



**Infestation of Sphingidae (Lepidoptera) by
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Prasadiseius kayosiekeri (Acari: Otopheidomenidae)**

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V. Prasad. Infestation of Sphingidae (Lepidoptera) by otopheidomenid mites in intertropical continental zones and observation of a case of heavy infestation by Prasadiseius kayosiekeri (Acari: Otopheidomenidae). *Acarologia*, 2013, 53 (3), pp.323-345. 10.1051/acarologia/20132100 . hal-01566165

HAL Id: hal-01566165

<https://hal.science/hal-01566165>

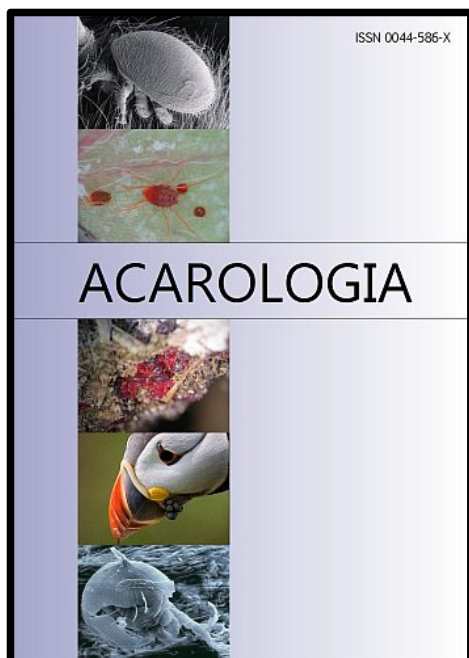
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Previous volumes (2010-2015): 250 € / year (4 issues)

Acarologia, CBGP, CS 30016, 34988 MONTFERRIER-sur-LEZ Cedex, France

The digitalization of Acarologia papers prior to 2000 was supported by Agropolis Fondation under the reference ID 1500-024 through the « Investissements d'avenir » programme (Labex Agro: ANR-10-LABX-0001-01)



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INFESTATION OF SPHINGIDAE (LEPIDOPTERA) BY OTOPHEIDOMENID MITES IN INTERTROPICAL CONTINENTAL ZONES AND OBSERVATION OF A CASE OF HEAVY INFESTATION BY *PRASADISEIUS KAYOSIEKERI* (ACARI: OTOPHEIDOMENIDAE)

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(Received 26 March 2013; accepted 17 June 2013; published online 30 September 2013)

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ABSTRACT — Examination of 761 Sphingidae in museum collections revealed infestation of 24 moths by 4 species of the ectoparasitic otopheidomenid mites (Acari: Otopheidomenidae). The infestation rate was 3.2 %. The mites were: *Prasadiseius cocytes*, *P. donahuei*, *P. kayosiekeri* and *P. pholusis*. Among the sphingid moths, *Pachylioides resumens*, collected in Guatemala, unusually, was found to be heavily infested with *P. kayosiekeri*. It had eggs, larvae, nymphs and the adults, many present on the prothorax.

KEYWORDS — Acari; Otopheidomenidae; Lepidoptera; Sphingidae; Guatemala; ectoparasitic; unusual infestation; new records

INTRODUCTION

Otopheidomenids are phytoseoid mites, known to infest insects of the orders Hemiptera, Isoptera, Lepidoptera and Orthoptera. The mites of subfamily Otopheidomeninae (Lindquist et al, 2009) are found usually in thoracoabdominal and tympanic areas of noctuid and sphingid moths (Prasad, 1968; Wanstein, 1972). While mites of genera *Noctuiseius* Prasad, 1968 and *Otopheidomenis* Treat, 1955 parasitize noctuid moths, the genus *Prasadiseius* Wainstein, 1972 is specialized infesting sphingid moths. All stages of these mites are found on the same host usually in between the dorsal wings including the tympanic-metathoracic-first abdominal region. In the Afrotropical, Indomalaya (Oriental) and Neotropical ecozones, eight species are known

infesting these moths (Prasad, 1970a, b, 1972, 1973, 1976, Prasad *et al.*, 2011). These include: *P. achlora* (Prasad, 1972), *P. aporodes* (Prasad, 1972), *P. cocytes* (Prasad, 1970) *P. donahuei* (Prasad, 1970), *P. incanus* Prasad and Guanilo, 2011, *P. indicus* (Prasad, 1973), *P. kayosiekeri* (Prasad, 1970) and *P. pholusis* (Prasad, 1970). A key for the identification of these species is given in Prasad *et al.* (2011).

Pachylioides resumens (Walker, 1856) collected in Guatemala was found to be very heavily infested with *P. kayosiekeri* (Prasad, 1970b). This mite was originally described from moths *Enyo lugubris* (Linnaeus) collected in Honduras, *Pachylia darceta* (Druce, 1881) in Peru and *Pachylioides resumens* (Walker, 1856) in Panama Canal Zone infesting different areas of the moths but not the prothorax.

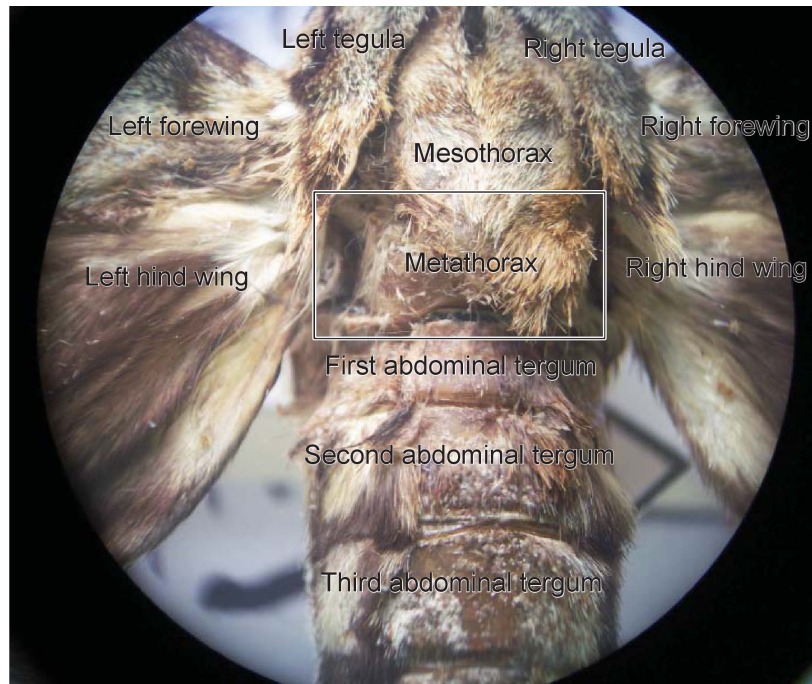


FIGURE 1: Dorsum of a sphingid moth with rectangular infestation area of *Prasadiseius* mites (in between the wings-tympanic-metathoracic-first abdominal cavity area, low magnification).

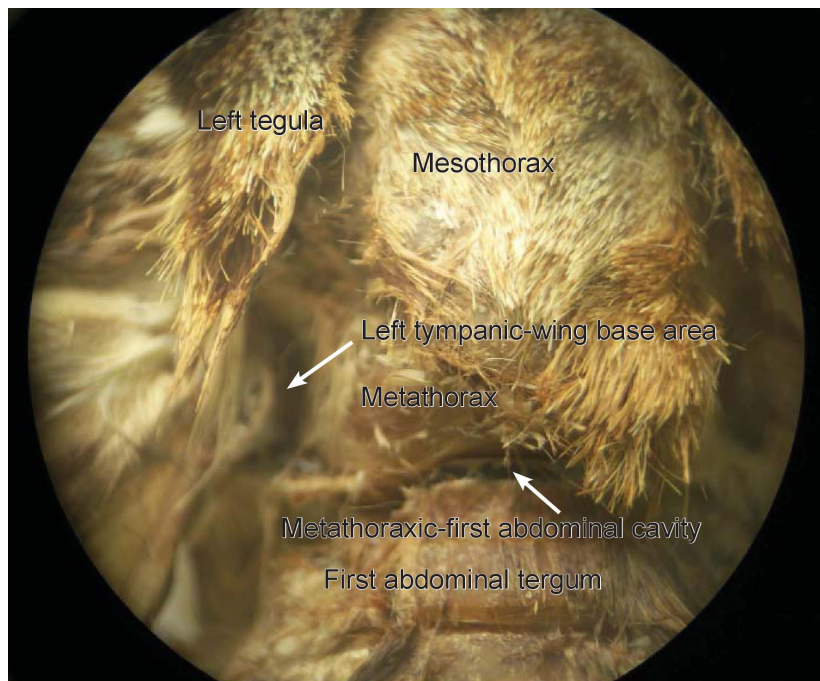


FIGURE 2: Dorsum of a sphingid moth host with rectangular infestation area of *Prasadiseius* mites (arrows) (in between the wings-tympanic-metathoracic-first abdominal cavity area, in high magnification).



FIGURE 3: Sphingid sclerites in between the left wings-tympanic-metathoracic area, showing the sclerites where *Prasadiseius* species inhabit, reproduce and multiply.

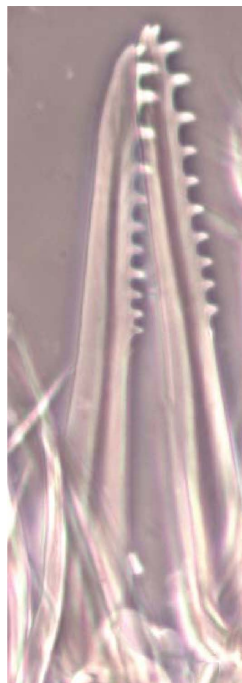


FIGURE 4: Movable chelicerae of a *Prasadiseius* species : the denticles possibly function as scrapers of the host tissue.

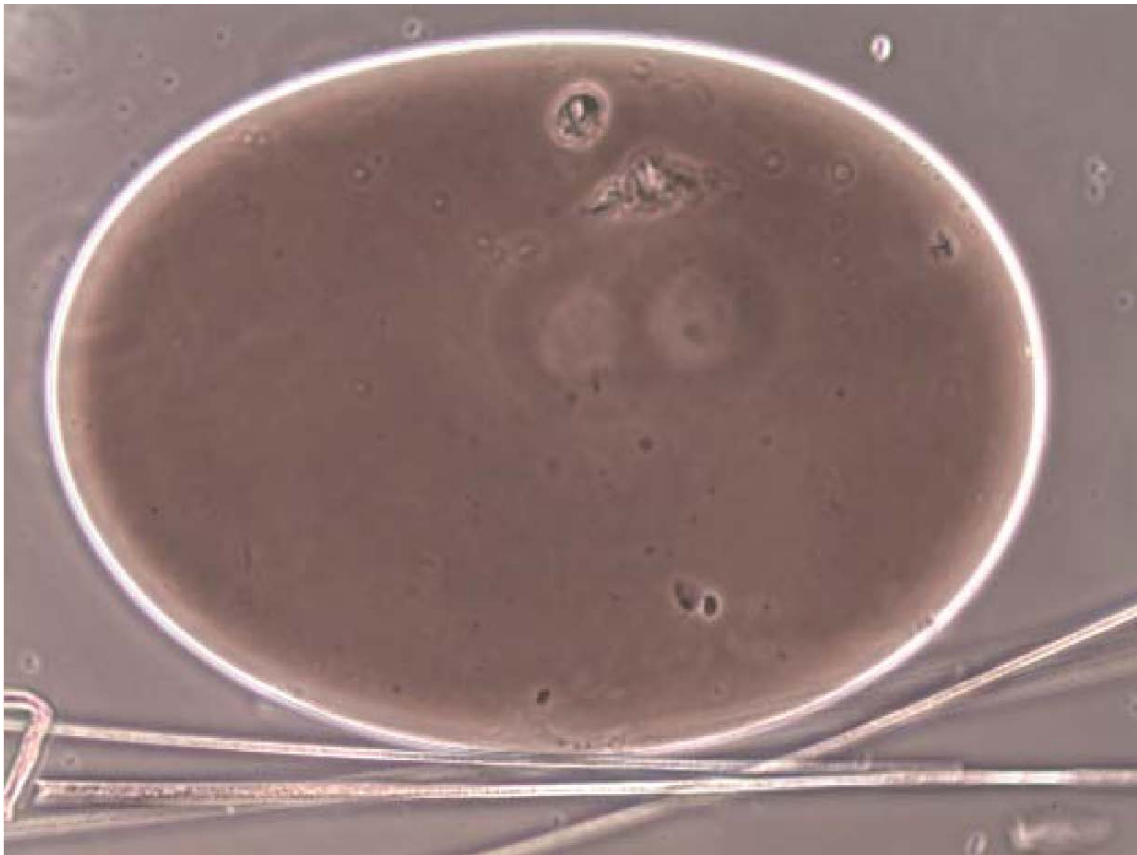


FIGURE 5: Egg of a *Prasadiseius* species attached with moth hairs: note the oval shape and absence of sculpturing pattern of the integument.



FIGURE 6: Egg of a Psocoptera: note both narrow ends and typical sculpturing pattern of the integument.



FIGURE 7: Large infestation of *P. kayosiekeri* on the prothorax of *Pachylioides resumens* (Sphingidae) in low magnification (Guatemala) (many mites were removed for identification).



FIGURE 9: Several *Prasadiseius* species mites in the left proximal half of the forewing and left wing base-tympanic-first abdominal cavity area (several mites shown within the circle) (low magnification).

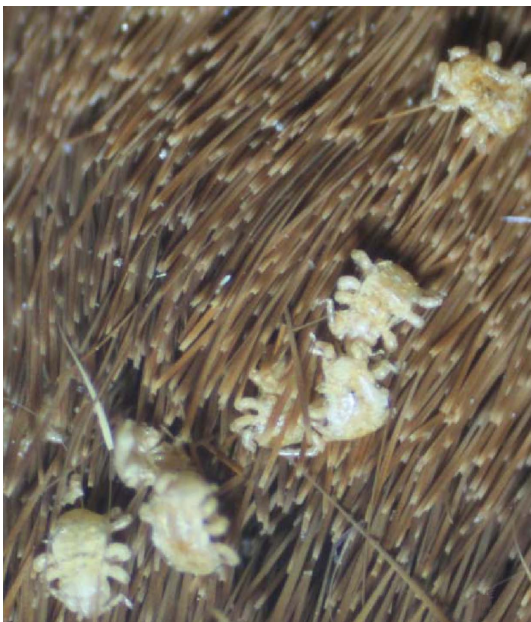


FIGURE 8: Unusual infestation of *P. kayosiekeri* on prothorax, *Pachylioides resumens* (Sphingidae) (VP09-23). Seven mites are attached to the hairs (high magnification, Guatemala) (many mites removed for identification).

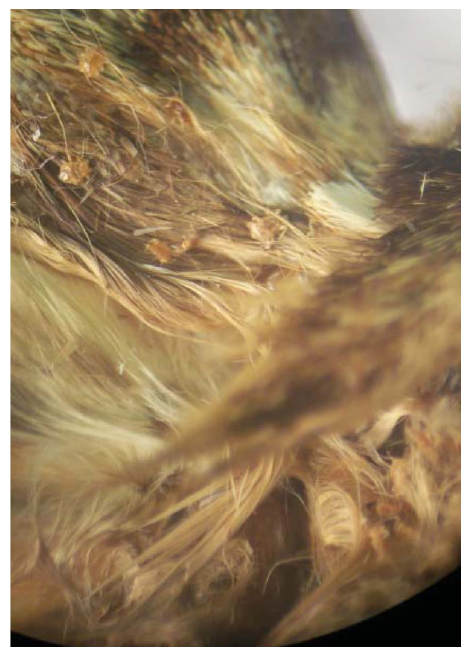


FIGURE 10: Several *Prasadiseius* species mites present in the left proximal half of the forewing and left wing base-tympanic area (high magnification).

Unusually, numerous mites were present on the prothorax. The details of the morphology of this mite studied using scanning electron micrographs were published by Prasad and Walker (2011). Here, the results of examination of 761 moths and the case of the heavy infestation are presented.

MATERIALS AND METHODS

The adult sphingid moths collected from many countries and preserved in A. J. Cook Arthropod Research Collection, Department of Entomology, Michigan State University, East Lansing, Michigan, USA, were examined during February 27 – March 27, 2009 and in the Chicago Natural History Museum, Chicago, USA, on September 11, 2009 by the author. In the former place, the moths were examined using a Wild M5-89111 binocular microscope under 48-96x magnification using the light provided with the microscope. The heavily infested moth was borrowed, photographed using a Kodak High Definition Easy Share Z812IS photo camera, a video was made using Sony Hi8 Handycam camera and placed on-line (www.indirapublishinghouse.com). The mites in the later place were examined under a binocular microscope without noting details of the microscope. All mites were removed from the moths. These were mounted in Hoyer's medium on glass slides (3 x 1" = 75 mm x 25 mm) under a 18 mm zero thickness round cover slip after clearing of mites in lactophenol for 5 – 10 minutes for positive species identification. They were dried for 5-7 days on a slide warming hot plate between 45 – 47 °C and edges of the coverslip sealed with Glyptal. The mites were finally identified by the author under Accu-Scope 3000 phase contrast microscope (New York, USA). Photographs of eggs and chelicerae (Figs. 4 - 6) were taken under 100 to 400 magnification using the mounted Micrometrics™ camera and saved in Photoshop CS2. Photographs of the moths with the mites (Figs. 1 - 3, 7 - 10) were taken under a Bausch and Lomb stereo binocular microscope having total magnification of 25x using a High Definition Kodak EasyShare Z812 IS camera and placing directly on the eye-piece lens. As these photographs were enlarged or cropped further, no

correct magnification are given on the figures. All mites collected from the sphingid moths were given collection numbers from VP09-01 to VP09-26 (VP09-13 and VP09-25 had no otopheidomenid mites).

The world data on previous collections of 8 *Prasadiseius* species known from the sphingid moths are given in Table 1 to compare with the data given in the results that are based on the present work. The voucher specimens of mites are deposited in the collection of MSU and US National Museum, Washington, DC, USA, now housed at USDA, Beltsville, MD, USA. The terms given in the collection data as MSU refers to the Michigan State University and CNHM refers to the Chicago Natural History Museum.

RESULTS

Collection data — The details of all collections are given below and summarized in Tables 2-4. Unless mentioned, all mites were found on dorsum of the moth host. As there is no true tympanum in the sphingid moths as noctuid moths have, these are written as left or right "tympanic area" where mites were found and indicated so in the results and the discussions. All mites were attached with the hairs or found among the hairs [F = Female, M = Male, E = Egg, L = Larva, PN = Protonymph, DN = Deutonymph].

(1) VP09-1 [*P. cocytes* (Prasad, 1970a)]:

Brazil, Rondônia – Pousada Rancho Grande, about 60 km south of Ariquemes, 150 m elevation, moth host: *Enyo ocypete* (Linnaeus), coll. M.C. Nielsen and F.W. Stehr, 14-23 April 1996, 2 mites in right tympanic area medial to the wing base, mites collected on 27 February 2009, 2F (= 2 mites), from MSU collection [Prasad, 2011c].

(2) VP09-2 [*P. cocytes* (Prasad, 1970a)]:

Peru, Cusco – San Pedro, Cosnipata Valley, about 1476 m elevation, moth host: *Xylophanes pyrrhus* Rothschild and Jordan, coll. A.M. West and F.M. West, 3-9 November 2007, few mites in left tympanic area and 2 mites on left wing base, mites collected on 27 February 2009, 1F, 2M, 1L, 1PN (= 5 mites), from MSU collection [Prasad, 2011c].

TABLE 1: Ecogeographical distribution of *Prasadiseius* spp. till 2012 and host distribution.

Otopheidomenid species (<i>P</i> = <i>Prasadiseius</i>)	Distribution	Country	Year of publication	Collection number of the author	Moth host
1. <i>P. achlora</i> (Prasad, 1972)	Afrotropical	UGANDA	1972	VP70-16	<i>Antinephele achlora</i> Holland
2. <i>P. aporodes</i> (Prasad, 1972)			1972	VP70-17	<i>Hippotion aporodes</i> R. & J.
3. <i>P. cocytes</i> (Prasad, 1970a)	Neotropical	BRAZIL	2011c	VP09-1, VP09-15, VP09-16	<i>Cocytius duponchel</i> (Poey), <i>Enyo ocypte</i> (L.)
			2011b	VP09-17	<i>Manduca rustica</i> (F.)
		ECUADOR	2011c	VP09-12, VP09-17, VP09-18	<i>Enyo gorgon</i> (Cramer), <i>Eumorpha labruscae</i> (L.), <i>Manduca rustica</i> (F.)
					<i>Adhemarius gannascus</i> (Stoll), <i>Lintneria merops</i> (Boisduval)
		GUATEMALA	2011c	VP09-19, VP09-21	<i>Adhemarius gannascus</i> (Stoll), <i>Lintneria merops</i> (Boisduval)
		MEXICO	2011b	VP09-26	<i>Manduca</i> sp.
		PERU	1970a	VP69-101, VP69-102	<i>Cocytius duponchel</i> (Poey)
			2011b	VP09-22	<i>Manduca</i> sp.
			2011c	VP09-2, VP09-3, VP09-4, VP09-5, VP09-14, VP09-22	<i>Cocytius duponchel</i> (Poey), <i>Manduca</i> sp., <i>Xylophanes docilis</i> (Butler), <i>Xylophanes pyrrhus</i> R. & J.
			2011d	VP10-35, VP10-36, VP10-37, VP10-38, VP10-39	<i>Xylophanes nabuchodonosor</i> Oberthür
			2012	VP10-36, VP10-38, VP10-39, VP10-42, VP10-43	<i>Adhemarius sexoculata</i> (Grote), <i>Xylophanes nabuchodonosor</i> Oberthür
			1970a	VP69-103	<i>Erinyis obscura</i> (F.)
4. <i>P. donahuei</i> (Prasad, 1970a)					<i>Xylophanes fusimacula</i> (R. Felder), <i>Xylophanes undata</i> R. & J.
5. <i>P. incanus</i> Prasad and Guanilo, 2011					
6. <i>P. indicus</i> (Prasad, 1973)	Indomalayan	INDIA	1973	VP72-193	Unknown
7. <i>P. kayosiekeri</i> (Prasad, 1970b)	Neotropical	GUATEMALA	2011	VP09-23	<i>Pachylioides resumens</i> (Walker)
		HONDURAS	1970b	VP69-187	<i>Enyo lugubris</i> (L.)
		PANAMA	1970b	VP69-208, VP69-209	<i>Pachylioides resumens</i> (Walker)
		PERU	1970b	VP69-190	<i>Pachylia darceta</i> Druce
8. <i>P. pholusis</i> (Prasad, 1970b)		BOLIVIA	1970b	VP69-210, VP69-211	<i>Eumorpha anchemolus</i> (Cramer), <i>Eumorpha obliquus</i> (R. & J.)
		HONDURAS	1970b	VP69-181	<i>Pholus</i> sp.

TABLE 2: Infestation with 4 species of otopheidomenids of 24 sphingids from the Museum of Department of Entomology, Michigan State University (East Lansing, Michigan, USA,) and in the Chicago Natural History Museum, (Chicago, Illinois, USA) (** new record).

Otopheidomenid species(<i>P</i> = <i>Prasadiseius</i>)	Distribution	Country	Collection number of the author	Moth host
1. <i>P. cocytes</i> (Prasad, 1970a) : (14)	South America	BRAZIL	VP09-1	<i>Enyo ocypte</i> (L.)
			VP09-15, VP09-16	<i>Cocytius duponchel</i> (Poey)
		ECUADOR	VP09-12	<i>Enyo gorgon</i> (Cramer)
			VP09-17	<i>Manduca rustica</i> (F.)
			VP11-18	<i>Eumorpha labruscae</i> (L.)
		PERU	VP09-2, VP09-3, VP09-4	<i>Xylophanes pyrrhus</i> (R. & J.)
			VP09-5	<i>Xylophanes docilis</i> (Butler)
			VP09-14	<i>Cocytius duponchel</i> (Poey)
	Central America	GUATEMALA	VP09-22	<i>Manduca</i> sp.
			VP09-19	<i>Adhemarius gannascus</i> (Stoll)
2. <i>P. donahuei</i> (Prasad, 1970a): (2)	Central America	GUATEMALA**	VP09-21	<i>Lintneria merops</i> (Boisduval)
	North America	MEXICO**	VP09-9	<i>Madoryx pluto</i> (Cramer)**
3. <i>P. kayosiekeri</i> (Prasad, 1970b) : (4)	Central America	GUATEMALA	VP09-26	<i>Manduca</i> sp.**
	South America	BRAZIL**	VP-23, VP-24	<i>Pachylioides resumens</i> (Walker)
			VP-10	<i>Pachylioides resumens</i> (Walker)
4. <i>P. pholusis</i> (Prasad, 1970b) : (4)	Central America	GUATEMALA**	VP09-11	<i>Pachylia darceta</i> Druce
			VP09-7, VP09-8	<i>Eumorpha</i> sp.
	South America	ECUADOR**	VP09-20	<i>Eumorpha triangulum</i> (R. & J.) **
			VP09- 6	<i>Eumorpha triangulum</i> (R. & J.) **

sphingid moths examined = 761; infested moths = 24; uninfested = 737; rate of infestation = 3.2%

(3) VP09-3 [*P. cocytes* (Prasad, 1970a)]:

Peru, Cusco – San Pedro, Cosnipata Valley, about 1476 m elevation, moth host: *Xylophanes pyrrhus* Rothschild and Jordan, coll. A.M. West and F.M. West, 3-9 November 2007, several mites in left and right tympanic and left and right wing base areas, mites collected on 27 February 2009, 1F, 1M, 3L, 4PN, 3DN (= 12 mites), some mites saved in 70 % ETOH, from MSU collection [Prasad, 2011c].

(4) VP09-4 [*P. cocytes* (Prasad, 1970a)]:

Peru, Cusco – San Pedro, Cosnipata Valley, about 1476 m elevation, moth host: *Xylophanes pyrrhus* Rothschild and Jordan, coll. A.M. West and F.M. West, 3-9 November 2007, some mites in right tympanic area, 2 mites on right wing 1/3 cm away from the wing base and some mites on posterior half of forewing, mites collected on 27 February 2009, 4F, 1M, 1PN (= 6 mites), from MSU collection [Prasad, 2011c].

(5) VP09-5 [*P. cocytes* (Prasad, 1970a)]:

Peru, Cusco – San Pedro, Cosnipata Valley, about 1476 m elevation, moth host: *Xylophanes docilis* (Butler), coll. A.M. West and F.M. West, 3-9 November 2007, 1 mite on left forewing near the base and 3 mites on metathorax-first abdominal area, mites collected on 27 February 2009, 2F, 1M, 1L (= 4 mites), from MSU collection [Prasad, 2011c].

(6) VP09-6 [*P. pholusis* (Prasad, 1970b)]:

New collection data, Ecuador, Rio Palenque, moth host: *Eumorpha triangulum* (Rothschild and Jordan), coll. B. Jayne, 1979, several hundred mites, many mites posterior to right tympanic area above metathoracic-first abdominal cavity, one mite on right hind wing base, many mites just posterior to left and right tympanic areas and several mites on venter of metathoracic-first abdominal cavity, mites collected on 13 March 2009, 14F, 3M, 9L, 15PN (= 41 mites), many eggs, some mites saved in 70 % ETOH, some mites used for SEM study (W = Walker), several Psocoptera eggs also found among the mites, from MSU collection (Fig. 6).

(7) VP09-7 [*P. pholusis* (Prasad, 1970b)]:

New collection data, Guatemala, Izabal – Morales, Cerro Negro Norte, Finca Firmeza, elevation 2100 feet, 15°23'01.5"N, 88°43'00.3"W, moth host: *Eumorpha* sp., coll. F.M. West, 8-9 July 2005, 3 mites

on right forewing base, 1 mite on anterior part of mesothorax (close to pinned needle), many mites on top of first and second abdominal segment, few mites on left prothorax and 1 mite on hind wing near base, mites collected on 13 March 2009, 21F, 5M, 4L, 5PN, 2DN (= 37 mites), from MSU collection.

(8) VP09-8 [*P. pholusis* (Prasad, 1970b)]:

New collection data, Guatemala, Suchitépquez – Patulul, Finca de Los Tarrales, elevation 4623 ft, 14°32'48.7"N, 91°09'42"W, moth host: *Eumorpha* sp., coll. A.M. West and F.M. West, 12-13 August 2006, 1 mite on middle of mesothorax just anterior to the pinned needle, 1 mite on middle of metathorax just behind the pinned needle, several mites on left of first abdominal segment, 1 mite on right of first abdominal segment, 1 mite on left anterior forewing close to base and 1 mite on right hind wing base close to base, mites collected on 13 March 2009, 8F, 4L, 1PN (= 13 mites), 1 egg, from MSU collection.

(9) VP09-9 [*P. donahuei* (Prasad, 1970a)]:

New collection data, Guatemala, Izabal – Morales, Cerro Negro Norte, Finca Firmeza, elevation 2100 feet, 15°23'01.5"N, 86°43'00.8"W, moth host: *Mado-ryx pluto* (Cramer), coll. F.M. West, 8-9 July 2005, 2 mites on posterior part of forewing close to wing base, many mites in right tympanic-first abdominal segment area, some mites in left tympanic-metathorax-first abdominal area and in the cavity, mites collected on 13 March 2009, 9F, 24M, 2PN, 2DN (= 37 mites), some mites saved in 70 % ETOH, some mites used for SEM study (T = Tiedt), from MSU collection.

(10) VP09-10 [*P. kayosiekeri* (Prasad, 1970b)]:

New collection data, Brazil, Rondônia – Cacauplandia, moth host: *Pachylioides resumens* (Walker), coll. A.M. West and F.M. West, 22 November 1991, 1 mite on side of first abdominal segment just posterior to the wing base and many mites in left tympanic area, mites collected on 13 March 2009, 7F, 2M, 3L, 5PN, 6DN (= 23 mites), some mites saved in 70 % ETOH, some mites used for SEM study (T), from MSU collection (Fig. 6).

(11) VP09-11 [*P. kayosiekeri* (Prasad, 1970b)]:

New collection data, Brazil, Rondônia – Franz Rancho Grande, 5 km south of Cacauplandia, moth host:

Pachylia darceta Druce, coll. not given, 24 August 1991, 2 mites on left mesothorax anterior and posterior to pinned needle, 4 mites on left hind wing, 1 mite hanging attached with hairs on left in between hind wing and first abdominal space, several mites on ventral side of right forewing within 1 cm from base and 2 mites on left ventral area of second abdominal segment, mites collected on 13 March 2009, 2F, 4M, 2L, 2PN, 3DN (= 13 mites), several Psocoptera eggs also found among the mites, from MSU collection.

(12) VP09-12 [*P. cocytes* (Prasad, 1970a)]:

Ecuador, Napo – Misahualli, on bank of Napo River, elevation 350 m; low land, moth host: *Enyo gorgon* (Cramer), coll. M. Churchill, 7-9 October 2001, over 15 mites on left side of head and dorsal prothorax, several mites on dorsal mesothorax-metathorax, 1 mite on ventral half of right eye, 3 mites under proboscis, several mites on ventral side of metathorax-first abdominal cavity near legs III and 3 mites on left ventrolateral side near tympanic area adjacent to forewing and hind wing bases, mites collected on 13 March 2009, 5F, 2M, 26L, 4PN (= 37 mites), some mites saved in 70 % ETOH, from MSU collection [Prasad, 2011c].

(13) VP09-14 [*P. cocytes* (Prasad, 1970a)]:

Peru, Ucayali – Pucallpa, moth host: *Cocytius duponchel* (Poey), coll. W.T. Van Velven, 23 July 1962, 1 mite in between dorsal cavity of head and prothorax, several mites in right dorsal metathorax-first abdominal area posterior to tympanic area, 1 mite on ventral side posterior but close to right hind wing base, mites collected on 27 March 2009, 9F, 4L (= 13 mites), some mites saved in 70 % ETOH, from MSU collection [Prasad, 2011c].

(14) VP09-15 [*P. cocytes* (Prasad, 1970a)]:

Brazil, Rondônia – Cacauplandia, moth host: *Cocytius duponchel* (Poey), coll. A.M. West and F.M. West, 10-22 August 1993, 2 mites on dorsal cavity of metathorax-first abdomen medial to left wing base, 2 mites on left side of first abdominal segment posterior to left wing base and 1 mite on right side posterior to right wing base, mites collected on 27 March 2009, 5F (= 5 mites), from MSU collection [Prasad, 2011c].

(15) VP09-16 [*P. cocytes* (Prasad, 1970a)]:

Brazil, Rondônia – Cacauplandia; moth host: *Cocytius duponchel* (Poey), coll. A.M. West and F.M. West, 10-22 August 1993, 1 mite on right first abdominal segment, mite collected on 27 March 2009, 1F (= 1 mite), from MSU collection [Prasad, 2011c].

(16) VP09-17 [*P. cocytes* (Prasad, 1970a)]:

Ecuador, Napo – Misahualli, on bank of Napo River, elevation 350 m, low land, moth host: *Manduca rustica* (Fabricius), coll. M. Churchill, 20 October 2001, over 1000 mites, most heavily infested moth ever seen (Prasad, 2011c) and VIDEO prepared (www.indirapublishinghouse.com), many eggs and other stages on all over body (including many on ventral and lateral side of body) including wings but most on thorax to third abdominal segments, some mites in pair or together and on proximal half of wings, mites collected on 27 March 2009, 17F, 3M, 2L, 7PN, 7DN (= 36 mites), 22 eggs, many mites saved in 70 % ETOH, some mites used for SEM study (T), from MSU collection [Prasad, 2011b, c].

(17) VP09-18 [*P. cocytes* (Prasad, 1970a)]:

Ecuador, Sucumbíos – Zabalo Village, Aguarico River, moth host: *Eumorphia labruscae* (Linnaeus), coll. D.O. Beaver and R. Xiyoguage, 9 August 2002, several mites in right tympanic area, 1 mite on mid posterior area of forewing, 1 mite on lateral side of first abdominal segment and 1 mite on left lateral posterior wing base, mites collected on 27 March 2009, 3F, 1M, 9L (= 13 mites), from MSU collection [Prasad, 2011c].

(18) VP09-19 [*P. cocytes* (Prasad, 1970a)]:

Guatemala, Izabal – Morales, Cerro Negro Norte, Finca Firenze, 689 m elevation, moth host: *Adhemarius gannascus* (Stoll), coll. F.M. West, 8-9 July 2005, 1 mite slightly on left side of first abdominal segment and 1 mite in hairs on the cavity of metathorax-first abdominal segment, mites collected on 27 March 2009, 2F (= 2 mites), from MSU collection [Prasad, 2011c].

(19) VP09-20 [*P. pholusis* (Prasad, 1970b)]:

New collection data, Guatemala, Suchitépquez – Patulul, Finca de Los Tarrales, elevation 4623 feet, 14°32'48.7"N, 91°09'42"W, moth host: *Eumorphia triangulum* (Rothschild and Jordan), coll. A.M. West and F.M. West, 12-13 August 2006, 1 mite on hind wing about 0.5 cm from wing base, 2 mites on right

lateral side of first abdominal segment, 1 mite on top of first abdominal and metathoracic cavity, 2 mites together on left hind wing base area and 11-12 mites on right metathorax and first abdominal cavity, mites collected on 27 March 2009, 4F, 1M (= 5 mites), some mites saved in 70 % ETOH, some mites used for SEM study (T), from MSU collection.

(20) VP09-21 [*P. cocytes* (Prasad, 1970a)]: Guatemala, Suchitépquez – Patulul, Finca de Los Tarrales, elevation 1517 m, moth host: *Lintneria merops* (Boisduval), coll. A.M. West and F.M. West, 12-13 August 2006, 1 mite on top left prothorax and 4 mites in right metathoracic-first abdominal cavity, mites collected on 27 March 2009, 1F, 2M, 1L, 1DN (= 5 mites), 3 eggs, from MSU collection [Prasad, 2011c].

(21) VP09-22 [*P. cocytes* (Prasad, 1970a)]: Peru, Junín – Junín District, elevation 1312 m, moth host: *Manduca* sp., coll. A.M. West and F.M. West, 3-12 December 2008, several mites in right tympanic area, 4 mites on top of left and right first abdominal segment and 2 mites on middle top of second abdominal segment, mites collected on 27 March 2009, 5F, 5M, 3PN, 4DN (= 17 mites), some mites saved in 70 % ETOH, from MSU collection [Prasad, 2011b, c].

(22) VP09-23 [*P. kayosiekeri* (Prasad, 1970b)]: Guatemala, Izabal – Morales, Cerro Negro Norte, Finca Firmeza, elevation 2220 feet, 15°22'53.7"N, 88°43'02.4"W, moth host: *Pachylioides resumens* (Walker), coll. A.M. and F.M. West, 18-19 August 2006, heavily infested moth, VIDEO prepared (www.indirapublishinghouse.com), over 20 mites on top of prothorax, 1 mite on left side of head just above middle of left eye, 7-8 mites inside and above metathoracic-first abdominal cavity, several mites in left and right tympanic area and on side of these and 1 mite on left antenna, mites collected on 27 March 2009, 19F, 2M (= 21 mites), many mites saved in 70 % ETOH, some mites used for SEM study (W), from MSU collection [Prasad and Walker, 2011].

(23) VP09-24 [*P. kayosiekeri* (Prasad, 1970b)]: New collection data, Guatemala, Izabal – Morales, Cerro Negro Norte, Finca Firmeza, elevation 2220 feet, 15°22'53.7"N, 88°43'02.4"W, moth host: *Pachylioides resumens* (Walker), coll. A.M. West and F.M. West, 18-19 August 2006, 2 mites on right lateral

side of metathorax close to wing base, 2 mites on middle top of first abdominal segment and 4 mites on top of first-second abdominal joint cavity, mites collected on 27 March 2009, 6F, 1M, 1PN (= 8 mites), from MSU collection.

(24) VP09-26 [*P. donahuei* (Prasad, 1970a)]: Mexico, Sonora – 1.1 mile west of Alamos, moth host: *Manduca* sp., coll. G. Noonan, 5 September 1964, 1 mite on top of first abdominal segment just posterior to metathorax, several mites on left and right metathorax-first abdominal cavity, mites collected on 11 September 2009, 6F, 2M (= 8 mites), from CNHM collection.

Infestation rate — Table 2 indicates details of 24 infested sphingid moths while Tables 3 and 4 indicate details of 737 uninfested moths. Thus, out of 761 moths examined, an infestation rate of 3.2 % in the museum preserved moths was present. This pooled data result indicates that a researcher has to examine at least 100 moths in order to find 3 infested moths.

Infested sphingid moths — As indicated in Table 2, only 15 species of sphingid moths (2 known from genus only) were infested.

Otopheidomenid mites infesting the sphingid moths — Table 2 shows only 4 species of otopheidomenid mites infesting 24 moths and the new records marked with **.

Geographical distribution of the moths and the mites — All 4 species of the mites mentioned in Table 2 were found infesting moths in different countries of North, Central and South Americas as follow (new records marked with **): Brazil (*P. cocytes* and *P. kayosiekeri*), Ecuador (*P. cocytes* and *P. pholusis*), Guatemala (*P. cocytes*, *P. donahuei*, *P. kayosiekeri* and *P. pholusis*), Mexico (*P. donahuei*) and Peru (*P. cocytes*). Thus, 3 species of *Prasadiseius* were present in Guatemala when only one each was found in Mexico and Peru. All of these moths were inhabitants of Neotropical ecozone. Mostly, they were present in South America (Brazil, Ecuador, Peru) but some were present in Central America (Guatemala) while one was present in North America (Mexico). None of the moths from the United States were found to be infested with any of the *Prasadiseius* species. Of all these, Guatemala and Mexico included new

country records for *P. donahuei*, Brazil for *P. kayosiekerei* and Ecuador and Guatemala for *P. pholusis*.

Tympanic areas of the moth host and the mites — Moths of the family Noctuidae have one true tympanum located posteromedial to the hind wing base on lateral side of the metathorax where some otopheidomenid mites have been reported feeding (Treat, 1955, 1975). There is no such true tympanum in the moths of the family Sphingidae. However, in that area of the metathorax and wing base, there are several sclerites that support the wings and the thorax (Fig. 3) where otopheidomenid mites are present. This tympanal region has been redefined giving a broad definition that includes the tympanal organ proper as well as functionally related structural modifications of the metathorax and the first abdominal segment (Speidel *et al.*, 1996). Many otopheidomenid mites parasitizing the sphingid moths are found in this area (Figs. 1, 2).

Metathoracic-first abdominal cavity of the moth host and the mites — In addition to the metathoracic-wing base-tympanic areas, in Sphingidae, the posterior part of the metathorax that attaches with the first abdominal segment, develops a cavity or space. It is concave posteriorly allowing attachment of the anteriorly rounded first abdominal segment and its free movement from the metathorax. Sometimes, the mites could be seen in this space and among the hairs on top of it. This concavity, depression or space may represent "acarinarium" where these mites harbor, feed and multiply.

What do these mites feed on — Each chelicera in the otopheidomenid mite parasitizing the sphingid moths has a well developed movable digit with several recurved denticles (Fig. 4). These mites have never been observed feeding on live sphingid moths. In fact, these mites were seen alive on live sphingid moths for the first time ever only during an expedition to Peru Amazon Forest in 2010 by this author and the expedition team members but the feeding could not be observed. The closely related Tretaiinae otopheidomenid mite having similar movable digit, *Hemipteroseius indicus* (Krantz and Khot, 1962), an ectoparasite of red cotton bug,

Dysdercus cingulatus (Fabricius), has been reported as scraping feeder (Costa, 1968). It is believed by this author that the otopheidomenid mites parasitizing the sphingid moths probably are scraper feeders also. Do these mites feed on some secretion or moth hairs also? This is not known and needs to be investigated.

Unidentified eggs among the mites — The eggs of the *Prasadiseius* species are typically whitish and oval (Fig. 5). The skin surface of these eggs is glistering without any sculpturing pattern. But, among the eggs of these mites, several eggs were found that had narrow ends having very typical skin sculpturing patterns (Fig. 6). These were identified as eggs of Psocoptera by Mr. Gary Parsons, Collection Manager, A. J. Cook Arthropod Research Collection, Department of Entomology, Michigan State University, East Lansing, Michigan, and considered laid after moths were dead, dried and stored in the collection.

Unusual heavy infestation of *Prasadiseius kayosiekerei* on *Pachylioides resumens* in Guatemala — In the present study, a sphingid moth, *Pachylioides resumens* Walker (VP09-23), collected in Guatemala was found infested with over 300 mites that were present mostly on dorsal side of the body. Many of these were present on metathorax-first abdominal segment attached with the hairs. However, unusually, many mites were present on prothorax (Figs. 7, 8). In addition some mites were present on head, left antenna, around the left eye and one on the proboscis. This kind of presence of so many mites on dorsum of the prothorax had never been seen before. As stated before, some of these mites were also found on dorsal proximal half of the forewing and the hindwing (Figs. 9, 10).

DISCUSSIONS

Infestation rate of the sphingid moths by the mites — The present study indicated the rate of infestation in 761 sphingid moths preserved in the museum to be about 3 %. The analysis of all 761 sphingid moths in the present study (Table 4) indicated the following: (1) All 24 infested sphingid moths came from Neotropical ecozone. (2) Remain-

TABLE 3: Species and geographic origin of the uninfested 737 sphingid moths (Museum of the Department of Entomology, Michigan State University, East Lansing, Michigan, USA), and in the Chicago Natural History Museum, Chicago, Illinois, USA).

Species of Sphingidae (Total number of moths examined)	Number of moths examined from each country (states also included for USA)
<i>Acherontia atropos</i> (L.) = 3	China = 1, European Collection = 1, Kenya = 1
<i>Acherontia styx</i> Westwood = 5	China = 2, India = 3
<i>Adhemarius gannascus</i> (Stoll) = 9	Guatemala = 8, Venezuela = 1
<i>Aellopos fadus</i> (Cramer) = 5	Brazil = 5
<i>Aellopus tantalus</i> (L.) = 3	USA = 3 (AZ = 1, FL = 1, TX = 1)
<i>Agrius cingulata</i> (F.) = 13	Brazil = 5, Guatemala = 2, USA = 6 (FL = 1, LA = 1, MI = 2, NM = 1, SC = 1)
<i>Agrius convolvuli</i> (L.) = 8	China = 1, India = 3, Nigeria = 1, Saipan = 2, Sudan = 1
<i>Aleuron chloroptera</i> (Perty) = 1	Peru = 1
<i>Amphimoea walkeri</i> (Boisduval) = 5	Guatemala = 5
<i>Atreides plebeja</i> (F.) = 1	USA = 1 (MI = 1)
<i>Cechnena lineosa</i> Walker = 2	Malaysia = 2
<i>Ceratomia amyntor</i> Hübner = 7	USA = 7 (MI = 5, OH = 2)
<i>Ceratomia catalpae</i> (Boisduval) = 4	USA 4 (MI = 3, OH = 1)
<i>Ceratomia hageni</i> Crote = 1	USA = 1 (IL = 1)
<i>Ceratomia sonorensis</i> Hodges = 3	USA = 3 (AZ = 3)
<i>Ceratomia undulosa</i> Walker = 8	USA = 8 (MI = 4, OH = 2, PA = 1, WI = 1)
<i>Chloroclanis virescens</i> Butler = 1	Gabon = 1
<i>Clanidopsis exusta</i> (Butler) = 1	USA = 1 (IN = 1)
<i>Clanidopsis goeldii</i> R. & J. = 2	Brazil = 2
<i>Cocytius antaeus</i> Drury = 4	USA = 4 (FL = 4)
<i>Cocytius duponchel</i> (Poey) = 23	Brazil = 23
<i>Daphnusa ocellaris</i> Walker = 2	Malaysia = 2
<i>Darapsa myron</i> (Cramer) = 5	USA = 5 (MI = 5)
<i>Darapsa versicolor</i> (Harris) = 5	USA = 5 (MI = 5)
<i>Dolba hyloeus</i> (Drury) = 18	USA = 18 (CT = 1, FL = 2, GA = 1, IL = 6, KS = 1, LA = 2, NJ = 1, OH = 2, TX = 2)
<i>Enyo lugubris</i> (L.) = 5	USA = 5 (FL = 4, MI = 1)
<i>Erinnyis crameri</i> (Schaus) = 6	Brazil = 3, Peru = 3
<i>Erinnyis domingonis</i> (Butler) = 9	Brazil = 1, Guatemala = 2, Peru = 1, USA = 5 (TX = 5)
<i>Erinnyis ello</i> L. = 14	Brazil = 2, Guatemala = 5, Mexico = 3, USA = 4 (AZ = 2, FL = 2)
<i>Eumorpha</i> sp. = 9	Brazil = 9
<i>Eumorpha capronnieri</i> (Boisduval) = 1	Country and year not given = 1
<i>Eumorpha fasciata</i> (Sulzer) = 4	USA = 4 (IL = 3, MI = 1)
<i>Eumorpha labruscae</i> (L.) = 2	USA = 2 (MI = 2)
<i>Eumorpha phorbis</i> (Cramer) = 2	Country and year not given = 2
<i>Eumorpha satellitia</i> Cramer = 8	Brazil = 5, Mexico = 1, Panama = 2
<i>Eumorpha satellitia pandorus</i> Hübner = 13	USA = 13 (MI = 9, OH = 4)
<i>Eumorpha triangulum</i> R. & J. = 10	Ecuador = 1, Guatemala = 2, Mexico = 6, Panama = 1
<i>Eumorpha typhon</i> (Klug) = 4	USA = 4 (AZ = 4)
<i>Eumorpha vitis</i> (L.) = 9	Mexico = 3, USA = 6 (LA = 1, TX = 5)
<i>Eupyrrhoglossum sagra</i> Poey = 2	Brazil = 1, Ecuador = 1
<i>Hemaris achemon</i> (Drury) = 7	USA = 7 (AZ = 2, MI = 5)
<i>Hemaris lugubris</i> (L.) = 5	Brazil = 5
<i>Hemaris ocypte</i> (L.) = 5	Belize = 2, Brazil = 2, Ecuador = 1
<i>Hemaris thesbe</i> (F.) = 2	USA = 2 (MI = 2)
<i>Hemorhodes parce</i> (F.) = 16	Belize = 2, Brazil = 7, Guatemala = 2, Mexico = 5
<i>Hippotion boerhaviae</i> (F.) = 23	India = 20, Malaysia = 3

TABLE 3: Continued.

Species of Sphingidae (Total number of moths examined)	Number of moths examined from each country (states also included for USA)
<i>Hippotion celerio</i> (L.) = 12	India = 9, Kenya = 1, Papua New Guinea = 1, Zimbabwe = 1
<i>Hippotion eson</i> Cramer = 3	Sudan = 3
<i>Hippotion osiris</i> Dalman = 3	Ghana = 1, Nigeria = 2
<i>Hippotion velox</i> (F.) = 1	India = 1
<i>Hyles gallii</i> (Rottemburg) = 7	European Collection = 4, USA = 3 (MI = 3)
<i>Hyles lineata</i> (F.) = 34	India = 12, Mexico = 2, USA = 20 (MI = 5; AZ, CA, LA, NM, NV, OH, WY = 15)
<i>Isognathus alope</i> (Drury) = 8	Brazil = 7, Peru = 1
<i>Isognathus caricae</i> (L.) = 1	Peru = 1
<i>Isognathus lassauxi omphaleae</i> (Boisduval) = 2	Brazil = 1, Peru = 1
<i>Isognathus mossi</i> Clark = 1	Peru = 1
<i>Isognathus rimosa inclitus</i> Edwards = 1	Mexico = 1
<i>Isognathus swinsonii</i> Felder and Felder = 7	Brazil = 7
<i>Isoparce cupressi</i> (Boisduval) = 2	USA = 2 (FL = 2)
<i>Laothao juglandia</i> (J.E. Smith) = 5	USA = 5 (MI = 3, OH = 2)
<i>Lapara bombycoides</i> Walker = 8	Canada = 3, USA = 5 (MI = 4, MN = 1)
<i>Lapara coniferarum</i> (J.E. Smith) = 4	USA = 4 (MS = 2, OH = 2)
<i>Leucomorpha triptolemus</i> (Cramer) = 1	Ecuador = 1
<i>Lophostethus demolini</i> Angas = 2	European Collection = 2
<i>Maganoton analis</i> Felder = 23	India = 20, Malaysia = 1, Saipan = 2
<i>Manduca albiplaga</i> (Walker) = 1	Panama = 1
<i>Manduca corallina</i> Drury = 1	Mexico = 1
<i>Manduca diffissa</i> Butler = 3	Chile = 1, Ecuador = 2
<i>Manduca florestan</i> Stoll = 5	USA = 5 (AZ = 5)
<i>Manduca hannibal</i> Cramer = 1	Brazil = 1
<i>Manduca jasminearum</i> Guérin = 10	USA = 10 (IL = 2, IN = 1, OH = 7)
<i>Manduca muscosa</i> (R. & J.) = 5	USA = 5 (AZ = 5)
<i>Manduca oculata</i> R. & J. = 4	Mexico = 2, Panama = 1, Peru = 1
<i>Manduca quinquemaculata</i> Haworth = 9	USA = 9 (MI = 6, OH = 2, TX = 1)
<i>Manduca rustica</i> (F.) = 5	Brazil = 1, Ecuador = 1, USA = 3 (AZ = 3)
<i>Manduca schausi</i> (Clark) = 11	Guatemala = 10, USA = 1 (AZ = 1)
<i>Manduca sexta</i> (L.) = 9	USA = 9 (AR = 3, AZ = 1, CA = 1, IL = 1, NM = 1, OH = 1, TX = 1)
<i>Marumba dryas</i> Walker = 1	European Collection = 1
<i>Mimas tiliae</i> (L.) = 2	European Collection = 2
<i>Neococytiis cluentius</i> (Cramer) = 1	Country and year not given = 1
<i>Neogene corumbensis</i> Clark = 1	Brazil = 1
<i>Neogene dynaeus</i> (Hübner) = 1	Brazil = 1
<i>Oryba tadeni</i> Schaufus = 1	Brazil = 1
<i>Oxyambulyx eremitus</i> (Hübner) = 3	USA = 3 (MI = 3)
<i>Oxyambulyx istar</i> (R. & J.) = 4	Mexico = 2, USA = 2 (AZ = 2)
<i>Oxyambulyx substrigilis brooksi</i> Clark = 1	Malaysia = 1
<i>Pachylia darceta</i> Druce = 6	Brazil = 1, Ecuador = 2, Peru = 3
<i>Pachylia ficus</i> (L.) = 4	Brazil = 2, Ecuador = 1, country not given = 1
<i>Pachylioides resumens</i> Walker = 8	Brazil = 4, Ecuador = 1, Guatemala = 3
<i>Pachysphinx medesta</i> Harris = 4	Canada = 2, USA = 2 (MI = 2)
<i>Paonias myops</i> (J.E. Smith) = 3	USA = 3 (MI = 3)
<i>Paratreia plebeja</i> (F.) = 2	USA = 2 (KS = 1, SC = 1)

TABLE 3: Continued.

Species of Sphingidae (Total number of moths examined)	Number of moths examined from each country (states also included for USA)
<i>Pergesa elpenor</i> (L.) = 7	European Collection = 6, Germany = 1
<i>Pergesa porcellus</i> (L.) = 12	European Collection = 12
<i>Phryxus caicus</i> Cramer = 2	Peru = 1, USA = 1 (FL = 1)
<i>Protambulyx eurycles</i> (Herrich-Schäffer) = 7	Brazil = 7
<i>Protambulyx strigilis</i> (L.) = 1	Ecuador = 1
<i>Pseudosphinx tetrio</i> (L.) = 8	Brazil = 7, country not given = 1
<i>Psilogramma increta</i> Walker = 4	China = 4
<i>Psilogramma menephron</i> (Cramer) = 1	India = 1
<i>Rhopalosyche cheron nechus</i> Cramer = 10	Brazil = 6, Guatemala = 3, Mexico = 1
<i>Rhopalosyche eraphus</i> Boisduval = 1	Brazil = 1
<i>Rhopalosyche nycteris</i> Kollar = 1	China = 1
<i>Smerinthus jamaicensis</i> Drury = 3	USA = 3 (MI = 3)
<i>Sphinx canadensis</i> Boisduval = 5	USA = 5 (ME = 1, MI = 3, MO = 1)
<i>Sphinx chersis</i> Hübner = 8	USA = 8 (AZ = 3, MI = 4, UT = 1)
<i>Sphinx drupliferarum</i> J.E. Smith = 3	USA = 3 (IN = 1, MI = 1, UT = 1)
<i>Sphinx franckii</i> Neum. = 2	USA = 2 (TN = 2)
<i>Sphinx gordeus</i> Kramer = 3	USA = 3 (MI = 3)
<i>Sphinx kalmiae</i> J.E. Smith = 4	USA = 4 (ME = 1, MI = 1, OH = 2)
<i>Sphinx ligustris</i> L. = 3	European Collection = 3
<i>Sphinx luscitiosa</i> Clemens = 6	Papua = 1, USA = 5 (MI = 5)
<i>Sphinx merops</i> Boisduval = 2	Mexico = 2
<i>Sphinx perelegans</i> Edwards = 3	USA = 3 (CA = 3)
<i>Sphinx pinastri</i> L. = 3	European Collection = 3
<i>Sphinx poecila</i> Stephens = 6	USA = 6 (MI = 6)
<i>Sphinx vashti</i> Strecker = 4	USA = 4 (CO = 1, NV = 1, UT = 2)
<i>Theretra alecto</i> L. = 9	Greece = 1, India = 7, Syria = 1
<i>Theretra boisduvalii</i> (Bugnion) = 1	Malaysia = 1
<i>Theretra clotho</i> Drury = 6	India = 2, Malaysia = 2, Papua New Guinea = 2
<i>Theretra gnoma</i> (F.) = 2	India = 2
<i>Theretra latreillii</i> (W.S. Macleay) = 3	Malaysia = 2, Papua New Guinea = 1
<i>Theretra nessus</i> (Drury) = 4	China = 1, India = 2, Papua New Guinea = 1
<i>Theretra oldenlandiae</i> (F.) = 6	India = 6
<i>Theretra polycosta</i> Walker = 1	China = 1
<i>Theretra suffusa</i> (Walker) = 2	Malaysia = 2
<i>Theretra tessmanni</i> Geht. = 1	Sudan = 1
<i>Xylophanes anubus</i> (Cramer) = 1	Guatemala = 1
<i>Xylophanes ceratomioides</i> (Grote-Robinson) = 7	Guatemala = 7
<i>Xylophanes falco</i> (Walker) = 3	Guatemala = 1, USA = 2 (AZ = 2)
<i>Xylophanes pluto</i> (F.) = 6	Guatemala = 2, Mexico = 1, USA = 3 (FL = 2, Virgin Islands = 1)
<i>Xylophanes porcus</i> (Hübner) = 1	Brazil = 1
<i>Xylophanes tersa</i> Drury = 13	Brazil = 3, Mexico = 1, USA = 9 (LA = 2, MI = 2, SC = 2, TN = 3)
<i>Xylophanes thyelia</i> L. = 3	Guatemala = 3
<i>Xylophanes titana</i> Druce = 2	Guatemala = 2

Unidentified Species = 31 [Brazil = 1 (1992), Fiji = 9 (1997), Malaysia = 11 (1999), Papua New Guinea = 2 (2000), Peru = 1 (2007), Taiwan = 2 (2005), USA = 5 (AZ = 5) (1991, 2001)].

Total uninfested sphingid moths examined = 737.

TABLE 4: Species and geographic origin of the unfested 737 sphingid moths (Coll. Museum of the Department of Entomology, Michigan State University, East Lansing, Michigan, USA, coll. of the Chicago Natural History Museum, Chicago, Illinois, USA).

Country (Total # of moths examined)	Species	#	Year collected
BELIZE (4)	<i>Hemaris ocypete</i> (L.)	2	2001
	<i>Hemorophanes parce</i> (F.)	2	2001
BRAZIL (123)	<i>Aellopos fadus</i> (Cramer)	5	1960, 1963, 1996
	<i>Agrius cingulata</i> (F.)	5	1993
	<i>Clanidopsis goeldii</i> R. and J.	2	8/1993, 4/1996
	<i>Cocytius duponchel</i> (Poey)	23	8/1991, 9/1991, 11/1991, 11/1995, 4/1996
	<i>Erinnyis cramer</i> (Schaus)	3	1993
	<i>Erinnyis domingonis</i> (Butler)	1	1993
	<i>Erinnyis ello</i> L.	2	1993
	<i>Eumorpha</i> sp.	9	1991, 1993, 1995, 1996
	<i>Eumorpha satellitia</i> Cramer	5	1991, 1993
	<i>Eupyrrhoglossum sagra</i> Poey	1	1996
	<i>Hemaris lugubris</i> (L.)	5	1993
	<i>Hemaris ocypete</i> (L.)	2	1993, 1996
	<i>Hemorophanes parce</i> (F.)	7	1991, 1993
	<i>Isognathus alope</i> (Drury)	7	1991, 1993, 1996
	<i>Isognathus lassauxi omphaleae</i> (Bois.)	1	1996
	<i>Isognathus swinsonii</i> Feld. & Feld.	7	1993
	<i>Manduca hannibal</i> Cramer	1	4/1996
	<i>Manduca rustica</i> (F.)	1	2/1996
	<i>Neogene corumbensis</i> Clark	1	1996
	<i>Neogene dynaeus</i> (Hübner)	1	1996
	<i>Oryba tadeni</i> Schaufus	1	1996
	<i>Pachylia darceta</i> Druce	1	1995
	<i>Pachylia ficus</i> (L.)	2	1994
	<i>Pachylioides resumens</i> Walker	4	1995, 1996
	<i>Protambulyx eurycles</i> (Herrich-Schäffer)	7	8/1991, 9/1991, 8/1993, 2/1996, 4/1996
	<i>Pseudosphinx tetrio</i> (L.)	7	1991, 1993, 1996
	<i>Rhopalosyche cheron nechus</i> Cramer	6	1993, 1996
	<i>Rhopalosyche eraphus</i> Bois.	1	1996
	<i>Xylophanes porcus</i> (Hübner)	1	1993
	<i>Xylophanes tersa</i> Drury	3	1996
	species not identified	1	1992
CANADA (5)	<i>Lapara bombycoides</i> Walker	3	1995, 7/1997
	<i>Pachysphinx medesta</i> Harris	2	1918
CHILE (1)	<i>Manduca diffissa</i> Butler	1	11/1958
CHINA (11)	<i>Acherontia atropos</i> (L.)	1	2003
	<i>Acherontia styx</i> Westwood	2	2003
	<i>Agrius convolvuli</i> (L.)	1	1992
	<i>Psilogramma increta</i> Walker	4	1992
	<i>Rhopalosyche nycteris</i> Kollar	1	1992
	<i>Theretra nessus</i> (Drury)	1	2002
ECUADOR (12)	<i>Theretra polycosta</i> Walker	1	2002
	<i>Eumorpha triangulum</i> R. and J.	1	2001

TABLE 4: Continued.

Country (Total # of moths examined)	Species	#	Year collected
ECUADOR (continued)	<i>Eupyrrhoglossum sagra</i> Poey	1	1979
	<i>Hemaris ocypete</i> (L.)	1	2001
	<i>Leucomorpha triptolemus</i> (Cramer)	1	1955
	<i>Manduca diffissa</i> Butler	2	10/2001
	<i>Manduca rustica</i> (F.)	1	10/2002
	<i>Pachylia darceta</i> Druce	2	2001
	<i>Pachylia ficus</i> (L.)	1	1955
	<i>Pachylioides resumens</i> Walker	1	2001
	<i>Protambulyx strigilis</i> (L.)	1	4/2003
EUROPE* (34)	<i>Acherontia atropos</i> (L.)	1	1956
	<i>Hyles gallii</i> (Rottemburg)	4	Year not given
	<i>Lophostethus demolini</i> Angas	2	Year not given
	<i>Marumba dryas</i> Walker	1	Year not given
	<i>Mimas tiliae</i> (L.)	2	Year not given
	<i>Pergesa elpenor</i> (L.)	6	1946, 1950
	<i>Pergesa porcellus</i> (L.)	12	1943, 1949, 1950
	<i>Sphinx ligustris</i> L.	3	Year not given
	<i>Sphinx pinastri</i> L.	3	Year not given
FIJI (9)	Species not identified	9	1997
GABON (1)	<i>Chloroclanis virescens</i> Butler	1	4/1989
GERMANY (1)	<i>Pergesa elpenor</i> (L.)	1	1996
GHANA (1)	<i>Hippotion osiris</i> Dalman	1	1971
GREECE (1)	<i>Theretra alecto</i> L.	1	1963
GUATEMALA (58)	<i>Adhemarius gannascus</i> (Stoll)	8	7/2005, 8/2005, 8/2006
	<i>Agrius cingulata</i> (F.)	2	2006
	<i>Amphimoea walkeri</i> (Bois.)	5	7/2005
	<i>Erinnyis domingonis</i> (Butler)	2	2005
	<i>Erinnyis ello</i> L.	5	2005
	<i>Eumorpha triangulum</i> R. and J.	2	2005, 2006
	<i>Hemorophanes parce</i>	2	2006
	<i>Manduca schausi</i> (Clark)	10	2005, 2006
	<i>Pachylioides resumens</i> Walker	3	2005, 2006
	<i>Rhopalosyche cheron nechus</i> Cramer	3	2006
	<i>Xylophanes anubus</i> (Cramer)	1	2006
	<i>Xylophanes ceratomioides</i> (Grote-Rob.)	7	2006
	<i>Xylophanes falco</i> (Walker)	1	2005
	<i>Xylophanes pluto</i> (F.)	2	Year not given
	<i>Xylophanes thyelia</i> L.	3	2006
	<i>Xylophanes titana</i> Druce	2	2006
INDIA (88)	<i>Acherontia styx</i> Westwood	3	7/1962, 9/1962,
	<i>Agrius convolvuli</i> (L.)	3	1962
	<i>Hippotion boerhaviae</i> (F.)	20	1959, 1962
	<i>Hippotion celerio</i> (L.)	9	Year not given, 1962
	<i>Hippotion velox</i> (F.)	1	Year not given
	<i>Hyles lineata</i> (F.)	12	8/1962
	<i>Magannoton analis</i> Felder	20	Year not given

TABLE 4: Continued.

Country (Total # of moths examined)	Species	#	Year collected
INDIA (continued)	<i>Psilogramma menephron</i> (Cramer)	1	1962
	<i>Theretra alecto</i> L.	7	1961, 1962
	<i>Theretra clotho</i> Drury	2	1962
	<i>Theretra gnoma</i> (F.)	2	1957, 1962
	<i>Theretra nessus</i> (Drury)	2	Year not given
	<i>Theretra oldenlandiae</i> (F.)	6	1962
KENYA (2)	<i>Acherontia atropos</i> (L.)	1	1998
	<i>Hippotion celerio</i> (L.)	1	1998
MALAYSIA (27)	<i>Cechmena lineosa</i> Walker	2	1999
	<i>Daphnusa ocellaris</i> Walker	2	5/1995
	<i>Hippotion boerhaviae</i> (F.)	3	1995, 1999
	<i>Maganoton analis</i> Felder	1	1995
	<i>Oxyambulyx substrigilis brooksi</i> Clark	1	1995
	<i>Theretra boisduvalii</i> (Bugnion)	1	1995
	<i>Theretra clotho</i> Drury	2	1995
	<i>Theretra latreillii</i> (W.S. MacLeay)	2	1995
	<i>Theretra suffusa</i> (Walker)	2	1995
	species not identified	11	1999
MEXICO (31)	<i>Erinnyis ello</i> L.	3	1961, 1970
	<i>Eumorpha satellitia</i> Cramer	1	Year not given
	<i>Eumorpha triangulum</i> R. and J.	6	10/1969, 1970
	<i>Eumorpha vitis</i> (L.)	3	1987
	<i>Hemoroplanes parce</i> (F.)	5	1971, 1984, 1987
	<i>Hyles lineata</i> (F.)	2	1962
	<i>Isognathus rimosa inclitus</i> Edwards	1	1961
	<i>Manduca corallina</i> Drury	1	9/1961
	<i>Manduca oculata</i> R. and J.	2	1956, 1961
	<i>Oxyambulyx istar</i> (R. and J.)	2	1956, 1960
	<i>Rhopalosyche cheron nechus</i> Cramer	1	1987
	<i>Sphinx merops</i> Bois.	2	Year not given
	<i>Xylophanes pluto</i> (F.)	1	1984
	<i>Xylophanes tersa</i> Drury	1	1961
NIGERIA (3)	<i>Agrius convolvuli</i> (L.)	1	1963
	<i>Hippotion osiris</i> Dalman	2	1962
PANAMA (5)	<i>Eumorpha satellitia</i> Cramer	2	1956, 1958
	<i>Eumorpha triangulum</i> R. and J.	1	1970
	<i>Manduca albiplaga</i> (Walker)	1	5/1969
	<i>Manduca oculata</i> R. and J.	1	3/1969
PAPUA (1)	<i>Sphinx luscitiosa</i> Clemens	1	1985
PAPUA NEW GUINEA (7)	<i>Hippotion celerio</i> (L.)	1	2000
	<i>Theretra clotho</i> Drury	2	2000
	<i>Theretra latreillii</i> (W.S. MacLeay)	1	2000
	<i>Theretra nessus</i> (Drury)	1	2000
	species not identified	2	2000
PERU (15)	<i>Aleuron chloroptera</i> (Perty)	1	1994
	<i>Erinnyis crameri</i> (Schaus)	3	1962
	<i>Erinnyis domingonis</i> (Butler)	1	1962

TABLE 4: Continued.

Country (Total # of moths examined)	Species	#	Year collected
PERU (continued)	<i>Isognathus alope</i> (Drury)	1	1962
	<i>Isognathus caricae</i> (L.)	1	1962
	<i>Isognathus lassauxi omphaleae</i> (Bois.)	1	1962
	<i>Isognathus mossi</i> Clark	1	1993
	<i>Manduca oculata</i> R. and J.	1	10/1994
	<i>Pachylia darceta</i> Druce	3	1962
	<i>Phryxus caicus</i> Cramer	1	1962
	species not identified	1	2007
SAIPAN (4)	<i>Agrius convolvuli</i> (L.)	2	2001
	<i>Maganoton analis</i> Felder	2	2001
SUDAN (5)	<i>Agrius convolvuli</i> (L.)	1	1982
	<i>Hippotion eson</i> Cramer	3	1982
	<i>Theretra tessmanni</i> Geht.	1	1982
SYRIA (1)	<i>Theretra alecto</i> L.	1	Year not given
TAIWAN (2)	Species not identified	2	2005
USA (277) --- Count of <i>Hyles lineata</i> (= 15) is included only once in this total count			
Arizona (AZ = 54)	<i>Aellopus tantalus</i> (L.)	1	1960
	<i>Ceratomia sonorensis</i> Hodges	3	1991
	<i>Erinnyis ello</i> L.	2	1960, 1991
	<i>Eumorpha typhon</i> (Klug)	4	1986
	<i>Hemaris achemon</i> (Drury)	2	Year not given
	<i>Hyles lineata</i> (F.)*	15	1965, 1972, 1985, 1998
	<i>Manduca florestan</i> Stoll	5	1985, 1986
	<i>Manduca muscosa</i> (R. and J.)	5	2007
	<i>Manduca rustica</i> (F.)	3	1985, 8/2007
	<i>Manduca schausi</i> (Clark)	1	2007
	<i>Manduca sexta</i> (L.)	1	1986
	<i>Oxyambulyx istar</i> (R. and J.)	2	2001
	<i>Sphinx chersis</i> Hübner	3	1986, 1991
	<i>Xylophanes falco</i> (Walker)	2	1985
	species not identified	5	1991, 2001
Arkansas (AR = 3)	<i>Manduca sexta</i> (L.)	3	1958, 1965
California (CA = 4)	<i>Hyles lineata</i> (F.)*	15	1965, 1972, 1985, 1998
	<i>Manduca sexta</i> (L.)	1	1984
	<i>Sphinx perelegans</i> Edwards	3	1959, 1987
Colorado (CO = 1)	<i>Sphinx vashti</i> Strecker	1	1982
Connecticut (CT = 1)	<i>Dolba hyloeus</i> (Drury)	1	1991
Florida (FL = 19)	<i>Aellopus tantalus</i> (L.)	1	Year not given
	<i>Agrius cingulata</i> (F.)	1	1945
	<i>Cocytius antaeus</i> Drury	4	1956, 2000, 2004
	<i>Dolba hyloeus</i> (Drury)	2	1973, 1975
	<i>Enyo lugubris</i> (L.)	4	1967, 1982
	<i>Erinnyis ello</i> L.	2	1964, 1983
	<i>Isoparce cupressi</i> (Bois.)	2	2004, 2005
	<i>Phryxus caicus</i> Cramer	1	Year not given
	<i>Xylophanes pluto</i> (F.)	2	2005

TABLE 4: Continued.

Country (Total # of moths examined)	Species	#	Year collected
Georgia (GA = 1)	<i>Dolba hyloeus</i> (Drury)	1	1994
	<i>Ceratomia hageni</i> Crote	1	2003
Illinois (IL = 13)	<i>Dolba hyloeus</i> (Drury)	6	1998
	<i>Eumorphia fasciata</i> (Sulzer)	3	1993, 1998
	<i>Manduca jasminearum</i> Guérin	2	1998
	<i>Manduca sexta</i> (L.)	1	1982
	<i>Clanidopsis exusta</i> (Butler)	1	1962
Indiana (IN = 3)	<i>Manduca jasminearum</i> Guérin	1	1960
	<i>Sphinx drupliferarum</i> J.E. Smith	1	1933
Kansas (KS = 2)	<i>Dolba hyloeus</i> (Drury)	1	1981
	<i>Paratreia plebeja</i> (F.)	1	1955
Louisiana (LA = 6)	<i>Agrius cingulata</i> (F.)	1	1971
	<i>Dolba hyloeus</i> (Drury)	2	1972
	<i>Eumorphia vitis</i> (L.)	1	1962
	<i>Hyles lineata</i> (F.)*	15	1965, 1972, 1985, 1998
	<i>Xylophanes tersa</i> Drury	2	1971
Maine (ME = 2)	<i>Sphinx canadensis</i> Bois.	1	1987
	<i>Sphinx kalmiae</i> J.E. Smith	1	1997
Michigan (MI = 102)	<i>Agrius cingulata</i> (F.)	2	1963
	<i>Atreides plebeja</i> (F.)	1	1966
	<i>Ceratomia amyntor</i> Hübner	5	1960, 1964, 1971, 1996
	<i>Ceratomia catalpae</i> (Bois.)	3	1992, 2001, 2003
	<i>Ceratomia undulosa</i> Walker	4	1940, 1983, 1984, 2002
	<i>Darapsa myron</i> (Cramer)	5	1966, 1971, 1978, 1989, 2006
	<i>Darapsa versicolor</i> (Harris)	5	2002
	<i>Enyo lugubris</i> (L.)	1	1915
	<i>Eumorphia fasciata</i> (Sulzer)	1	1973
	<i>Eumorphia labruscae</i> (L.)	2	1991
	<i>Eumorphia satellitia pandorus</i> Hübner	9	1933, 1943, 1973, 1979
	<i>Hemaris achemon</i> (Drury)	5	Year not given
	<i>Hemaris thesbe</i> (F.)	2	2001
	<i>Hyles gallii</i> (Rottemburg)	5	Year not given
	<i>Hyles lineata</i> (F.)	5	Year not given
	<i>Laothao juglandia</i> (J.E. Smith)	3	1983
	<i>Lapara bombycoides</i> Walker	4	1967, 2006
	<i>Manduca quinquemaculata</i> Haworth	6	1911, 1979, 1980
	<i>Oxyambulyx eremitus</i> (Hübner)	3	1945, 2001
	<i>Pachysphinx medesta</i> Harris	2	Year not given
	<i>Paonias myops</i> (J.E. Smith)	3	2006
	<i>Smerinthus jamaicensis</i> Drury	3	1964
	<i>Sphinx canadensis</i> Bois.	3	1989, 2002
	<i>Sphinx chersis</i> Hübner	4	1960, 1971, 1985
	<i>Sphinx drupliferarum</i> J.E. Smith	1	1941
	<i>Sphinx gordeus</i> Kramer	3	1956, 1958
	<i>Sphinx kalmiae</i> J.E. Smith	1	1985
	<i>Sphinx luscitiosa</i> Clemens	5	1975, 1985

TABLE 4: Continued.

Country (Total # of moths examined)	Species	#	Year collected
Michigan (continued)	<i>Sphinx poecila</i> Stephens	6	1960, 1964, 2004
	<i>Xylophanes tersa</i> Drury	2	1973
Minnesota (MN = 1)	<i>Lapara bombycoides</i> Walker	1	1993
Mississippi (MS = 2)	<i>Lapara coniferarum</i> Stracker	2	1965
Missouri (MO = 1)	<i>Sphinx canadensis</i> Bois.	1	1975
Nevada (NV = 1)	<i>Hyles lineata</i> (F.)*	15	1965, 1972, 1985, 1998
	<i>Sphinx vashti</i> Strecker	1	1987
New Jersey (NJ = 1)	<i>Dolba hyloeus</i> (Drury)	1	Year not given
New Mexico (NM = 2)	<i>Agrius cingulata</i> (F.)	1	2007
	<i>Hyles lineata</i> (F.)*	15	1965, 1972, 1985, 1998
Ohio (OH = 27)	<i>Ceratomia amyntor</i> Hübner	2	1984, 1985
	<i>Ceratomia catalpae</i> (Bois.)	1	1960
	<i>Ceratomia undulosa</i> Walker	2	1974, 1975
	<i>Dolba hyloeus</i> (Drury)	2	1988
	<i>Eumorpha satellitia pandorus</i> Hübner	4	1964
	<i>Hyles lineata</i> (F.)*	15	1972, 1985, 1998
	<i>Laothao juglandia</i> (J.E. Smith)	2	1981
	<i>Lapara coniferarum</i> (J.E. Smith)	2	1981
	<i>Manduca jasminearum</i> Guérin	7	1974, 1998
	<i>Manduca quinquemaculata</i> Haworth	2	2006
Pennsylvania (PA = 1)	<i>Manduca sexta</i> (L.)	1	1976
	<i>Sphinx kalmiae</i> J.E. Smith	2	1973, 1976
South Carolina (SC = 4)	<i>Ceratomia undulosa</i> Walker	1	1971
	<i>Agrius cingulata</i> (F.)	1	1982
Tennessee (TN = 5)	<i>Paratreia plebeja</i> (F.)	1	2001
	<i>Xylophanes tersa</i> Drury	2	1982
Texas (TX = 15)	<i>Sphinx franckii</i> Neum.	2	1974, 1976
	<i>Xylophanes tersa</i> Drury	3	1999
	<i>Aellopus tantalus</i> (L.)	1	Year not given
	<i>Dolba hyloeus</i> (Drury)	2	1958
	<i>Erinnyis domingonis</i> (Butler)	5	Year not given
	<i>Eumorpha vitis</i> (L.)	5	Year not given
Utah (UT = 4)	<i>Manduca quinquemaculata</i> Haworth	1	1960
	<i>Manduca sexta</i> (L.)	1	1960
	<i>Sphinx chersis</i> Hübner	1	1989
	<i>Sphinx drupiferarum</i> J.E. Smith	1	1987
Virgin Islands (VI = 1)	<i>Sphinx vashti</i> Strecker	2	1955
	<i>Xylophanes pluto</i> (F.)	1	1969
Wisconsin (WI = 1)	<i>Ceratomia undulosa</i> Walker	1	1986
Wyoming (WY = 0)	<i>Hyles lineata</i> (F.)*	15	1965, 1972, 1985, 1998
VENEZUELA (1)	<i>Adhemarius gannascus</i> (Stoll)	1	7/1943
ZIMBABWE (1)	<i>Hippotion celerio</i> (L.)	1	1993
COUNTRIES NOT GIVEN (6)	<i>Eumorpha capronnieri</i> (Boisduval)	1	Year not given
	<i>Eumorpha phorbis</i> (Cramer)	2	Year not given
	<i>Neococytiis cluentius</i> (Cramer)	1	Year not given
	<i>Pachylia ficus</i> (L.)	1	Year not given
	<i>Pseudosphinx tetrio</i> (L.)	1	Year not given

* Present in AZ, CA, LA, NM, NV, OH, WY in 1965, 1972, 1985, 1998 but counted only once in AZ to avoid duplication in counting

Number of sphingid moths examined

Total uninfested sphingid moths examined = 737.

ing 240 sphingid moths from Neotropical ecozone did not show any infestation and, thus, the infestation rate of these moths in this ecozone was 10 %. (3) Remaining sphingid moths (727 - 240 = 487) distributed in Afrotropical, Australasia, Indomalaya, Oceania and Palearctic ecozones did not reveal infestation. Prasad (1976) reported infestation rate of 1.0 % in 6,524 sphingid moths he examined from many countries: this included moths from (a) Afrotropical [= Congo, Madagascar, Mozambique]; (b) Indomalaya [= India, Indonesia, Philippines]; and (c) Neotropical [= Bolivia, Brazil, Ecuador, Honduras, Jamaica, Peru, Surinam, Venezuela] ecozones. The present study indicated higher infestation rate of 3.2 % as all moths were collected in the Neotropical ecozone only.

Geographical distribution of the mites — Prasad (1976) reported that the otopheidomenid mites were mostly distributed on the sphingid moths in various countries located in between the latitude of 30° North and 30° South of the equator. Out of 151 genera and 623 species and subspecies of sphingid moths studied, 30 genera and 47 species and subspecies were found infested with the otopheidomenid mites. Based on past and present study, it is evident that the genus *Prasadiseius* has primarily Tropical-Neotropical distribution.

Sex ratio of mites — 154 females, 62 males, 69 larvae, 51 protonymphs and 28 deutonymphs on all 24 infested sphingid moths in the present study (Note – Mites saved in ETOH were not included and only the mites randomly mounted on the slides were included in the above count). This brings the sex ratio at 2.5:1.0 or about 3 females to 1 male. This had not been reported before.

Any sex preference of the sphingid moths by the mites — This study on museum preserved or live sphingid moths has never been conducted and needs to be done in future to see if mites prefer the female or the male moth to infest.

When and where are the moths infested by the mites — This is not known if an infested female or an infested male transmits the mites to uninfested moth during feeding on flower nectar, resting on the tree trunk or the vegetation, or during flight. Future studies are essential to resolve some of these

and many other questions in the native areas in the peak abundance season of the moths.

Is there any re-infestation or multiple infestation of the infested moths present — In almost last over 40 years of studying these mites, this author has never found infestation of a single moth by 2 species of *Prasadiseius*. So far, only 3 sphingid moths have been found, each infested with several hundred mites, that indicated infestation of moth by a single species only.

Presence of mites on the host — Otopheidomenid mites infesting the sphingid moths are known to be present dorsally among the hairs mostly in the tympanic-metathoracic-first abdominal region of the body. It has been believed by this author that the adult mites invade the new adult sphingid hosts either during feeding on nectar of the flowers, mating or congregation on the tree trunk and climb on the proboscis and head. Then move to the thorax in the tympanic-metathoracic-first abdominal area where they reside, feed and reproduce. So, the question has been as to what they feed on and as to why they congregate mostly in these areas. Treat (1975) had believed that some food source was present in the tympanic area where *Otopheidomenis zalelestes* Treat, 1955, was feeding, residing and reproducing on the noctuid moths of the genus *Zale*. This author had also believed before that probably some secretion was present on the sphingid moths where these mites were feeding. But, now, here, he believes that these areas possibly present different kinds of specialized cavities, spaces or acarinarium allowing mites to reside and possibly feed either by scraping on the host or by feeding on the moth hairs but not on any secretion of the moth. These mites have only the movable cheliceral digit with denticles and possibly serve the purpose of feeding as a scraper on the host tissue. Similar kind of movable cheliceral digit (and reduced fixed digit) is known in *Hemipteroseius indicus* (Krantz and Khot, 1962) which has been considered a scraper feeder (Costa, 1968). Prasad (1975) had studied the biology of this mite in India, had not observed the feeding behavior, but had noted the presence of these mites in different grooves on the dorsum under the wings of the bug. Thus, pres-

ence of acarinarium and scrape feeding on the host tissue and or feeding on the moth hairs on the sphingid moths are new considerations. The later could be proven either by studying the feeding habits of live mites on live sphingid hosts or by studying the feces of these mites and noticing if some undigested moth hairs are present. Thus, future studies are necessary to confirm these points of views.

Why *P. kayosiekerei* on *Pachylioides resumens* in Guatemala on the head and prothorax — In most cases studied by this author over last 40 years, less than 50 mites were found parasitizing a single noctuid or sphingid moth. These mites included all motile stages. Other than these, eggs were also found among these mites attached to the hairs. As stated before, these mites were present mostly in the rectangular tympanic-metathoracic-first abdominal region of the body (Fig. 1). But, in the present study, *Prasadiseius kayosiekerei* infesting the sphingid moth, *Pachylioides resumens*, was present on dorsum of prothorax in large number (Figs. 7, 8) along with a few on the proboscis, antenna and the head. This was very unusual. It is believed that, possibly, the moth had been infested on the day it was caught and the mites were still moving upward from proboscis to the head and to the common areas of congregation in the tympanic-metathoracic-first abdominal region when they died. Could these mites represent a migratory phase, cannot be said with certainty as not too many such cases have been studied. This is only the first case of this kind known having so many mites on the prothorax. Prasad (2011b) described an unusual case of very heavy infestation of *P. cocytes* on a sphingid moth, *Manduca rustica* (Fab.), collected in Ecuador (VP09-17) but in this case over 1000 mites were present on all over the body (mostly on dorsal side, some on the ventral side as well).

Are these mites present on pupae or larvae of the sphingid moths — Several pupae and skin mounts of the larvae of the sphingid moths preserved in the museum collection were examined in the present study but no otopheidomenid mites were found. Thus, where do these mites live, if they hibernate during winter and in what stage, how do they infest the new hosts, and if they infest the

adults during emergence from pupae or in the adult stage only – need to be studied in future to answer these questions.

ACKNOWLEDGEMENTS

I am grateful to Dr. Ernest S. Delfosse, Chairman, Dr. Anthony Cognato, Museum Director, and Mr. Gary Parsons, Collection Manager, A. J. Cook Arthropod Research Collection, all of Department of Entomology, Michigan State University, East Lansing, Michigan, USA for allowing me to examine the sphingid collection. Mr. Gary Parsons helped me in numerous other ways. I am thankful also to several collectors of the sphingid moths including Mr. Mark A. Churchill and Mr. and Mrs. Frank and Anna M. West for collecting many of the sphingid moths on which this paper is based. Indira Prasad, my wife, aided in the examination of the moths and collection of the mites and Mr. George Vieira, Fowlerville, helped in the preparation of some figures. The draft of the paper was read and improved by Mr. Gary Parsons, MSU, Lansing, MI and Dr. Gregory A. Evans, Beltsville, MD. These are acknowledged with thanks. Thanks also to anonymous reviewers of *Acarologia* for their help in the improvement of the manuscript.

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