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THE PHYTOPHAGOUS INSECT FAUNA ASSOCIATED WITH *BACCHARIS HALIMIFOLIA* L. AND *B. NEGLECTA* BRITTON IN TEXAS, LOUISIANA, AND NORTHERN MEXICO

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Abstract.—A survey of the phytophagous insect fauna on *Baccharis halimifolia* and *B. neglecta* was undertaken between 1982 and 1986 as part of a program to find biological control agents for *B. halimifolia* in Australia. One hundred and thirty three phytophagous insect species were collected and these included 11 species that were considered monophagous. The monophagous group of species contained a high proportion of Lepidoptera and endophages, and all monophagous species were collected from *B. halimifolia.* Over 50% of the monophagous group and 21% of the total number of species were found on both species of *Baccharis.* The relevance of the survey to the biological control program is discussed.

The woody shrub *Baccharis halimifolia* L. (Family Asteraceae: Tribe Astereae: Sub-Tribe Baccharinae), which was introduced from North America in the latter part of the 19th century (Bailey, 1900), has become one of the most serious weeds in Queensland, Australia. The shrub invades cattle pastures, reforested areas, and disturbed sites and is a declared noxious weed under the Stock Routes and Rural Lands Protection Acts (1944–1967) of Queensland (Stanley and Ross, 1986). As part of its efforts to control this weed the Queensland Department of Lands has supported a long ranging research program by the Alan Fletcher Research Station to find suitable biological control agents from the New World where the Baccharinae are native.

Although the genus *Baccharis* is best represented in South America with over 300 species, some 21 species including *B. halimifolia* are native to North America. The Alan Fletcher Research Station set up field stations in Lake Placid, Florida (1968) and Curitiba, Brazil (1974) to survey the phytophagous insect fauna on *Baccharis* and to determine which species were sufficiently stenophagous (i.e. having a limited host range) for introduction to Australia. A number of insects were subsequently introduced (McFadyen, 1981). In 1982 the North American Field Station was established in Temple, Texas to survey *B. halimifolia* at the western margin of its range and the closely related species *B. neglecta* Britton which is found in central and western Texas.

Various surveys of insects on *Baccharis sp.* have been reported. Bennett (unpublished) surveyed the fauna on *B. halimifolia* in southeastern United States and on various species of *Baccharis* in Brazil. Tilden (1951), after a very comprehensive survey, listed the insects associated with the vegetative parts of *B. pilularis* in the area to the south of San Francisco, California. Kraft and Denno (1982) listed the major herbivores attacking *B. halimifolia* in Maryland. All the studies, with the exception of that of Kraft and Denno (1982) indicated the *Baccharis* is associated with a considerable number of insect species and that a number of species were most probably monophagous.

The Phenology and Range of *B. halimifolia* and *B. neglecta*

Both *B. halimifolia* and *B. neglecta* are perennial, dioecious woody shrubs growing to a height of about 15 feet. Both species produce massive amounts of seed which are dispersed by air and so they are often found colonizing disturbed or denuded areas. They are typically found along watercourses, in neglected pastures, along roadsides and drainage ditches, and in vacant lots in towns. The plants usually maintain their foliage during winter but hard freezes can cause defoliation and stem dieback.

New growth begins in late winter. Kraft and Denno (1982) reported that the leaf biomass of *B. halimifolia* increased steadily throughout spring and summer and then dropped slowly during autumn in response to an increase in inflorescence biomass. However, possibly more important, they reported that the leaves became significantly tougher and thicker during the growing season while the moisture content and nitrogen content declined. The maturing leaves also increased in the concentration of an acetone soluble secondary chemical that acted as a deterrent to herbivory (Kraft and Denno, 1982). These parameters suggested to these authors that there was a general decrease in the quality and availability of the foliage to herbivorous insects, and they noted that no major herbivore was found to feed on *B. halimifolia* in Maryland after early summer.

Both species flower in autumn. The staminate inflorescences, which are a rich creamy color, are first to bloom followed a couple of weeks later by the white pistillate inflorescences. By late autumn the very small achenes, each attached to a feathery pappus, are dispersed by air. The reproductive output of a stand of *B. halimifolia* has been estimated as high as 376,000 achenes per m^2, a figure exceeding that of any other plant species reported in the literature (Panetta, 1979).

B. halimifolia and *B. neglecta* are morphologically very similar. Mahler and Waterfall (1964) separate the species on the characters of leaf shape and involucre length: *B. halimifolia* has elliptic to rhomboid leaves and involucres 4–6 mm in length and *B. neglecta,* narrowly elliptic, linear or oblanceolate leaves and involucres 4–8 mm in length. In areas where the two species overlap it is often difficult to separate them because of the tremendous variation in leaf shape and because intermediate types exist. These intermediate types are a good indication that the two species are very closely related indeed.

The habitat range of *B. halimifolia* extends along coastal areas from Massachusetts to Texas (Correll and Johnston, 1979). In Texas it is found east of a line that could be drawn between Victoria, Bryan and Dallas i.e. in higher rainfall areas with acid soil types. It is abundant in coastal areas, low lying and poorly drained areas, and in disturbed habitats in townships and oil drilling areas. It is not found in forested areas because the large trees soon completely displace it. *B. neglecta* on the other hand, is found throughout almost all of Texas to the west and south of that line (Correll and Johnston, 1979); in areas with moderate to low rainfall and alkaline soil types. It also is found along roadsides, creeks, vacant lots in townships and other disturbed areas. In some areas it is known as "New Deal weed" or "Roosevelt weed" (Correll and Johnston, 1979) because it became weedy in the 1930s when farmers, for financial reasons, were unable to properly tend to their pastures. Specimens of *B. neglecta* have been collected from Arizona through to North Carolina and also into Mexico (Correll and Johnston, 1979).

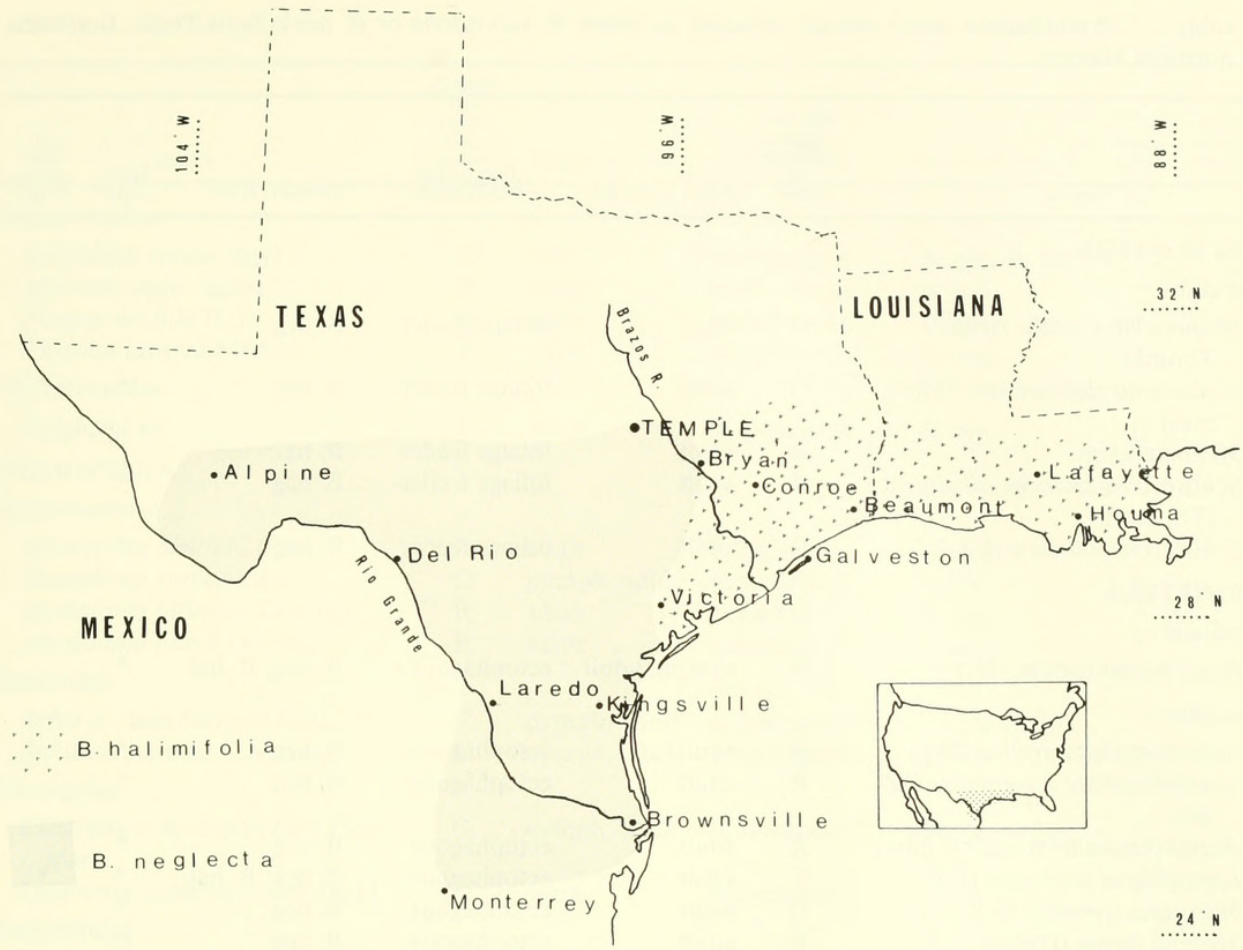

Fig. 1. The area surveyed in Texas, Louisiana and northern Mexico. Cities that were often visited are shown.

The Area and Methods of Survey

The area covered by this survey is given in Fig. 1. It might be described as consisting of southern Louisiana, the Gulf Prairies and Marshes of Texas, the Blackland Prairies of Central Texas, the southern Edwards Plateau of Texas, the South Texas Plains and northern Mexico (cf. Correll and Johnston (1979) for descriptions of the vegetational areas of Texas).

The survey was conducted over a four year period between 1982 and 1986. In 1983 and 1984 regular inspections at about two weekly intervals were conducted at a number of sites in close proximity to Temple, Texas with particular emphasis being placed on a site on Lake Stillhouse Hollow about 15 miles west of Temple. The areas farther afield from Temple were visited on an irregular basis by 3–4 day trips to such cities as Lafayette, Beaumont, Conroe, Galveston, Brownsville, Del Rio and Monterrey, Mexico. Stands of *Baccharis* were inspected along the roadside on these trips particularly where the plants looked to be unhealthy because of possible insect attack. In addition, certain sites were established near all of the above cities and these were inspected at every visit to that city.

Insects were collected by both visually inspecting the plant and by sweeping the foliage. When evidence of internal insect infestation was present, plants were either removed from the ground and dissected or the appropriate limb sawn off and split. Any evidence of feeding by the insect was noted. When immatures were found without adults being present, the immatures were collected and reared through to maturity to obtain adults for identification. This applied par-

Table 1. Phytophagous insect species collected on either *B. halimifolia* or *B. neglecta* in Texas, Louisiana or northern Mexico.

Species	Relative Frequency Collected[1]	Stages Collected	Insect-Host Relationship	*Baccharis* Hosts	Specificity[2]	Economic Pests[3]
ORTHOPTERA						
Acrididae						
Hesperotettix viridis viridis Thomas	O	adult	foliage feeder	B. neg	*	
Melanoplus differentialis (Thomas)	O	adult	foliage feeder	B. neg	*	*
Melanoplus sp.	R	adult	foliage feeder	B. hal	*	
Schistocerca alutacea albolineata (Thomas)	R	adult	foliage feeder	B. neg	*	
Schistocerca obscura (F.)	O	adult	foliage feeder	B. neg	*	
HEMIPTERA						
Alydidae						
Hyalymenus tarsatus (F.)	R	nymph, adult	ectophagous	B. neg; B. hal	*	
Coreidae						
Acanthocephala declivis (Say)	R	adult	ectophagous	B. neg	*	
Acanthocephala terminalis (Dallas)	R	adult	ectophagous	B. neg	*	
Acanthocephala thomasi (Uhler)	R	adult	ectophagous	B. neg	*	
Leptoglossus phyllopus (L.)	C	adult	ectophagous	B. neg; B. hal	*	*
Merocoris typhaeus (F.)	O	adult	ectophagous	B. neg	*	
Mozena lurida (Dallas)	R	adult	ectophagous	B. neg	U	
Corimelaenidae						
Corimelaena pulicaria (Germar)	O	adult	ectophagous	B. neg	*	*
Cyndnidae						
Pangaeus bilineatus (Say)	R	adult	ectophagous	B. neg	*	
Largidae						
Largus cinctus (Herrich-Schaeffer)	R	nymph, adult	ectophagous	B. neg	*	
Lygaeidae						
Lygaeus kalmii Stål	O	adult	ectophagous	B. neg	*	
Melanopleuris belfragei (Stål)	R	adult	ectophagous	B. neg	U	
Neocoryphus bicrucis (Say)	R	adult	ectophagous	B. neg	*	
Nysius niger Baker	R	adult	foliage feeder	B. neg	*	*
Nysius raphanus Howard	O	adult	foliage feeder	B. neg; B. hal	*	
Ochrimnus mimulus (Stål)	C	nymph, adult	flower and seed feeder	B. neg; B. hal	**	
Oncopeltus fasciatus (Dallas)	O	adult	flower and seed feeder	B. neg	*	
Oncopeltus sexmaculatus Stål	O	adult	ectophagous	B. neg	*	
Miridae						
Lygus lineolaris (Palisot de Beauvois)	O	adult	flower feeder	B. neg, B. hal	*	*
Polymerus basalis (Reuter)	R	adult	ectophagous	B. neg	*	
Pseudatomoscelis seriatus (Reuter)	O	adult	flower feeder	B. neg; B. hal	*	*
Talorilygus pallidulus (Blanchard)	O	adult	flower feeder	B. neg; B. hal	*	

Table 1. Continued.

Species	Relative Fre- quency Col- lected[1]	Stages Collected	Insect-Host Relationship	*Baccharis* Hosts	Speci- ficity[2]	Eco- nomic Pests[3]
Pentatomidae						
Euschistus servus (Say)	O	adult	ectophagous	B. neg; B. hal	*	*
Mecidea major Sailer	R	adult	ectophagous	B. neg	*	
Nezara viridula (L.)	R	adult	ectophagous	B. hal	*	*
Thyanta accerra McAtee	R	adult	ectophagous	B. neg	*	
Thyreocoridae						
Galgupha sp.	R	adult	ectophagous	B. neg	U	
HOMOPTERA						
Acanaloniidae						
Acanalonia bivittata (Say)	R	adult	ectophagous	B. neg	*	
Acanalonia conica (Say)	O	nymph, adult	ectophagous	B. hal	*	
Acanalonia laticosta Doering	R	adult	ectophagous	B. neg	*	
Acanalonia parva Doering	R	adult	ectophagous	B. hal	*	
Aphididae						
Aphis pr. baccharicola HRL	C	nymph, adult	ectophagous	B. neg; B. hal	*?	
Aphis coreopsidis (Thomas)	C	nymph, adult	ectophagous	B. hal	*	
Cercopidae						
Clastoptera xanthocephala Germar	C	nymph, adult	ectophagous	B. neg; B. hal	*	
Lepyronia quadrangularis (Say)	O	adult	ectophagous	B. neg	*	
Cicadellidae						
Aceratagallia calcaris Oman	R	adult	ectophagous	B. neg	U	
Balclutha sp.	R	adult	ectophagous	B. neg	U	
Chlorotettix viridius Van Duzee	R	adult	ectophagous	B. neg	U	
Empoasca fabae (Harris)	O	nymph, adult	ectophagous	B. neg; B. hal	*	*
Homalodisca coagulata (Say)	C	adult	ectophagous	B. neg; B. hal	U	
Menosoma cinctum (Osborn & Ball)	R	adult	ectophagous	B. neg	U	
Cixiidae						
Oecleus productus Metcalf	R	adult	ectophagous	B. neg	U	
Oliaris aridus Ball	R	adult	ectophagous	B. neg	U	
Delphacidae						
Stobaera pallida Osborn	C	nymph, adult	ectophagous	B. neg; B. hal	***	
Dictyopharidae						
Rhynchomitra recurva (Metcalf)	O	nymph, adult	ectophagous	B. hal	U	
Flatidae						
Anormenis septentrionalis (Spinola)	O	adult	ectophagous	B. hal	*	
Metcalfa pruinosa (Say)	O	adult	ectophagous	B. neg; B. hal	*	*
Ormenis saucia Van Duzee	O	adult	ectophagous	B. neg	U	
Ormenis sp.	R	adult	ectophagous	B. hal	U	
Ormenoides venustus (Melichar)	O	adult	ectophagous	B. hal	*	
Fulgoridae						
Poblicia fuliginosa (Olivier)	R	adult	ectophagous	B. neg	U	
Issidae						
Hysteropterum auroreum (Uhler)	R	adult	ectophagous	B. neg	U	

Table 1. Continued.

Species	Relative Frequency Collected[1]	Stages Collected	Insect-Host Relationship	*Baccharis* Hosts	Specificity[2]	Economic Pests[3]
Membracidae						
Tortistilus abnormus (Caldwell)	R	adult	ectophagous	B. neg	U	
Vanduzeea segmentata (Fowler)	O	nymph, adult	ectophagous	B. neg	*?	
LEPIDOPTERA						
Gelechiidae						
Aristotelia ivae Busck	O	larva	foliage feeder	B. neg; B. hal	***	
Geometridae						
Anacamptodes defectaria (Guenée)	O	larva	foliage feeder	B. neg	*	
Anavitrinelia pampinaria (Guenée)	R	larva	foliage feeder	B. neg	*	*
Eupithecia miserulata Grote	R	larva	foliage feeder	B. neg	*	
Itame varadaria (Walker)	O	larva	foliage feeder	B. hal	***	
Pero meskearia Packard	R	larva	foliage feeder	B. neg	U	
Pleuroprucha insulsaria (Guenée)	O	larva	flower feeder	B. neg; B. hal	*	
Lyonetiidae						
Bucculatrix ivella Busck	C	larva, pupa	leaf miner	B. neg; B. hal	***	
Noctuidae						
Platysenta videns (Guenée)	O	larva	foliage feeder	B. neg; B. hal	*?	
Spodoptera frugiperda (Smith)	O	adult	foliage feeder	B. neg	*	*
Spodoptera ornithogalli (Guenée)	O	larva	foliage feeder	B. neg; B. hal	*	*
Pterophoridae						
Oidaematophorus balanotes (Meyrick)	C	larva, pupa	stem borer	B. neg; B. hal	***	
Oidaematophorus kellicotti (Fish)	R	larva	stem borer	B. neg	**	
Pyralidae						
Homoeosoma electellum (Hulst)	R	larva	flower feeder	B. neg	*	*
Tortricidae						
Epiblema discretivana (Heinrich)	C	larva	stem gall	B. hal	***	
Platynota sp.	R	pupa		B. neg	U	
Sonia paraplesiana Blanchard	C	larva, pupa	root feeder	B. hal	U	
COLEOPTERA						
Cerambycidae						
Amniscus perplexus (Haldeman)	C	larva, pupa	stem borer	B. hal	***	
Ancylocera bicolor (Olivier)	R	adult		B. neg	*	
Anelaphus sp.	R	adult		B. neg		
Dendrobias mandibularis Serville	R	adult		B. hal	*	
Dorcasta cinerea (Horn)	R	adult		B. neg	U	
Eliphidion linsleyi Knull	O	larva	stem borer	B. neg	*	
Eliphidionoides incertus Newman	O	larva	stem borer	B. neg	*	
Euderces pini (Olivier)	R	adult		B. neg	U	
Stenosphenus dolosus Horn	R	adult		B. neg	U	
Tragidion coquus L.	R	adult		B. neg	U	

Table 1. Continued.

Species	Relative Frequency Collected[1]	Stages Collected	Insect-Host Relationship	*Baccharis* Hosts	Specificity[2]	Economic Pests[3]
Chrysomelidae						
Altica sp.	R	adult	ectophagous	B. hal	U	
Calomicrus prob. blakeae Wilcox	R	adult		B. neg	U	
Colaspis planicostata Blake	R	adult		B. hal	U	
Colaspoides opacicollis Horn	R	adult		B. neg	U	
Cryptocephalus cribripennis Le Conte	R	adult		B. neg	*	
Cryptocephalus nr. *pumilis* Haldeman	C	adult	ectophagous	B. neg; B. hal	*	
Diabrotica balteata Le Conte	O	adult	ectophagous	B. hal	*	*
Diabrotica connexa Le Conte	R	adult	ectophagous	B. hal	*	
Diabrotica undecimpunctata howardi Barber	C	adult	ectophagous	B. neg; B. hal	*	*
Diachus auratus (Fab.)	O	adult	flower feeder	B. neg; B. hal	*	
Exema elliptica Karren	C	larva, adult	foliage feeder	B. hal	***	
Microtheca ochroloma Stål	R	adult	ectophagous	B. hal	U	
Monoxia sp.	R	adult	ectophagous	B. hal	U	
Nodonota rotundicollis Schaeffer	C	adult	foliage feeder	B. neg	*	
Nodonota texana Schaeffer	R	adult	ectophagous	B. neg	*	
Nodonota tristis (Olivier)	O	adult	ectophagous	B. neg	*	
Systena blanda Melsheimer	O	adult	foliage feeder	B. neg	*	*
Ophraella sexvittata Le Conte	R	adult	foliage feeder	B. hal	*?	
Paria thoracica (Melsheimer)	R	adult	ectophagous	B. hal	*?	
Trirhabda bacharidis (Weber)	C	larva, adult	foliage feeder	B. neg; B. hal	***	
Curculionidae						
Baris sp.	R	adult		B. neg	U	
Compsus auricephalus (Say)	O	adult		B. neg	*	
Cophes texanus Sleeper	R	adult	endophagous?	B. neg	U	
Eudiagogus pulcher Fahraeus	R	adult	ectophagous	B. hal	*	
Isodacrys burkei Howden	O	adult		B. neg; B. hal	*	
Lixus scrobicollis Boheman	R	adult	endophagous?	B. neg	*	
Mitostylus setosus (Sharp)	R	adult	ectophagous	B. neg	*	
Prosaldius blanditus (Casey)	R	adult		B. hal	U	
Prosaldius deplanatus (Casey)	O	adult		B. neg; B. hal	U	
Dermestidae						
Cryptorhopalum uteanum Casey	R	adult		B. neg	U	
Elateridae						
Melanotes indistinctus Quate	R	adult		B. hal	U	
Lampyridae						
Lucidota sp.	R	adult		B. neg	U	
Pyropyga sp.	R	adult		B. hal	U	
Scarabaeidae						
Cotinus mutabilis Gory and Percheron	O	adult	ectophagous	B. hal	*	
Euphoria sepulchralis (F.)	O	adult	ectophagous	B. hal	*	
Tenebrionidae						
Bothrotes canaliculatus acutus (Le Conte)	R	adult		B. neg	*?	

Table 1. Continued.

Species	Relative Frequency Collected[1]	Stages Collected	Insect-Host Relationship	*Baccharis* Hosts	Specificity[2]	Economic Pests[3]
DIPTERA						
Agromyzidae						
Phytobia sp.	O	pupa	leaf miner	B. neg	U	
Cecidomyiidae						
Neolasioptera lathami Gagné	C	larva	stem galler	B. neg; B. hal	***	
Tephritidae						
Acinia picturata (Snow)	R	adult	seed feeder	B. hal	*	
Dioxyna picciola (Bigot)	R	adult		B. hal	U	
Euarestoides acutangulus (Thomson)	R	adult		B. neg	U	
Neaspilota dolosa Benjamin	R	adult		B. neg	U	
Neotephritis finalis (Loew)	R	adult		B. neg	U	
Tephritis new sp.	C	larva	stem galler	B. neg; B. hal	***	
Tephritis subpura (Johnson)	C	larva	stem galler	B. hal	***	
Trupanea nr. *actinobola* (Loew)	R	adult		B. neg	U	
Tomoplagia obliqua (Say)	R	adult		B. hal	U	

[1] R = rare, O = occasional, C = common.
[2] *** = monophagous (host plants apparently restricted to the genus *Baccharis*); ** = oligaphagous (host-plants apparently restricted to the tribe Astereae; * polyphagous (having a wider host range than above two categories); *? = specificity unknown but very likely polyphagous; U = specificity unknown.
[3] * = pest species.

ticularly to caterpillars, leafminers, and gall formers. Samples of inflorescences were also collected in the autumn and placed in emergence cages and any resulting insects collected.

All insect specimens were first submitted to the Biosystematic and Beneficial Insects Institute, Agricultural Research Service, USDA, Beltsville, Maryland for expert identification by specialists of that Institute's Systematic Entomology Laboratory. When species could not be fully identified by this laboratory the specimens were later forwarded elsewhere to other taxonomists expert with the particular group in question.

After the insects had been properly identified, entomologists knowledgeable about the particular species or group and the literature were consulted to determine the degree of stenophagy exhibited by the species. Species that appeared to be sufficiently stenophagous were then selected for formal host specificity testing in order to obtain permission to introduce the insect into Australia (e.g. Palmer, 1986).

Results

The phytophagous species (excluding pollen and nectar gatherers) found on either species of *Baccharis* are shown in Table 1. One hundred and thirty three species were collected representing six orders. The Orthoptera, Hemiptera, Homoptera, Lepidoptera, Coleoptera and Diptera were represented by 5 (or 4% of the species), 27 (20%), 27 (20%), 17 (13%), 46 (35%) and 11 (8%) species respectively.

The insects were classified as monophagous if restricted to *Baccharis,* oligophagous if the host range was restricted to the Tribe Astereae and polyphagous if having a wider host range. Evidence of host range was obtained from formal host testing, observations during the course of the survey, consultations with acknowledged experts on specific groups of insects, examination of major insect collections, and texts such as Arnett (1985), Slater and Baranowski (1978), Arnett et al. (1980) and Borrer et al. (1981). Eleven insects were considered monophagous, and interestingly, all were found on *B. halimifolia.* Six of these eleven were also found on *B. neglecta* but only one monophagous species, *Tephritis new sp.,* was more commonly found on *B. neglecta* than on *B. halimifolia.* The monophagous fauna thus represented about 8% of the total phytophagous fauna.

Six of the 11 monophagous insects (or approximately 55%) were endophagous for at least part of their lifecycle. Of ten species that were definitely endophagous on *Baccharis,* six were monophagous, one was oligophagous, two were polyphagous, and the hosts of one were not known although it also was quite probably monophagous. A very high proportion (80%) of the endophages therefore had a limited host range.

Only two insects were classified as oligophagous. The remaining 118 species were considered either polyphagous, host unknown or hosts unknown but probably polyphagous. The proportion of oligophagous to polyphagous species depends, of course, on what arbitrary criteria are set for oligophagy.

Five of 11 monophagous species were also Lepidoptera. This proportion is considerably higher than the proportion of Lepidoptera found in the total number of species.

While six of 11 (or 55%) monophagous species were common to both *B. halimifolia* and *B. neglecta,* only 28 of the total 133 species (21%) were common to both species. This perhaps indicates that many of the polyphagous insects did not have any substantial relationship with these hosts but rather their occurance (or absence) was dependent primarily on other factors.

A number of well known crop pests were collected on *Baccharis.* These included the differential grasshopper, *Melanoplus differentialis* Thomas; the lygus bug *Lygus lineolaris* (Palisot de Beauvois); the cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter); the brown stinkbug, *Euschistus servus* (Say); the southern green stinkbug, *Nezara viridula* (L.); the southern corn rootworm, *Diabrotica undecimpunctata howardi* Barber and the fall armyworm, *Spodoptera frugiperda* (Smith).

During the course of the study many non-phytophagous insects were collected. These included known predator and flower feeding species as well as many insects that were probably only casually associated with the plant. These species are listed in Table 2. The collection of these insects was only a very secondary aspect of the project and quite likely there were many more such species present on *Baccharis* than are listed.

Notes on the More Important Species

By far the most important phytophage was the chrysomelid *Trirhabda bacharidis* (Weber) which was found throughout the survey area except for the lower Rio Grande Valley and northern Mexico. It is univoltine in the study area with larvae occurring in late winter and adults being found from late April to early August. However in one year, 1984, following an unusually wet autumn, early instar larvae were found in mid-December but these were killed during winter. It therefore appears that at least some individuals in the population do not have a diapause mechanism and that the regularity of emergence at the end of winter may be more a function of extreme mortality of early emerging individuals rather than a diapause. Both larvae and adults can occur in tremendous numbers and are capable of completely defoliating a bush. The effect is particularly destructive if late winter freezes occur while the bushes are regenerating their foliage following larval attack. In this situation the stems are frequently killed.

The case bearing chrysomelid *Exema elliptica* Karren was common throughout the *B. halimifolia* area in spring and summer. Larvae were found in April and May and adults thereafter. Both stages fed on foliage

Table 2. Non-phytophagous insect species collected on either *B. halimifolia* or *B. neglecta* in Texas, Louisiana or Northern Mexico.

Species	Habit
HEMIPTERA	
Anthocoridae	
Orius insidiosus (Say)	predator
Miridae	
Deraeocoris nebulosus (Uhler)	predator
Pentatomidae	
Euthyrhynchus floridanus (L.)	predator
Podisus maculiventris (Say)	predator
Phymatidae	
Phymata americana Melin	predator
Phymata sp.	predator
Reduviidae	
Zelus bilobus (Say)	predator
Thyreocoridae	
Galgupha sp.	incidental
COLEOPTERA	
Bruchidae	
Merobruchis major (Fall)	pollen feeder
Cantharidae	
Cantharis sp.	pollen feeder
Cantharis sp.	pollen feeder
Chauliognathus basalis Le Conte	pollen feeder
Chauliognathus marginatus (F.)	pollen feeder
Chauliognathus scutellaris Le Conte	pollen feeder
Chauliognathus sp.	pollen feeder
Podabrus sp.	pollen feeder
Carabidae	
Colliuris pennsylvanica (Linne)	predator
Coccinellidae	
Coleomegilla maculata fuscilabris (Mulsant)	predator
Cycloneda sanguinea (L.)	predator
Hippodamia convergens Guerin	predator
Olla v nigrum Mulsant	predator
Scymnus loewii Mulsant	predator
Meloidae	
Epicauta pennsylvanica (DeGeer)	predator
Melyridae	
Collops balteatus LeConte	predator
Collops quadrimaculatus F.	predator
Nitidulidae	
Carpophilus nr. *transitans* Sharp	incidental

Table 2. Continued.

Species	Habit
Phalacridae	
Phalacrus sp.	incidental
DIPTERA	
Bibionidae	
Plecia nearctica Harcy	incidental
Bombyliidae	
Villa sp.	incidental
Calliphoridae	
Chrysomya rufifacies (Macquart)	incidental
Cochliomyia macellaria (Fab.)	incidental
Chironomidae	
Procladius bellus (Loew)	incidental
Chloropidae	
Apallates particeps (Becker)	incidental
Conioscinella grisescens (Sabrosky)	incidental
Conioscinella nuda (Adams)	incidental
Liohippelates pusio (Loew)	incidental
Thaumatomyia glabra (Mg.)	incidental
Ephydridae	
Ditrichophora argyrostoma (Cresson)	incidental
Ochthera lauta Wheeler	incidental
Philygria debilis Loew	incidental
Muscidae	
Musca domestica (L.)	incidental
Sepsidae	
Palaeosepsis pusio (Schiner)	incidental
Syrphidae	
Allograpta obliqua (Say)	pollen feeder
Palpada agrorum (Fab.)	pollen feeder
Palpada pusilla (Macquart)	pollen feeder
Palpada vinetorum (Fab.)	pollen feeder
Syrphus rectus O. S.	pollen feeder
Toxomerus politus (Say)	pollen feeder
Tachinidae	
Angiorhina sp.	incidental
Pseudomyothria nr. *ancilla* (Walker)	incidental
Ptilodexia sp.	incidental
HYMENOPTERA	
Apoidae	
Apis mellifera L.	pollen feeder
Vespidae	
Dasymutilla sp.	incidental
Polistes apachus Saussure	incidental
Polistes sp.	incidental

and heavily infested small plants may exhibit damage to their terminals. Although the type series for *E. elliptica* was reported from *Iva frutescens* L. (Karren, 1966), it was not found on *I. frutescens* in this survey even though this plant was growing in close proximity to infested *B. halimifolia* on many occasions. It is therefore considered that a misidentification of the morphologically similar plant species may have occurred and that *E. elliptica* may be specific to *Baccharis.* Two other genera of chrysomelids are quite commonly found on *Baccharis.* Adults of *Nodonota spp.* were found on *B. neglecta* in the spring. Infestations of *N. rotundicollis* Schaeffer were often seen along the Rio Grande Valley. Damage was invariably noticeable but of little significance. Adults of the three polyphagous *Diabrotica* species were taken quite commonly in the autumn but never in damaging numbers.

The lepidopterous foliage feeders caused at most only minor damage to the plant. *Bucculatrix ivella* Busck was the most abundant of these; and in April populations of several hundred per plant were sometimes seen, particularly on *B. halimifolia.* The first three instars feed inside a serpentine mine while the last two instars are external feeders. The very characteristic ribbed pupal cocoons were also found on the plant. During the rest of the year only very occasional specimens were seen. Greater detail on the biology and host specificity is given by Palmer and Diatloff (in press). The leaf webbing caterpillar, *Aristotelia ivae* Busck, was also quite commonly found in spring but there were rarely more than one or two per plant. These small greenish larvae feed under a web on the leaf and become explosively active when touched. The geometrid, *Itame varadaria* (Walker) was collected from *B. halimifolia* at a number of sites by sweeping the foliage. It had three generations per year with larvae being present in April, July and October. It was never very abundant: a collection of half a dozen larvae after an hour's sweeping was a typical result.

The most abundant stem borer was the plume moth *Oidaematophorus balanotes* (Meyrick), which was found throughout the survey area. The phenology of this univoltine species was clearly defined. Moths were active in late summer and early autumn. Early instar larvae were often seen in inflorescences placed in emergence cages. They were also found in damaged vegetative terminals. Later instar larvae bored into the woody tissue of the stem and created a characteristic gallery which were up to a meter in length. The exit hole was covered with woody frass which had been removed from the gallery. Pupation and eclosion of the moth occured in the gallery. Occasionally bushes were heavily infested with this insect and on one occasion 15 larvae were found in the one stem. However, it was much more common to find plants infested with just one or two larvae. The related species, *O. kellicotti* (Fish) was found in *B. neglecta* in northern Mexico. This is a new host record for this species that has previously been reported only from *Solidago spp.* (Cashatt, 1972).

The cerambycid, *Amniscus perplexus* (Haldeman), was found to infest a large proportion of *B. halimifolia* plants at just a few sites. It was also univoltine with adult activity in late spring and early summer. Eggs were oviposited under the bark, usually near the crown of the plant and within 30 cm of ground level. Larval feeding continued from summer to the following spring when both pupae and teneral adults were found in the larval galleries. A characteristic finely powdered frass was found at the base of infested plants. Both large and small plants were attacked and it was quite common to find 2–3 larvae in quite small plants. The larvae significantly weakened the stems and predisposed the plants to attack by disease organisms.

Two cerambycids *Eliphidion linsleyi* Knull and *Eliphidionoides incertus* were found in *B. neglecta* stems along the Rio Grande Valley. Both species were associated with weakened or dying branches, but it was not ascertained whether they had caused this damage or whether they had attacked already dying material.

Four gall forming species were commonly found. The cecidomyiid *Neolasioptera lathami* Gagné was found on both *Baccharis* species throughout the survey area. It forms a soft globular gall on the stems and terminals. A large gall (3 cm in diameter) might contain as many as 15 larvae, each in an individual chamber. Isolated patches of *Baccharis* were infested with up to 10 galls per plant in spring. For the rest of the year only very occasional galls were found. Significant damage to the plant was not observed within this survey area. A more detailed account of this insect is given by Diatloff and Palmer (1987).

The two tephritids, *Tephritis subpura* (Johnson) and *T. new sp.*, appeared to occupy very similar ecological niches on *B. halimifolia* and *B. neglecta* respectively. Both fed in the terminal stems in spring and caused characteristic swelling of the final few centimeters of the stem and ultimately terminal die-off. Flies of both species emerged in autumn from inflorescences placed in emergence cages. The autumn adults of both species were smaller and darker than the individuals emerging in the spring.

The tortricid *Epiblema discretivana* (Teinrich) occurred in elongate woody stem galls, approximately 3 cm in length, on *B. halimifolia*. This insect was also univoltine, with adults emerging in early spring and the insect overwintering as larvae. *E. discretivana* is generally distributed throughout the habitat of *B. halimifolia*. As many as ten galls have been found on plants, but damage attributable to them was not discerned.

The delphacid *Stobaera pallida* Osborn was found to be quite abundant on *B. halimifolia* and much less abundant on *B. neglecta*. There appears to be three generations a year with population peaks occurring in May, July and September. It was possible to collect over 100 individuals by sweeping one large bush. The life cycle is similar to that of other species of *Stobaera* (McClay, 1983; Reimer and Goeden, 1982). Eggs are oviposited into the pith of stems and both nymphs and adults remain on the plant.

With the onset of flowering the lygaeid *Ochrimnus mimulus* (Stål) adults were present in tremendous numbers on both male and female inflorescences. Later in autumn nymphs were found by dissecting the female inflorescences. The insect overwintered as late instar nymphs or adults, which were quite commonly found throughout the spring and summer. A more detailed account of this insect is given by Palmer (1986). The coreid *Leptoglossus phyllopus* (Say) was also very commonly associated with these plant species while they were flowering.

Prospects for Biological Control

Four of the insects, *Trirhabda bacharidis, Aristotelia ivae, Oidaematophorus balanotes* and *Neolasioptera lathami* had previously been found elsewhere in the United States and had been proved host specific by various officers of the Queensland Department of Lands. *T. bacharidis* was released in Queensland where it now occurs in damaging populations in some localized areas. *A. ivae* became generally distributed but has only been found at low, non-damaging population levels. *O. balanotes* is at present being released in the field and *N. lathami* has not yet been reared in the laboratory in Australia.

A further five insects have been tested at the North American Field Station, Temple and permission to introduce these species into quarantine in Australia has been approved or is anticipated. The species are *Tephritis new sp., Stobaera pallida, Bucculatrix ivella, Itame varadaria* and *Amniscus perplexus*. The remaining monophagous insects will be tested in the near future.

These 11 insects were rated in two ways in an attempt to predict their eventual effectiveness as biocontrol agents in Australia. Ideally it would be highly desirable if a reliable quantitative formula were available for use by biocontrol researchers. Harris (1973) devised a formula that was later modified by Goeden (1983), and this latter formula is possibly the best available at this stage. All the insects were therefore scored by Goeden's formula (Table 3). The scores ranged from 34 to 53. In this system *N. lathami, O. balanotes* and *B. ivella,* by scoring more than 50 points, would be considered superior prospects and the rest were predicted to be partially effective agents.

The insects were also assessed subjectively by the author based on observations in the United States only and rated from 1 (poor prospect) to 5 (superior prospect) after considering such aspects as damage observed, ecoclimatic similarity to Australia, potential reproductive rate and degree of parasitism observed. *T. bacharidis, B. ivella* and *A. perplexus* were considered to be the best prospects.

It should be pointed out, however, that a general and reliable method for predicting eventual effectiveness of potential biocontrol agents has not yet been devised and its reliability proved. Aspects of Goeden's formula have been criticized by both Palmer (unpublished) and Wapshere (1985) who questioned whether it was indeed possible to quantify potential effectiveness in a new habitat. Perhaps the point to be made is that, while it is highly desirable to attempt to predict the best possibilities, preferably by quantitative methods, all sufficiently stenophagous agents should ultimately be utilized when at all possible.

Table 3. The potential effectiveness of the monophagous species as biocontrol agents as predicted by the formula of Goeden (1983) and by the author's subjective assessment (with a poor candidate scoring 1 and a superior prospect scoring 5).

Species	Goeden's Formula	Author's Assessment
Amniscus perplexus	47	5
Trirhabda bacharidis	45	5
Exema elliptica	34	3
Aristotelia ivae	49	3
Oidaematophorus balanotes	53	4
Bucculatrix ivella	51	5
Itame varadaria	44	2
Epiblema discretivana	36	1
Stobaera pallida	41	2
Tephritis subpura	40	3
Tephritis palmeri n. sp.	35	2

Discussion

Faunal richness of species inhabiting a plant species is determined by many factors but Strong et al. (1984) considered the two most important factors to be the size of the geographic range and the plant "architecture" (i.e. its size and growth form). Both *Baccharis* species are rather large, woody, perennial shrubs that occupy an extensive geographic habitat and these factors should indicate a rich insect fauna such as was found in the survey. Perhaps it could also be argued that as the geographic area occupied by *B. halimifolia* is much greater than that of *B. neglecta* a greater number of monophagous insects might be associated with *B. halimifolia,* as was found in this study.

Another factor influencing the number of species found is, of course, the length of time devoted to the survey. New species were still being found in the last year of this project and undoubtedly the faunal list would have been longer had the survey been continued for a longer period. Nevertheless, four years represents a very adequate time frame for such a survey.

The number of insect species common to both species of *Baccharis* clearly indicates that these plant species are very similar chemically as well as morphologically. In fact, the association is even closer than the data indicate. In the laboratory *A. perplexus, I. varadaria,* and *E. elliptica,* found only on *B. halimifolia* in the field, fed readily on *B. neglecta.* Furthermore, a number of stenophagous insects collected from *B. pilularis* D.C. have fed equally well on both local species of *Baccharis* and also *B. sar-*

athoides Gray, which is found in Arizona. It is therefore very probable that the differences in insect fauna found between the two *Baccharis* species in this survey are due to different climatic factors or factors other than intrinsic differences between the species themselves.

A very close association between stenophagy and endophagy was evident. Endophages by their very nature are specialized with adaptions for internal living and must develop a close relationship with their host. It is therefore not surprising that a significant proportion of them are highly stenophagous. The high proportion of endophages that were also monophagous in this survey highlights the need for those involved in biological control programs such as this to place great importance on searching for endophages.

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