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Artículo

Leaf beetles attracted to light in a tropical dry forest of northern Mexico (Coleoptera: Chrysomelidae)

Crisomélidos atraídos a la luz en un bosque seco tropical del norte de México (Coleoptera: Chrysomelidae)

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ABSTRACT

This is the first study of the composition of leaf beetles attracted to light in Mexico. We analyze the richness, temporal abundance and similarity between four localities of tropical dry forest in Sierra de San Javier, Sonora. A total of 3217 individuals belonging to 45 morphospecies, 31 genera and 10 tribes within five subfamilies of Chrysomelidae were collected in light traps in the tropical dry forest of Sierra de San Javier, Sonora. Galerucinae was the subfamily with the greatest number of genera and species. The genera with the highest number of species were *Pachybrachis* Chevrolat and *Alagoasa* Bechyné. Eight genera were represented by two species and 21 genera by only one species. *Metrioidea rugipennis* (Blake) was the species with the highest number of individuals (80% of the abundance recorded). According to the taxonomic and species similarity analysis, the sites San Javier and La Barranca had the highest similarity, while the lowest values were recorded at Rancho Las Peñitas and Cañón de Lo de Campa. The low similarity between sites cannot be explained by the geographic distance since it was not a determining factor to explain the low similarity in Sierra de San Javier.

Key words. Light trap, nocturnal chrysomelids, taxonomic similarity

RESUMEN

Este trabajo es el primer estudio sobre la composición de crisomélidos atraídos a la luz en México. Se analizó la riqueza, la abundancia temporal y la similitud entre cuatros localidades de bosque tropical seco en la Sierra de San Javier, Sonora. Se colectaron un total de 3217 individuos pertenecientes a 445 morfoespecies, 31 géneros y 10 tribus dentro de cinco subfamilias de Chrysomelidae en un bosque seco tropical de la Sierra de San Javier, Sonora. Galerucinae fue la subfamilia con el mayor número de géneros y especies. Los géneros con un mayor número de especies fueron *Pachybrachis* Chevrolat y *Alagoasa* Bechyné, ocho géneros estuvieron representados por dos especies y 21 por solo una especie. *Metrioidea rugipennis* (Blake) fue la especie con el mayor número de individuos (80% de la abundancia registrada). De acuerdo con el análisis de similitud taxonómica y de especies, San Javier y La Barranca tuvieron la mayor similitud, mientras que la menor se encontró en el Rancho Las Peñitas y el Cañón de Lo de Campa. La baja similitud entre los sitios no puede explicarse por la distancia geográfica ya que no fue un factor determinante para explicar la baja similitud en la Sierra de San Javier.

Palabras clave. Crisomélidos nocturnos, similitud taxonómica, trampa de luz

Light affects insect activity and development in several ways. Insects exhibit various manifestations to light; phototaxy is the typical response (Jander 1963). When the insects move towards the light source (attraction), the taxi is positive, as it happens with many nocturnal insects; if the insects move away from the light (repulsion), the taxi is negative. Light intensity and wavelength, time of exposure or direction of light source are some of the factors that affect the response of insects to light (Shimoda and Honda 2013). Insect activity is greatest in the first hours after sunset (O'Donnell 2000).

Among Coleoptera, the families most commonly attracted to light are Bostrichidae, Carabidae, Cerambycidae, Curculionidae, Scarabaeidae, Scolytidae and Tenebrionidae (Morón and Terrón 1988). However, there are records indicating that some species of Chrysomelidae and Coccinellidae are attracted to light traps (Yang *et al*. 2003; Lopatin and Nesterova 2006; Abdullah *et al*. 2008; Kishimoto-Yamada *et al.* 2008, 2009; Martínez-Hernández *et al.* 2010; Jiuxuan *et al*. 2013; Nalepa 2013; Torkey and Dhafer 2015; González-Ramírez *et al*. 2017; Medeiros *et al*. 2017; Sharma *et al*. 2017; Sia *et al.* 2017; Van 2017; Nowinszky *et al*. 2017).

Chrysomelidae is one of the most speciose beetle taxa; the family contains more than 32500 species within 11 subfamilies distributed worldwide (Bouchard *et al.* 2011; Ślipiński *et al.* 2011). Mexico has 2508 species recorded; however, it is estimated that there are 3532 species (Ordóñez-Reséndiz *et al.* 2014; Ordóñez-Reséndiz and López-Pérez in press). Comparing this number of species with countries like Brazil (4486 spp.), Mexico has a considerable richness of leaf beetles (Costa 2000; Ordóñez-Reséndiz *et* *al.* 2014). Ordóñez-Reséndiz and López-Pérez (in press) documented the state distribution of Mexican leaf beetles based on published literature and examination of specimens in some museum collections, most of the species of leaf beetles are recorded from Veracruz (930), Oaxaca (782) and Guerrero (645), Sonora state has 218 species recorded; however, faunistic inventories need to be made in various entities of the country.

Leaf beetles are mainly phytophagous and diurnal insects, they are caught mostly during daylight hours and frequently correspond to the highest proportion of beetle individuals collected (Riley *et al*. 2002; González-Ramírez *et al.* 2017). However, some species of the genera *Luperodes, Monolepta*, *Phyllotreta*, among others, have been collected in light traps (Yang *et al.* 2003; Lopatin and Nesterova 2006; Abdullah *et al.* 2008; Kishimoto-Yamada *et al.* 2008, 2009; Martínez-Hernández *et al.* 2010; Torkey and Dhafer 2015; Medeiros *et al.* 2017).

Most of the studies carried out in Mexico have been carried out during daylight hours and they are biased to certain geographic areas and certain vegetation such as low thorn forests, oak forest or pine-oak forest (Niño-Maldonado *et al.* 2014a, 2014b, 2016; Furth 2009; Ordóñez-Reséndiz 2016, Sandoval-Becerra *et al.* 2017; Sanchez-Reyes *et al.* 2015, 2019) and tropical dry forest (Ordóñez-Reséndiz and López-Pérez 2009).

One of the reasons why many studies on chrysomelids have focused on the tropical dry forest (TDF) is because it is one of the most diverse vegetation of American tropical ecosystems. TDF present a heterogeneous and widely distributed vegetation type, and their different variants show particular physiological and phenological adaptations in plants and animals (Prieto-Torres *et al.* 2016). It covers 8% of the land area in Mexico, distributed in the continental slope of the Mexican Pacific, with Sonora being the northern limit. However, in Mexico, this type of vegetation has been altered by human activities; in 1990 only 27% of the original TDF remained intact (Trejo and Dirzo 2000), but there are not precise estimates of its deforestation rate.

Little is known about which and how many species of leaf beetles are collected in light traps. Thus, the objective of this work is providing the first insight into the composition of leaf beetles in Mexico collected by light traps, also we analyze the richness, temporal abundance and similarity between four localities of TDF in Sierra de San Javier, Sonora.

MATERIAL AND METHODS

Study site

The study was conducted in Sierra de San Javier, Sonora, northern Mexico (Fig. 1). This site is considered a priority terrestrial conservation region in Mexico; the vegetation is classified as TDF (Arriaga *et al.* 2000). According to the Köppen system modified by García (1981), the main climate of the region is semi-warm temperate, with hot summers and rains occurring predominantly in summer and infrequently in winter. The weather is considered very extreme [type (A)Ca(w_0) (x') (e')], with 14.2 °C thermal oscillation, 18.7°C annual mean temperature, and 638.2 mm annual mean precipitation (Noguera *et al.* 2009).

Sampling procedures

The data considered in this study are part of the project "Los Insectos del Bosque Seco (LIMBOS)". The sampling with lights traps was designed to collect longhorn beetles, which have their most richness during the months rainy season (Noguera *et al*. 2002; 2007; 2009). Samples were taken in November 2003 and February, April, July, August, September and October 2004. The sampling sites were chosen in poorly lit areas along Highway 16 (Hermosillo-Cuauhtémoc) near the village of San Javier.

Site 1: Rancho Las Peñitas, 28º32'21.7'' N 109º41'31.5'' W, 645–733 m elevation; 29 km SE of Tecoripa, a road crosses the "Rancho Las Peñitas" property in a southerly direction and extends 6 km until reaching a small dam. Site 2: San Javier, 28º34'53''N, 109º 44' 51.5''W, 795 m elevation; km 120 Hermosillo-Yécora highway, 20 km of Tecoripa. Site 3: La Barranca, 28º34'40.1''N, 109º39'54.3''W, 562 m elevation; 37 km SE of Tecoripa and parallel to the highway, in deep canyons where a stream runs seasonally. Site 4: Cañón de Lo de Campa, 28º 32' 18.2N, 109º44'37.7'' W, 433 m elevation; Rancho El Cajón, Km 124.4 Hermosillo-Yécora highway, 24.4 km SE of Tecoripa.

Light trap design

For light trapping, a combination of two light sources was used: a mercury vapor lamp and a Minnesota-type light trap (see Southwood 1966). The latter had two 20 W UV tubes (one unfiltered) over a single 20 cm diameter collection jar filled with 70% ethyl alcohol. The light trap and the mercury vapor lamp were placed against a vertical white sheet measuring 1.80 x 1.50 m. The traps were placed at the same place during each collection session and alternating a day in each one of them. The traps were operated beginning at the twilight for four hours one day each month, from 20:00 to 24:00 h during the daylight-saving time during April to October and from 19:00 to 23:00 the rest of the year.

Data analysis

The richness and abundance values correspond to the number of species and individuals collected in the four sampling sites. The difference in richness and abundance of species was observed for each month to understand the local and temporal distribution pattern of the species. To estimate the richness, three non-parametric estimators were used based on species abundance and/or incidence, Chao 1, ACE and Jacknife 2. This analysis was performed using EstimateS 9.1.

To know the similarity between pairs tramps we used two measures: species similarity and taxonomic similarity. The similarity of species was measured by the Jaccard index (J) (Jaccard 1912). Taxonomic similarity was measured by the method of Bacaro *et al.* (2007), so that total taxonomic similarity equals the Jaccard similarity coefficient, but also taking into account higher taxa. Taxonomic similarity has advantages over conventional similarity indices which utilize data at the species level only, since it makes comparisons between sites or areas by taking into account higher taxonomic levels. For example, in a pair of sites that have exactly the same species similarity, the two sites may have higher taxonomic similarity than another pair if the former has more shared higher taxa, such as genera and families (Calderón-Patrón *et al.* 2016; García de Jesús *et al.* 2016). Both indices were calculated with Past 3.0 (Hammer *et al.* 2001). To calculate the taxonomic similarity, the matrix was configured to represent the higher taxonomic levels and was calculated with the Jaccar index.

Additionally, to discard an influence of the geographic distance on the similarity and know the relationship between the species and taxonomic similarity, we used a Mantel test with the average lineal distance between pairs of traps expressed in kilometers. Mantel correlation were calculated with Past 3.0 (Hammer *et al.* 2001).

RESULTS

Richness and abundance

A total of 3217 individuals belonging to 45 species, 31 genera and 10 tribes within five subfamilies of Chrysomelidae were caught in light traps (Fig. 2). The estimates of the richness of leaf beetles attracted to light were higher (62.14 to 69.59 species) than the number of species observed; thus, the richness observed represents between 64.72 to 72.41% of the total estimated (Fig. 3). The subfamily with the greatest number of genera and species was Galerucinae, with three tribes, 19 genera (61% of the total) and 26 species (59% of the total). Cryptocephalinae was represented by two tribes, five genera (16%) and 10 species (22%) (Table 1). Alticini was the tribe represented by the greatest number of species (19 spp.), followed by Cryptocephalini with seven, Eumolpini with five, Luperini with four, Galerucini with three. Clytrini was the tribe with the fewest species richness (just two species registered). Bruchini, Cassidini, Megascelidini and Typophorinini were represented by a single species. The genera with the highest number of species were *Pachybrachis* Chevrolat with four and *Alagoasa* Bechyné with three. The genera *Brachypnoea* Gistel, *Chaetocnema* Stephens, *Colaspis* Fabricius, *Derospidea* Blake, *Epitrix* Foundras, *Griburius* Haldeman, *Metrioidea* Fairmaire and *Systena* Chevrolat were represented by two species each one and twenty-one genera were represented by a single species.

The abundance pattern of leaf beetles attracted to light (Fig. 4) showed the dominance of one species with several codominant species and many others were represented by a few or one individual only. *Metrioidea rugipennis* (Blake) was the most abundant species, with 2573 specimens, which represented more than 80% of all individuals sampled. Other codominant species were *Walterianella durangoensis* (Jacoby), *Derospidea brevicollis* (LeConte), *Derospidea* sp., *Alagoasa virgata* (Harold) and *Metrioidea varicornis* (LeConte), *Trirhabda* sp., and *Pachybrachis* sp.1 (Table 1).

Most of Chrysomelidae species collected in light traps were active mainly from June to October (rainy summer season). The highest numbers of species were recorded during July (24), August (22) and September (11); only one species was collected in April (dry season) (Fig. 5). Additionally, differences in abundance among moths were also recorded. The highest numbers of individuals were recorded in August (2903) and July (229); in contrast to the months of April with 10 individuals and November with only one (Fig. 5). On the other hand, twenty-six species were caught for one month only, 13 for two months, five for three months, and only *W. durangoensis* was caught from July to October.

Spatial similarity among traps light

Our results showed a high spatial diversity in San Javier. The species turnover between traps contributes significantly to the richness of the leaf beetles attracted to light. The similarity based on their species structure was always lower than taxonomic similarity. San Javier and La Barranca had the highest similarity (40 and 47% for species and taxonomic similarity, respectively), while the lowest values were recorded at Rancho Las Peñitas and Cañón de Lo de Campa (7 and 17% for species and taxonomic similarity, respectively) (Table 2). The Mantel test showed that geographic distance was not significant ($P<0.05$). There was no decrease in similarity related to geographic distance, neither at the species nor at the taxonomic similarity level.

DISCUSSION

The leaf beetles caught in this study represents 2% of the species recorded in Mexico (Ordóñez-Reséndiz and López-Pérez in press). This percentage is low compared with other studies performed in similar vegetation (13%) but based on daytime collecting (Ordóñez-Reséndiz and López-Pérez 2009). However, it represents a high percentage of species with a positive phototactic response, which must be studied in the future.

The species of Chrysomelidae collected by light trap in Sierra San Javier were active mainly during the rainy season; there are studies showing that July and August are the months with the greatest number of individuals (Noguera *et al*. 2009). This high abundance is correlated with the food availability and the seasonality of the TDF, considering that leaf beetles are phytophagous. Moreover, one reason for this response is that during these months the ecological factors in the TDF are favorable for leaf beetles (Sánchez-Reyes *et al.* 2015).

In the present study, we found a high heterogeneity of chrysomelid species in light traps. The low similarity between the studied sites suggests a particular composition of nocturnal chrysomelids in each area. The relative similarity between San Javier and La Barranca indicates, in this case, that geographic distance has little effect on reducing biological similarity, because these sites are further away from each other than with Rancho Las Peñitas and Cañón de Lo de Campa, so the differences in similarity must obey other aspects of the areas. The floristic composition and the state of conservation of TDF in each site, may be determining different environmental conditions that decreasing similarity (Soininen *et al.* 2007). However, the geographic distance was not a determining factor in the variation between the species collected. When we incorporated higher taxa into the analysis, more shared elements were included, and the composition of communities tends to homogenize. Thus, there is a taxonomic structure common to species attracted to light. Alticini, Galerucini, Luperini, Cryptocephalini, Eumolpini and Megascelidini could be share an evolutionary component. Also, the genera *Alagoasa*, *Pachybrachis*, *Metrioidea*, *Griburius*, *Derospidea*, *Colaspis*, *Chaetocnema* and *Systena*. Moreover, these genera have been repeatedly collected in light traps (Andrews and Gilbert 2005; Barney et al. 2013; Riley and Barney 2015; Barney 2018).

Diurnal insects are the least affected by light, but they may fly towards illuminated areas or UV lamps when disturbed (Lewontin 1959; Grewal *et al.* 2017). There are records of species caught by light traps in studies lasting more than six years, where 32% of the leaf beetle species were represented by a single specimen only (Kishimoto-Yamada and Itioka 2008; Kishimoto-Yamada *et al.* 2009). *Metrioidea rugipennis* represented 80% of the specimens collected in our study. Moreover, Andrews and Gilbert (2005) recorded *M. rugipennis* as the most abundant species collected by UV light trap in Baja California, Mexico. Some insects have made evolutionary transitions to nocturnality; these changes have been observed between congeneric species, presumably because of lower predation and competition pressures (Somanathan *et al*. 2008, 2009); it could be the case of this species.

Our study set-up allows us to observe the heterogeneity of light-attracted leaf beetle species and the relationship among them. It is necessary more studies to know if light traps could be a complementary method to collect leaf beetles.

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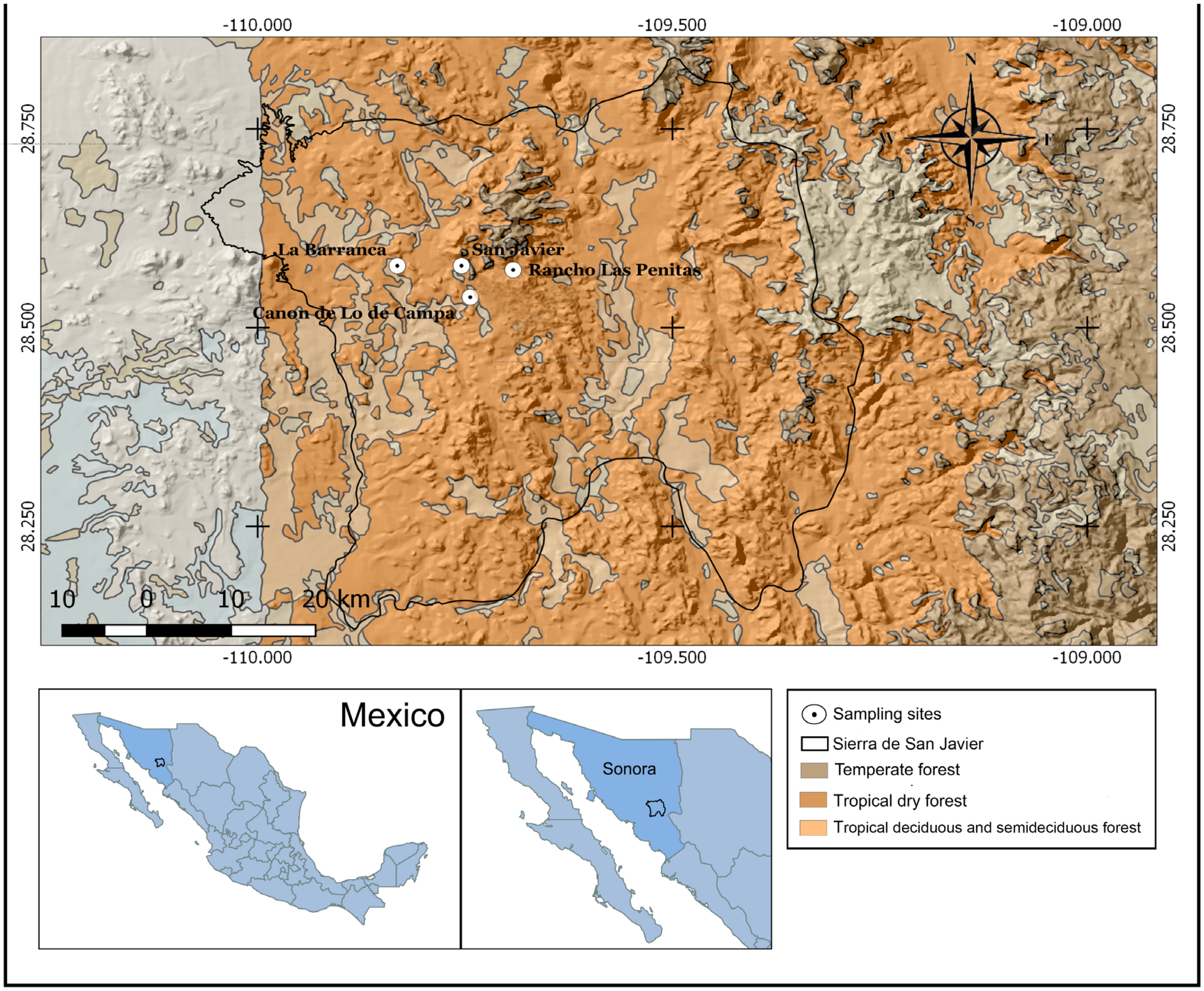

Figure 1. The sampling sites in Sierra San Javier, Sonora.

Figure 2. Example of leaf beetle biodiversity from Sierra San Javier, Sonora. A) *Lupraea* sp.; B) *Metachroma* sp. 1; C) *Metrioidea rugipennis* (Blake); D) *Alagoasa tenuilineata* (Horn); E) *Blepharida* sp. 1; F) *Trirhabda* sp. 1; G) *Metrioidea varicornis* (LeConte); H) *Walterianella durangoensis* (Jacoby); I) *Megascelis* sp.; J) *Derospidea* sp.; K) *Colaspis* sp. 1; L) *Brachypnoea* sp. 2.

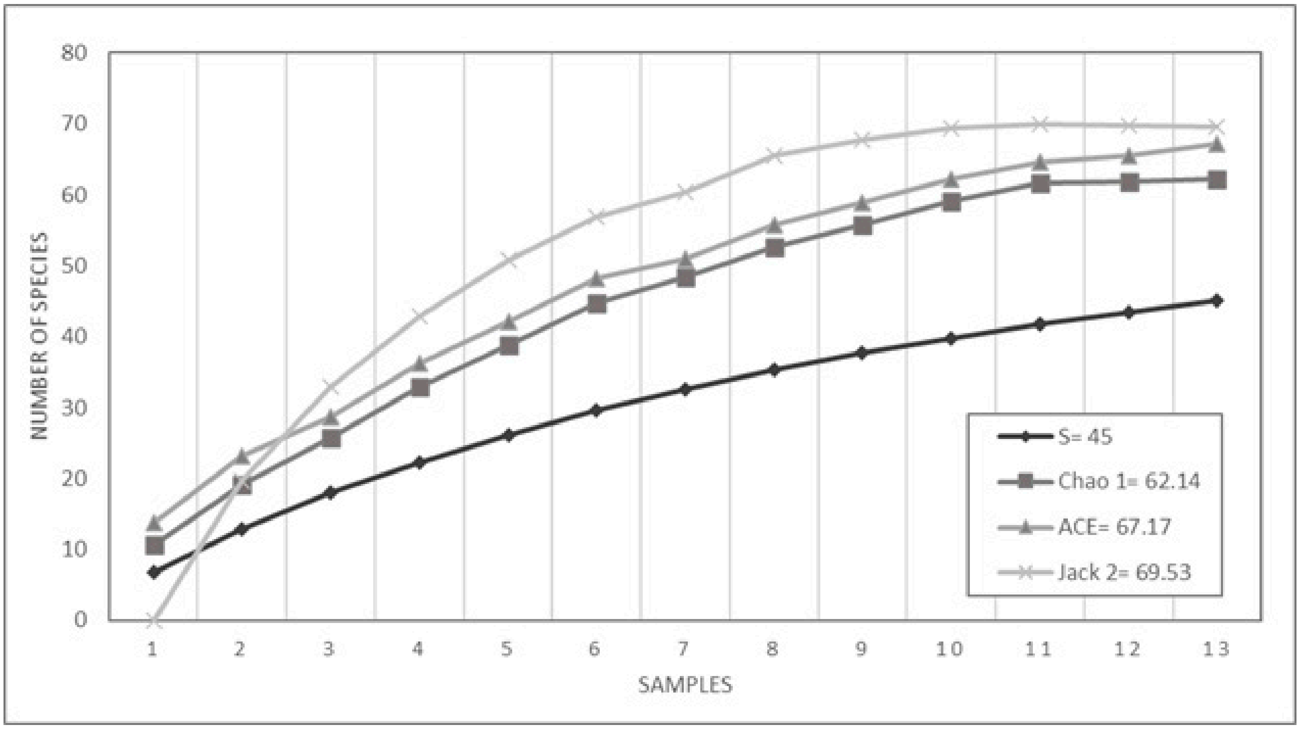

Figure 3. Richness observed and estimated of Chrysomelidae in Sierra de San Javier, Sonora.

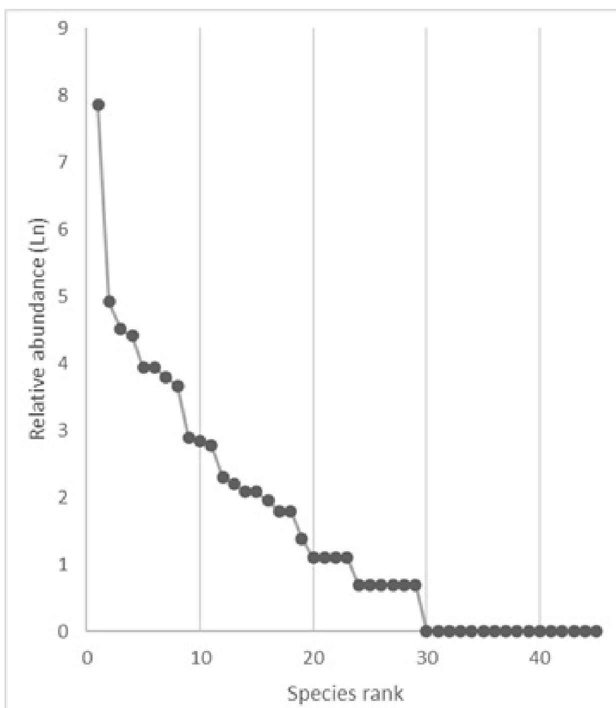

Figure 4. Rank-abundance pattern of the Chrysomelidae species recorded in Sierra de San Javier, Sonora.

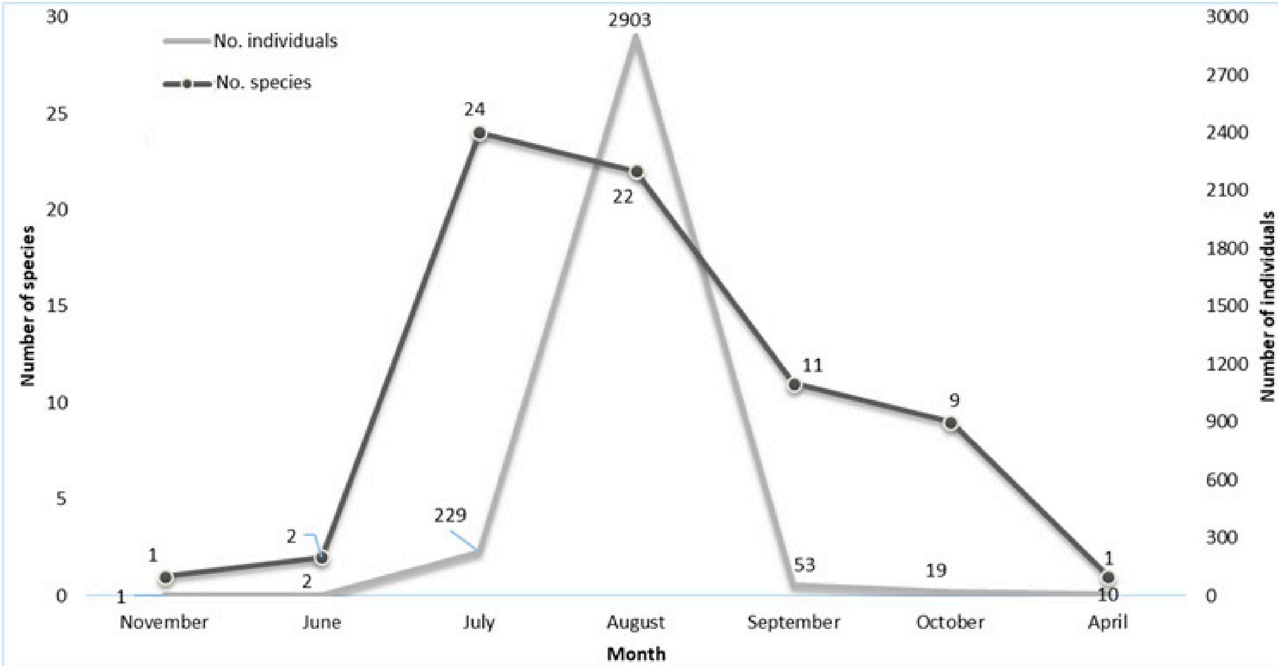

Figure 5. Temporal pattern of species richness and abundance of Chrysomelidae recorded in Sierra de San Javier, Sonora.

Table 1. Checklist of leaf beetles attracted to light in San Javier, Sonora. The number of individuals caught per species is indicated at each site.

	La Barranca	Cañón de Lo de Campa	Rancho Las Peñitas	San Javier
Bruchinae				
Bruchini				
Acanthoscelides sp.		1		
Cassidinae				
Cassidini				
Charidotella emarginata (Boheman)		1		
Chryptocephalinae				
Clytrini				
Anamoea sp.			1	
Coscinoptera sp. 1	1			
Coscinoptera sp. 2			1	
Cryptocephalini				
Cryptocephalus sp.	3			
Griburius sp. 1		1		
Griburius sp. 2		1		
Pachybrachis sp. 1	3		36	
Pachybrachis sp. 2	2			
Pachybrachis sp. 3	1			
Pachybrachis sp. 4	1		2	

Eumolpinae				
Eumolpini				
Brachypnoea sp. 1	4	2		
Brachypnoea sp. 2	1			1
Colaspis sp. 1	1			
Colaspis sp. 2				1
Euphytus sp.	2	15		
Megascelidini				
Megascelis sp.	4		2	3
Typophorini				
Metachroma sp.	4			
Galerucinae				
Alticini				
Alagoasa sp.	1			
Alagoasa tenuilineata (Horn)	2			
Alagoasa virgata (Harold)	3			48
Blepharida sp.	9		2	7
Chaetocnema sp. 1	1			
Chaetocnema sp. 2			1	
Disonycha glabrata (Fabricius)			1	5
Dysphenges rileyi (Gilbert and Andrews)			3	
Epitrix sp. 1	1		7	
Epitrix sp. 2	1			
Glyptina sp.	1		14	1
Hemiphrynus sp.	1			1
Longitarsus sp.	1		1	
Lupraea sp.	7			3
Phylotreta sp.		1	1	
Syphrea sp.	1			
Systena sp. 1	2		1	4
Systena sp. 2		1		
Walterianella durangoensis (Jacoby)	42			95
Galerucini				
Derospidea brevicollis (LeConte)	90			1
Derospidea sp.	81			1
Trirhabda sp.	35		9	
Luperini				
Acalymma vittatum (Fabricius)	1	2		
Diabrotica balteata LeConte	2	3		3
Metrioidea rugipennis (Blake)	2497		48	28
Metrioidea varicornis(LeConte)	35	10	5	1

Table 2. Jaccard similarity between light traps. Upper diagonal = Species similarity. Lower diagonal = Taxonomic similarity.

	La Barranca	Rancho Las Peñitas	Cañón de Lo de Campa	San Javier
La Barranca		0.12821	0.28205	0.4
Rancho Las Peñitas	0.21951		0.076923	0.08
Cañón de Lo de Campa	0.37975	0.17742		0.26923
San Javier	0.47887	0.18966	0.32203	