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THE SPHINGIDAE (HETEROCERA) OF THE "EL OCOTE" RESERVE, CHIAPAS, MEXICO

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ABSTRACT. A study of the family Sphingidae was conducted in the Reserve, "El Ocote," located in the northeast portion of the state of Chiapas, Mexico. Collections were made principally using a blacklight between 1994 and 1997. A total of 60 species were collected, from 20 genera in five tribes and three subfamilies. *Xylophanes, Manduca, Eumorpha* and *Erinnyis* had the greatest number of species. *Nyceryx mulleri* Clark is a new record for Chiapas. Eighty percent of the species were collected in the first two months of the rainy season. It was estimated that the present collection accounted for 75% of the species of Sphinigidae in the reserve, based on the accumulation of species per collection effort. The fauna of the Sphingidae collected from "El Ocote" was compared with that reported from two other reserves of southern México, "Los Tuxtlas", Veracruz and "Chajul", Chiapas. "El Ocote" and "Chajul" were the most similar with 87% affinity.

Additional key words: tropical forests, biodiversity, neotropical region, invertebrate inventory.

RESUMEN. Se presenta un estudio faunístico de la familia Sphingidae de la selva "El Ocote", ubicada al noreste del estado de Chiapas, México. Se efectuaron colectas con trampa de luz tipo pantalla entre 1994 y 1997, que aportaron 60 especies de 20 géneros comprendidos en cinco tribus y tres subfamilias. El mayor número de especies se distribuye en los géneros *Xylophanes, Manduca, Eumorpha y Erinnyis*. *Nyceryx mulleri* Clark es un nuevo registro para Chiapas. El 80% de las especies se colectó en los dos primeros meses de la temporada lluviosa. La estimación de la riqueza de especies por esfuerzo de colecta indica que esta investigación aporta el 75% de las especies de esta región. Se incluye una comparación con la fauna de Sphingidae de Los Tuxtlas, Veracruz y Chajul, Chiapas, resultando que El Ocote y Chajul presentan una afinidad de 87%.

There has been tremendous international publicity and concern surrounding the unprecedented rate at which tropical forests are being lost. The concern is well warranted because although tropical forests cover only about 7% of the terrestrial surface of the planet, they probably support around 50% of the flora and fauna (Myers 1986). Despite this diversity, these forests are increasingly threatened and destroyed.

Although much of the international attention has been directed at the larger tracts of tropical forest such as the Amazon and the Congo basin of Africa, Mexico has important tracts of tropical forests that merit serious conservation efforts. However, it is estimated that 80% of the tropical forests of Mexico have already been destroyed and those that remain are seriously threatened (Estrada et al. 1995). This is the case with the tropical forest reserve, "El Ocote" in the northeastern Chiapas. Of the 48,140 hectares designated as reserve lands in 1982 (Diario Oficial de la Federación 1982), only 57%, (27,437 ha), can now be considered as forested and not directly affected by agricultural activities (García et al. 1996).

As for other tropical forests, a high diversity of vertebrates have been reported from "El Ocote" Reserve (Domínguez et al. 1996, Muñoz et al. 1996, Navarrete-Gutiérrez et al. 1996), but there is a lack of inventories of the invertebrate fauna. Knowledge of the invertebrate diversity could complement the findings concerning the vertebrate fauna, and give further information on the species most threatened by habitat destruction, and, in general, give an indication of the biological significance of the reserve based on species richness (Toledo 1988).

The present study is a contribution to the knowledge of the Lepidoptera fauna of southeastern Mexico, and in particular, of the family Sphingidae of the "El Ocote" Reserve of northwestern Chiapas. An inventory was conducted of the Sphingidae of the Reserve, from which a comparison was made of the species richness of this family reported from two other tropical forests of southern Mexico. "Los Tuxtlas" of the Gulf Coast of Veracruz, and "Chajul" of the Lacandon region of eastern Chiapas. These forests, together with "El Ocote", presumably formed a single tract of tropical forest stretching from the Gulf coast of Veracruz to what is now the border with Guatemala (Challenger 1998).

MATERIALS AND METHODS

Description of the study area. The protected forest and fauna reserve known as the "Selva El Ocote" is located in the northwest portion of the state of Chiapas (16°53′–17°05′N and 93°30′–93°47′W) in the municipality of Ocozocoautla de Espinoza (Fig. 1). The reserve has an area of 48,140 ha (Diario Oficial de la Federación 1982) and ranges in altitude from 180 to 1500 m above sea level. The mean annual temperature and precipitation is 25.2°C and 2387 mm, respectively (INEGI 1984).

The soils of the reserve are thin and fragile, of limestone origin, with large numbers of exposed rocks and boulders (García et al. 1996). The topography is highly

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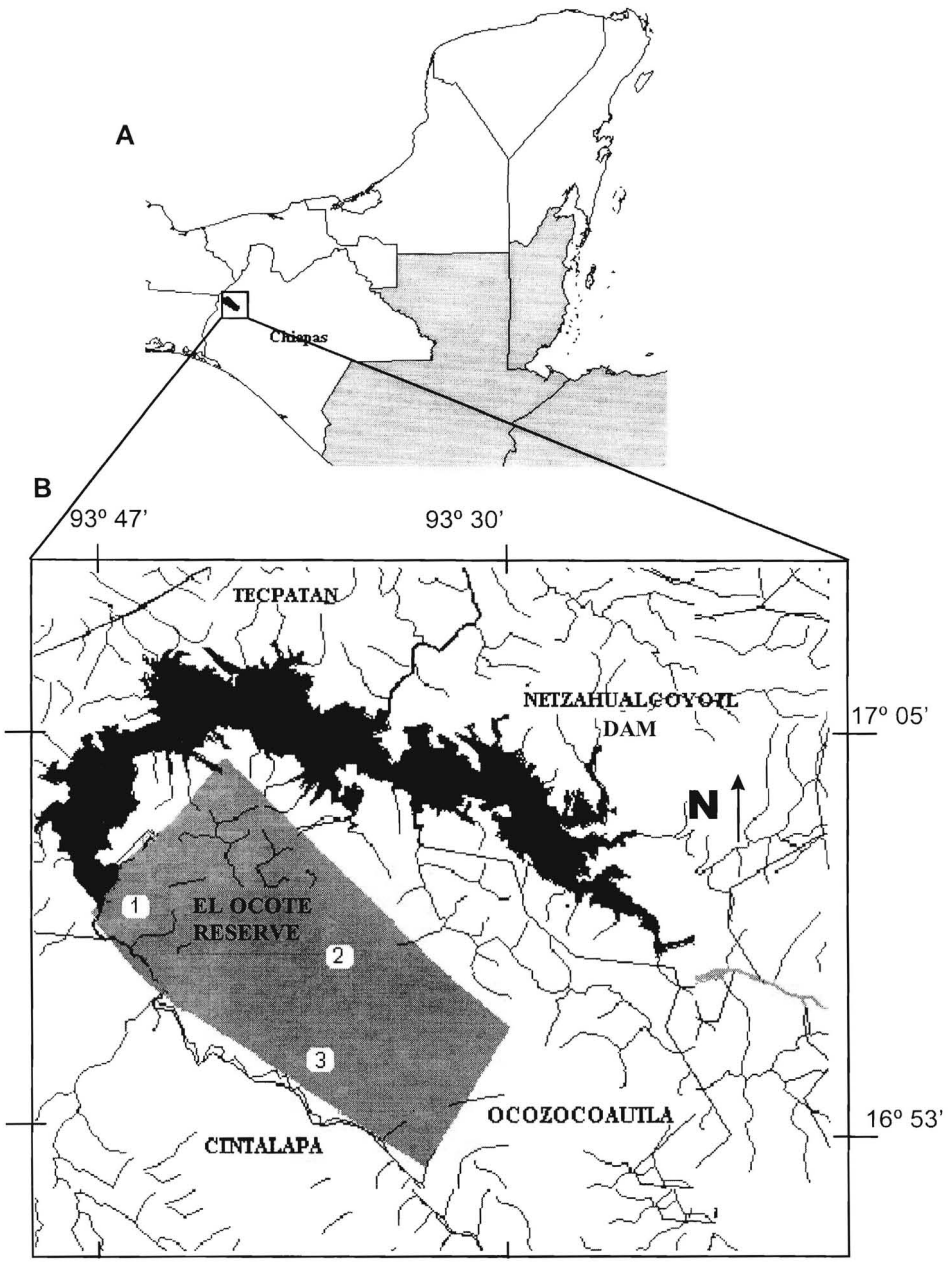

FIG. 1. A. Geographic position of the "El Ocote" Reserve in Southeastern México. B. Detail of the reserve and location of sampling areas: 1= El Encajonado, 2 = 9 km SW of Ejido Cuauhtémoc 3 = Finca Nueva Providencia.

irregular and has contributed to the existence of very diverse floral assemblages, of which the high tropical semi-evergreen tropical forest is the dominant vegetation. This forest type coexists with fragments of medium height evergreen tropical forest, low semi-evergreen tropical forest, low deciduous tropical forest, and associated successional stages: "acahuales," savanna, and pastures (Ochoa-Gaona 1996).

Sampling. Night sampling was conducted at three locations that mostly comprised well preserved medium height evergreen tropical forest: El Encajonado, Ejido Cuauhtémoc and Finca Nueva Providencia (Fig. 1). These three locations provide a good representation of the spatial complexity of this type of tropical rain forest in the Reserve. Collections were mostly made during 1994. Supplementing field work

TABLE 1. Characteristics of the collection localities compared in this study. Vegetation categories are: TRF = Tropical Rain Forest, ESF = Evergreen Seasonal Forest, TDF = Tropical Deciduous Forest , and SS = Short-tree Savanna (Breedlove, 1981).

Locality	Elevation (m)	Latitude (N)	Longitude (w)	Mean annual temp (°C)	Mean annual precipitation(mm)	Vegetation
"El Ocote", Chiapas	750	16°53′	90°30′	25.2	2387	TRF, EST, TDF SS
"Chajul", Chiapas	140	16°06′	90°55′	25.0	3000	TRF, ESF
"Los Tuxtlas", Veracruz	675	18°25′	90°13′	24.4	2900	TRF, TDF, ESF

was conducted in 1995, 1996 and 1997. Each collection coincided with the new moon and had an average duration of five days. A twelve volt ultraviolet light and sheet were placed from 1800 to 0500 h each night to attract moths. At the time of capture, each captured specimen was injected in the thorax with 95% ethyl alcohol and placed in individually labeled glassine envelopes. Species were identified using Hodges (1971), D'Abrera (1986) and by comparison with reference material from the Entomology Collection of the Instituto de Biología, Universidad Nacional Autónoma de México (IBUNAM), in Mexico City. Collected specimens were deposited in the Entomology Collection of the El Colegio de la Frontera Sur, Unidad San Cristóbal, Chiapas (ECOSC-E) and the entomology collection of IBUNAM.

Analysis of data. Estimations of the species richness of the Sphingidae of "El Ocote" Reserve were based on the Clench equation of species accumulation:

$$S(t) = at/(1 + bt)$$

where S (t) is the expected number of species at time (t), a is the list increase rate, b is the species accumulation parameter, and the asymptote is given as a/b (Soberón & Llorente 1993). The model estimates total number of species present in the study area based on the characteristics of the decrease in new species collected as more time is spent in the field, this process will eventually generate an asymptote as an estimated total number of species (Soberón & Llorente 1993, León-Cortés 1995). The model was fitted by the non linear regression module provided by the package SPSS (v.6.1) using Levenberg-Marquardt algorithm.

The fauna of Sphingidae from "El Ocote" Reserve was compared with that reported for the Chajul Biological Station, Chiapas (León-Cortés & Pescador 1998) and Los Tuxtlas, Veracruz (Beutelspacher 1989) (Table 1), using the Simpson's similarity Index. This index is appropriate when compared faunas are disproportionate in size and number of shared taxa (Sánchez & López 1988). We applied cluster analyses using the unweighted arithmetic average clustering method (UPGMA) to show the total relationships among these faunas (Crisci & López 1983).

RESULTS AND DISCUSSION

Species richness and seasonal abundance. A total of 60 species of the family Sphingidae were collected from the "El Ocote" Reserve, belonging to three subfamilies, five tribes, and 20 genera (Table 2). The genus with the largest number of species was *Xylophanes* with 15 species, followed by *Manduca* with 10 species, and both *Eumorpha* and *Erinnyis* had five species each. These four genera represented 58% of the species collected in "El Ocote". León-Cortés and Pescador (1998) reported the same pattern in the abundance of species per genera from the Chajul Biological Station, in eastern Chiapas, and, in general, this also appears to be common to other tropical forests of America (León-Cortés & Pescador 1998).

The species collected from "El Ocote" Reserve represented 64% of the sphingids collected in the state of Chiapas and are all new records for the locality. Of these, *Nyceryx mulleri* Clark is a new state record. With our records, Chiapas has 49% of the Sphingidae reported from Mexico by White et al. (1991).

We estimated a species accumulation curve using Clench's equation. Our collection represents 75% of the Sphingidae of "El Ocote" Reserve predicted over 100 nights. Additional collection effort may provide only 10 to15 more sphingid species (Fig. 2).

Three abundance categories were established using the criteria of Rabinowitz et al. (1986) and based on the numbers of specimens of each of the species collected. These categories were: "rare," (1 to 2 specimens); "common," (3 to 19 specimens); and "abundant," (20 to 50 specimens). Using these groupings, 16 of the collected sphingids were rare, 40 were common, and 4 were abundant (Table 2).

The number of species collected varied greatly between seasons. Forty-six species (77%) were only collected during the rainy season (May to October), whereas only one species was found exclusively during the dry season, as compared to 13 species (21%) which were found in both wet and dry seasons. Of the species

TABLE 2. List of species of Sphingidae (Insecta: Lepidoptera) collected in the "Selva El Ocote" Reserve in Chiapas, México during 1994–1997. F = February, A = April, M = May, J = June, Jl = July, Au = August, O = October and N = November, Total = Total number of specimens captured.

Species	Month	Total
Subfamily Sphinginae		
Tribe Sphingini		
Cocytius lucifer (Rothschild and Jordan,1903)	Au	1
Neococytius cluentius Cramer,1775	J	1
Manduca dilucida Edwards,1887	M, J	4
Manduca occulta Rothschild and Jordan,1903	F, M, J, O, N	12
Manduca lefeburei (Güerin,1844)	M, J	5
Manduca ochus (Klug,1836)	J, Jl	3
Manduca rustica (Fabricius,1775)	M, J, O	10
Manduca albiplaga (Walker,1856)	J	4
Manduca muscosa (Rothschild and Jordan,1903)	J	4
Manduca corallina (Druce,1883)	M	1
Manduca lichenea (Burmeister,1856)	M, J, Jl, N	7
Manduca florestan Cramer,1782	M, J, Jl	15
Sphinx leucophaeta Clemens,1870	F	1
Sphinx merops (Boisduval,1870)	F, M, J	4
Subfamily Ambulicinae		
Tribe Smerinthini		
Protambulyx strigilis (Linnaeus,1771)	J, Jl, O	5
Adhemarius gannascus (Stoll,1790)	M, J, Jl, Au, O. N	13
Adhemarius ypsilon Rothschild and Jordan,1903	M. J, Jl, Au, O, N	20
Subfamily Macroglossinae		
Tribe Dilophonotini		
Pseudosphinx tetrio (Linnaeus,1771)	J, Jl, Au, O, N	7
Isognathus rimosus Grote,1865	M, J	4
Erinnys alope (Drury,1770)	F, J	3
Erinnyis lassauxi (Boisduval,1859)	J	1
Erinnys ello (Linnaeus,1758)	M, J	7
Erinnys oenotrus (Cramer,1782)	M, J	10
Erinnyis obscura (Fabricius,1775)	M	1
Pachylia ficus (Linnaeus,1758)	M, Jl	3
Pachyliodes resumens (Walker,1856)	M, J	4
Hemeroplanes ornatus (Rothschild and Jordan,1894)	M	3
Hemeroplanes triptolemus (Cramer,1779)	F, M	1
Madoryx oiclus (Cramer,1779)	M, Jl	14
Madoryx pluto Cramer,1779	M	1
Callionima innus (Rothschild and Jordan,1903)	Jl	1
Callionima parce Fabricius,1775	M, J, Jl, N	18
Callionima falcifera (Gehler,1943)	F, J, Jl, Au, O	26
Enyo lugubris (Linnaeus,1777)	M	1
Enyo ocypete (Linnaeus,1758)	O	1
Enyo gorgon (Cramer,1777)	A, M	2
Perigonia lusca Fabricius,1777	M, J	5
Subfamily Macroglossinae		
Tribe Philampelini		
Eumorpha anchemola (Cramer,1780)	M, J	3
Eumorpha triangulum Rothschild and Jordan,1903	F, J, Jl, Au, O, N	10
Eumorpha elisa (Smyth,1901)	J, Jl	8
Eumorpha satellita Linnaeus,1771	F, J, Jl	25
Eumorpha vitis (Linnaeus,1758)	M, J	4
Subfamily Macroglossinae		
Tribe Macroglossini		
Cauthetia spuria Boisduval,1875	M, J, Jl	47
Nyceryx mulleri Clark,1917	M	1
Nyceryx riscus Schaus,1890	M	1
Xylophanes pluto (Fabricius,1777)	M, J	3
Xylophanes tyndarus (Boisduval,1875)	M, J	6
Xylophanes pistacina (Boisduval,1877)	M, J	7
Xylophanes porcus (Hübner,1829)	M, J	3
Xylophanes ceratomiodes (Grote and Robinson,1867)	M, J, Au, O	8
Xylophanes anubus (Cramer,1877)	J, Jl, Au	18
Xylophanes amadis amadis Stoll	J, Au	2
Xylophanes amadis cyrene (Druce,1777)	J, Au	9
Xylophanes belti (Druce,1878)	M, Jl	3
Xylophanes eumedon (Edwards,1887)	J	2
Xylophanes turbata Edwards,1887	M, J	4
Xylophanes chiron nechus Drury,1770	M, J	7
Xylophanes libya (Druce,1878)	M, J, Jl, A	10
Xylophanes neoptolemus (Stoll,1782)	M, J, A, O	4
Xylophanes thyelia Linnaeus,1758	O, N	4

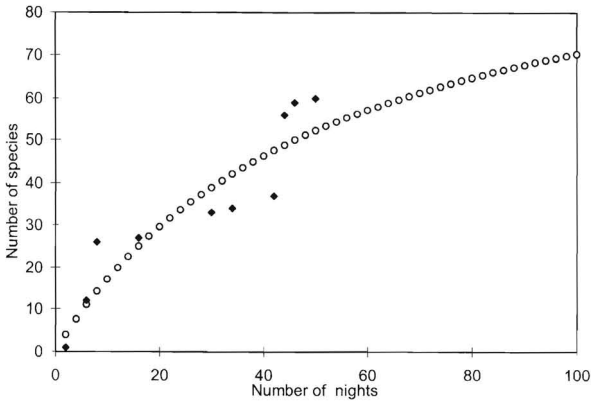

FIG. 2. Species accumulation curve of Sphingidae as a function of collection effort from "El Ocote", Reserve, Mexico. (○ = Cumulative number of expected species, (◆ = Cumulative number of observed species.

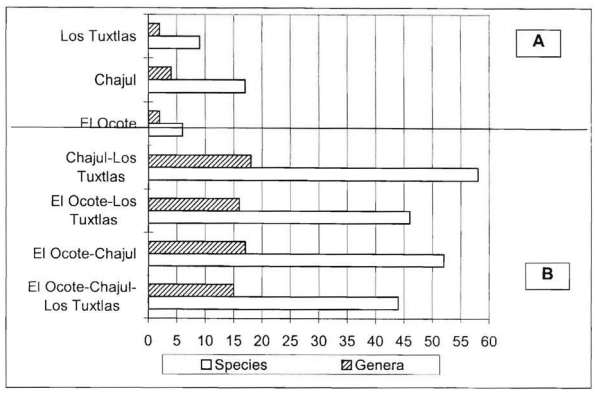

FIG. 4. Number of genera and species from the three localities compared from southern Mexico: A. number of genera and species not shared between sites, and B. number of genera and species shared between sites.

of sphingids collected during the rainy season, 48 of these (80%) were collected during the first two months of the season in May and June. Towards the end of the wet season, the abundance of each species declined and with fluctuations at low densities, in a manner similar to that observed during the dry season. This seasonal pattern in abundance and activity is similar to that reported in other studies (Haber & Frankie 1989, Janzen 1984, 1986, Powell & Brown 1990, Pescador 1994, Gregg et al. 1993). Haber and Frankie (1989) and Janzen (1984) state that precipitation and vegetative productivity are closely linked to the life cycle of the sphingids. During the dry season, the majority of the sphingids are in the pupal stage, while the larval and adult stages are found during the wet season. This pattern is reflected in reduced photosynthetic activity and productivity in host plants during the dry season, including the complete loss of leaves in some species, with the resumption of productivity during the wet season.

Similarity among fauna of the Sphingidae in Southern Mexico. The similarity among the sphingid fauna at the three sites analyzed are presented in Fig. 3. Within the three localities, 29 genera and 100 species have been collected, of which only 15 genera and 44 species were shared. The dendrogram derived from the cluster analysis indicates that there is greater similarity between "El Ocote" and the "Chajul" region of the Lacandon Forest of eastern Chiapas, than with "Los Tuxtlas" located on the Gulf coast (Fig. 3). These two latter localities shared 18 genera and 58 species, whereas "El Ocote" shared 17 genera and 52 species with "Chajul" and 16 genera and 46 species with "Los Tuxtlas"(Fig. 4).

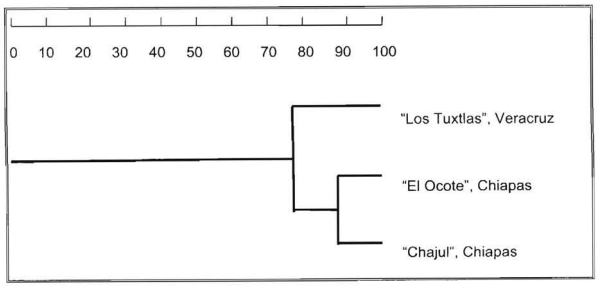

FIG. 3. Dendrogram of Sphingidae from three sites in southern Mexico. The unweighted arithmetic average (UPGMA) was used to cluster related groups.

In 1998 forest fires devastated approximately 7.4% of "El Ocote" reserve during the National severe drought associated with the El Niño phenomenon of 1997 (Aguilera 1998). Since this study represents the only non-vertebrate faunal data available of the species richness of a specific group from the reserve before the fires, the data presented here may serve as a baseline for estimating the speed and nature of the recovery of the reserve following this major disturbance event. In addition, Sphingidae, being highly vagile species, easily monitored, and with relatively high diversity may be an especially appropriate group of organisms in the study of what is hopefully a process of recovery.

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