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The Phytophagous Arthropods Associated with *Lantana camara, L. hirsuta, L. urticifolia,* and *L. urticoides* (Verbenaceae) in North America

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A survey of the phytophagous arthropod fauna associated with four closely related species of *Lantana* (*L. camara, L. urticifolia, L. urticoides,* and *L. hirsuta*) was undertaken in Mexico and the southern United States between 1988 and 1992 to find biological control agents for *L. camara,* a serious weed in Australia and elsewhere. Some 261 phytophagous insect or mite species (and two rust fungi) were found. Records of species collected during three previous entomological surveys were added to produce a more complete data set of 550 phytophagous species collected throughout North America. Twenty-six of these were considered to have host ranges confined to the subfamily Verbenoideae and thus to be prospective or actual biological control agents.

KEY WORDS: ***Lantana;* biological control; host range; biology; insect fauna; survey.**

INTRODUCTION

The woody shrub *Lantana camara* L. (family Verbenaceae, subfamily Verbenoideae) is one of the world's 10 worst noxious weeds (Muniappan *et al.*, 1992) and infests millions of hectares of grazing and cropping land in 47 countries (Holm *et al.*, 1977) where its highly aggressive nature leads to its taking over rangeland (Perkins and Swezey, 1924; Kleinschmidt and Johnson, 1977; Cilliers and Neser, 1991), particularly gullies and hillsides with rich soils. Some varieties are also poisonous to livestock (Everist, 1974). In Queensland, Australia, it is also regarded as an environmental weed of subtropical rainforest (Humphries *et al.*, 1991) and open eucalypt forest (Humphries and Stanton, 1992).

The neotropical genus *Lantana* consists of about 155 species (Bailey and Bailey, 1976) grouped in a number of sections. The section *camara,* comprising some 16 species, is distinguished by having swollen inflorescence receptacles, drupes blue black with obovoid inflated indehiscent endocarps, and flower color in the yellow to orange–red range (R. Sanders, Botanical Research Institute of Texas, personal communication). The origin of *L. camara* is thought to be Jamaica where it existed as a diploid (R. Sanders, personal communication). It was introduced into Europe from the New World in the early 17th century and there subject to considerable plant breeding efforts to produce ornamental varieties. In three centuries some 650 cultivars or varieties of varying ploidy were produced from *L. camara* (in some cases by hybridizing it with other closely related species of *Lantana*) so that the species as we know it today is best described as a man-made polyploid complex (Stirton, 1977). These European cultivars were then introduced into tropical and subtropical colonial countries such as Australia, South Africa, India, and Hawaii and also reintroduced into tropical America (Stirton, 1977) and some became weedy (Swarbrick, 1986).

L. camara has long been a desirable target for biological control because it is an introduced plant, it infests rangelands where it may not be economic to treat with herbicides or clear physically, and because herbicide programs have not been particularly effective. In fact, the biological control program against *L. camara* was the very first to incorporate foreign exploration and importation of the insect species from the plant's native area.

This first survey was made in 1902 by Albert Koebele, who spent 7 months in Veracruz and Morelos, Mexico (Perkins and Swezey, 1924). In 1954, a second search was made in a cooperative program. John Mann of the Queensland Department of Lands surveyed much of central Mexico from a base in Cuernavaca while Noel Krauss of the Hawaiian Department of Agriculture surveyed Florida, the West Indies, Central America, and Mexico, where he joined Mann.

In South America, a 10-year survey of the fauna associated with *Lantana* spp. (chiefly *L. tiliaefolia* Cham. and *L. glutinosa* Poepp, now both considered subspecies of *L. urticifolia* Mill.) in Brazil was initiated in 1968 (Winder and Harley, 1983). The study reported 345 phytophagous species.

These major projects do not account for all records of

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insects on *Lantana*. Over the years entomologists have also collected on *Lantana* while pursuing other biological control projects. For example, G. Diatloff and C. García of the Queensland Department of Lands have worked in Costa Rica and Argentina, respectively, where they have been primarily concerned with host testing of selected species.

From these investigations, 32 insect species have been released in various countries (Julien, 1992), a number easily surpassing that for any other weed species. However, effective control has been achieved only in parts of Hawaii (Perkins and Swezey, 1924; Harley, 1974). The biological control achieved in Australia was considered only partially effective (Winder and Harley, 1983) and more biological control agents are desired (Taylor, 1989).

Our own investigation for the Queensland Department of Lands commenced in 1988. Three factors influenced the decision to resurvey North America. First, some areas such as south Texas, the Yucatán Peninsula, and Chiapas had not been thoroughly investigated. Second, studies of insect taxonomy over the past 40 years may have resulted in the redefinition of some species complexes leading to new host-specific taxa. Third, additional species might be found by studying the plant throughout the full year and for more than 1 year, as is the current recommendation (Harley and Forno, 1992).

MATERIALS AND METHODS

The investigation was conducted from the North American Field Station, Temple (Texas, U.S.A.) and Cuernavaca (Morelos, Mexico) where the first and second authors, respectively, were based. The area of search (Fig. 1) consisted of south Texas, Mexico with the exception of the northwestern corner, and, to a limited extent, Florida. Throughout these areas, plants were usually examined along roadsides after being spotted from a car. Selected areas around Cuernavaca (Morelos), Jalapa (Veracruz), Alvarado (Veracruz), Chilpancingo (Guerrero), and Alice (Texas) were reexamined at regular intervals throughout the 5 years. In all, stands of *Lantana* were examined on some 300 separate occasions during the project.

The survey concentrated on four species of *Lantana* belonging to the section *camara*. These were *L. camara*, which was found along both the Gulf and Pacific Coasts and as a cultivated plant in many cities; *L. urticoides* Hayek, found in southern Texas and northeastern Mexico; *L. urticifolia*, found throughout central and southern Mexico and the Yucatán Peninsula; and *L. hirsuta* Mart. & Gal., which had a rather limited distribution at higher rainfall sites such as Jalapa and Orizaba, Veracruz. These four species (*L. camara, L. urticoides, L. urticifolia,* and *L. hirsuta*) were examined on 157, 45, 75, and 23 separate occasions respectively.

All four species were similar in gross morphology. The plants were usually shrubs of 1–2 m in height occurring as scattered populations. On many occasions, especially in southern Mexico, only 1–2 isolated plants were found in an area. Only rarely were dense stands or weedy situations seen. Hybrids between species were also encountered.

Insects were collected both by visually inspecting the plant and, when appropriate, by sweeping the foliage. When evidence of internal insect infestation was present, the plant part was either removed and placed in an emergence enclosure or it was opened and the insect removed. Any evidence of feeding by the insect was noted. Immatures were reared to maturity to obtain adults for identification.

All insect specimens were first submitted to the Systematic Entomology Laboratory, Agricultural Research Service, USDA, Beltsville, Maryland, for identification. When not identified by this laboratory, they were forwarded to other taxonomists as appropriate. Specimens of some species were retained by the taxonomists responsible for identification. These were mostly deposited in the U.S. National Museum of Natural History. Specimens of most species were returned and are retained in the collection of the North American Field Station. Additional material was deposited in the collections of Texas A&M University and the Universidad Nacional Autónoma de Mexico.

After identification, the insects were firstly classified as phytophagous or nonphytophagous. Species thought to feed on plant parts other than nectar, pollen, or dead tissue were considered phytophagous (Strong *et al.*, 1984). Nonphytophagous insects were known predators, parasites, fungivores, pollen or nectar feeders, and others whose habits indicated only casual association with the plant. Insects captured only in a nonphytophagous life stage (e.g., adult Lepidoptera and almost all adult Diptera) were treated as not phytophagous and are not reported.

The host range of each identified, phytophagous species was assessed by consulting entomologists knowledgeable about the particular species or group, insect collections in various institutions, and the literature. Some species were also subjected to host-specificity experiments to define further their host range and, if appropriate, to gain approval for their importation into Australia for further testing. All available knowledge about each species was used to assign it to a host-range category (Table 1) which ranged from "*" for a species thought to have hosts outside the family Verbenaceae to "******" for one having only a single species of *Lantana* as its host. However, it must be emphasized that these ratings in many cases are no more than our "best estimate" at the conclusion of the project.

Each species was recorded in a computer database along with details gathered at the time of collection and

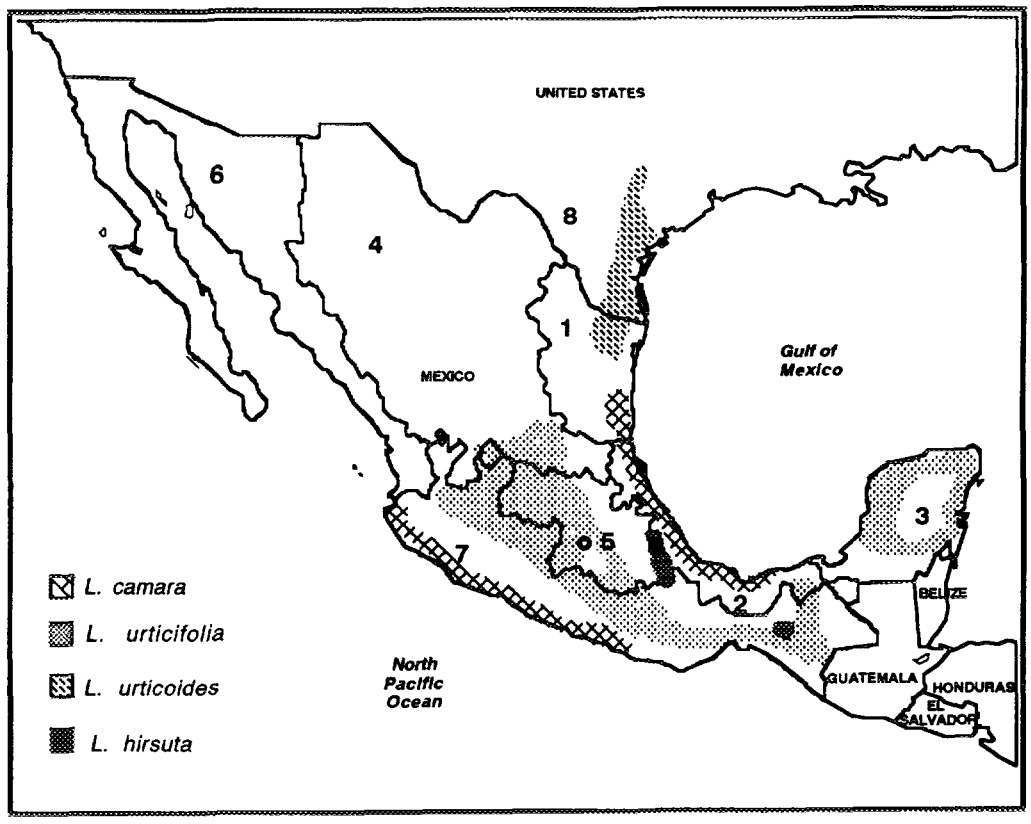

FIG. 1. The principal areas searched by the authors between 1988 and 1992 for phytophagous arthropods on four species of *Lantana*. Key to regions: 1, Mexico, NE (Nuevo León, Tamaulipas); 2, Mexico, Gulf Coast (Veracruz, Tabasco); 3, Mexico, Yucatán, (Campeche, Yucatán, Quintana Roo); 4, Mexico, N. Central (Chihuahua, Coahila, Durango, Zacatecas, San Luís Potosí); 5, Mexico, S. Central (Aguascalientes, Guanajuato, Querétaro, Hidalgo, México, Puebla, Morelos, Distrito Federal); 6, Mexico, N. Pacific (Sonora, Sinaloa, Nayarit, Baja California Norte, Baja California Sur); 7, Mexico, S. Pacific (Chiapas, Guerrero, Oaxaca, Colima, Michoacán, Jalisco); 8, Texas.

relevant literature (Palmer, 1994). In this way a profile about each species was developed and these are available on request from the first author.

The collection records of Albert Koebele (Perkins and Swezey, 1924), John Mann, and Noel Krauss (Florida, Mexico, Central America) were then also examined and similarly treated. The insects found by Mann and Krauss have not, to our knowledge, been published but are contained in a departmental report made by Mann in 1954 to the Queensland Department of Lands. Many species had undergone nomenclatural changes over time requiring their names to be changed to their modern synonymies. Species fully identified to the species level but not collected by us were added to the list we report. Finally, taxa identified to genus were added if those genera were not already represented.

RESULTS

General Analyses

The phytophagous species found in North America on the four species (*L. camara, L. urticifolia, L. hirsuta,* and *L. urticoides*) during the present survey or by the three previous collectors are listed in Table 1. Some 550 species, representing 9 orders and 71 families, were found by at least one of the exploration teams.

Of this total fauna, 261 were found in the present survey. The numbers of species found on *L. camara, L. urticifolia, L. hirsuta,* and *L. urticoides* were 120, 82, 58, and 31, respectively, and were roughly in proportion to the searching effort on each plant. Many of the insects were found on more than one species of *Lantana*. Some 35 of the insects found on *L. camara* were found on at least one other *Lantana* species. Of these, 30, 16, and 6 species were also found on *L. urticifolia, L. hirsuta,* and *L. urticoides,* respectively (again roughly in proportion to the searching effort on these other plants). Four species were found on all 4 species of *Lantana*, while 15 species were found on three species of *Lantana* and 24 on two species of *Lantana*.

A high proportion of the species in the present survey were found only once or twice (Table 1), and it appeared that *Lantana* is utilized intermittently by a large number of species. Only nine species were considered to be com-

TABLE 1

The Phytophagous Species Found on Four Species of *Lantana* in North America

Species[a]	Frequency[b] of collection	Stages found	Plant[c] part	Specificity[d] index	*Lantana*[e] hosts	Distribution[f]
Acarina						
Eriophyidae						
Aceria lantanae (Cook)	C	All stages	Leaf, flower	*****	c, h, u, t	1, 2, 4, 5, 7, 8, 9
Mochlozetidae						
Mochloribatula calycifera Mahunlea	R	Immatures, adults	Leaf		c	2
Orthoptera						
Acrididae						
Aidemona azteca Saussure[1]						
Dactylotum bicolor pictum (Thomas)	R	Nymph	Leaf		t	8
Dichroplus sp.	R	Adult	Leaf		u	3
Heliastus sumichrasti Saussure[1]						
Hippiscus compactus Scudder[1]						
Hippopedon saltator Saussure[1]						
Machaerocera mexicana Saussure[1]						
Melanoplus sp.	R	Adult	Leaf		t	8
Metaleptea brevicornis (Johannson)	R	Adult	Leaf	*	c	5
Orphulella saussureana Bruner[1]						
Plectrotettix mexicanus Bruner[1]						
Proctolabus mexicanus Saussure[1]						
Schistocerca alutacea Harris[1]				*		
Syrbula mexicana Saussure[1]						
Gryllidae						
Oceanthus niveus De Geer[3]				*		
Pyrgomorphidae						
Icthyotettix mexicanus (Saussure)[3]						
Prosphena scudderi Bolivar[3]						
Sphenarium campestre Bruner[1]						
S. marginatus (Bruner)[1]						
S. mexicanum Saussure[1]						
S. rugosum Bruner	C	Adult	Leaf		c, h, u	2, 5, 7
Romaleidae						
Brachystola magna (Girard)	R	Adult	Leaf	*	u	7
Taeniopoda stali Brunner[1]						
Tetrigidae						
Paratettix mexicanus Saussure[1]						
Tettigidea plagiata Morse[1]						
Tettigoniidae						
Anaulacomera sp.	R	Adult	Leaf		u	7
Conocephalus strictus (Scudder)	R	Nymph	Leaf		t	8
Dichopetala caudelli Behn and Hebard	O	Adult	Leaf		u	5, 7
Dichopetala sp.	R	Nymph			t	8
Scudderia ungulata Scudder[1]						
Xiphidium unispina Saussure[1]						
Phasmatodea						
Heteronemiidae						
Diapheromera sp.	R	Adult	Leaf	*	u	5
Pseudosermyle sp.[3]						
Phasmidae						
Bacteria tridens Burmeister[1]						
Dermaptera						
Forficulidae						
Sphingolabis taeniata Dohrn[1]						
Hemiptera						
Alydidae						
Hyalymenus pulcher (Stål)[1]						
H. tarsatus (F.)	O	Adult	Flower	*	c, u	2, 5
Berytidae						
Jalysus macer (Stål)	R	Adult	Leaf		c	5

TABLE 1—*Continued*

Species[a]	Frequency[b] of collection	Stages found	Plant[c] part	Specificity[d] index	*Lantana*[e] hosts	Distribution[f]
Coreidae						
Anasa maculipes Stål	R	Adult	Stem	*	c	5
Catorhintha guttula (F.)[2]				*		B
C. mendica Stål[2]				*		
Chariesterus albiventris Burmeister	R	Adult	Leaf	*	c	3
C. antennator (F.)[2]				*		
Hypselonotus interruptus Hahn	R	Adult	Leaf	*	u	5, B
H. lineatus Stål[1]				*		
H. punctiventris Stål	O	Adult		*	u	5
Leptoglossus zonatus (Dallas)	R	Adult	Fruit	*	u	7
Merocoris sp.	R	Adult	Flower		h	3
Mozena lunata (Burmeister)[2]				*		
Piezogaster spurcus (Stål)[2]				*		
Zicca taeniola (Dallas)[1]				*		
Cydnidae						
Melanaethus subglaber (Walker)[1]				*		
Largidae						
Largus convivus Stål[1]				*		
Largus sp.	O	Adult			c, u	3, 5, 7
Stenomacra cliens (Stål)[1]				*		
S. marginella (Herrich-Schaeffer)	R	Nymph, adult	Leaf	*	c	5
Lygaeidae						
Craspeduchus pulchellus (F.)	R	Adult	Leaf	*	u	3
Kleidocerys suffusus Barber[3]				*		
Ligyrocoris sp.	R	Adult			h	2
Lygaeus pallidocinctus Stål[1]						
L. reclivatus Say	R	Adult	Leaf	*	u	5
Neortholomus jamaicensis (Dallas)[3]				*		
Ozophora concava (Distant)[1]						
Paromius longulus (Dallas)[1]				*		
Miridae						
Adfalconia intermedia (Distant)	O	All stages	Leaf	*****	c, h, u	2, 5
Clivinema sp.[1]						
Cyrtopeltis modesta (Distant)	R	Adult	Leaf	*	u	5
C. rubescens (Distant)[3]				*		
Dicyphus agilis (Uhler)[3]				*		
Dicyphus sp.	R	Adult	Leaf		c	5
Horcias plagosus Distant[3]						
Lampethusa anatina Distant[3]				*		
L. collaris Reuter	O	Nymph, adult	Flower	*	c	5
Macrolophus praeclarus (Distant)	R	Nymph, adult	Leaf	*	t	3
Monalonion versicolor Distant[1]				*		
Neurocolpus fusicornis Henry	R	Adult	Leaf		h	2
N. mexicanus Distant	O	Adult	Leaf	*	c	5
Ofellus mexicanus Carvalho & Sailer	R	Adult	Leaf	*		
Parthenicus sp.[3]						
Phytocoris tibialis Reuter[3]				*		
Platylygus tinctus (Reuter)[1]				*		
Poecilocapsus lineolatus (L.)	O	Nymph, adult	Leaf		h	2
P. nigriger (Stål)[2]				**		
Poecilocapsus sp.	R	Adult	Leaf		u	7
Proba sallei (Stål)	R	Adult	Leaf	*	h	2
Psallas sp.[3]						
Reuteroscopus chillcotti Kelton	O	Adult	Leaf		u	5
R. longirostris Knight[2]						
R. ornatus (Reuter)[3]				*		
Rhinacloa forticornis (Reuter)	R	Adult	Leaf	*	c	5
R. pallidipes Maldonado	R	Adult	Leaf	*	c	3
Sixeonotus sp.	R	Adult	Leaf		h	2
Tropidosteptes sp.[1]						

TABLE 1—*Continued*

Species[a]	Frequency[b] of collection	Stages found	Plant[c] part	Specificity[d] index	*Lantana*[e] hosts	Distribution[f]
Pentatomidae						
Acrosternum marginatum (Palisot)[2]				*		
Banasa stigmosa Distant[1]						
Chlorochroa ligata (Say)	R	Nymph, adult	Fruit	*	t	8
Cryptocephala antiguensis (Westood)[2]				*		
Edessa cordifer (Walker)[3]						
Edessa sp.	R	Adult	Leaf		u	5
Euschistus bifibulus (Palisot)	R	Adult		*	h	2
E. biformis Stål[3]				*		
E. comptus Walker	R	Adult	Fruit	*	t	8
E. crenator (F.)[2]				*		
E. servus servus (Say)	R	Adult	Fruit	*	c	9
E. tristigmus (Say)	R	Adult	Fruit	*	c	9
Euschistus sp.	R	Adult			h	2
Hymenarcys reticulata Stål[1]						
Macropygium parvum Distant[1]						
Mormidea collaris Dallas[1]				*		
M. notulata (Herrich-Schaeffer)[2]				*		
Padaeus trivittatus Stål[1]						
Thyanta custator (F.)	R	Adult	Fruit	*	c	9
T. perditor (F.)	R	Adult	Fruit	*		5
Piesmatidae						
Piesma cinereum (Say)[3]						
Pyrrhocoridae						
Dysdercus flavolimbatus Stål[1]				*		
D. mimulus Hussey	R	Adult	Flower	*	c	5, B
D. mimus (Say)[1]				*		
D. obliquus (Herrich-Schaeffer)	R	Adult	Leaf	*		5
Rhopalidae						
Arhyssus lateralis (Say)[1]				*		
Arhyssus sp.	R	Adult	Leaf		c	5
Aufeius impressicollis Stål[1]				*		
Harmostes reflexulus (Say)	R	Adult	Leaf	**	u	8
H. serratus (F.)[3]				*		
Niesthrea sidae (F.)[2]				*		
Scutelleridae						
Chelysomidea strictum (Dallas)[2]						
C. variabilis (Herrich-Schaeffer)	O	Nymph, adult	Leaf	*	c, u	5, 7
Homaemus proteus Stål[1]						
Homaemus sp.	R	Adult	Leaf		h	2
Sphyrocoris sp.[3]						
Stethaulax sp.	R	Adult	Fruit		c	2
Symphylus plagiatus Walker[1]						
Tiridates mexicanus (Herrich-Schaeffer)[1]						
Thyreocoridae						
Corimelaena coerulescens Stål[1]						
C. quadrisignata Stål[1]						
Corimelaena sp.	R	Adult	Leaf		c	5
Galgupha sp.	R	Adult	Leaf		t	8
Tingidae						
Corythaica carinata Uhler	R	Nymph, adult	Leaf	*	c	2
C. venusta (Champion)[1]				*		
Corythucha gossypii (F.)	R	Adult	Leaf	*	u	3
C. spinosa (Duges)[1]				*		
Corythuca sp.	R	Adult	Leaf		u	7
Dictyla monotropidia (Stål)[3]				*		
Teleonemia cylindricornis Champion[3]				***		
T. notata Champion[1]				**		
T. prolixa (Stål)[3]				***		B
T. scrupulosa Stål	C	All stages	Leaf	*	c, h, u, t	2, 3, 5, 7, 8, 9, B
T. variegata Champion	O	Nymph, adult	Leaf	*	c, h, u	2, 5, 7

TABLE 1—*Continued*

Species[a]	Frequency[b] of collection	Stages found	Plant[c] part	Specificity[d] index	*Lantana*[e] hosts	Distribution[f]
Homoptera						
Acanaloniidae						
Acanalonia invenusta Doering	R	Adult	Leaf	*	t	8
A. laticosta Doering	R	Adult	Stem	*	u	8
A. virescens Stål[1]						
Aleyrodidae						
Bemisia tabaci (Gennadius)	R	All stages	Leaf	*	c	3
Tetralicia sp.	R	All stages	Leaf		c	5
Aphididae						
Aphis sp.[3]						
Asterolecaniidae						
Asterolecanium sp.	R				h	2
Cercopidae						
Cephisus siccifolius (Walker)[3]				*		
Clastoptera funesta Stål[3]				*		
C. globosa Fowler	R	Adult	Stem		u	3
Tomaspis imperans Fowler[1]						
T. inca Guerin[1]						
T. simulans Walker[1]				*		
Cicadellidae						
Agallia sp.[3]						
Agalliana sp.[3]						
Agalliopsis sp.[3]						
Agalliota sp.[3]						
Agrosoma akenalis Medler	R	Adult	Leaf		h	2
A. placetis Medler	R	Adult	Stem	*	u	3
A. pulchella (Guérin)[1]				*		
A. nr. *syklis* Medler	R	Adult	Leaf		h	9
Apogonalia germana (Fowler)[1]						
A. mediolineata (Fowler)[1]						
Aulacizes rubriventris Signoret[1]						
Balclutha hebe (Kilkaldy)	R	Adult	Leaf	*	u	7
Barela aureocosta (Ruppel & DeLong)	O	Adult	Leaf	*	c, u	5
B. decorata (Osborn)[3]						
Caldewelliola nr. *reservata* (Fowler)[3]						
Chlorogonalia coeruleovittata (Signoret)[1]						
Chlorotettix sp.[3]						
Cloanthanus sp.	R	Adult	Leaf		u	5
Coelidia sp.[3]						
Cuerna costalis (F.)	O	Adult	Stem	*	t	8
Cyrtodisca major (Signoret)	O	Adult	Stem	*	c, h, u	5, 7
Deltoryhchus quadrinotus DeLong[3]						
Dikrella sp.[3]						
Empoasca sp.[3]						
Graphocephala atropunctata (Signoret)	R	Adult	Leaf	*	h	2
G. punctulata (Signoret)[3]				*		
G. rufimargo (Walker)[3]				*		
G. versuta (Say)[3]				*		
Graphogonalia vulgaris Young[3]						
Gypona fuscinervis Stål[1]						
G. verticalis (Stål)	R	Adult	Leaf		c	5
Gypona sp.	R	Adult	Leaf		u	5
Gyponana sp.	O	Adult	Leaf		c	5
Ladoffa rubriguttata (Walker)[3]						
Macropsis sp.[1]						
Macugonalia redundans (Fowler)[3]						
Macunolla ventralis (Signoret)[3]						
Neocoelidia pr. *obscura* Baker	R	Adult	Leaf		c	5
Neocoelidia sp.	R	Adult	Leaf		c	5
Omanana nigrifrons De Long[3]						
Oncometopia alpha Fowler[2]				*		

TABLE 1—*Continued*

Species[a]	Frequency[b] of collection	Stages found	Plant[c] part	Specificity[d] index	*Lantana*[e] hosts	Distribution[f]
O. clarior (Walker)	O	Adult	Stem	*	c, h, u	2, 3, 7
O. fuscipennis Fowler	R	Adult	Stem	*	c, u	5, 7
O. nigricans (Walker)	R	Nymph, adult	Stem	*	t	8
O. obtusa (F.)[1]				*		
O. orbona (F.)[3]				*		
O. rufipennis (Signoret)	R	Adult	Stem		c, u	5, 7
O. tartarea (Stål)[1]						
Phera aterrima Fowler[3]						
Phlepsius sp.[1]						
Plesiommata mollicella (Fowler)[3]						
Rhabdotalebra octolineata (Baker)[3]						
Rugosana rugosa (Spangberg)[1]						
Scaphytopius falcatus DeLong[3]						
S. nr. *heldoranus* (Ball)[3]				*		
Sibovia occatoria (Say)[1]				*		
S. tunicata (Fowler)[3]				*		
Typhlocyba sp.[1]						
Cixiidae						
Bothriocera signoreti Stål	R	Adult	Leaf		u	5
Neaethus sp.	R	Adult	Stem		t	8
Oecleus nr. *apterapunctatus* Caldwell[3]						
O. parallelus Caldwell[3]						
O. pellucens Fowler[3]				*		
Oliarus sp.[1]						
Delphacidae						
Copicerus irroratus Swartz	R	Adult	Leaf	*	u	3
Delphacina sp.[1]						
Derbidae						
Cedusa plummeri Caldwell[3]						
Cenchrae sp.[3]						
Omolicna nr. *brunnea* McAtee[3]						
Persis foveatis[3]						
Dictyopharidae						
Nersia florens Stål	R	Adult	Leaf	*	c	2
Taosa herbida (Walker)[3]				*		
Eriococcidae						
Acanthococcus nr. *palmeri* (Cockerell)[3]				*		
Flatidae						
Cyarda difformis Walker[1]						
C. melichari Van Duzee[3]				*		
Epormenus roscida (Germar)[3]						
Flatormenis dolobrata Fowler	R	Adult		*	c	7
F. paramensis (Schmidt)[3]						
Flatormenis sp.	R	Adult	Stem		c, u	5, 7
Metcalfa pruinosa (Say)	O	Nymph, adult	Stem	*	c, t	8
Monoflata pallescens (Stål)	R	Nymph, adult	Stem	*	c	7
Issidae						
Colpoptera albavenosa Caldwell	R	Adult			c	2
C. nigridorsa Caldwell	R	Adult	Stem		c	7
Hysteropterum sp.[3]						
Issus sp.[1]						
Membracidae						
Aconophora compressa Walker	C	All stages	Stem	***	c, h, u	2, 5, 7
Acutalis sp.	R	Adult	Leaf		c	5
Ceresa sp.[1]						
Entylia sinuata F.[3]				*		
Hyphinoe camelus Gray[1]						
Micrutalis sp.[3]						
Polyglypta costata Burmeister[3]				*		
Spathocentrus sp.[3]						
Umbonia crassicornis Amyot & Serville	R	Adult		*	u	5
Umbonia sp.	R	Adult	Leaf		c	5
Vestistilus vacca Fowler[2]						
Ortheziidae						
Orthezia insignis Browne	R	Nymph, adult	Stem	*	u	B
O. pseudinsignis Morrison	O	Nymph, adult	Stem, leaf	*	c, h, u	2, 3, 5

TABLE 1—*Continued*

Species[a]	Frequency[b] of collection	Stages found	Plant[c] part	Specificity[d] index	*Lantana*[e] hosts	Distribution[f]
Pseudococcidae						
Ferrisia virgata (Cockerell)	R	Nymph	Leaf	*	c	5
Phenacoccus gossypii Townsend & Cockerell[3]				*		B
P. solenopsis Tinsley	O	Nymph, adult	Leaf	*	c, u	3
Pseudococcus elisae Borchsenius[3]						
Putoidae						
Puto barberi (Cockerell)	R		Stem	*	u	7
P. mexicanus (Cockerell)	R		Leaf	*		5
Thysanoptera						
Phlaeothripidae						
Hoplothrips gowdeyi (Franklin)[3]				*		
Leptothrips cassiae Watson[3]						
Thripidae						
Frankliniella bispinosa (Morgan)[3]				*		
F. inutilis Prisner[3]				*		
F. nr. *cephalica* (Crawford)[3]						
F. nr. *occidentalis* (Pergrande)[3]				*		
F. nr. *runneri* Morgan[3]				*		
F. parvula Hood[3]				*		
Coleoptera						
Anobiidae						
Calymmaderus sp.[1]						
Trichodesma truncata[3]						
Tricorynus sp.[1]						
Apionidae						
Apion sp.[1]						
Coelocephalapion aduncirostre (Gerstaeker)	R	Adult	Flower		c	5
Attelabidae						
Haplorhynchites sp.	R		Leaf		h	2
Pilolabus nr. *sumptuosus* (Gory)[2]						
Buprestidae						
Acmaeodera flavomarginata Gray[2]						
A. rubronotata Laporte[2]						
A. venusta Waterhouse	R	Adult	Flower		u	5
Agrilus nr. *oculatus* Waterhouse[2]						
A. toteci Fisher	R	Adult	Leaf		c	5
Agrilus sp.	R	Adult	Leaf		u	5, 7
Chrysobothris basalis (LeConte)[1]				*		
Paragrilus sp.[2]						
Psiloptera sp.[1]						
Cerambycidae						
Acanthoderes borrei Duges[1]				*		
Adetus obliqua (Bates)[1]						
A. subellipticus Bates[1]				*		
Aerenicopsis championi Bates	C	All stages	Stem*	*****	c, h, u	1, 2, 4, 7
Anelaphus debilis (LeConte)	R	Adult	Leaf	*	t	8
Deliathis pulchra (Thomson)	R	Adult	Flower		c	2
Entomosterna sp.[1]						
Lagocheirus undatus (Voit)[1]				*		
Lissonotus flavocinctus (Dupont)[2]				*		
Mecas oberioides Bates[1]						
Parevander xanthomelas (Guerin-Meneville)	R	Larva	Root*	****	c	7
Parmenonta valida Thomson[1]						
Paroxoplus poecilus (Bates)[1]						
Phaea phthisica Bates[1]						
Placosternus erythropus Chevrolat[1]				*		
Plagiohammus spinipennis (Thomson)	O	All stages	Stem*	****	h	2
Platyarthron sp.[1]						
Rhopalophora incrustata Chevrolat[1]						
R. laevicollis (LeConte)	R	Adult	Leaf	*	t	8
Spalacopsis sp.[1]		Larva, adult	Stem*			5
Stenaspis verticalis Serville[1]						
Stenosphenus cribripennis Thomson[1]						
Stenygra histrio (Serville)[1]				*		
Taricanus truquii Thompson[1]				*		
Trachyderes elegans Dupont	R	Adult	Flower		c	2
T. mandibularis Serville[2]				*		
Tylosis puncticollis Bates[1]						

TABLE 1—*Continued*

Species[a]	Frequency[b] of collection	Stages found	Plant[c] part	Specificity[d] index	*Lantana*[e] hosts	Distribution[f]
Chryosomelidae						
Alagoasa acutangulus (Jacoby)	O	Adult	Leaf		c, h, u	2, 5, 7
A. bipunctata (Chevrolat)	R	Adult	Leaf		u	3
A. brevicornis (Jacoby)	O	Adult	Leaf		c, u	2, 3
A. ceracollis (Say)	O	Adult	Leaf		h	2
A. chevrolati (Baly)	O	Adult	Leaf	*	u	3
A. clypeatus (Jacoby)	R	Adult	Leaf		h	2
A. decemguttata (F.)	O	Adult	Leaf	*	u	5
A. nr. *duodecimmaculatus* (Jacoby)[3]						
A. pr. *extrema* (Harold)[2]						
A. lateralis (Jacoby)	R	Adult	Leaf		u	5
A. nr. *lateralis* (Jacoby)	R	Adult	Leaf		u	3
A. petaurista (F.)	O	Adult	Leaf		c, t	8
A. nr. *petaurista* (F.)	R	Adult	Leaf			7
A. nr. *petaurista* (F.)	O	Adult	Leaf		c, u	2, 3
A. nr. *seriata* (Baly)[2]						
A. virgata (Harold)	O	Adult	Leaf	*	c, h	2, 7, B
Amphelasma sp.[2]						
Anomoea nr. *laticlavia* (Forster)[2]						
Asphaera mexicanus (Harold)	R	Adult	Leaf		h	2
Babia pr. *quadriguttata* (Olivier)	R	Adult	Leaf		u	5
Calligrapha aeneopicta Stål[1]				*		
C. multipustulata Stål[1]						
C. notatipennis Stål[1]						
C. nr. *pantherina* Stål	R	Adult	Leaf		c	7
C. suboculata Stål[1]						
Chaetocnema sp.[2]						
Chalcophana cincta Klug	R	Adult	Leaf		h	2
Charidotella trisignata (Boheman)	R	Adult	Leaf	*	h	2
Chelymorpha hopfneri Boheman[1]						
Chlamys cinerea LeConte[1]						
Chthoneis sp.[3]						
Colaspis nr. *lebasi* Lefevre[1]				*		
C. nr. *prasina* Lefevre[1]						
C. pr. *zanthophaia* Blake	R	Adult	Leaf		c	7
Colaspoides pr. *opacicollis* Horn	O	Adult	Leaf		u	8
Coptocycla leprosa Boheman[1]						
C. testudinaria Boheman[1]						
C. tuberculata F.[1]						
Coraia nr. *maculicollis* Clark[2]						
Crepidodera sp.	O	Adult	Flower		c	5
Cryptocephalus nr. *militaris* Suffrian[1]						
C. nr. *patheticus* Suffrian	R	Adult	Leaf		h	2
C. trizonatus Suffrian[2]				*		
Diabrotica balteata LeConte[1]				*		
D. biannularis Harold[1]				*		
D. lepida Say[1]						
D. scutellata Jacoby	R	Adult	Leaf		h	2
D. sexmaculata Baly	R	Adult	Leaf		h	2
Diachus auratus (F.)	R	Adult	Leaf	*	h	2
D. nr. *squalens* Suffrian[3]						
Diphaulaca sp.	R	Adult	Leaf		u	5
Disonycha sp.[2]						
Exema nr. *complicata* Jacoby	R	Adult	Leaf		u	3
Galerucella fuscomaculata Jacoby[1]						
Haltica sp.[1]						
Heikertingerella nr. *variabilis* Jacoby[2]						
Heikertingerella sp.	O	Adult	Leaf		c, h, u	3, 5, 7
Homotyphus sp.[1]						
Lamprosoma approximans LeConte[1]						
Lema sp.	R	Adult	Leaf		c	5

TABLE 1—*Continued*

Species[a]	Frequency[b] of collection	Stages found	Plant[c] part	Specificity[d] index	*Lantana*[e] hosts	Distribution[f]
Leptinotarsa signaticollis Stål[2]						
Lobropa sp.[1]						
Longitarsus nr. *varicornis* Suffrian[2]				*		
Longitarsus sp.	R	Adult	Leaf		c	5
Megalopus sp.[3]						
Megalostomis dimidiata Lacordaire[1]				*		
M. notabilis Lacordaire[2]						
Mesomphalia tristigma Boheman[1]						
Metriona nr. *erratica* Boheman[2]						
Monomacra ornata Jacoby[1]						
Nodonota tristis (Olivier)	R	Adult	Leaf		t	8
Nodonota sp.	R	Adult	Leaf		h	2
Octotoma championi Baly	O	All stages	Leaf*	*****	c, h, u	2, 3, 5
O. scabripennis Guerin	C	All stages	Leaf*	*****	c, u	2, 4, 5, 7
Ogdoecosta biannularis Boheman[2]				*		
Omophoita sp.[2]						
Pachybrachis sp.[1]						
Pentispa fairmairei Chapuis[1]						
P. nr. *melanura* Chapuis[2]						
Physonota alutacea Boheman[1]				*		
P. citrina Boheman[1]						
P. nr. *attenuata* Boheman[2]						
Plectotetra dohrni Jacoby	O	Adult	Leaf		h	2
Saxinus sp.[2]						
Systena sp.[1]						
Trirhabda variabilis Jacoby[2]						
Typophorus nigritus chalceus Lefevre[1]						
Uroplata fulvopustulata Baly	O	All stages	Leaf*	*****	c, u	3, 7, B
Walterianella biarcuata (Chevrolat)[1]						
W. nr. *venustula* (Schaufuss)[3]						
Walterianella sp.	R	Adult	Leaf		u	3
Zygogramma piceicollis Stål[1]				*		
Z. signatipennis Stål[1]				*		
Coccinellidae						
Epilachna borealis (F.)[1]				*		
E. mexicana (Guerin)[1]				*		
E. nigrocincta Mulsant[2]						
E. varivestis Mulsant[1]				*		
Curculionidae						
Anthonomus baridioides Champion	R	Adult	Leaf	*	c	5
Artipus floridanus Horn[3]				*		
Baris aerea Boheman[3]				*		
Chalcodermus sp.	R	Adult	Flower		c	5
Compsus auricephalus (Say)	O	Adult	Leaf	*	c	7
Conotrachelus corallinus Champion[3]						
Copturus sp.[1]						
Crotanius trivittatus (Champion)	R	Adult	Leaf		c	5
Epicaerus sp.	R	Adult		*	u	7
Epicaerus sp.	R	Adult	Leaf	*	c	2
Geraeus linellus LeConte[3]						
G. nr. *curvispinis* Champion	O	Egg, larva, adult	Peduncle	****	c	5
G. penicellus (Herbst)[3]						
Geraeus sp.	R	Adult	Flower		c	5
Glyptobaris rugata Boheman[2]						
Hadromeropsis sp.[1]						
Isodacrys orizabae Sharp	R	Adult	Flower		h	2
Lachnopus sp.[1]						
Lixus sp.[1]						
Nicentrus lineicollis Boheman[3]						
Nicentrus sp.	R	Adult	Flower		h	2

TABLE 1—*Continued*

Species[a]	Frequency[b] of collection	Stages found	Plant[c] part	Specificity[d] index	*Lantana*[e] hosts	Distribution[f]
Odontocorynus sp.	R	Adult	Flower		h	2
Ophryastes sp.	R	Adult	Stem		u	5
Pandeleteius sp.[1]						
Pantomorus sp.[1]						
Phyllotrox sp.	R	Adult	Leaf		c	5
Promecops brevisetis Champion[2]						
Pseudoptatus dentipes Champion[3]						
Rhodobaenus sanguineus (Gyllenhal)	R	Adult	Leaf	*	h	2
R. tredecimpunctatus (Illiger)[2]				*		
Rhyssomatus sp.[1]						
Sibinia sp.	R	Adult			c	5
Sitophilus zeamais Motschulsky	R	Adult		*	h	7
Solaria curtula Boheman[3]						
Sphenophorus sp.[1]						
Stegotes ruficollis Boheman[2]						
Sternechus extortus Chevrolat[3]						
Trepobaris inornata Champion[2]						
Elateridae						
Aptopus lateralis Erichson	R	Adult			c	2
Cardiophoris aptopoides Candéze[2]						
Lacon brevis Candéze[1]						
Lagriidae						
Statira limbata Champion[1]						
Meloidae						
Epicauta sericans LeConte	R	Adult	Flower		t	1
Tetraonyx frontalis Chevrolat	O	Adult	Flower		h, u	2, 5
Rhynchitidae						
Eugnamptus sp.	R	Adult	Leaf		h	2
Haplorhynchites mexicanus (Gyllenhal)	R	Adult	Leaf		c	5
Scarabaeidae						
Anomala donovani Steph.[3]				*		
A. foraminosa Bates	R	Adult	Flower		c	5
Anomala sp.	R	Adult	Flower		c	5
Antichira splendens[1]				*		
Cotinis mutabilis Gory & Percheron[3]				*		
Euphora sp.	R	Adult				
Golofa sp.	R	Adult	Stem	*	h	2
Hoplia squamifera Burmeister[1]						
Macrodactylus sericeicollis Bates[3]				*		
Macrodactylus sp.	O	Adult	Leaf	*	h	2
Strigoderma protea Burmeister[1]				*		
S. sulcipennis Bates	R	Adult	Flower	*	c	5
Lepidoptera						
Arctiidae						
Bertholdia sp.	R	Larva	Leaf		h	2
Estigmene acrea (Drury)	O	Larva	Leaf	*	t	8
E. albida (Stretch)[2]				*		
Hypercompe caudata (Walker)	R	Larva	Leaf	*	u	5
H. suffusa (Schaus)	R	Larva	Leaf	*	c, u	5
Lophocampa nimbifacta (Dyar)[2]				*		
Syntomeida melanthus (Cramer)[2]						
Cosmopterigidae						
Anoncia diveni (Heinrich)	O	Egg, larva, pupa	Leaf*	*****	c, t	2, 8
Geometridae						
Anacamptodes pseudoherse Rindge	R	Larva	Leaf		c	5
Cyclophora coecaria (Herrich-Schaeffer)	O	Larva	Flower	*	c	5
Eupithecia cercina Druce[2]			Flower			
Eupithecia sp.	R	Larva	Flower		h	2
Leptostales nycteis (Druce)[1]						
Melandophia bostar (Druce)[1]						

TABLE 1—*Continued*

Species[a]	Frequency[b] of collection	Stages found	Plant[c] part	Specificity[d] index	*Lantana*[e] hosts	Distribution[f]
Pleuroprucha asthenaria (Walker)	R	Larva	Flower	*	c	5, B
Synchlora herbaria (F.)[1]				*		
Thyrinteina arnobia (Stoll)	R	Larva	Leaf	*	u	3
Urapteryx sp.[1]						
Gracillariidae						
Cremastobombycia lantanella Busck	C	Egg, larva, pupa	Leaf*	****	c, h, u, t	2, 5, 7, 8
Lithocolletis sp.[2]						
Hepialidae						
Hepialus sp.[1]						
Phassus argentiferus Walker[2]		Larva	Stem*	*		
Lycaenidae						
Cyanophrys amyntor (Cramer)[1]						
C. herodotus (F.)	R	Larva	Flower	*	u	3
C. longula (Hewitson)	R	Larva		*	c	5
Parrhasius nr. *polybetes* Cramer[1]				*		
Rekoa marius (Lucas)	R	Larva	Leaf	*	u	3
R. palegon (Cramer)	R	Larva	Flower	*	c	5, B
Strymon bazochii (Godart)	R	Larva	Flower	*	c, u	2, 5
S. melinus (Hubner)	R	Larva	Flower	*	t	8
Tmolus echion (Druce)	R	Larva	Flower	*	c	5
Noctuidae						
Anomis editrix Guenée[1]						
Diastema cnossia (Druce)	R	Larva	Leaf		t	8
D. tigris Guenée	O	Larva	Leaf	*****	u	3, 5, 7
Heliothis virescens (F.)	R	Larva	Leaf	*	u	5, B
Lophoceramica pyrrha Druce	O	Larva	Leaf	*	c, h	2, 5
Magusa orbifera (Walker)	R	Larva	Leaf	*	u	8
Neogalea sunia (Guenée)	O	Larva	Leaf	*****	c, u, t	5, 8, B
Palthis sp.[1]						
Peridroma saucia Huebner	R	Larva	Flower	*	c	5
Rachiplusia ou (Guenée)	R	Pupa	Leaf	*	u	8, B
Spodoptera praefica (Grote)[1]				*		
Oecophoridae						
Durrantia amabilis Walsingham	R	Larva	Leaf		c	2
Pyramidobela sp.	R	Larva	Leaf		h	2
Pyramidobela sp.	R	Larva	Leaf		c	5
Psychidae						
Cryptothelea gloverii (Packard)	R	Larva	Flower	*	c	2
Oiketicus pr. *abbotti* Grote	O	Larva	Leaf	*	c	5
O. pr. *kirbyi* Guild	R	Larva	Leaf	*	c	5
Thyridopteryx sp.	R	Larva	Leaf		c	5
Pterophoridae						
Lantanophaga pusillidactyla (Walker)	O	Larva	Flower	*****	c, h	2, 5, 7
Postplatyptilia palmeri Gielis	R	Pupa	Leaf		h	2
Trichoptilus nr. *pygmaeus*[2]		Larva	Flower			
Pyralidae						
Lineodes sp.[1]						
Palpita sp.[1]						
Phidotricha erigens Ragonot	R	Larva	Terminal	*	c	5
Pseudopyrausta santatalis (Barnes & McDunnough)	C	Larva	Leaf	***	c, u, t, h	2, 3, 5, 7, 8
Salbia haemorrhoidalis (Guenée)	R	Larva	Leaf	*****	c, h, u	3
Saturniidae						
Automeris iris (Walker)	R	Larva	Leaf	*	c	5
Hylesia umbratula Dyar	R	Larva	Leaf		u	7
Sesiidae						
Vitacea sp.[2]						
Tortricidae						
Amorbia emigratella Busck	O	Larva	Leaf	*	c	5
Amorbia sp.	R	Larva	Leaf		c	5

TABLE 1—*Continued*

Species[a]	Frequency[b] of collection	Stages found	Plant[c] part	Specificity[d] index	*Lantana*[e] hosts	Distribution[f]
Argyrotaenia montezumae (Walsingham)	R	Larva	Leaf	*	c	5
Bonagata nr. *cranwodes* (Meyrick)	R	Larva	Flower		c	5
Epinotia lantana (Busck)	C	Larva, pupa	Flower, leaf	*	c, u	2, 3, 5
Lorita sp.[3]						
Platynota rostrana (Walker)	R	Larva	Leaf	*	t	8
Strepsicrates smithiana (Walsingham)	R	Larva			c	5
Diptera						
Agromyzidae						
Calycomyza lantanae (Frick)	O	All stages	Leaf*	***	c	2, 5, B
Liriomyza pr. *sativae* Blanchard	R	All stages	Leaf*	*	c	5
Ophiomyia camarae Spencer	O	Larva, pupa	Leaf*	*****	c	5, B
O. lantanae (Froggatt)[1]				*****		B
Cecidomyiidae						
Asphondylia camarae Mohn	O	Larva, pupa	Flower*	*****	u	5, 7
Neolasioptera camarae Mohn	O	Larva, pupa	Stem*	*****	c, u	
Schismatodiplosis lantanae (Rubsaamen)	O	Larva, pupa	Leaf*	*****	c, h, u	2, 3, B
Tephritidae						
Eutreta xanthochaeta Aldrich	O	Larva, pupa	Stem*	*****	c, u	7
Hymenoptera						
Formicidae						
Atta texana (Buckley)	O	Workers	Leaf	*	c	5

[a] A superscript following the species indicates that this species was not found by the authors and gives the first collector to record it with 1, Koebele; 2, Mann; 3, Krauss.

[b] R, rare, being found 1–2 times; O, occasional, being found 3–9 times; C, common, being found 10 or more times.

[c] An * following the plant part indicates the insect was found inside that plant part.

[d] *, Host range exceeds family Verbenaceae; **, hosts restricted to Verbenaceae; ***, hosts restricted to subfamily Verbenoideae; ****, hosts restricted to genus *Lantana*; *****, hosts restricted to *Lantana* species of the *camara* group; ******, monophagous.

[e] Insect found on the following species: c, *L. camara*; h, *L. hirsuta*; u, *L. urticifolia*, t, *L. urticoides*.

[f] Insect was found in the following regions: 1, Mexico, NE (Nuevo León, Tamaulipas); 2, Mexico, Gulf Coast (Veracruz, Tabasco); 3, Mexico, Yucatan (Campeche, Yucatán, Quintana Roo); 4, Mexico, N. Central (Chihuahua, Coahuila, Durango, Zacatecas, San Luís Potosí); 5, Mexico, S. Central (Aguascalientes, Guanajuato, Querétaro, Hidalgo, México, Puebla, Morelos, Distrito Federal); 6, Mexico, N. Pacific (Sonora, Sinaloa, Nayarit, Baja California Norte, Baja California Sur); 7, Mexico, S. Pacific (Chiapas, Guerrero, Oaxaca, Colima, Michoacán, Jalisco); 8, Texas; 9, Florida; B, Found in Brazil by Winder and Harley (1983).

monly found. Unlike some other plants we have studied, *Lantana* did not appear to have a suite of insects seen regularly on it with some measure of certainty and at some level of abundance. With the possible exception of the tingid *Teleonemia scrupulosa* Stål, even the insects we report as commonly encountered were found sporadically and rarely in large numbers.

Table 2 shows the contributions of the surveys in terms of total number of species and the number *now* thought to be stenophagous (those having a host range limited to the subfamily Verbenoidae). Some of these stenophages were not recognized as such at the time they were collected. For the purposes of this analysis, the contributions of Mann and Krauss were pooled as they were conducted at the same time in a coordinated program. Each survey significantly increased both the total number and the number of stenophages known to be associated with *Lantana*.

TABLE 2

The Contributions of Three Surveys to the Present Knowledge of the Arthropod Fauna Associated with Four *Lantana* Species in North America

Explorer	Year	No. of phytophagous species	No. of additional phytophagous species	No. of stenophagous species found	No. of additional stenophagous species
Koebele	1902	194	—	9	—
Mann and Krauss	1954	242	198	17	10
Palmer and Pullen	1988–1992	261	158	24	7

Though all surveys had the common purpose of finding biocontrol agents, the interests and strengths of the individual collectors can be seen from Table 1, especially in groups less important to biocontrol. Thus, Koebele collected most of the Acrididae and adult Cerambycidae, while Krauss contributed many of the Cicadellidae and Thysanoptera.

A total of 26 species (approximately 5% of the total arthropod fauna) are presently considered stenophagous. These stenophagous species by definition become potential biological control agents.

Nineteen of the North American species (Table 1) were also reported on *Lantana* in Brazil (Winder and Harley, 1983). The degree of overlap of the faunas was much higher for Diptera than for any other order. Four of the eight species of Diptera reported in Table 1 were also found in Brazil.

Two rusts were also found. *Puccinia lantanae* Farlow was found attacking *Lantana camara* along the Gulf Coast of Mexico. It appeared to be the more damaging of the two. *Prospodium tuberculatum* (Speg.) J. C. Arthur was found attacking *L. urticifolia* in the state of Oaxaca. These rusts will eventually be evaluated for host specificity.

Notes on Important Species

The eriophyiid mite *Aceria lantanae* (Cook) was found in many different areas and on all four *Lantana* spp. It attacks two quite distinct parts of the plant, forming either an inflorescence gall or a tiny leaf gall (Craemer and Neser, 1990). These two forms were rarely seen on the same plant, or indeed in the same region. Further study may reveal a species complex. We regarded the inflorescence gall-former as one of the most potentially useful species encountered during the survey. Attempts to rear it in the laboratory have been unsuccessful (C. Creamer, personal communication), but further study is recommended.

Little additional comment is warranted on the Hemiptera. With the exception of the tingids *Teleonemia* spp. and the mirids *Adfalconia intermedia* (Distant) and *Lampethusa collaris* Reuter it suffices to say that a number of pentatomids and scutellerids attacked the fruit while various species of mirids, lygaeids, coreids, and tingids were found on the leaves. Five species of *Teleonemia* attack *Lantana*. These species, and *T. scrupulosa* in particular, were probably the most ubiquitous and consistently damaging group encountered and two have already been utilized as biological control agents (Julien, 1992). *Adfalconia* is a little studied mirid genus, the species of which are generally thought to be polyphagous (T. Henry, personal communication). However, populations of *A. intermedia* were host-tested in Cuernavaca (our unpublished data) and found to be narrowly stenophagous. This insect was found only occasionally in Mexico but, because of its small size, it could have been missed when populations were low. It is more abundant in Honduras. On some occasions, it caused yellowing of the leaves. It is currently under further investigation in Australia. The mirid *L. collaris* fed on flowers of ornamental *L. camara* in the city of Cuernavaca and caused the inflorescences to blacken. In host-specificity trials, it also oviposited on *Salvia splendens* F. Sellow ex. Roem. & Schult. (Lamiaceae), *Jacaranda mimosifolia* D. Don (Bignoniaceae), and *Odontonema callistachyum* (Schlech. & Cham.) O. Kuntze (Acanthaceae) and fed on the *S. splendens*. It was therefore not considered further.

Among the Homoptera, a great number of Auchenorrhyncha but relatively few Coccoidea were taken from *Lantana*. The Cicadellidae alone contributed 55 species to the list. With few exceptions these species were each seen rarely and many represent casual visitations (and some possibly misidentifications). The membracid *Aconophora compressa* Walker commonly attacked *Lantana* around Cuernavaca. We think that Mann also found this species causing significant damage to stems although he reported it as *A. marginata* Walker. In a revision of *Aconophora* it was noted that the concepts for several species were previously incorrect (Dietrich and Deitz, 1991). *A. compressa* was particularly abundant and damaging late in the growing season (November–February). Preliminary host testing was conducted in Cuernavaca where it attacked only *Lantana* and *Duranta*, and it is currently under further examination in Australia.

Three cerambycids utilize *Lantana* as a larval host. The most widespread species was the lamiine *Aerenicopsis championi* Bates, which was found on three species of *Lantana* throughout central and southern Mexico. Early instars attack the terminal stem causing a "die-back" while later instars are found lower down where they can kill stems. This species was unsuccessfully imported into Hawaii in 1902 and again in the 1950s (Julien, 1992) and is currently being studied further in Australia. The lamiine *Plagiohammus spinipennis* (Thomson) was found to have a much more limited distribution, being found only on *L. hirsuta* at the cooler, wetter sites of Jalapa and the Nogales ravine, both in the state of Veracruz. On one occasion over 30 larvae were extracted from one large plant which was not unduly stressed. This species has already been introduced into Hawaii, where it exerts partial control, and Australia, where there was very limited establishment (Julien, 1992). The third cerambycid is the cerambycine *Parevander xanthomelas* (Guerin-Meneville) which Koebele first found in the crowns of *Lantana*. We confirmed this host association by finding larvae in crowns of *L. camara* near Chilpancingo, Guerrero. However, the adults were found on yellow composite flowers, as are the very closely related *P. hovorei* (Giesbert and Penrose,

1984). Adults collected from yellow flowered *Tithonia* spp. and *Helianthus* spp. in Jalisco, Oaxaca, and Tamaulipas oviposited only on *L. camara* and *Lippia myriocephala* in laboratory experiments and it is intended to import it into Australia for further study. Koebele found the larvae of a fourth cerambycid, *Spalacopsis* sp., attacking *Lantana* in Morelos (Perkins and Swezey, 1924) but it has not been found since. The remaining cerambycids were probably all collected as adults and are of little consequence.

A number of hispine chrysomelids attack *Lantana*. The most common was *Octotoma scabripennis* Guerin which was damaging as both adult and larva. Populations of *O. plicatula* (F.) collected by N. Krauss and introduced into Hawaii (Julien, 1992) have now been determined to be *O. championi* Baly (Staines, 1989). *Uroplata fulvopustulata* Baly was occasionally found. This species has been introduced into a number of countries under the incorrect name *U.* nr. *bilineata* Chapius (Julien, 1992) . We confirmed its identity during the course of the project by resubmitting material from Australia to the appropriate taxonomist. A number of species of the alticine genera *Alagoasa*, *Asphaera*, and *Walterianella* (previously all placed in the genus *Oedionychus*) were collected. The taxonomy of this group is very difficult and the names only associated with the earlier surveys should be treated with caution. Jolivet (1991) indicated that *Alagoasa* is most closely associated with Verbenaceae and Lamiaceae and that alticines are generally specific in their food-plant choice. One South American congener, *A. parana* Samuelson, has already been introduced into Australia for control of *Lantana* (Winder *et al.*, 1988) . However, none of the North American species were seen at significant levels of abundance nor was larval activity discovered as was reported for *A. parana*. Nevertheless, this group may warrant further study. Populations of *Plectotetra dohrni* Jacoby were regularly found near Jalapa, often causing, in association with *A. acutangulatus* (Jacoby), *A. clypeatus* (Jacoby), and *A. virgata* (Harold), discernible feeding damage but attempts to breed it in the laboratory were unsuccessful.

One curculionid was clearly associated with *Lantana*. The baridine *Gereaus* nr. *curvispinis* Champion was found only around Cuernavaca where it attacked the flower peduncles. Adults emerged from the soil soon after the commencement of the new season's growth and inserted whitish eggs in the peduncle. The resultant larvae galled the peduncle, causing loss of flowers and fruit before they dropped to the soil to pupate and overwinter. In host-specificity tests, it attacked only *L. camara* and *L. montevidensis* and will be further tested in Australia.

Some 67 species of Lepidoptera were reared through to adults from larvae collected on the plants and are true associates of *Lantana*. Eleven of these species have already been released as biocontrol agents (Julien, 1992), but name changes for the lycaenids *Strymon bazochii* (Godart) [reported as *Thecla bazochii* (Godart)] and *Tmolus echion* (Druce) [= *Thecla* sp. (*echion* group)]; the noctuid *Neogalea sunia* (Guenée) [= *N. esula* (Druce)]; and the pyralid *Pseudopyrausta santatalis* (Barnes & McDonnough) [*P. acutangulalis* (Sneller)] should be noted. None of the noctuids or geometrids were abundant and usually only a few were taken after careful search. Very occasionally, the pyralid *P. santatalis* which feeds under a web on the leaf was seen to partially defoliate a plant. The cosmopterigid *Anoncia diveni* (Heinrich), which previously has not been investigated, caused a large blotch mine in leaves. Preliminary testing indicated that it might be sufficiently stenophagous for further consideration. The gracillariid *Cremastobombycia lantanella* Busck caused a small blotch mine on the leaf. It was most common in south Texas but was also found throughout Mexico. This insect was introduced into Hawaii following Koebele's survey and contributed to the overall control of *L. camara* there (Perkins and Swezey, 1924). It was also host-tested in Temple and found to attack only *L. camara* and *L. montevidensis*. It is currently being investigated further in Australia.

All three of the major phytophagous families of Diptera attack *Lantana*. Agromyzid species attack both leaf and fruit, but the leaf-feeding species were never seen to be particularly damaging. The three cecidomyiid gall-formers are most probably narrowly stenophagous. However, *Asphondylia camarae* Mohn and *Neolasioptera camarae* Mohn belong to groups that have obligate fungal symbionts within the gall (Borkent and Bissett, 1985) and are difficult to rear in captivity. The third, *Schismatidiplosis lantanae* (Rubsaamen), caused a tiny leaf gall. Only *A. camarae* would be likely to damage the plant significantly. One tephritid, *Eutreta xanthochaeta* Aldrich, is associated with *Lantana*. It causes a swollen stem gall but was never seen in damaging numbers.

DISCUSSION

The number of species (550) we list from *Lantana* at first appears remarkably high for a woody shrub. Some taxa undoubtedly refer to species later reported under a different name because we incorporated the lists of Koebele, Mann, and Krauss without examining their specimens. However, we do not believe this to be a major factor in accounting for the large insect fauna. There are very few surveys of woody shrubs comparable in size, number of species, and geographic area. One such survey is that of *Baccharis* in the United States and Mexico. Some 450 species have been recorded from 6 *Baccharis* spp. in the section *Baccharis* (Boldt and Robbins, 1987, 1994; Palmer, 1987; Palmer and Bennett, 1988; Palmer and Pullen, 1994).

Another yardstick that might be used to compare this reported fauna with that of other faunal studies is the number of species of Lepidoptera collected as larvae and

reared through to adults. This group is quite clearly defined and is thus more likely to be consistent between authors who must often make decisions as to what to include in a faunistic list. In this study 67 species of such Lepidoptera were found, or 12% of the total phytophages. By comparison, the Lepidoptera comprised 13% of the total phytophagous fauna on *Baccharis halimifolia* L. in the eastern United States (Palmer and Bennett, 1988), 13% on *B. halimifolia* and *B. neglecta* Britt. in and near Texas (Palmer, 1987), 14% on *Ambrosia psilostachya* DC (Goeden and Ricker, 1976), 12% on *Prosopis* spp. in southern South America (Cordo and DeLoach, 1987), and 10% of phytophages on *Gutierreza* spp. in Argentina (Cordo and DeLoach, 1992). These studies have shown a consistent 10–15% of total phytophages to be Lepidoptera collected as larvae, and the 12% reported here gives a measure of confidence about the total insect fauna of *Lantana* reported.

Factors which might explain the large fauna on *Lantana* might be the very large area of search, the intensity of the search, the perennial nature and structure of the plant, the tropical climate, and the plant's attractiveness to insects. Strong *et al.* (1984) discuss in detail some of these factors in relation to insect species abundance.

The comparison of this North American fauna with that found on *Lantana* in South America (Winder and Harley, 1983) revealed that the two faunas were almost completely different. Although 550 and 345 species were found in North and South America, respectively, only 19 species were found on both continents. This fully justified the decision to survey in South America after surveys in North America had already been undertaken.

No insect in Table 1 has, to our knowledge, been conclusively demonstrated to be truly monophagous (i.e., having only one host species). In all probability even the most specific species utilize more than one species in the *camara* group as a host. Most of the stenophagous species, which tended to be more closely studied than the polyphages, were found on at least two species of *Lantana*. Although we did find some species on only one *Lantana* sp., we felt this was most likely because the insect species was confined by climatic conditions rather than the host acceptibility per se. It would be reasonable to consider any stenophagous insect found on any of the species in the *camara* group as a candidate biological control agent for *L. camara*.

However, even an insect associated with a number of *Lantana* species may not necessarily utilize all varieties of cultivated or weedy lantanas. *Teleonemia scrupulosa*, a good example of this phenomenon, was found to infest and damage all four *Lantana* species in the survey, yet when introduced into Australia it was selective about the cultivars of *L. camara* it attacked (Harley, 1974). This suggests that the natural genetic variability between species in the section *camara* may be less than that between the artificially bred ornamental varieties of *L. camara*.

The question then arises as to how broad a host range is acceptable in a potential agent. The ultimate acceptable host range will, of course, vary from country to country and will depend on each country's endemic plant fauna and risk philosophy. In Australia's case any insect with a host range restricted to the subfamily Verbenoideae was considered worth sending to Australia for the final stage of testing in quarantine facilities against native species not available to the overseas worker. This level of specificity would be a reasonable guideline for many other countries.

Fifteen species in Table 1 have already been utilized as biocontrol agents by Australia or other countries (Julien, 1992). Interestingly, some of these have host ranges far exceeding the subfamily Verbenoidae. These were introduced following Koebele's work and before formal host testing was required. For example, *Epinotia lantana* attacked *Tecoma stans* (family Bignoniaceae) after its introduction into Hawaii (Perkins and Swezey, 1924). The tingid *T. scrupulosa* attacked sesame in Uganda (Davies and Greathead, 1967) and attacks *Leucophyllum* spp. (Scrophulariaceae) in Texas (R. L. Crocker, personal communication) and the lycaenid *T. echion* attacked eggplant, pepper pods (both Solanaceae), and *Cordia* (Boraginaceae) in Hawaii (Perkins and Swezey, 1924). However, as we now review this situation many years after the introduction of these insects we must conclude that these biological agents with broader host ranges have not done significant damage to nontarget plants in the countries of their introduction. While we do not, of course, advocate the use of insects with host ranges spanning plant families, we would suggest that more broadly stenophagous species that are not confined to *Lantana* be considered seriously on their individual merits.

This study presented a rather rare opportunity to evaluate the prospective benefits of searching again an area for biological control agents (Table 2). In this case, the plant was reexamined not once, but twice after it had been surveyed by Koebele, who was described by his colleague R. C. L. Perkins as "a field worker *par excellence*" (Mallis, 1971). In terms of a faunistic study per se this present study undoubtedly made a significant contribution as 158 phytophagous species were added to those already recorded on *Lantana*. New stenophagous species were found in both the 1954 and present surveys and each project (survey and associated host range testing) resulted in further introductions of biological control agents. Undoubtedly, the widening of the area of search contributed to finding further species.

It is anticipated that eight species not already introduced into Australia will be forwarded to quarantine facilities at the Alan Fletcher Research Station for the final phase of testing as a direct result of this project. They

are not the same as the seven additional stenophages listed in Table 2. The species to be introduced are the membracid *A. compressa*, the mirid *A. intermedia*, the gracillariid *C. lantanella*, the cerambycids *A. championi* and *P. xanthomelas*, the curculionid *G.* nr. *curvispinis*, the cosmopterigid *A. diveni*, and the eriophyiid mite *A. lantanae*. A ninth species, the pyralid *P. santatalis*, might also be suitable after further host-testing in North America.

However, it should be noted that all eight of the present potential agents being considered for Australia were previously discovered on *Lantana* by Koebele, Mann, Krauss, or some other worker even though they may not have recognized them as stenophagous. This emphasizes the importance of maintaining an accessible insect collection and adequate field notes for later study after a survey such as this is concluded.

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