)	3	x	-	-
	Anthanassa sitalces (A. Hall, 1917)	6	x	-	-
	Agraulis vanillae (Riley, 1926)	2	x	-	-
	Anaea aidea (Guérin-Méneville,[1844])	17	-	x	-
	Dione moneta Butler, 1873	1	x	-	-
	Danaus gilippus (H.W. Bates, 1863)	2	x	-	-
	***Danaus plexippus* (Linnaeus, 1758)	15	x	-	-
	Junonia coenia Hübner, [1822]	1	x	-	-
	Asterocampa idyja (Geyer, [1828])	1	x	x	-
	Cissia similis (Butler, 1867)	1	-	x	-
	Nymphalis antiopa (Linnaeus, 1758)	3	x	x	
	Biblis hyperia (Cramer, 1779)	1	-	x	-
	***Smyrna blomfidia* (Fabricius, 1781)	1	-	x	-
	Morpho polyphemus Westwood, 1851	5	-	x	-
	**Hamadryas atlantis* (H. Bates, 1864)	1	-	x	-
	Cyllopsis sp. R. Felder, 1869	14	x	x	-
Papilionidae	*Battus philenor* (Linnaeus, 1771)	38	x	-	-
	Parides photinus (Doubleday, 1844)	13	x	-	x
	Papilio polyxenes Cramer, 1782	8	x	-	-
Lycaenidae	*Hemiargus isola* (Reakirt, [1867])	3	x	x	x
	Hemiargus ceraunus (Butler & H. Druce, 1872)	8	x	x	x
	Strymon melinus Hübner, 1818	1	x	-	-
	Strymon astiocha (Prittwitz, 1865)	5	x	-	-
	Ziegleria ceromia (Hewitson, 1877)	1	x	-	x
	Leptotes marina (Reakirt, 1868)	9	x	x	x
	Leptotes cassius (Cramer, 1775)	3	x	x	x
Riodinidae	*Calephelis* spp. Grote & Robinson, 1869	35	x	-	-
Hesperiidae	*Pyrgus communis* (Grote, 1872)	109	x	x	x
	Ancyloxypha arene (W.H. Edwards, 1871)	60	x	-	-
	Lerema spp. Scudder, 1872	4	x	-	-
	Urbanus dorantes (Stoll, 1790)	17	x	-	-

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	Urbanus procne (Plötz, 1881)	2	x	-	-
	Pholisora mexicana (Reakirt, 1867)	1	x	-	-
	Cogia hippalus (W.H. Edwards, 1882)	6	x	-	-
	Poanes zabulon (Boisduval & Le Conte, [1837])	2	x	-	-
	Pyrrhopyge chalybea Scudder, 1872	1	x	-	-
	Cymaenes fraus (Godman, 1900)	1	x	-	-
	Pompeius pompeius (Latreille, [1824])	3	x	-	-
	Staphylus spp. Godman & Salvin, 1896	4	x	-	-
6	**57**	**1749**			

The environmental variables were not significantly different between transects throughout the year. But the abundance and diversity of butterflies showed significant differences between months; August and September always had the most abundance (H = 7.822, p = 0.0107), while February, March and April had the highest diversity (H = 5.92, p = 0.0034). The ACC between environmental variables and species families showed that environmental variables explained 38.6% of the variation in butterfly abundance in the first ordination axis and 10.2% in the second (Figure 1). Lycaenidae and Papilionidae were affected mostly by temperature, while Pieridae was affected by relative humidity and Nymphalidae was mostly affected by speed of wind. Sampling efficiency, as shown by a species accumulation curve was 87%. We identified three feeding guilds: nectar-feeding, mud-puddling and yeast-feeding (Table 2) that were present all year.

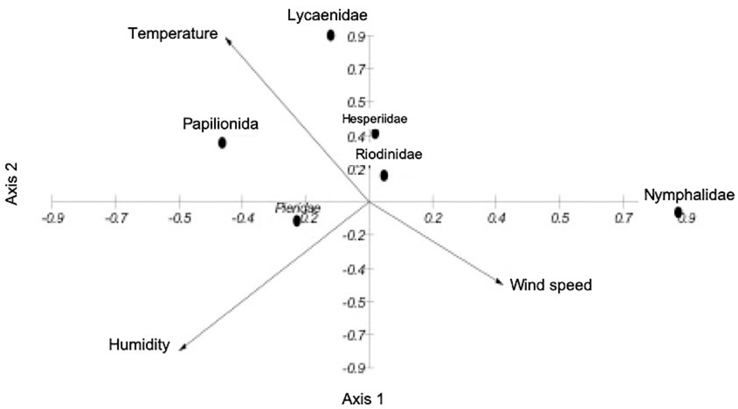

Figure 1. Canonical Correspondence Analysis between Lepidoptera (Rhopalocera) families and environmental variables (Temperature, Humidity, Speed of wind) along two years in the edges of the *Medicago sativa* crop (38.6% in the first ordination axis and 10.2% in the second).

3.2. Influence of plants on the butterfly community

The Canonical Correspondence Analysis between butterfly species and plant families showed three groups (Figure 2). Plant families explained 58.4% of the abundance of butterfly species in the first ordination axis, and 42.6% in the second ordination axis. The plant families in the first group (Table 3) were associated with a higher number of butterfly species (17 species).

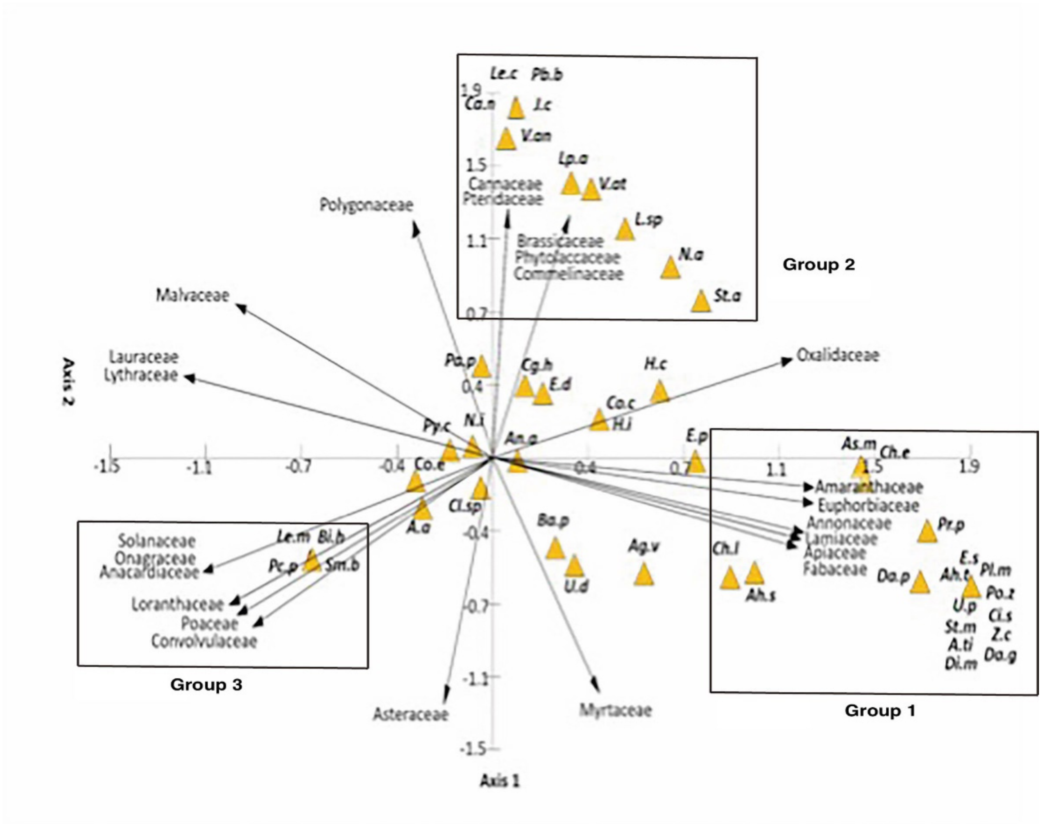

Figure 2. Canonical Correspondence Analysis between butterfly and plant families (in the first ordination axis 58.4%; second ordination axis 42.6%). Butterfly species: **Ag.v:** Agraulis vanillae, **An.a:** Anaea aidea, **A.a:** Ancyloxypha arene, **As.m:** Ascia monuste, **At.i:** Asterocampa idyja, **Ba.p:** Battus philenor, **Bi.h:** Biblis hyperia, **Cl.sp:** Calephelis sp., **Ca.n:** Catasticta nimbice, **Ch.e:** Chlosyne ehrenbergii, **Ch.l:** Chlosyne lacinia, **Ci.s:** Cissia similis, **Cg.h:** Cogia hippalus, **Co.c:** Colias cesonia, **Co.e:** Colias eurytheme, **Da.g:** Danaus gilippus, **Da.p:** Danaus plexippus, **Di.m:** Dione moneta, **E.d:** Eurema daira, **E.p:** Eurema proterpia, **E.s:** Eurema salome, **H.c:** Hemiargus ceraunus, **H.i:** Hemiargus isola, **J.c:** Junonia coenia, **Lp.a:** Leptophobia aripa, **Le.c:** Leptotes cassius, **Le.m:** Leptotes marina, **L.sp:** Lerema sp., **N.i:** Nathalis iole, **N.a:** Nymphalis antiopa, **Pa.p:** Papilio polyxenes, **Pr.p:** Parides photinus, **Pb.b:** Phoebis boisdusvalii, **Pl.m:** Pholisora mejicanus, **Pc.p:** Phyciodes pallescens, **Ah.s:** Anthanassa sitalces, **Ah.t:** Anthanassa texana, **Po.z:** Poanes zabulon, **Py.c:** Pyrgus communis, **Sm.b:** Smyrna blomfildia, **St.a:** Strymon astiocha, **St.m:** Strymon melinus, **U.d:** Urbanus dorantes, **U.p:** Urbanus procnes, **V.an:**Vanessa anabella, **V.at:** Vanessa atalanta y **Z.c:** Ziegleria ceromia.

Table 3. Correlation analysis between plant and butterfly species in the edges of the Medicago sativa crop. Groups are defined in Figure 2.

Group	Plant species	Butterfly species	*p*	r^2
1	*Erythrina coralloides*	*Ascia monuste*	0.0001	0.42
		Anthanassa texana	0.004	0.164
		Anthanassa sitalces	0.0001	0.609
1	*Salvia longistyla*	*Ascia monuste*	0.0001	0.503
		Anthanassa texana	0.004	0.067
		Anthanassa sitalces	0.0001	0.718
		Chlosyne lacinia	0.006	0.208
1	*Melilotus albus*	*Anthanassa sitalces*	0.014	0.066
1	*Leonotis nepetifolia*	*Chlosyne ehrenbergii*	0.019	0.032
1	*Alternanthera sp.*	*Chlosyne ehrenbergii*	0.0001	0.378
		Ziegleria ceromia	0.0001	0.385
1	*Melilotus albus*	*Anthanassa sitalces*	0.014	0.066

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1	*Vigna luteola*	*Chlosyne ehrenbergii*	0.0002	0.104
1	*Euphorbia heterophylla*	*Chlosyne ehrenbergii*	0.0009	0.078
		Ziegleria ceromia	0.0003	0.104
1	*Ricinus communis*	*Ziegleria ceromia*	0.0001	0.88
2	*Lepidium virginicum*	*Leptophobia aripa*	0.0001	0.909
2	*Nasturtium officinale*	*Leptophobia aripa*	0.0001	0.039
2	*Commelina diffusa*	*Leptophobia aripa*	0.007	0.01
2	*Canna indica*	*Leptophobia aripa*	0.0001	0.049
		Junonia coenia	0.0020	0.286
		Vanessa anabella	0.0010	0.303
3	*Chloris gayana*	*Biblis hyperia*	0.001	0.561
3	*Bromus carinatus*	*Smyrna blomfildia*	0.003	0.201
3	*Ixophorus unisetus*	*Smyrna blomfildia*	0.003	0.194

The correlation analysis between plant and butterfly species (Table 3) showed that the plant species Salvia longistyla Benth was correlated with more butterfly species (4). The butterflies that visited more species of plants were Leptophobia aripa (4) and Anthanassa sitalces (4). When applied this analysis only for migratory butterflies (Table 4), we found that A. sitalces and S. blomfildia were correlated with the highest number of plant species.

Table 4. Correlation analysis between plant species and migratory butterfly species in the Medicago sativa crop**.**

Plant species	**Migratory butterfly species**	***p***	**r^2**
Erythrina coralloides	*Eurema daira*	0.0009	0.231
	Ascia monuste	0.0001	0.420
Aldama dentata	*Eurema proterpia*	0.0275	0.070
Medicago lupulina	*Eurema proterpia*	0.0001	0.570
Sanvitalia procumbens	*Eurema proterpia*	0.0018	0.362
Salvia longistyla	*Ascia monuste*	0.0001	0.503
Leonotis nepetifolia	*Ascia monuste*	0.007	0.087
Alternanthera sp.	*Danaus plexippus*	0.027	0.194
Chloris gayana	*Smyrna blomfildia*	0.001	0.598
Bromus carinatus	*Smyrna blomfildia*	0.003	0.201
Ixophorus unisetus	*Smyrna blomfildia*	0.003	0.194

4. Discussion

4.1. Abundance and diversity

The results of the present study showed a similar number of plant families than other studies [2,17,26]. However, have been reported [11] a greater number of species (64) than our (48) in a lucerne crop, but with larger surface during a longer period of time. On the other hand, most than half of the plant species found are native flora of central Mexico, and 91.6% of them have ethnobotanical use. These results are similar to those reported by other authors [11,43,53]. This occurs when remnants of native flora colonize sites with adequate conditions such as the edges of crop fields; if these plants are not to removed from those sites, the diversity increase [10,37,40,41,52,55]. In our study, the ANOSIM test showed significant differences in floristic composition between transects. These results agree with literature [3,27,51], in areas with different crops, a consequence of the movement of seeds across neighboring habitats, especially when crop fields are distributed in a mosaic pattern. In our study site, the presence of farming plots with corn, beans and lucerne crops, as well as small remaining wooded areas containing native vegetation, could create a large-scale mosaic pattern with a high diversity of plants along the edges.

With respect to the butterfly community, the species accumulation curve showed that sampling effectiveness was adequate (87%), but the collection period could be extended. In spite of this, the butterfly community found had a higher species richness (57) than other studies that sampled for longer time over a larger area (27 species [10], 58 species [7], 31 species [9], 61 species [21], 30 species [13]). Also, only four of our species have been reported in other lucerne crops [9,22,57]. Our results showed that the butterfly community was sensible to environmental variables, as has been reported in other studies [15,58,65]. Nymphalidae was mostly affected by speed of wind, possibly because some species of this family are migratory (*D. plexippus*, *S. blomfildia* and *V. atalanta*). Furthermore some authors have reported that abundance of Nymphalidae increased in conserved areas or in biological corridors [15,49]. Particularly, *Anaea aidea* Guérin-Méneville (Nymphalidae) present in our study, has been reported by literature [49] as an indicator species in conserved areas; this called our attention, and because Nymphalidae was the second most abundant family in our study site, even though the agroecosystem under study was under an intense management (the crop is harvested every 28 days).

4.2. Influence of plants on the butterfly community

The correlation analysis between plant and butterfly species showed that endemic plants *S. longistyla* (Lamiaceae) and *Erythrina coralloides* DC. (Fabaceae) were positively correlated with more butterfly species (Table 3) and one migratory species: *A. monuste*. While *Leptophobia aripa* was associated with more plants, this butterfly has been reported as a crop pest of *Brassica oleracea* (Brassicaceae) in central Mexico [28,54], but in our study site it was associated with other plant families. The migratory butterfly *D. plexippus* was associated with *Alternanthera sp* Forssk (Amaranthaceae), but in literature [22,31], it was associated with the plant *Asclepias curassavica* (Apocynaceae), were it lays its eggs. We didn't find specimens of *A. curassavica* in our study site. The explanation may be that *D. plexippus* is a migratory butterfly the uses our agroecosystem as a feeding site, not as a reproduction site. The migratory butterflies *E. proterpia* and *S. blomfildia* visited more plant species; both have been reported in areas with crop fields and little remaining wooded sites [44], similar to our study site. Therefore the endemic butterfly *Chlosyne ehrenbergii* was positively associated with the plants *Leonotis nepetifolia* L.R.Br. (Lamiaceae) and *Alternanthera sp.* (Amaranthaceae).

5. Conclusions

The particular structure and high diversity of plants that exists in the agroecosystem under study played an important role in sustaining a high diversity of butterflies. However, we must consider that a larger-scale mosaic of different crops surrounds our study site, and that could be responsible for the diversity of the butterfly community, as mentioned elsewhere in the literature [6,10,21,55]. The high diversity of the native vegetation (including endemic species) and the positive correlation between butterflies and plant species, despite intensive crop management system, are probably the factors that generate most of the resources needed for a rich butterfly community that includes migratory and endemic species. These factors also create an effective network that allows for movement between habitats, serving probably as biological corridors [7,13,19]. Considering that many plant species found in crop field edges have ethnobotanical use, the results of this study suggest crop fields can provide refuge for butterflies as well as other benefits derived from the use of edge plants.

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