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The Sphingidae (Lepidoptera) of the Galápagos Islands: their identification, distribution, and host plants, with new records

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Two species of Sphingidae (*Perigonia lusca lusca* (FABRICIUS) and *Xylophanes pluto* (FABRICIUS)) are reported for the first time from the Galápagos Islands. Fourteen new host plant records are given for nine of the fifteen species now found in the Galápagos. Forty-one new island records of distribution are given for species already mentioned from the archipelago. An illustrated key to the adults of Galápagos Sphingidae is included and their distribution and host plants are summarized.

Keywords: Sphingidae, Galápagos Islands, faunistics, host plants, illustrated key

INTRODUCTION

The Sphingidae, or hawk moths, are medium-sized to large moths with elongate wings and a large body allowing for powerful flight. They are often seen at dusk hovering and sipping nectar from flowers with their long proboscis. They are present basically everywhere on earth and there are some 1100 described species (HEPPNER 1998). Because hawk moths and their caterpillars can be identified easily, they are prime subjects for ecological and other studies.

The occurrence of hawk moths in the Galápagos Islands was first recorded in a report by BUTLER (1877), in which he mentioned two larvae of "a Sphinx moth" in the collection of Commander W. E. Cookson made during the visit of H.M.S. "Peterel" to the Galápagos in 1875. HOLLAND (1889) made the second mention of Sphingidae from the Archipelago. He reported a series of worn specimens collected by a member of the steamer Albatross in 1887-1888 and described a new endemic species (*Protoparce calapagensis* HOLLAND, 1889). ROTHSCHILD & JORDAN (1903) later considered *calapagensis* a subspecies of *Manduca rustica* (FABRICIUS, 1775). The classic world revision of the Sphingidae family by ROTHSCHILD & JORDAN (1903) and the excellent monograph of the Galápagos hawk moths made by WILLIAMS (1911) mentioned that nine species occurred in the archipelago. Subsequently, BEEBE (1923), CLARK (1926), KERNBACH (1962, 1964), PARKIN *et al.* (1972), HAYES (1975), SCHREIBER (1978) and HICKIN (1979) added new data. LINSLEY & USINGER (1966) and LINSLEY (1977) in their checklist of insects of the Galápagos, list 13 species of Sphingidae in eight genera but one of these, *Pachygonia drucei* ROTSCHILD & JORDAN, 1903, is based on a specimen now presumed to have been taken on Cocos Island (HAYES 1975).

During the last 22 years (1979-2001), only two notes pertaining to the faunistics and taxonomy of the Galápagos Sphingidae have been published. HAXAIRE

(1993) synonymized the subspecies *Hyles lineata florilega* (KERNBACH 1962) under *Hyles lineata* and ROQUE-ALBELO (1999) reported for the first time *Cocytius antaeus* (DRURY, 1773) from the islands. Therefore, prior to the present paper, 13 species in eight genera were known from the archipelago.

There is little additional information available on Galápagos Sphingidae. LINSLEY (1966) and MCMULLEN (1986, 1990, 1993) summarized the known flower-insect relationships in the Galápagos, including some with hawk moths, while KERNBACH (1964) and CURIO (1965a, b) studied the development and behavior of some caterpillars.

This paper reports new information on the distribution of hawk moths in the Galápagos and contains a key to the species of Sphingidae presently known from the islands, as well as new host plant records. The number of Sphingidae known to occur in the Galápagos now totals 15 species in 9 genera. One species, *Xylophanes norfolki* KERNBACH, is endemic to the archipelago.

MATERIAL AND METHODS

We collected the majority of the specimens studied between January 1989 and June 2001 during an extensive survey of the Galápagos butterfly and moth fauna. The study included the majority of the Galápagos islands.

The moths were collected with light traps (mercury vapor lamps (MVL), ultraviolet lights (UL) and fluorescent lights (FL)) and immediately killed with an injection of ethyl acetate. Caterpillars were also collected and reared in the laboratory. The majority of this material is deposited in the Invertebrate Collection of the Charles Darwin Research Station (CDRS), Santa Cruz Island, Galápagos, while some is at the Canadian National Collection of Insects (CNCI), Ottawa. Representative samples are deposited at the Pontificia Universidad Católica del Ecuador (PUCE). Additional records of distribution were obtained from the literature and from specimens deposited in The Natural History Museum, London (BMNH), Museo Ecuatoriano de Ciencias Naturales (MECN), Quito, and the California Academy of Sciences, San Francisco (CAS). The collectors' names are abbreviated below as follows: Charlotte Causton (CC), Valentina Cruz (VC), B. Landry (BL), and Lazaro Roque-Albelo (LRA).

The classification adopted here follows KITCHING & CADIOU (2000). We accept the current nomenclatural status of the Galápagos species although we are not certain that all endemic subspecies are valid. The nomenclature of the host plants follows MCMULLEN (1999).

NEW ISLAND, HOST PLANT AND SPECIES RECORDS

Tables 1 and 2 summarize all known distribution and host plant records of Galápagos Sphingidae.

Sphinginae

Agrius cingulata (FABRICIUS)

New island records. FERNANDINA: Punta Espinoza, 12.V.I992, MVL, BL (1♂, CNCI); Punta Mangle, 13-14.VI.1998, UL, LRA & CC (1♂, 1♀, CDRS); Punta Gavilan, 17.VI.1998, UL, LRA & CC (1♀, CDRS); 4 km S Punta Espinoza, 18.VI.1998, UL, LRA & CC (1♂, CDRS); Zona de vegetación, 19.VI.1998, UL, LRA & CC (1♂, CDRS). MARCHENA: Playa Negra, 12.III.1992, MVL, BL (2♂, CNCI). RABIDA: 13.III.1998, UL, LRA (1♂, CDRS). SANTIAGO: Cerro Inn, 27.III.1992, MVL,

Species	Host plants	References
Agrius cingulata	*Ipomoea pes-caprae* (L.)	Williams (1911)
	Ipomoea habeliana Oliv.	This article
	Ipomoea nil (L.)	This article
	Ipomoea triloba L. [as *I. galapagensis*]	Williams (1911)
	Stictocardia tilifolia (Desr.) [as *I. campanulata*]	Williams (1911)
	Ipomoea spp	Hayes (1975)
Cocytius antaeus	*Annona cherimola* Mill.	Roque-Albelo (1999)
Manduca sexta leucoptera	*Physalis pubescens* L.	Hayes (1975)
	Nicotiana tabacum L.	This article
	Acnistus ellipticus Hook. f.	This article
Manduca rustica calapagensis	*Clerodendrum molle* HBK	Williams (1911), Hayes (1975)
	Cordia lutea Lam.	Williams (1911), Hayes (1975)
	Cordia leucophlyctis Hook. f.	Hayes (1975)
	Tournefortia rufo-sericea Hook. f.	Williams (1911)
	Croton scouleri Hook. f.	Williams (1911)
	Bastardia viscosa HBK	Williams (1911)
	Darwiniothamnus lancifolius (*Hook. f.*) Harling	Williams (1911)
	Commicarpus tuberosus (Lam.) Standl.	This article
	Lantana camara L.	This article
Erinnyis alope dispersa	*Carica papaya* L.	This article
	Manihot esculenta Crantz	This article
Erinnyis ello encantada	*Hippomane mancinella* L.	Williams (1911), Curio (1965), Hayes (1975)
	Psidium guajaba L.	Williams (1911)
	Chamaesyce viminea (*Hook. f.*)	This article
Erinnyis obscura conformis	*Sarcostemma angustissimum* (Andersson) R. W. Holm	Williams (1911), Hayes (1975)
Enyo lugubris delanoi	*Cissus sicyoides* L.	Williams (1911), Hayes (1975)
Perigonia lusca	*Cinchona succirubra* Pav. Ex Klotzsch	This article
Eumorpha labruscae yupanquii	*Cissus sisyoides* L.	This article
Xylophanes tersa	*Diodia radula* (Roem. & Schult) Cham. & Schlecht.	This article
	Clerodendrum molle HBK	Williams (1911)
Xylophanes norfolki	*Psychotria rufipes Hook. f.*	This article
Hyles lineata	*Portulaca oleracea* L.	Hayes (1975)
	Commicarpus tuberosus (Lam.) Standl.	Hayes (1975)
	Boerhaavia caribaea Jacq.	This article

Table 1. Summary of the known Galápagos host plants of Galápagos Sphingidae.

BL (1♀, CNCI); Los Aguacates, 520m, 7.IV.1992, MVL, BL (1♀, CNCI); Central, 700m, 9.IV.1992, MVL, BL (2♀, CNCI); Playa Espumilla, 17.III.1998, UL, LRA (1♂, CDRS).
New host plant records. Convolvulaceae: *Ipomoea habeliana* Oliv., *Ipomoea nil* (L.).

Manduca sexta leucoptera (Fabricius)

New island records. ESPAÑOLA: Bahia Manzanillo, 25.IV.1992, MVL, BL (1♀, CNCI). RABIDA: 13.III.1998, UL, LRA (2♂, CDRS). SANTIAGO: Central, 700m, 9.IV.1992, MVL, BL (1♂, CNCI); Los Aguacates, 5.VII.1998, UL, LRA (1♀, CDRS).
New host plant records. Solanaceae: *Nicotiana tabacum* L., *Acnistus ellipticus* Hook. *f.*

Manduca rustica calapagensis (Holland)

New island records. FERNANDINA: Punta Espinoza, 12.IV.1992, MVL, BL (1♀, CNCI). GENOVESA: Bahia Darwin, 10m, 25.III.1992, MVL, BL (1♂, 3♀, CNCI). MARCHENA: Playa Negra,

12.III.1992, MVL, BL (1♂, 1♀, CNCI). PINTA: Arid Zone, 16.III.1992, reared, BL (1♀, CNCI); 15m, 21.III.1992, MVL, BL (1♂, CNCI); 50m, 20.III.1992, MVL, BL (1♂, CNCI). RABIDA: 8.IV.1992, MVL, BL (1♂, CNCI). SANTIAGO: Cerro Inn, 28.III.1992, MVL, BL (1♀, CNCI); Bahia Espumilla, 4.IV.1992, MVL, BL (1♀, CNCI); 17.III.1998 UL, LRA (2♂, CDRS); 200m, 5.IV.1992, MVL, BL (1♀, CNCI); Los Aguacates, 520m, 6.IV.1992, MVL, BL (1♀, CNCI); 5.VII.1998, UL, LRA (3♂, CDRS); Los Jaboncillos, 900m, 8.IV.1992, MVL, BL (1♀, CNCI); Central, 700m, 9.IV.1992, MVL, BL (1♂, CNCI).
New host plant records: Nyctaginaceae: *Commicarpus tuberosus* (LAM.) STANDL.; Verbenaceae: *Lantana camara* L.

Macroglossinae

Erinnyis alope dispersa KERNBACH

New island records. FLOREANA: Las palmas farm, 130m, 17.IV.1997, MVL, LRA & VC (1♂, CDRS). ISABELA: Puerto Villamil, 2.III.1989, MVL, BL (1♂, CNCI); 8.5 km North Puerto Villamil, 8.III.1989, MVL, BL (1♂, CNCI); V[olcán] Al[cedo], 1100m, 7.VI.1997, MVL, LRA (1♂, CDRS). SAN CRISTOBAL: 4 km SE Puerto Baquerizo, 12.II.1989, MVL, BL (1♂, CDRS).
New host plant records. Caricaceae: *Carica papaya* L.; Euphorbiaceae: *Manihot esculenta* CRANTZ.

Erinnyis ello encantada KERNBACH

New island records. RABIDA: Tourist trail, 3.IV.1992, MVL, BL (1♂, CNCI). SANTA FÉ: Arid zone, 6-9.V.1997, MVL, LRA (2♂, 2♀, CDRS). SANTIAGO: Bahia Espumilla, 4.IV.1992, MVL, BL (1♀, CNCI); Los Aguacates, 520m, 6.IV.1992, MVL, BL (1♂, 1♀, CNCI); Los Jaboncillos, 900m, 8.IV.1992, MVL, BL (1♀, CNCI).
New host plant record. Euphorbiaceae: *Chamaesyce viminea* (HOOK. *f.*).

Erinnyis obscura conformis KERNBACH

New island records. BARTOLOMÉ: 18.III.1998, UL, LRA (1♂, CDRS). FERNANDINA: Punta Espinoza, 12.V.1992, MVL, BL (1♂, CNCI); Zona de vegetación, 19.VI.1998, UL, LRA & CC (1♂, CDRS). GENOVESA: Bahia Darwin, 10m, 25.III.1992, MVL, BL (1♂, CNCI). MARCHENA: Playa Negra, 12.III.1992, MVL, BL (1♂, CNCI). PINTA: Playa Ibbetson, 14.III.1992, MVL, BL (2♂, CNCI); 200m, 16.III.1992, MVL, BL (1♂, CNCI); 50m, 20.III.1992, MVL, BL (1♂, CNCI). SANTIAGO: Cerro Inn, 28.III.1992, MVL, BL (1♂, CNCI); Bahia Espumilla, 4.IV.1992, MVL, BL (1♂, CNCI); 17.III.1998, UL, LRA (1♂, CDRS); 200m, 5.IV.1992, MVL, BL (1♂, CNCI); Los Aguacates, 520m, 6.IV.1992, MVL, BL (2♂, CNCI); Central, 700m, 9.IV.1992, MVL, BL (1♂, CNCI). SEYMOUR NORTE: 29.III.1992, MVL, BL (1♀, CNCI).

Enyo lugubris delanoi KERNBACH

New island records. RABIDA: Tourist trail, 3.IV.1992, MVL, BL (1♂, CNCI). SANTA FÉ: Arid Zone, 6-9.V.1997, MVL, LRA (2♂, CDRS). Seymour Norte: Arid Zone, 23.I.1989, MVL, BL (1♂, CDRS); 29.III.1992, MVL, BL (1♂, CNCI). SANTIAGO: Bahia Espumilla, 4.IV.1992, MVL, BL (1♂, CNCI); 17.III.1998, UL, LRA (2♂, CDRS); Central, 700m, 9.IV.1992, MVL, BL (1♂, CNCI).

Perigonia lusca lusca (FABRICIUS)

New Archipelago record. ISABELA: Volcan Alcedo, pampas, 1150m, 16.IV.2001, UL, LRA (1♂, CDRS). SANTA CRUZ: Barranco, 10m, 14.VII.1999; 8.II.2000, MVL, LRA & VC (3♂, CDRS).
New host plant record. Rubiaceae: *Cinchona succirubra* PAV. EX KLOTZSCH.

Eumorpha fasciatus tupaci KERNBACH

New island record. FLOREANA: Asilo de la Paz, 27.V.1998, MVL, LRA & C. Covell (2♂, CDRS).

Eumorpha labruscae yupanquii KERNBACH

New island record. ISABELA: Volcan Alcedo, Arid zone 10m, 3.VI.1997, MVL, LRA (3♂, CDRS); Volcan Alcedo, pampas, 1100m, 7.VI.1997, MVL, LRA (2♂, CDRS).
New host plant record. Vitaceae: *Cissus sicyoides* L.

Xylophanes pluto (FABRICIUS)

New Archipelago record. SANTA CRUZ: Barranco, 14.VII.1999, MVL, LRA & VC (6♂, CDRS); Puerto Ayora, 5.II.2000, FL, LRA (1♀, CDRS).

Xylophanes tersa tersa (LINNAEUS)

New island records. FLOREANA: Asilo de la Paz, 24.IV.1996, MVL, LRA & VC (1♂, CDRS). ISABELA: Volcan Sierra Negra, Santo Tomás, 23.IV.1996, FL, LRA (4♂, CDRS); Volcan Alcedo, Arid zone, 10m, 3.IV.1997, MVL, LRA (1♂, CDRS); Volcan Alcedo, pampas, 1100m, 7.VII.1997, MVL, LRA (1♂, CDRS). SANTA CRUZ: El cascajo, 7.III.1997, MVL, LRA (1♀, CDRS); Los Gemelos, I.1997, MVL, LRA (4♂, 9♀, CDRS); 27.II.1997, MVL, LRA (2♂, CDRS); 1.III.1997, MVL, LRA (2♂, CDRS); 7.IV.1997, MVL, LRA (2♂, 1♀, CDRS); VI.1997, MVL, LRA (1♂, CDRS); 27.VIII.1997, MVL, LRA (1♀, CDRS); Media Luna, 26.V.1996, MVL, LRA (1♂, 1♀, CDRS); IV.1997, MVL, LRA (2♂, 2♀, CDRS); Transition zone, 5.IV.1997, MVL, LRA (2♂, CDRS).
New host plant record. Rubiaceae: *Diodia radula* (ROEM. & SCHULT.) CHAM. & SCHLECHT.

Xylophanes norfolki KERNBACH

New island records. FERNANDINA: W Side, 1100m 5.II.1964, D. Q. Cavagnaro, (1♂, CAS). ISABELA: Volcan Alcedo, Bursera forest, 3.VI.1997, MVL, LRA (1♂, CDRS); Volcan Alcedo, 850m, 6.VI.1997, MVL, LRA (2♂, CDRS).
New host plant record. Rubiaceae: *Psychotria rufipes* HOOK. *f.*

Hyles lineata (FABRICIUS)

New island records. PINTA: 400m, 17.III.1992, MVL, BL (1♀, CNCI). RABIDA: Tourist trail, 3.IV.1992, MVL, BL (1♂, CNCI). SANTA FÉ: Arid zone, 6-9.V.1997, MVL, LRA (2♀, CDRS). SEYMOUR NORTE: 29.III.1992, MVL, BL (1♂, CNCI).
New host plant record. Nyctaginaceae: *Boerhaavia caribaea* JACQ.

Species	St.	Islands															
		B	Bt	Es	Fe	Fl	Ge	I	M	P	Pz	SN	SC	SF	Sg	Sl	R	W
Sphinginae																		
Agrius cingulata	N	X			X	X		X	X				X		X	X	X	X
Cocytius antaeus	N												X			X		
Manduca sexta leucoptera	E			X		X		X					X		X	X	X	
Manduca rustica calapagensis	E	X		X	X	X	X	X	X	X			X		X	X	X	
Macroglossinae																		
Erinnyis alope dispersa	E					X		X					X			X		
Erinnyis ello encantada	E					X		X					X	X	X	X	X	
Erinnyis obscura conformis	E	X	X		X	X	X	X	X	X	X		X		X			
Enyo lugubris delanoi	E					X		X				X	X	X	X		X	
Perigonia lusca	N							X				X	X					
Eumorpha fasciatus tupaci	E					X							X					
Eumorpha labruscae yupanquii	E					X		X					X					
Xylophanes pluto	N												X					
Xylophanes tersa	N					X		X					X					
Xylophanes norfolki	E				X			X					X					
Hyles lineata	N	X		X		X		X		X		X	X	X	X	X	X	

Table 2. Status and distribution of Sphingidae in the Galápagos Islands. St.: Status; N: native, E: endemic; Islands: B: Baltra, Bt: Bartolomé, Es: Española, Fe: Fernandina, Fl: Floreana, Ge: Genovesa, I: Isabela, M: Marchena, P: Pinta; Pz: Pinzón, SN: Seymour Norte, SC: Santa Cruz, SF: Santa Fé, Sg: Santiago, Sl: San Cristóbal, R: Rábida, W: Wolf.

KEY TO GALÁPAGOS SPHINGIDAE BASED ON EXTERNAL STRUCTURES

1 Wingspan 50-120 mm 2
- Wingspan 150-190 mm.....*Cocytius antaeus* (DRURY) (Fig. 2)
2 Forewing outer margin scalloped, wavy or very angular.....3
- Forewing outer margin more or less smooth 6
3 Body and wings dark brown; outer margin of forewings strongly scalloped .....*Enyo lugubris delanoi* KERNBACH (Fig. 8)
- Not as described above 4
4 Forewings gray with dark markings, hindwings reddish-orange with the outer border black 5
- Forewings dark brown; basal area of hindwings bright yellow.....14
5 Abdomen with black bars.....*Erinnyis ello encantada* KERNBACH (Fig. 6)
- Abdomen without black bars.....
.....*Erinnyis obscura conformis* KERNBACH (Fig. 7)
6 Antenna enlarging toward apex, apically constricted and hook-shaped.....
.....*Hyles lineata* (FABRICIUS) (Fig. 14)
- Antenna of same width for whole length except for constricted and hook-shaped apex.....7
7 Abdomen with 3-6 pairs of yellow spots.....8
- Not as described above.....9
8 Abdomen with 5-6 pairs of yellow spots; forewings gray with black and white markings .....*Manduca sexta leucoptera* (FABRICIUS) (Fig. 3)
- Abdomen with 3 pairs of yellow bars; forewings gray, golden or dark brown with white markings.....*Manduca rustica calapagensis* (HOLLAND) (Fig. 4)
9 Abdomen long and pointed; hindwings with row of yellow triangular bars.....10
- Not as described above.....11
10 Forewings with a diffuse diagonal whitish line from before middle of dorsal margin to apex.....*Xylophanes tersa* (LINNAEUS) (Fig. 13)
- Forewings without diagonal whitish line.....
.....*Xylophanes norfolki* KERNBACH (Fig. 12)
11 Body and forewing green 12
- Not as described above.....13
12 Hindwing with red, black and blue markings.....
.....*Eumorpha labruscae yupanquii* KERNBACH (Fig. 11)
- Hindwing across with large yellowish-orange band.....
.....*Xylophanes pluto* (FABRICIUS) (Fig. 15)
13 Forewing dark-greenish brown with sharply defined whitish bands; abdomen dorsally with longitudinal whitish bands .....*Eumorpha fasciatus tupaci* KERNBACH (Fig. 10)
- Forewing brownish gray; abdomen with 4-5 pairs of pink spots.....
.....*Agrius cingulata* (FABRICIUS) (Fig. 1)
14 Wingspan 80-98 mm; forewing outer margin scalloped.....
.....*Erinnyis alope dispersa* KERNBACH (Fig. 5)
Wingspan 53-68 mm; forewing outer margin curving outward near middle
.....*Perigonia lusca* (FABRICIUS) (Fig. 9)

DISCUSSION

The new distribution records mentioned here are believed to reflect better collecting efforts rather than recent expansions of distributions as most Galápagos hawk moths (except the endemic *X. norfolki*) are widely distributed in the New World and good dispersers.

The discovery of the host plant of *X. norfolki* will help in the conservation of this unique species. The host plant (*Psychotria rufipes*) is endemic to the Galápagos and is present on six islands (McMULLEN 1999). Factors limiting the actual distribution of *X. norfolki* to only three islands should be investigated.

The host plants of the other Galápagos hawk moths are usually not endemic species. Some of these are actually invasive plants on Galápagos landscapes (for ex.: *Cinchona succirubra* and *Psidium guajaba*) but the impact of sphingid caterpillars on their control is not expected to be important as wasps and other predators feed on them extensively (unpublished data). Moreover, sphingid caterpillars are rarely present in large numbers at any given time and place.

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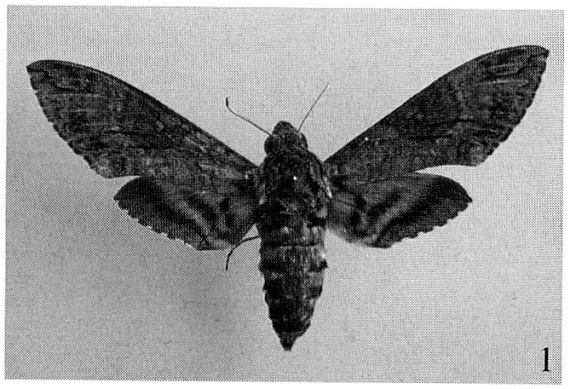
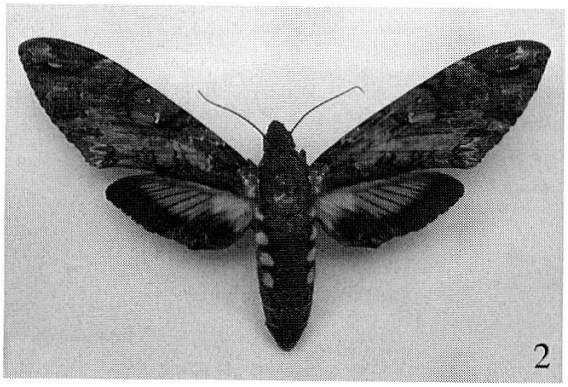
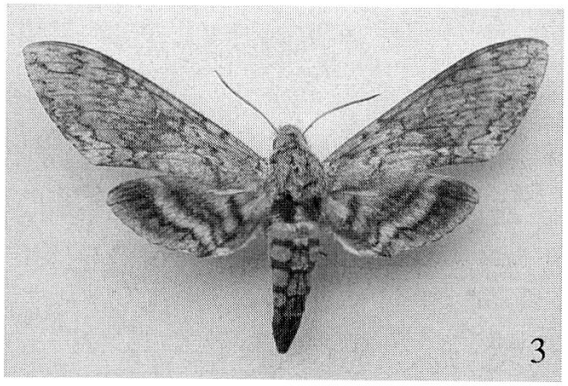
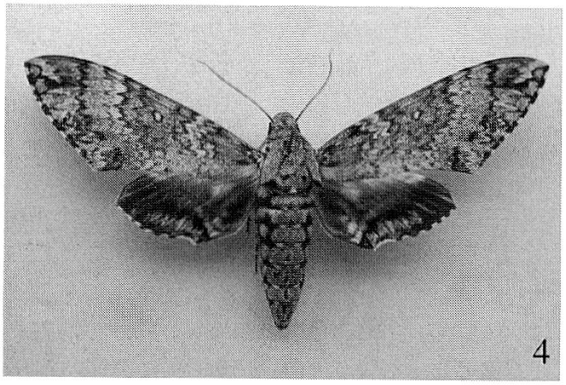
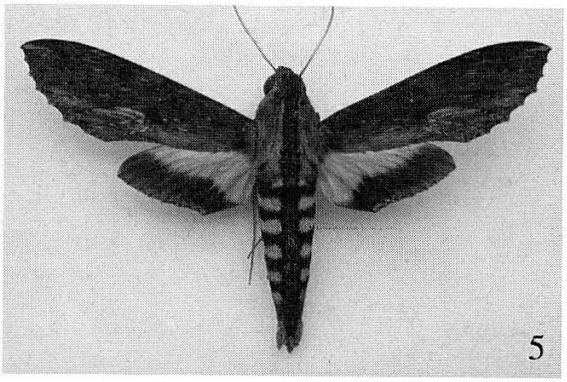
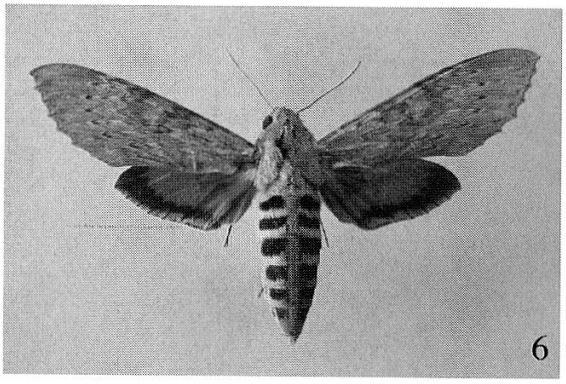


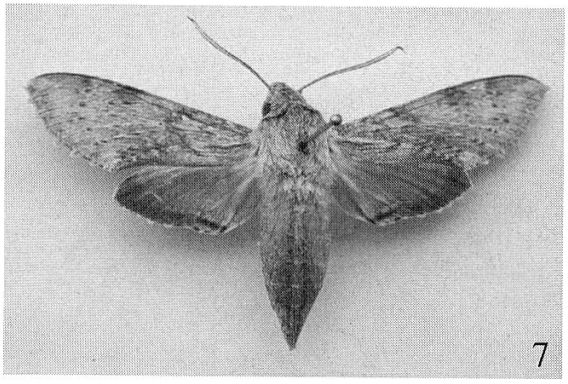


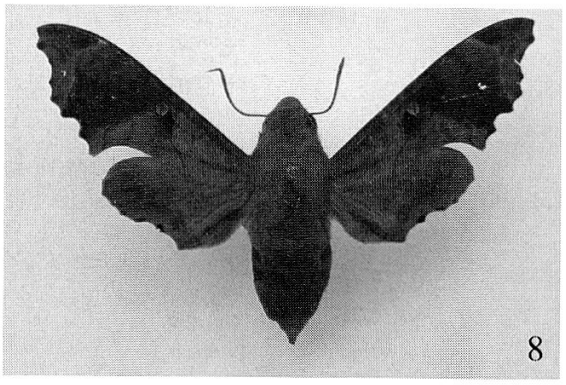




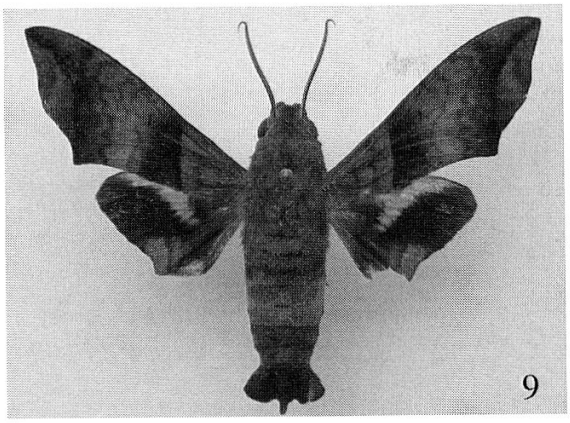


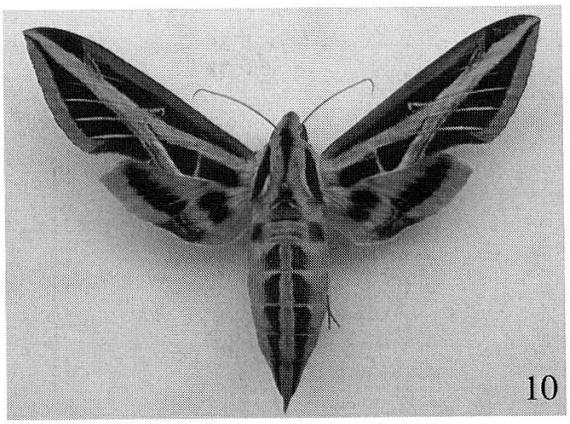


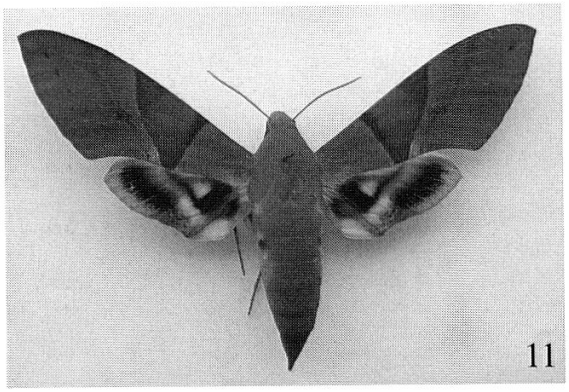


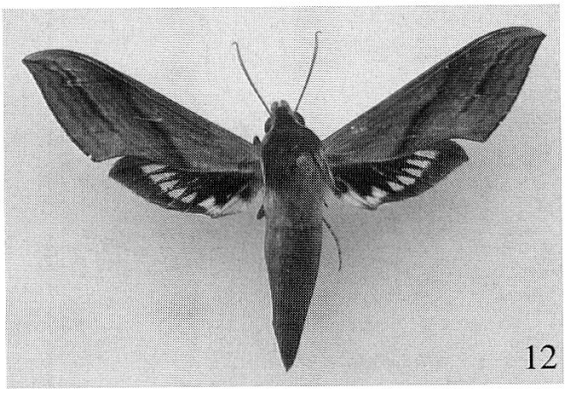


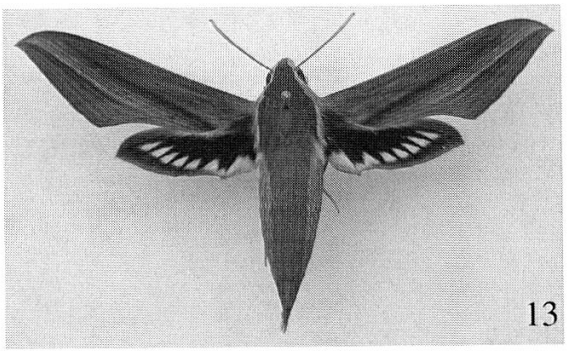
Figs. 1-8. Sphingidae species of the Galápagos. 1: *Agrius cingulata* (FABRICIUS); 2: *Cocytius antaeus* (DRURY); 3: *Manduca sexta leucoptera* (FABRICIUS); 4: *Manduca rustica calapagensis* (HOLLAND); 5: *Erinnyis alope dispersa* KERNBACH; 6: *Erinnyis ello encantada* KERNBACH; 7: *Erinnyis obscura conformis* KERNBACH; 8: *Enyo lugubris delanoi* KERNBACH.

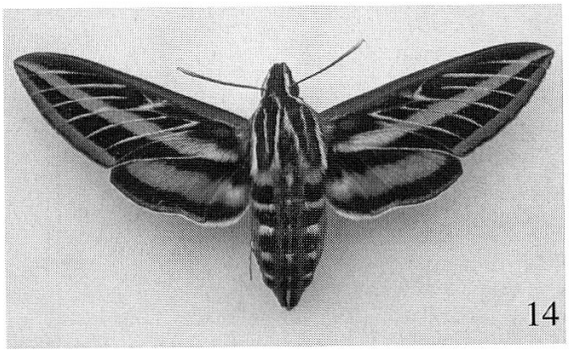


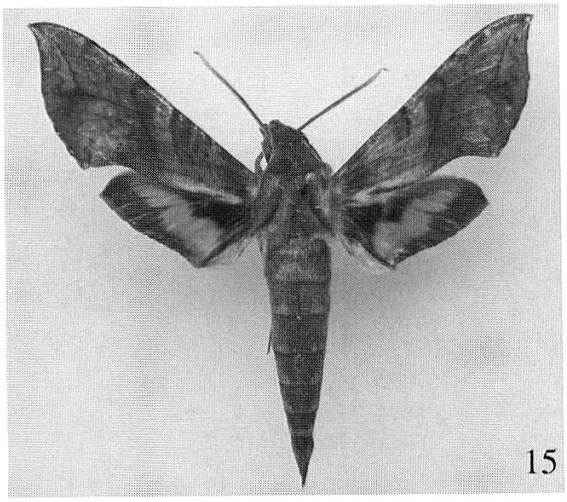












Figs. 9-15. Sphingidae species of the Galápagos. 9: *Perigonia lusca* (FABRICIUS); 10: *Eumorpha fasciatus tupaci* KERNBACH; 11: *Eumorpha labruscae yupanquii* KERNBACH; 12: *Xylophanes norfolki* KERNBACH; 13: *Xylophanes tersa* (L.); 14: *Hyles lineata* (FABRICIUS); 15: *Xylophanes pluto* (FABRICIUS).

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