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Habitat association of Orthoptera in El Cimatario National Park, Querétaro, México

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Abstract

Orthopteran community composition varies with habitat quality. The distribution of Orthoptera species depends primarily on which vegetation type provides food resources and habitat. For insight into this relation between distribution and habitat quality we studied the 21 most-abundant orthopteran species in El Cimatario National Park (State of Querétaro, México) in four vegetation types. We found that nearly half of these species tended to inhabit a particular vegetation type. This study is a first contribution exploring the relation between vegetation and distribution of Mexican Orthoptera.

Key words

grasshoppers, vegetation, spatial distribution, communities, habitat

Introduction

Orthoptera are often the most abundant insects in open habitats with short (knee-length or less) vegetation, where the rays of the sun fall directly on the soil. These insects are thus very common in prairies, grasslands, xerophytic scrubs, and disturbed and cultivated areas (Fontana *et al.* 2002, Capinera *et al.* 2004). In contrast, there are fewer species, and these usually lower in abundance, inhabiting mature forests, where incoming radiation is filtered by tree canopies, and living in wetlands with flooded soils that might cause difficulties for oviposition (Capinera *et al.* 2004).

Orthoptera community composition can vary considerably, depending on habitat type (Kemp *et al.* 1990). Many biotic and abiotic habitat variables influence orthopteran populations and communities: plant species composition (Strohecker *et al.* 1968, Kemp *et al.* 1990), vegetation structure (Clarke 1948), soil type (Pdaft 1984), temperature, radiation, humidity, food availability, oviposition sites, shelters from predators (Kemp *et al.* 1990), or biotic interactions such as predation or parasitism (Joern & Pruess 1986). Vegetation is one of the key factors that determines Orthoptera distribution, since the different species occupy specific habitats according to food availability and their microhabitat thermic requirements (Anderson 1964, Fielding & Brusven 1992, Squitier & Capinera 2002).

El Cimatario National Park is located in the state of Querétaro in the central part of México: the aim of this study was to determine the habitat association by vegetation type of the most abundant species of Orthoptera in the park.

Materials and methods

El Cimatario National Park (lat 20° 28' 30" and lat 20° 33' 23" North, long 100° 09' 37" and long 100° 23' 12" West) is located to the Southwest of the State of Querétaro, México, and covers 2 447.84 ha (National Official Gazette 1982). Its surface is of volcanic origin from the Pliocene, with a soil texture that runs from fine to medium (INEGI 1986). Its maximum altitude is 2400 m (SARH 1994). The climate is temperate-semidry, with a rainy season from June through September. The annual rainfall is 549.3 mm and the annual average temperature 18 to 19 °C, with a maximum of 22 °C in May (INEGI 1997).

Vegetation types

El Cimatario National Park has heterogeneous native vegetation, representative of semidesertic zones in Querétaro (Baltazar *et al.* 2004). It has different vegetative communities (Fig. 1), which include cactus scrub (Fig. 1A), tropical deciduous forest (Fig. 1B), induced pasture (Fig. 1C) and reforested vegetation (Fig. 1D). The natural prevalent vegetation is cactus scrub (Zamudio *et al.* 1992). All of the vegetation in the Park is disturbed to different degrees due to human activities in the past, such as agriculture, grazing, extraction of forest resources, and human settlements. The four vegetation types are described below.

Cactus scrub.— This vegetation type (Fig. 1A) is characterized by shrubs measuring *ca* 4 m high, with small leaves, spines and thick stems (Zamudio *et al.* 1992). It is the predominant vegetation in the park, and grows principally where there is a flat surface, or little slope. Baltazar *et al.* (2004) give the cacti comprising this vegetation as *Myrtillocactus geometrizans*, *Opuntia leucotricha*, *O. imbricata* and *Nyctocereus serpentinus*. Trees include *Acacia schaffneri*, *A. farnesiana* (Fabaceae), *Ipomoea mucuroides*, *Karwinskia humboldtiana* (Rhamnaceae), *Anisacanthus quadrifidus*, *A. pumilis* (Acanthaceae), *Calliyrria eriophylla* (Fabaceae), *Condalia velutina* (Rhamnaceae), *Croton ciliatoglyulifer* (Euphorbiaceae) and *Zaluzania augusta* var. *rzadowskii*. (Asteraceae). The most abundant herbs are *Bouvardia laevis* (Rubiaceae), *Oxalis decaphylla* (Oxalidaceae) and *Zephyranthes* sp.

Tropical deciduous forest.— This forest is dominated by trees between 4 and 12 m high that ramify near their base and that lose their leaves during the dry season (Fig. 1B). Several species have an exfoliating bark with bright colors (Zamudio *et al.* 1992). Baltazar *et*



Fig. 1A. The commonest vegetation type of El Cimatario Park is Opuntia Scrub. For color version, see Plate VI.



Fig. 1B. Tropical forest characterized by seasonal leaf-loss. For color version, see Plate VI.



Fig. 1C. Induced pasture is an open, grassy vegetation type, the soil scarred by tezontle extraction. For color version, see Plate VI.



Fig. 1D. Reforested areas of the park have involved replanting of *Eucalyptus* and other exotics. For color version, see Plate VI.

al. (2004) mention that the tree stratum in El Cimatario National Park is dominated by *Bursera fagaroides*, *B. palmeri* (Burseraceae), *Cedrela dugesii* (Meliaceae), *Ipomoea murucoides* (Convolvulaceae), *Erythrina coralloides* (Fabaceae), *Lysiloma microphylla* (Fabaceae), *Senna polyantha* (Fabaceae) and *Zanthoxylum fagara* (Rutaceae). Also several herbs grow on this kind of vegetation, such as *Rivina humilis* (Phytolaccaceae), and climbing plants, including *Dioscorea militaris* (Dioscoreaceae) and *Passiflora suberosa* (Passifloraceae). Furthermore, some epiphytic plants, such as *Tillandsia recurvata* and *T. calothyrsus* (Bromeliaceae), grow at the tree canopy level. Although disturbed, the tropical deciduous forest has native trees such as *Albizia plurijuga* (Fabaceae), *Cedrela dugesii* and *Erythrina coralloides*, which are under (legal) ecological protection, according to Mexican Official Standard NOM-059-ECOL-2001.

Induced pasture.—The pastures selected for this study were those where a red porous volcanic rock called tezontle has traditionally been extracted for construction of light bricks, temazcal baths, and bread ovens (Fig. 1C). This habitat is made up mostly of very short

grasses (30 cm tall at most) that grow on the tezontle, as well as scattered shrubs of *Eysenhardtia polystachya*. Some of the grasses found are *Melinis repens*, *Chloris gayana*, *Cynodon dactylon*, *Bromus carinatus*, *Setaria grisebachii*, and *Sporobolus atrovirens*.

Reforested vegetation.— According to Baltazar *et al.* (2004) reforestation took place where there was pastureland caused by overgrazing with goats and cows (Fig. 1D). The representative species from induced pastures are *Rhynchelytrum repens*, *Brachiaria meziana* (both Poaceae), *Evolvulus alsinoides* (Convolvulaceae), *Dyssodia pinnata* (Asteraceae), *Hoffmanseggia glauca* (Fabaceae), *Macroptilum gibbosifolium* (Fabaceae), *Milla biflora* (Alliaceae), *Oxalis decaphylla* (Oxalidaceae), and *Phyla nodiflora* Greene (Verbenaceae). Into these disturbed areas were introduced plants from other parts of the country: *Pinus greggii*, *P. michoacana*, *P. cembroides*, *P. montezumae* (Pinaceae), *Cupressus lindleyi* (Cupressaceae), *Fraxinus uhdei* (Wenz.) Lingelsh. (Oleaceae), *Ulmus mexicana* Planch. (Ulmaceae), and *Acacia* spp. (Fabaceae). From foreign countries *Jacaranda mimosaeifolia* (Bignoniaceae), *Eucalyptus* spp. (Myrtaceae), *Casuarina equisetifolia* L. (Casuarinaceae), *Schinus molle* L. (Anacardiaceae), and *Melia azedarach* L. (Meliaceae).

In recent years, wild plants have been used for reforestation such as *Acacia farnesiana*, *Eysenhardtia polystachya* (Fabaceae), *Prosopis laevigata* (Fabaceae), and *Yucca filifera* (Agavaceae) — but we sampled only in the old reforestation zones.

Sampling

We visited the park once or twice a month from June 2005 through May 2006. On each visit we sampled from a total of 12 sites: cactus scrub (4 sites), tropical deciduous forest (2 sites), induced pasture (2 sites), and reforested vegetation (4 sites). Four people using nets, swept all vegetation within a 50 × 50-m plot at each site. We spent 50 min per site (Joern 1979, Squitier & Capinera 2002) during the day, varying sampling times from 9:00 to 18:00 h; sampling effort was made comparable at each site.

We rotated assignments among observers in order to minimize sampling and counting differences (Przybyszewsky & Capinera, 1990). We counted the nymphs and adults for each species. We selected the 21 most abundant Orthoptera species, and compared the species abundance between sites, adding together all the data obtained during the sampling year.

Data analysis

To determine whether or not the species found are randomly distributed throughout vegetation types, we employed the 'Indicator value method' of Dufrêne & Legendre (1997). This procedure (IndVal) computes a percent index for each species. For a particular species it is the product of its specificity and fidelity to a vegetation type: of a species' abundance in a given vegetation type [specificity], and of its relative frequency in all vegetation types studied [fidelity]. Its value for a given species does not depend on the relative abundance of other species, or on the classification method used for the sites. We applied the Dufrêne & Legendre formulae as follows:

$$A_{ij} = N \text{ individuals}_{ij} / N \text{ individuals}_i$$

$$B_{ij} = N \text{ sites}_{ij} / N \text{ sites}_i$$

$$INDVAL_{ij} = A_{ij} \times B_{ij} \times 100$$

We calculated A_{ij} , mean abundance, for each species i in each sampled site of vegetation type j . $N \text{ individuals}_{ij}$ is the mean number of individuals of species i across sample sites of the vegetation type j ; $N \text{ individuals}_i$ is the sum of the mean numbers of individuals of species i in all the vegetation types. A_{ij} is highest when species i is only present in vegetation type j .

We calculated B_{ij} , the relative frequency of occurrence of species i at sites of vegetation type j . $N \text{ sites}_{ij}$ is the number of sites with the vegetation type j where species i is present, while $N \text{ sites}_i$ is the total number of sites belonging to the same vegetation type. B_{ij} is highest when species i is present at all sites with vegetation type j .

We computed A_{ij} , mean abundance of species i at sites of each vegetation type j , compared to all groups in the study; we then multiplied it by B_{ij} , the relative frequency of occurrence of species i at the sites of each vegetation type j .

We tested the statistical significance of each IndVal by using a Monte Carlo Permutation test ($N=1000$) implemented in PC-ORD (McCune & Grace 2002).

Results

The Indicator Species Analysis shows nine of 21 species clearly associated with one vegetation type. The Gomphocerinae species stand out: *Achurum sumichrasti*, *Amblytropidia mysteca*, *Eritettix simplex*, and *Psoloessa texana* were preferentially distributed on reforested vegetation (on the grass); these four have a high indicator value (Table 1). Both species of *Conocephalus* (*Conocephalus* (*Aphauropus*) *leptopterus* and *Conocephalus* (*Anisoptera*) *magdalenae*) were clearly associated with reforested vegetation, along with *Aidemona alticola* (all on the grasses). The melanopline *Philocleon anomalus* was characteristic of cactus scrub. For the remainder of the species we found no strong habitat association. Two of the Dichopetala species found have not yet been described; we have used their 'field names' D. n. sp. "long ovipositor tauriformis" and D. n. sp. "Cercus I tauriformis".

Discussion

In this study we found Orthoptera species were strongly associated with vegetation type. This finding could depend mainly on the different food requirements of the taxonomic groups.

Gomphocerinae are commonly distributed in prairies and pastures, because they feed on grasses (Uvarov 1977, Otte 1981, Joern 1982, Craig *et al.* 1999). We found them very clearly associated with grasses in the reforested vegetation of the Park. We can also confirm that the genus *Conocephalus* occurs on grasses in open pastures (Naskrecki 2000, Capinera *et al.* 2004).

Melanoplineae prefer habitats in which grasses are mixed with abundant herbs and Poaceae on which they normally feed (Uvarov 1977, Joern & Pruess 1986, Evans 1988). At El Cimatario National Park the cactus scrub shows these characteristics having gone through great anthropogenic disturbance. We found two melanopline species strongly tied to the cactus scrub, *Aidemona alticola* and *Philocleon anomalus*.

Our results show that some gomphocerinae, conocephalinae and melanoplineae species, by their association with the habitats, can serve as indicators of the vegetation perturbation of the entire park. This is because the natural prevalent vegetation is cactus scrub (Zamudio *et al.*, 1992) which includes neither grasses nor herbs as representative plants. Though further studies on host plants must be done.

Unfortunately we sampled in only a few sites per vegetation type, particularly for the reforested vegetation (2) and induced pasture (2); so more sampling sites are needed to clarify preferences of the other species for vegetation types. Nonetheless a melanopline, *Phoetaliotes nebrascensis*, was commonly observed on grasses (its food supply) (Craig *et al.*, 1999). *Brachystola mexicana* was observed more abundantly on low bushes or even on the litter, *Oecanthus varicornis* on bush branches, and *Schistocerca cohni* on tall bushes or on three branches where its occurrence is well known (Uvarov 1977).

It is interesting to note that the three *Dichopetala* species, which as a group comprised the most abundant species of the Park (Table 1), showed some association tendency to different habitats, perhaps thus avoiding competition. However, other studies have found that competition among Orthoptera seems to be low (Mulkern 1980). Further investigations on their oviposition site preferences and food sources are needed. The *Dichopetala* species were found principally on the shrubs of the different vegetation types, and in the lower and medium height tree strata. Other researchers have found that

Table 1. Indicator value (INDVAL) of the 21 most-abundant species at El Cimatario National Park, Querétaro, in regard to different vegetation types. *Significant indicator species from a Monte Carlo Permutation test (N = 1000).

Suborder	Family	Subfamily	Species	Indicator value (INDVAL)				Number of individuals
				Reforested vegetation	Cactus scrub	Tropical deciduous forest	Induced pasture	
Ensifera	Tettigoniidae	Phaneropterinae	<i>Dichopetala serrifera</i> Rehn & Hebard 1914	5.2	25.9	56.3	12.6	2307
			<i>Dichopetala</i> n.sp. "cercus I <i>tauriformis</i> "	5.6	22.4	23.6	48.4	2381
			<i>Dichopetala</i> n.sp. "long. ovipositor <i>tauriformis</i> "	22.2	43.2	22.2	12.3	495
Caelifera	Acrididae	Conocephalinae	<i>Conocephalus (Anisoptera) magdalenae</i> Naskrecki 2000	75.6*	13.4	0.0	11.0	120
			<i>Conocephalus (Aphauropus) leptopterus</i> Rehn & Hebard 1915	84.0*	13.8	0.7	1.4	279
		Oecanthinae	<i>Oecanthus varicornis</i> Walker 1869	37.7	35.2	10.1	17.1	172
		Romaleinae	<i>Brachystola mexicana</i> Bruner 1904	4.4	33.5	60.8	1.3	109
		Melanoplinae	<i>Aidemona alticola</i> Roberts H.R. 1947	53.3*	27.2	8.7	10.9	78
			<i>Aztecacris laevis</i> (Rehn 1900)	17.7	43.8	4.7	33.8	306
			<i>Melanoplus lakinus</i> (Scudder 1878)	5.6	66.8	15.7	11.9	275
			<i>Melanoplus cimatario</i> Fontana & Buzzetti 2007	24.8	59.1	5.8	10.2	106
			<i>Netrosoma xanthops</i> Roberts 1947	4.0	55.2	31.7	9.2	382
			<i>Philocleon luceroae</i> Fontana & Buzzetti 2007	11.2	52.7	26.2	10.0	213
			<i>Philocleon anomalus</i> Roberts H.R. 1941	5.7	67.2*	23.2	3.9	575
			<i>Phoetaliotes nebrascensis</i> (Thomas C. 1872)	51.7	27.4	10.9	9.9	2377
		Cyrthacantacridinae	<i>Schistocerca cohnii</i> Song 2006	5.5	27.6	57.0	9.8	1961
			<i>Achurum sumichrasti</i> (Saussure 1861)	73.7*	7.6	0.0	16.2	91
			<i>Amblytropidia mysteca</i> (Saussure 1861)	84.2*	9.6	0.5	5.2	1655
		Gomphocerinae	<i>Boopedon diabolicum</i> Bruner 1904	32.6	46.9*	11.7	8.7	905
			<i>Eritettix simplex</i> (Scudder 1869)	85.0*	7.5	0.0	3.7	103
			<i>Psoloessa texana</i> Scudder 1875	2.2	1.6	0.0	84.8*	53

this genus lives in bushes and tall grasses (Cohn & Fontana pers. com.).

We should clarify that we found few examples of Oedipodinae species, because these are mostly distributed at sites where vegetation is almost absent and where they exhibit (cryptic) camouflage with the bare ground (Rowell 1971, Craig *et al.* 1999). And we did not take terrestrial Orthoptera, such as Gryllidae, into account.

We found that nearly half of the examined orthopteran species inhabit particular vegetation types (9 of 21 species). The next step should be to identify the food resources of these species: to assess the richness, abundance, and seasonal turnover of their host plants and to determine how they are available during the year. Our work is a first attempt to address these topics for a Mexican orthopteran community.

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