THE INSECTS OF JOJOBA, SIMMONDSIA CHINENSIS, IN NATURAL STANDS AND PLANTATIONS IN SOUTHWESTERN NORTH AMERICA

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ABSTRACT

The insect associates of jojoba, Simmondsia chinensis, based on collections at 32 sites in southwestern North America are listed. Almost 50% of the 204 species recorded are phytophagous. Of these, species of aphids, scale insects and Lepidoptera are the most significant. Most of the remainder are parasites of the phytophages. Jojoba does not have a distinctive entomofauna. Instead, almost all of the phytophagous species are known from other plant hosts. Many of them are generalists, and almost 20% are economic pests of other crops.

Sorenson's index of similarity was used to compare faunal overlap at the five most frequently collected locales. Overlap was relatively low between all pairs of sites.

INTRODUCTION

This is the second and final survey of the insect associates of jojoba, Simmondsia chinensis (Link) Schneider, a dioecious wind pollinated shrub from southwestern North America. Our earlier survey (Pinto and Frommer 1980) was based primarily on collections from near Radec, California, a chaparral community. Some collections from other sites were included but these were incomplete. In this report we add results from completed year-round surveys in two other natural stands in the Sonoran Desert as well as collections from 29 other sites representing both natural populations and plantations.

Commercialization of jojoba is increasing not only in southwestern North America where it is native but also in other parts of the world including Australia, India, Israel, and several nations in Africa and South America. According to a recent report of the National Research Council (1985), plantings in the United States alone increased 60% between 1982 and 1984, representing close to 50 million shrubs and an investment of $200 million. Oil derived from jojoba seed already has widespread use in the cosmetics industry and shows promise for pharmaceuticals and several industrial products (NRC 1985).

Considering the growing economic significance of jojoba, a qualitative characterization of its entomofauna is important. Although no major arthropod pests have been associated with the plant thus far, there are several reports of severe local damage. The purpose of this study is to provide a more complete list of insects associated with jojoba and to compare the faunas among disjunct sites.

METHODS

Methods follow those in our initial survey (Pinto and Frommer 1980). Collecting sites are listed in Table 1. The three most frequently collected sites were: 7.4 km N Radec on Hwy R3, Riverside, Co., CA (Site 1); Black Hill, 16 road km S jct Hwys 111 & 74 in Palm Desert, Riverside, Co., CA (Site 2); and several locales 5-15 km W Superior, Pinal Co., AZ (Site 10). All three represent natural stands. Site 1

was collected bimonthly for 2 yr (Feb. 1976-Feb. 1978) and sporadically until 1981. Site 2 was visited weekly throughout 1978. Site 10 was collected on 21 occasions in 1979-80 during all seasons, but primarily in spring and early summer. In addition, substantial collections were made 20 km SE El Rosario, Baja California Norte (Site 15) on four occasions in the spring of 1979, 1980 and 1981. The only plantation collected frequently was at the University of California Moreno Valley Field Station (Site 5), visited 14 times in the spring and autumn of 1978 and 1979. Additional locales contributing to this survey are itemized in Table 1.

TABLE 1. Source of Jojoba Insect Collections

Site No.	Site Location	Natural Stand (N) Plantation (P)
1	7.4 km N Radec, Riverside Co., CA	N
2	Black Hill, 16 km S Palm Desert, Riverside Co., CA	N
3	Scissors Crossing, San Diego Co., CA	N
4	Jacumba, San Diego Co., CA	N
5	Moreno Valley, Riverside Co., CA	P
6	Rosamond, Kern Co., CA	P
7	Riverside, CA	P
8	Lompoc, Santa Barbara Co., CA	P
9	San Ysidro, San Diego Co., CA	P
10	5-15 km W Superior, Pinal Co., AZ	N
11	Joshua Tree Natl. Monument, CA	N
12	Tucson Mts., Pima Co., AZ	N
13	Inkopah Co. Park, San Diego Co., CA	N
14	Las Barracas, Baja Calif. Sur	N
15	20 km SE El Rosario, Baja Calif. Norte	N
16	Ray, Pinal Co., AZ	N
17	Niland, Imperial Co., CA	P
18	Menifee Valley, Riverside Co., CA	P
19	San Felipe Creek, San Diego Co., CA	N
20	Bakersfield, Kern Co., CA	P
21	Catavina, Baja Calif. Norte	N
22	Desert Center, Riverside Co., CA	P
23	Indian Wash, Imperial Co., CA	N
24	Usury Pass, Maricopa Co., AZ	N
25	Vizcaino Peninsula, Baja Calif. Sur	N
26	Kofa Mts., Yuma Co., AZ	N
27	Quartzsite, La Paz Co., AZ	N
28	Roosevelt, Gila Co., AZ	N
29	Bouse, La Paz Co., AZ	P
30	Maricopa Co., AZ (unspecified locale)	N
31	Aguanga, E of, San Diego Co., CA	N
32	7-Level Hill (1200 m), on Hwy 74, Riverside Co., CA	N

Sites 1, 2, 10, and 15 were chosen because they represent native stands associated with distinct plant communities. The Radec area (Site 1) represents a mixture of Chaparral and Coastal Sage Scrub communities (see Munz 1959). Sites 2, 10, and 15 lie in different subdivisions of the Sonoran Desert, namely the Lower Colorado Valley, Arizona Upland, and Central Gulf Coast, respectively. Vegetational characteristics of these zones were discussed by Shreve and Wiggins (1964).

As indicated by Gentry (1958), the sex ratio of jojoba varies geographically.

It approximated 1:1 at sites 1 and 15, and was male-biased at sites 2 and 10 (ca. 2:1 and 4:1, respectively). Sex ratios at other sites were not determined.

Most collections were made during daylight hours (0900 - 1500 hrs) by beating, sweeping and visually examining jojoba plants. Roots were infrequently examined. An equal number of male and female plants were sampled (10 of each), and care was taken not to collect from plants that physically contacted other species. Specimens were collected in the field or as they emerged from material held in the laboratory.

To minimize spurious associations, species listed in Tables 2-5 only include those that were observed feeding on jojoba, emerging from jojoba vegetation, recorded as parasitizing or preying on jojoba associates, or collected on at least five sampling dates. In some cases simple presence suggested meaningful association. This includes the presence of adult scales and mealybugs, apterous aphids, and large populations of larval and adult bugs, thrips or psocids.

Faunal similarity among sites 1, 2, 5, 10, and 15 was estimated by Sorenson's index of similarity, derived by the equation $2j/a+b$, where *a* is the number of species found at one site, *b* the number from the second site, and *j* the number of species common to both (Southwood 1966). This index is sensitive to differences in sample size but gave similar results as Mountford's (1958) index which is considered less dependent on this factor. Sorenson's index is utilized here because of its more common use in the literature and its relative ease of calculation. Only the phytophagous species were considered in these comparisons.

RESULTS AND DISCUSSION

We recorded 204 species of insects from jojoba. Our initial survey, focusing on the Radec site, listed 101. Of the fauna now known, 100 (49%) are phytophagous (Table 2), 72 (35.3%) are parasitic (Table 3), and 19 (9.3%) are predaceous (Table 4). Thirteen species (6.4%) are not assignable to one of these categories on jojoba and include primarily psocids and ants (Table 5). Numerous mites and spiders also were collected and probably were more important as predators than the insects listed in Table 3. From the Radec site (Site 1) alone, we collected at least four species of predaceous mites and 39 species of spiders (Pinto and Frommer 1980).

TABLE 2. Phytophagous Insects Collected from Simmondsia chinensis

Taxon	Assoc.[a]	On other plants (+)[b]	Stages collected A=adult L=larva P=pupa	Site(s)[c]
ORTHOPTERA				
Acrididae				
Melanoplus aridus Scudder	C(6)	+	L	2,10
Schistocerca alutacea shoshone (Thomas)	F-L	+	L	1,10
Timemidae				
Timema sp.	C(7)	?	A,L	2
THYSANOPTERA				
Aeolothripidae				
Dactuliothrips spinosus Moulton	F-♂ Fl & ?	+	A,L	1,2
Phlaeothripidae				
Haplothrips mali (Fitch) Complex	F(Fr)	+	A,L,P	1,2,10,15
Thripidae				
Frankliniella gossypiana Hood	C(6)	+	A	10

Frankliniella occidentalis (Pergande)	C(55)	+*	A,L	1,2,5,10,15,21
Scirtothrips ewarti Bailey	F-♂Fl	-	A,L,P	1,2,10,15,25
Sericothrips floridanus Watson	C(6)	+	A	1,2,10
ISOPTERA				
Kalotermitidae				
Incisitermes fruticavus Rust	F(S)	+	A,L	1
HEMIPTERA				
Lygaeidae				
Crophius scabrosus (Uhler)	C(7)	+	A	1
Melanopleurus bicolor (H-S)	C(7)	+*	A	1,2
Nysius raphanus Howard	C(8)	+	A	1,2,6
Nysius tenellus Barber	C(9)	+	A	1,10
Nysius sp.	F-V	?	L	22
Miridae				
Irbisia californica Van Duzee	C(8)	+	A	1
Irbisia oreas Bliven	C(23)	+	A	1,2,10
Gen. nr. Microphyllelus	F-V	?	A,L	15
Pentatomidae				
Chlorochroa uhleri (Stal)	C(7)	+	A	1,2,5
Thyanta pallidovirens (Stal)	F-L	+	A	1,5
Rhopalidae				
Arhyssus spp.	C(6)	+	A	1,5,10
Aufeius impressicollis Stal	C(5)	+	A	2,5,10
Tingidae				
Corythuca sphaeralceae Drake	C(7)	+	A	1,2
HOMOPTERA				
Acanaloniidae				
Acanalonia mollicula VanDuzee	C(7)	+	A	1
Aphididae				
Acyrthosiphon pisum (Harris)	C(5)	+*	?	1,2,5,10
Aphis craccivora Koch	F-L,S	+*	A,L	1,2,5,10,18
Aphis fabae Scopoli	F-V	+*	A,L	2,5,8
Aphis gossypii Glover	F-V	+*	A,L	5,18
Macrosiphum euphorbiae (Thomas)	F-V	+*	A,L	2,5,18
Myzus persicae (Sulzer)	C(29)	+*	A,L	1,2,5,10
Sitobion avenae (Fab.)	F-V	+	A,L	1
Cicadellidae				
Aceratagallia californica (Baker)	C(13)	+	A	1,2,5,10
Aceratagallia longula (VanDuzee)	C(5)	+	A	1,5
Aceratagallia sp.	C(9)	?	L	1,2,5,10,15
Ceratagallia lobata (Oman)	C(15)	+	A	5,10
Homalodisca lacerta (Fowler)	C(43)	+	A,L	1,5,7,10,15,22
Cicadidae				
Genus? species?	O-S	?	ova	2
Coccidae				
Philephedra sp. prob. parvula (Cockerell)	F-V	?	A	10
Diaspididae				
Aspidiotus nerii Bouche	F-V	+*	A	15
Clavaspis covilleae (Ferris)	F-V	+*	A	10
Diaspis sp. nr. manzanitae (Whitney)	F-L	+	A,L	15
Diaspis simmondsiae Ferris	F-L	-	A	10,14
Situlaspis yuccae (Cockerell)	F-L	+	A	2,10
Flatidae				
Mistharnophantia sonorana Kirkaldy	C(5)	+	A	10
Ormenis sp.	C(9)	?	A	10
Issidae				
Dictyobia atra VanDuzee	C(6)	+	A	1
Dictyssa fenestrata Ball	C(18)	?	A	1
Dictyssa marginepunctata (Melich.)	C(14)	+	A	1

Lecanodiaspididae				
Lecanodiaspis hodgsoni Howell & Koszt.	F-S	+	A	10
Orthezиidae				
Orthezia ferrisi Morrison	F-V	+	A	10
Orthezia sp. nr. artemisiae Cockerell	F-V	?	A	1
Pseudococcidae				
Phenacoccus alleni McKenzie	F-L	+	A	2
Phenacoccus helianthi (Cockerell)	F-L	+	A	1,10,12
Phenacoccus solenopsis Tinsley	F-V	+	A	2
Puto simmondsiae McKenzie	F-L	-	A	2,4,10,14,15
Spilococcus pressus (Ferris)	F-L	+	A,L	1,10
Psyllidae				
Leuronota maculata (Crawford)	C(5)	+*	A	10,12
Paratrioza cockerelli (Sulc)	C(11)	+*	A	1,10,23
COLEOPTERA				
Anobiidae				
Megorama frontalis (LeC.)	C(9)	+	A	1
Ozognathus cornutus (LeC.)	C(16)	+	A	1
Tricorynus californicus White, or near	F-(DrS)	?	L	30
Tricorynus obsoletus (LeC.), or near	F-(DrS)	?	L	7,15
Bostrichidae				
Amphicerus cornutus (Pallas)	F-(S)	+*	A,L	1,7,12
Amphicerus simplex (Horn)	F-(S)	+	A,L	10
Buprestidae				
Acmaeodera dolorosa Fall	F-(DS)	+	L	4
Acmaeoderoides verityi Nelson	F-(DS)	-	L	2
Chrysobothris lucana Horn	F-(S)	+	L	1
Hesperorhipis mirabilis albipennis Knull	F-(DS)	-	L	32
Trichinorhipis knulli Barr	F-(DS)	-	L	4,13
Cerambycidae				
Aethecerinus latecinctus (Horn)	F-(DS)	+	A?	10,12,16
Dendrobias m. mandibularis Aud.- Serv.	F(LR)	+	L	12
Pseudomethia arida Linsley	F-(DS)	-	L	13
Rhodoleptus femoratus (Schaeffer)	F-(DS)	+	L	12
Schizax s. senex LeC. or nr.	F-(S)	+	L	11
Tragidion peninsulare Schaeffer	F-(DS)	+	P	31
Chrysomelidae				
Diabrotica u. undecimpunctata Mann.	C(6)	+*	A	5
Curculionidae				
Smicronyx albidosquamosus Klima	C(9)	+	A	10
Smicronyx imbricatus (Casey)	C(11)	+	A	1,2,10,11,26,27
Melyridae				
Dasytastes bicolor (Casey)	C(5)	+	A	1
Tenebrionidae				
Metaponium abnorme LeC.	F-L	+	A,L	17
DIPTERA				
Cecidomyiidae				
Asphondylia websteri Felt[d/]	F-(F)	+	ALP	1,4,10,15
LEPIDOPTERA				
Arctiidae				
Estigmene acrea (Drury)	F-L	+*	L	5,20
Blastobasidae				
Holcocera sp.	F-(DF)	?	L	1,15
Geometridae				
Aethaloida packardaria Hulst	C(5)	+	L	1
Anacamptodes clivinaria impia Rindge	F-L	-	L	1
Anacamptodes obliquaria (Grote)	C(8)	+	L	1,2,5,10
Anacamptodes sanctissima (B. & McD.)	F-I	-	L	1
Glaucina eureka (Grossb.)	C-9	?	L	1,10,12,15
Pero mcdunnoughi (C. & S.)	F-L	+	L	1,10

Synaxis hirsutaria B. & McD.	F-L	+	L	1
Synaxis sp.	F-L	?	L	15
Lymantriidae				
Orgyia vetusta (Bdv.)	F-L	+*	L	1,18
Noctuidae				
Amphipyra pyramidoides Gn.	F-L	+*	L	1
Egira curialis (Grote)	F-L	+*	L	1,5,10,28
Tineidae				
Acrolophus sp.	F?	?	L	2
Tortricidae				
Epinotia kasloana (McD.)	F-(Fr), ♂ Fl	+	L	1,2,10,15
Platynota stultana Walsm.	F-(Fr)	+*	L	24
Saturniidae				
Hemileuca electra Wright	F-L	+	L	1,5
Cosmopterigidae				
Periploca sp. n.	F(L)	-	L	2,3,4,11,14,15,19
HYMENOPTERA				
Formicidae				
Acromyrmex versicolor (Pergande)	cutting-L	?	A	29

a/ F=feeding; O=ovipositing; Fr=on fruit; (Fr)=in fruit; (DFr)=in decayed fruit; (DrS)=in dried seeds; L=on leaf; (L)=in leaf; Fl=on flower; S=on living stems; (S)=in living stems; (DS)=in dead stems; (LR)=in living roots; V=on unspecified vegetation; C=listed by criteria of 5 or more collections (No. collections in parens.), association unknown.

b/ + or - based on personal knowledge, the literature, and/or species range relative to that of jojoba; asterisks (*) refer to species of known economic importance in agriculture.

c/ See Table 1.

d/ As Asphondylia sp. n. in Pinto and Frommer (1980).

TABLE 3. Parasitic Insects Collected from Simmondsia chinensis

Taxon	Association[a/]	Site(s)[b/]
DIPTERA		
Bombyliidae		
Phthiria similis Coq.	Epinotia kasloana larva	1
Geron hybus Coq.	Epinotia kasloana larva	1
Tachinidae		
Aphantorhapha sp.	Pero mcdunnoughi larva	1
Hesperomyia erythrocera B.& B.	Glaucina eureka larva	10
Lespesia archippivora Riley	Estigmene acrea larva	5
Nemorilla pyste Walk.	Epinotia kasloana larva	1
HYMENOPTERA		
Aphelinidae		
Aphytis margaretae DeBach & Rosen	Diaspis simmondsiae	10
Aphytis simmondsiae DeBach	Diaspis simmondsiae	14
Centrodora sp.	Diaspis simmondsiae	10
Coccobius sp.	Diaspis simmondsiae	10,14
Bethylidae		
Goniozus clarimontis Kieffer	Periploca leaf mines	1,2,19
Goniozus gordhi Evans	Undet. Lepidoptera larva	1
Goniozus sp.	Periploca leaf mines	2

Braconidae		
Agathis prob. sp. n.	Epinotia kasloana larva	1
Apanteles aristoteliae Viereck	Epinotia kasloana larva	1
Apanteles sp.	Epinotia kasloana larva	1
Ascogaster provancheri Group	Epinotia kasloana larva	1
Chelonus periplocae McComb	Periploca leaf mines	2
Chelonus sp.	Periploca leaf mines	19
Cotesia sp. 1	Anacamptodes obliquaria	10
Cotesia sp. 2	Glaucina eureka larva	10
Heterospilus sp.	Amphicerus cornutus tunnels	7
Meteorus sp.	Undet. Geometridae larva	10
Rogas sp.	Undet. Geometridae larva	10
Xenosternum ornigis Muesebeck	Periploca leaf mines	2
Homolobus truncator (Say)	Undet. Lepidoptera larvae	2,10
Encyrtidae		
Anagyrus yuccae (Coq.)	Puto simmondsiae	4
Anagyrus sp.	Undet. Pseudococcidae	14
Metaphycus sp.	Puto simmondsiae	10
Microterys sp.	Diaspis simmondsiae (prob.)	10
Ooencyrtus sp.	Undet. eggs	1,2,10
Prochiloneurus sp.	Undet. Pseudococcidae	14
Eulophidae		
Elasmus sp.	Periploca leaf mines	2
Euplectrus pachyscapha Girault	Egira curialis larva	10
Galeopsomyia sp.	Asphondylia gall	15
Necremnus sp.	Periploca leaf mines	2
Sympiesis sp.	Undet. larva	2
Tetrastichus sp.1	Undet. Lepidoptera larva	1
Tetrastichus sp.2	Asphondylia gall	1
Tetrastichus sp.3	Female flower, fruit	1
Tetrastichus sp. 4	Undet. Pseudococcidae	14
Zagrammosoma sp.	Periploca leaf mines	2,3,19
Eupelmidae		
Eupelmus sp.1	Damaged fruit	1
Eupelmus sp.2	Undet. Lepidoptera pupa	1
Eupelmus sp.3	Undet. eggs	2
Eurytomidae		
Eurytoma sp.	Asphondylia gall	15
Rileya piercei Crawf.	Fruit	1
Rileya sp. n.	Asphondylia gall	1
Ichneumonidae		
Charops annulipes Ash.	Undet. Lepidoptera larva	1
Diadegma albicinctum Walley	Undet. Arctiidae larva	2,15
Glypta rufiscutellaris Cresson	Epinotia kasloana larva	1
Mastrus sp.1	Epinotia kasloana larva	1
Mastrus sp.2	Female flower	1
Netelia sp.	Egira curialis larva	10
Pristomerus sp. n.	Periploca larva	3
Scambus aplopappi (Ashmead)	Epinotia kasloana larva & Undet. Lepidoptera larva	1,24
Pteromalidae		
Dibrachys cavus (Walker)	C(5)	1
Mesopolobus sp.	Epinotia kasloana larva?	10
Pseudocatolaccus americanus Gahan	Asphondylia gall?	1,10
Pseudocatolaccus sp.	Asphondylia gall	15
Zatropis sp.	Epinotia kasloana larva	1
Genus? sp.?	Decayed fruit	1
Scelionidae		
Psix sp.	Pentatomidae eggs	2
Telenomus sp.	Undet. eggs	1,2

Trissolcus sp.	Pentatomidae eggs	1,2
Torymidae		
Torymus c. capillaceus (Hubner)	Asphondylia gall	10
Torymus hainesi Ashmead	Asphondylia gall	15
Torymus umblicatus (Gahan)	Asphondylia gall	10
Torymus sp. nr. solitarius (O.S.)	Asphondylia gall	1,15
Trichogrammatidae		
Trichogramma deion Pinto & Oatman	Epinotia kasloana eggs	1
Ufens sp.	Unk. eggs on leaves	1,10
LEPIDOPTERA		
Epipyropidae		
Epipyrops barberiana Dyar	Pupae & adults on leaves	1
Fulgoraecia exigua (Hy. Ed.)	Pupae on vegetation	10

a/ Primary and hyperparasites not distinguished.
b/ See Table 1.

TABLE 4. Predaceous Insects Collected from Simmondsia chinensis

Taxon	Association[a/]	Stages coll.[a/]	Site[a/]
THYSANOPTERA			
Aeolothripidae			
Aeolothrips kuwanaii Moulton	C(12)	A	1,15
Aeolothrips sp	C(6)	L	1,10,12
Erythrothrips arizonae Moulton	C(8)	A	1,2,10
HEMIPTERA			
Anthocoridae			
Orius tristicolor (Wh.)	C(21)	A,L	1,2,5,10
Miridae			
Phytocoris californicus Knight	C(18)	A,L	1
Phytocoris relativus Knight	C(6)	A	10
NEUROPTERA			
Chrysopidae			
Chrysoperla comanche (Banks)	C(21)	A,L	1,2,5,10,11,12,15
Chrysoperla plorabunda (Fitch)	C(19)	A,L	1,2,10
Eremochrysa punctinervis (McLachlan)	C(12)	A,L	1,2,10
Raphidiidae			
Agulla bicolor (Alb.)	C(30)	A,L	1,2,10
COLEOPTERA			
Cleridae			
Phyllobaenus scaber (LeC.)	C(?)	A	1,15
Coccinellidae			
Exochomus fasciatus (Casey)	C(5)	A	1
Exochomus subrotundus (Casey)	F-Puto & Situlaspis	A	2,10,12
Hippodamia convergens (Guerin-M.)	C(24)	A	1,2,5,10
Hyperaspis osculans (LeC.)	C(7)	A	1
Stethorus punctum picipes (Casey)	C(5)	A	1
Melyridae			
Amecocerus nr. famelicus (Casey)	C(8)	A	1
DIPTERA			
Chamaemyiidae			

Leucopis sp.	With Aphis craccivora & Myzus persicae	L	1
Syrphidae			
Syrphus sp.	With Aphis craccivora	L	8

[a] See Tables 1 and 2 for key to sites and abbreviations, respectively.

TABLE 5. Miscellaneous Insects Collected from Simmondsia chinensis.

Taxon	Association[a]	Stages coll.[a]	Site[a]
PSOCOPTERA			
Elipsocidae			
Elipsocus obscurus Mockford	C(7)	A	1
Lachesillidae			
Lachesilla pacifica Chapman	C(30)	A,L	1,15
Psocidae			
Camelopsocus bactrianus Mockford	C(13)	A,L	1
Camelopsocus hiemalis Mockford	C(6)	A	1,2
Camelopsocus tucsonensis Mockford	C(1)[b]	A,L	12
Loensia maculosa (Banks)	C(6)	A,L	1
Troglidae			
Cerobasis sp.	C(35)	A,L	1,15
THYSANOPTERA			
Phlaeothripidae			
Oedaleothrips jacksoni Hood	C(23)	A	1,2,10,11
HYMENOPTERA			
Formicidae			
Apis mellifera (L.)	Collecting pollen	A	1
Formica plicornis Emery	Tending Aphis craccivora	A	8
Crematogaster californica Emery	C(12)	A	1
Iridomyrmex pruinosus (Roger)	C(11)	A	1
Monomorium minimum (Buckley)	In Periploca mines	A	2

[a] See Tables 1 and 2 for key to sites and abbreviations, respectively.
[b] Listed because of large numbers of adults and immatures.

As suggested in our earlier report, jojoba does not harbor a distinctive entomofauna even though the plant is unique botanically and has no close relatives (Melikyan 1968, Thorne 1976). Most of the phytophagous species are known from other plants (Table 2), and a large number are known generalists [e.g. Frankliniella occidentalis (Pergande), Aphis craccivora Koch, Orgyia vetusta (Bdv.), Platynota stultana (Walsm.), Aspidiotus nerii Bouche]. The only species possibly specific to jojoba are Acmaeoderoides veritiyi Nelson, Diaspis simmondsiae Ferris, Puto simmondsiae McKenzie, Trichinorhipis knulli Barr, Periploca sp. n., Anacamptodes clivinaria impia Rindge, Anacamptodes sanctissima (B. & McD.), Pseudomethia arida Linsley, and Scirtothrips ewarti Bailey.

This absence of distinctive insect associates also was reflected by the faunal comparisons among sites. As indicated by the number of species in common and indices of similarity (Table 6), faunal overlap was not extensive. Perhaps this was a function of the utilization of jojoba by generalists in that its associated entomofauna at any given locale was largely a reflection of the adjacent plant community. That

faunal similarity was not obviously a function of distance was indicated by a comparison of Site 1, dominated by chaparral, and Site 2, at the western edge of the Sonoran Desert. Although they are the two closest natural stands compared, separated by only 48 km, each has greater overlap with Site 10 in Arizona, over 350 km to the east. The lack of similarity between sites 1 and 2 as based on certain common jojoba insects was presaged in our earlier survey (Pinto and Frommer 1980).

A concerted effort to intensively sample plantations was not made, and we are unable to critically compare faunal diversity of cultivated vs natural stands. The greatest number of collections in a plantation was at the U.C. Moreno Valley Field Station (Site 5). Collections at this locale were not appreciably different from those in natural stands. This site overlaps almost equally with sites 1, 2, and 10, and least of all with Site 15. Again, distance of collecting sites from each other is not correlated with indices of similarity.

Table 6. Similarity of the Phytophagous Insect Fauna on Jojoba Among Four Natural Stands and one Plantation as Estimated by Sorenson's Index of Similarity (Lower Left of Matrix), and Number of Species in Common (Upper Right of Matrix).

Sites[a/]	1 (51)[b/]	2 (32)[b/]	10 (41)[b/]	15 (15)[b/]	5 (21)[b/]
1	X	16	21	5	14
2	0.39	X	18	8	10
10	0.46	0.49	X	8	12
15	0.15	0.35	0.29	X	3
5	0.39	0.38	0.39	0.17	X

a/ See Table 1 and Methods section for location of sites and calculation of Sorenson's Index of Similarity, respectively.

b/ Total number of phytophagous species from site.

As reported in our earlier studies, certain insects appear to be more commonly associated either with male or female plants. Thus, Asphondylia websteri Felt was collected only from female plants; Epinotia kasloana (McD.) was more abundant on male plants; and certain species of thrips were more commonly found on one sex or the other (Pinto and Frommer 1980, 1984). The data for other species did not suggest bias. However, for many of them collections were too small for adequate analysis.

Relatively few reports of significant economic damage to jojoba by arthropods have been documented thus far. Thomson (1982) listed a species of Nysius (Lygaeidae) as potentially damaging to young plants in California as well as grasshoppers and "armyworms." Johnson (1978) listed the cowpea aphid, Aphis craccivora, the omnivorous leafroller, P. stultana, crickets and grasshoppers as pests on California plantations. The NRC report (1985) noted spider mites, Tetranychus spp., grasshoppers, salt-marsh caterpillars, Estigmene acrea (Drury), and thrips as causing damage to plantations in desert areas of southwestern United States. Gonzalez Vasquez (1980) reported several species of leafhoppers, Estigmene acrea, and aphids as potentially damaging on a plantation in Hermosillo, Mexico. Of these, the most pestiferous was a leafhopper, Homalodisca lacerta (Fowler), which required periodic chemical control. As indicated in Table 2 most of these species also were taken in our surveys.

The only information regarding pests that we have from plantations outside southwestern North America is from Israel and the Sudan. Khairi (1978) reported

Parlatoria scale and Aphis gossypii Glover as damaging in the Sudan. In Israel, citrus mealy bug, Planococcus citri (Risso), oleander scale, Aspidiotus nerii, aphids, near Aphis fabae Scopoli, leaf-cutting bees, Megachile sp., and noctuid larvae, Spodoptera littoralis (Boisd.) (from leaves) and Heliothis sp. (boring into young fruit), are known to attack jojoba (Berlinger et al. 1985). Again, this assemblage of insects is similar to that in our study. Heliothis was not conspicuous in our surveys, but we did encounter it once at Site 10.

As indicated in our earlier studies (Pinto and Frommer 1980, 1984), the potentially most damaging insects to jojoba in the southwestern United States appear to be species of Lepidoptera which feed in young fruit. This includes E. kasloana, the omnivorous leafroller, P. stultana, and the citrus cutworm, Egira curialis Grote. Based on the Israeli report Heliothis may represent a fourth species especially in areas where jojoba is grown adjacent to cotton.

No attempt was made to determine potential pests of stored jojoba seed. However, Cline and Highland (1986) tested 20 species of stored product insects on jojoba seed and meal, and they concluded that the jojoba was unsuitable for development and reproduction of the insects tested. Species of Tricorynus (Anobiidae), known from our collections to feed on dried jojoba seed (Table 2), were not tested, and their potential as stored products pests is unknown.

Our survey indicates that a unique suite of jojoba insects does not exist. Only 8 of the 100 phytophagous species have been taken only from jojoba (Table 2). Of these, the scale insects and Anacamptodes spp. have close relatives on other plants and more extensive collecting may reveal additional hosts. It is also likely that A. verityi feeds on another host(s) (D. S. Verity, pers. comm.). Instead, collections show a large number of polyphagous species on jojoba throughout its range. Since, as indicated in Table 2, several of these (ca. 20%) are known to be of economic significance on other crops, their presence on jojoba may be important. Considering the relatively high number of generalists encountered in its home range, it is likely that as the popularity of jojoba continues to spread, a variety of local pestiferous species in other parts of the world will also find the plant an acceptable host.

ACKNOWLEDGMENT

During the course of this investigation we have drawn upon the expertise of numerous cooperative systematists for identifications, the majority of whom were mentioned in our earlier paper (Pinto & Frommer, 1980). To this list we gratefully add the names of P. A. Adams (CSU, Fullerton) (Neuroptera), P. D. Ashlock (U. Kansas) (Lygaeidae), R. C. Froeschner (USDA) (Tingidae), G. Gordh (UCR) (Bethylidae, Encyrtidae), F. T. Hovore (Newhall, CA) (Cerambycidae, determination and records), J. LaSalle (UCR) (Aphelinidae, Encyrtidae, Eulophidae), M. D. Schwartz and G. M. Stonedahl (AMNH) (Miridae), L. B. O'Brien (Florida A & M) (Fulgoroidea), R. W. Hodges (USDA) (Lepidoptera: Cosmopterygidae; Periploca), and N. Evenhuis (B. P. Bishop Museum) (Bombyliidae). L. V. Knutson (USDA) expedited requests made to USDA staff members of the Biosystematics and Beneficial Insects Institute. For his efforts in our behalf we are thankful. W. H. Ewart, of our department, has, over the years, devoted many hours to the identification of Thysanoptera and Coccoidea.

T. D. Eichlin and R. J. Gill (both CDFA) deserve very special mention and thanks. We have drawn extensively upon their expertise in the Lepidoptera and Homoptera, respectively.

To E. M. Fisher (CDFA) we owe a vote of thanks for his assistance in the field at a time when he was a student at UCR. R. K. Velten (UCR) provided assistance both in the field and in the laboratory. J. Cicero (Gainesville, Florida) contributed voucher material, records and other data on the association of Aethecerinus, Dendrobias, and Amphicerus. D. S. Verity (UCLA) provided the records of Tragidion and Acmaeoderoides. P. DeBach and M. Rose collected the material from Site 14.

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