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Seasonal insect abundance and distribution on three California chaparral shrubs

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**SEASONAL INSECT ABUNDANCE AND DISTRIBUTION
ON THREE CALIFORNIA CHAPARRAL SHRUBS**

A Thesis

Presented to

The Faculty of the Department of Biology

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Mark Allen Isaak

May 2000

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ABSTRACT

SEASONAL INSECT ABUNDANCE AND DISTRIBUTION ON THREE CALIFORNIA CHAPARRAL SHRUBS

by Mark A. Isaak

1. To investigate seasonal insect abundance and distribution between three shrub species, beating samples were taken from western poison oak (*Toxicodendron diversilobum*), coyote brush (*Baccharis pilularis*) and toyon (*Heteromeles arbutifolia*) eight times over a year.

2. Overall abundance was highest and varied least on coyote brush; coyote brush also supported the greatest richness and most specialist species. Total populations on toyon and poison oak were seasonal, highest in July and April respectively. Poison oak demonstrated low species richness, held fewest specialist species, and supported fewer insects.

3. Chewers, sap-suckers, predators, and parasitoids showed different patterns of seasonal variation on different shrubs. These guilds and ants were found primarily on coyote brush; epiphyte grazers were found primarily on toyon.

4. The results show that seasonality is an important factor in macroecological patterns. The richness, abundance, and degree of specialization within insect communities may be much reduced by greater seasonal variation of the host plant.

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Introduction

Seasonal population patterns and geographic patterns of species abundance are both important to ecological theory and to applications such as conservation of biodiversity and predicting pest outbreaks. Host plants influence the communities of insects which live on them in a number of ways, including chemical and mechanical defenses, mutualistic relationships, effects of plant architecture, and hiding from herbivores by virtue of rarity or by phenological escape (Strong et al., 1984; Coley & Barone, 1996). However, little attention has been given to temporal variations of communities on host plants, and in particular to links between plant seasonality and their communities.

Many patterns of species abundance and distribution have been studied, including the species-area relationship, abundance-distribution relationship, and higher richness in complex and persistent habitats, but most such patterns are treated as static (Lawton & Strong, 1981; Gaston, 1996). However, the environment is not static, nor are patterns of population and richness. It is well known that populations fluctuate in time and that these fluctuations have important consequences. Furthermore, several macroecological hypotheses and theories, such as those involving energy, habitat complexity, and metapopulation dynamics, have implications for the effects of seasonal plants on their insect communities.

Metapopulation dynamics, based on the equilibrium theory of island

biogeography, states that populations are maintained in an equilibrium between extinction and immigration. Metapopulation dynamics has been proposed as an explanation for the species-area relationship, the well-established pattern that larger areas support more species (Connor & McCoy, 1979; Strong, 1979; Lawton & Strong, 1981). A corollary of this theory is that larger patches of plants support more species (Strong et al., 1984). The theory has been tested on patches of a landscape; fragmentation of a moss landscape caused a reduction in populations which was ameliorated by corridors allowing immigration between patches (Gonzalez et al., 1998). The apparency of plants should also be important according to this theory. In particular, common plants should be more apparent to herbivores, leading to more immigration and thus increased herbivore numbers on them. This theory can also be applied to seasonal plants. When plants are leafless or otherwise a poor resource for herbivores, extinction rates should rise, decreasing abundance and richness. If deciduous plants are common, less emigration from them would lead to lower populations on other plants in the area. When plants leaf again, generalists would recover as they migrate from other hosts, but specialists on deciduous plants would remain rare; only those specialists which are dormant during leaf loss or which utilize plant parts other than leaves would survive to repopulate the plant.

Carrying capacity, which depends largely on available energy, has an obvious influence on abundance. Brown (1981) emphasized that energetic relationships are important to understanding community ecology and suggests that species richness is related to available energy. Such a connection has been observed with British birds

(Turner et al., 1988). Energy relationships may be tied with habitat complexity, since it has been observed that increase in carrying capacity decreases niche width, which allows species richness to increase (McNaughton & Wolf, 1970). Energy has been included in the species-area relationship, as available energy over an area is a better predictor of number of species than area alone (Wright, 1983). The implications for seasonally changing host plants are straightforward. Since leaves are the main source of available energy for most herbivores, deciduous plants become a poorer energy source when their leaves have fallen and perhaps even poorer when averaged across the year. Nutritional levels and chemical and physical defenses of plants also vary, further affecting the available energy and thus the carrying capacity on a seasonal level.

Species richness tends to be higher in complex habitats. In particular, species richness is higher on architecturally more complex plants (Lawton & Strong, 1981). For example, the species richness reported in Britain on trees was higher than on shrubs, which in turn was higher than the richness reported on herbs (Strong & Levin, 1979). This pattern can be explained by the habitat diversity hypothesis, which states that larger or more diverse areas simply include a greater variety of habitats, and thus a greater variety of species adapted to the habitats (Connor & McCoy, 1979). The habitat diversity hypothesis is also one possible explanation for the species-area relationship. A plant's architectural complexity typically varies seasonally due to flowering and leafing. Though the effect of complexity is probably minor compared with effects of other factors such as energy and apparency, the habitat diversity hypothesis predicts fewer species on

flowerless and leafless plants. However, the habitat diversity hypothesis says nothing about overall abundance and suggests no reason why richness would not recover when plants are in leaf. Indeed, if the hypothesis also applies to diversity over time, we might expect deciduous plants, when studied throughout the year, to support a greater total richness of insects than plants which keep their form relatively stable.

One seasonal interrelation between plants and their herbivores which has received attention is phenological escape. Plant phenology affects abundance and composition of herbivores (Crawley & Akhteruzzaman, 1988), and seasonal changes in herbivore populations cause adaptive pressures to the phenology of plants (van Schaik et al., 1993). Seasonality, and deciduousness in particular, can also affect herbivory by eliminating the possibility of a steady food supply for specialist herbivores. Persistent habitats tend to have more species than ephemeral habitats. This pattern has been reported mostly for herbivores on perennial vs. annual herbs (Lawton & Schröder, 1977; Strong & Levin, 1979). Also, macroinvertebrate communities were richer in permanent Oxfordshire ponds than in temporary ones (Collinson et al., 1995). However, the pattern is not universal (Lawton & Strong, 1981).

A thorough understanding of community structure requires that species be examined over time as well as space. Only then can questions of community structure, abundance, diet breadth, and species interactions be answered. Establishing and testing models of how species abundances change over time will require much more fieldwork over long periods. Testing how abundance patterns change seasonally is an essential part

of that task. Only a few studies in the past have examined insect communities on host plants over more than one season. These studies have examined tropical understory and secondary growth (Janzen, 1973), Finnish deciduous trees (Niemi & Haukioja, 1982), and conifer forest (Schowalter & Ganio, 1998).

In addition to the general questions of abundance patterns, many communities are poorly known in their details of individual species. Chaparral communities represent some of the most widespread vegetation types in California, covering roughly 9% of the state. Mixed evergreen forests are also communities characteristic of the Mediterranean climate found in California, covering about 4.7% of the state (Holland & Keil, 1995). Insects of both communities are known mainly from scattered studies of individual species of plants and single insects or groups of insects.

Three shrubs are widespread in the chaparral community: western poison oak, (*Toxicodendron diversilobum* (Torrey & Gray) E. Greene: Anacardiaceae), coyote brush (*Baccharis pilularis* De Condolle: Asteraceae) and toyon (*Heteromeles arbutifolia* (Lindley) Roemer: Rosaceae). Western poison oak grows as a shrub (sometimes tree-like) or vine with thin leaves composed of three leaflets. Plants leaf and flower in the early spring, and the leaves turn bright red and drop in the fall (Gillis, 1971). Considered the most common shrub in California (Jepson, 1936, 1963), western poison oak grows mainly in oak forests and chaparral (Hickman, 1993) and is adapted to wide ranges of rainfall, temperature, insolation, and soil type. Poison oak is most well known for its medical importance. At least half of the people who come in contact with it quickly

develop an allergy to it, and in California, *Toxicodendron dermatitis* is responsible for more lost work than any other allergy (Gellin et al., 1971). Coyote brush is an evergreen shrub rarely more than 2 m. tall, with small, often somewhat sticky leaves. It grows rapidly and can produce new foliage year-round if water is available (Tilden, 1948). It produces large numbers of wind-dispersed seeds in the winter. Toyon grows as an evergreen shrub or small tree with oblong leathery leaves. New leaves begin growth in early spring; they quickly reach maximum size (5-10 cm long) and grow in toughness and density through the summer and fall. The plants flower in late summer. Small fleshy pomes appear in August or September and mature in December (Dement & Mooney, 1974). All three shrubs have similar ranges within California (Hickman, 1993). In addition to growing in chaparral, poison oak and toyon are also found in mixed-evergreen woodland, and coyote brush is common in disturbed areas.

This study describes and compares the insect species compositions of poison oak, coyote brush, and toyon and how they change seasonally. Guild compositions are also compared across seasons and shrubs, investigating whether different guilds show different patterns of change and whether the same guilds change differently on different shrubs. Community structure is examined for seasonal and between-shrub differences. Species richness and overall abundance are examined seasonally.

Materials and Methods

Sampling was done in the Santa Cruz Mountains, which straddle Santa Clara, Santa Cruz, and San Mateo counties in Northern California (Fig. 1). The study area is a mosaic of mixed chaparral and mixed evergreen forest, and samples were collected in both types of habitat. Locations were randomly selected and used in this study if all three shrub species were present in quantities sufficient for sampling within a range of approximately 1 km. Nine new locations were sampled for each sampling period. There were eight sampling periods throughout the year with five weeks between the start of periods except for two ten-week intervals during the winter (Table 1). All sampling was done during the day in dry weather.

At each location, a sample from each species of shrub was taken which consisted of beatings from ten healthy branches for each species. The ten branches were selected to be spaced evenly across the patch of shrubs within the sampling location; branches close to other plant species were avoided. Branches were beaten with a length of broomstick

Table 1. Sampling periods.

Dates	Notes
June 3, 4, and 10, 1995	
July 8, 9, and 15, 1995	Toyon flowering
Aug. 12, 13, and 19, 1995	
Sep. 16, 17, and 18, 1995	
Nov. 24, 25, and 26, 1995	Poison oak leafless; coyote brush in seed
Feb. 10, 11, and 14, 1996	Poison oak leafless
Mar. 20, 22, 23, and 24, 1996	
Apr. 21, 23, 26, and 28, 1996	Some poison oak flowering

Fig. 1. Sampling sites. The outlined area in the inset shows the region covered by the larger map.

over a 0.5 m² square linen beating tray-funnel (Fig. 2), and dislodged material was collected in a large jar. The funnel was examined for any remaining arthropods, which were included in the sample. Samples were kept in plastic bags and frozen before sorting arthropods from debris.

After beating, leaf areas of the sampled branches were measured for computing insect densities on the foliage. A 0.5 m² board was painted with a grid of small dots spaced 4 cm apart. This board was held behind each sampled branch, and an estimate of leaf area was obtained by counting the number of dots obscured.

Identification

Several resources were used for specimen identification, including specialists, keys in the literature, and by comparison with specimens in the collections at the California Academy of Sciences and San Jose State University (Table 2). Voucher specimens have been deposited in the J. Gordon Edwards Museum at San Jose State University.

Generally, immatures were counted with adults of the same species. When possible, immature insects were reared to adulthood for identification, by either rearing out immature insects caught during sampling or by field collecting immatures and rearing them in the laboratory. Holometabolous immatures were counted separately from adults to reflect possible habitat differences.

Fig. 2. Beating tray/funnel used for sampling. The funnel was made from white canvas. Two strings attached to the corners and looped around the neck held the tray level while allowing hands to be free. A wide-mouth plastic jar hung by detachable hooks from the bottom of the tray. Each sample was collected in a plastic bag (not shown) which lined the jar. The entire tray/funnel is reversible.

Table 2. Resources used to identify insects. Specialists are given by full name and affiliation. Keys are given by literature reference. (Cal Academy = California Academy of Sciences; SEL = Systematics Entomology Laboratory, Agricultural Research Service, U.S. Department of Agriculture; SJSU = San Jose State University)

Group	Resource
Coleoptera	
Anthicidae, Byturidae, <i>Listrus</i> (Melyridae), Ptinidae	SJSU collection
Apionidae, Bruchidae, <i>Sibinia</i> (Curculionidae)	Cal Academy collection
Cantharidae	Arnett, 1973; Fender, 1951
Chrysomelidae	J. Gordon Edwards, SJSU
Coccinellidae	Gordon, 1985
Dermestidae	Arnett, 1973; Beal, 1985
Elateridae	SJSU and Cal Academy collections
Leiodidae	Arnett, 1973; Fall, 1933
<i>Pseudolesteva</i> (Staphylinidae)	Arnett, 1973
Collembola	
Entomobryidae, <i>Dicyrtoma</i> (Sminthuridae) <i>Bourletiella</i> (Sminthuridae)	Christiansen & Bellinger, 1980 Richard Snider, Michigan State University
Dermaptera	SJSU collection
Diptera	McAlpine et al., 1981
Heteroptera	
Anthocoridae, Lygaeidae, <i>Irbisia</i> , <i>Parthenicus</i> (Miridae), Reduviidae, Tingidae <i>Plagiognathus</i> (Miridae)	Cal Academy collection Thomas J. Henry, SEL
Rhopalidae	SJSU collection
Homoptera	
Aphididae	Gary L. Miller, SEL
Cicadellidae	Cal Academy collection
Membracidae	SJSU collection
Psyllidae, Triozidae, Coccidae	Douglass R. Miller, SEL
Hymenoptera	
Formicidae	Phil Ward, U.C. Davis
Lepidoptera	
Coleophoridae, Lyonetiidae	Cal Academy collection
Geometridae	SJSU and Cal Academy collections
<i>Episimus</i> (Tortricidae)	John Brown, SEL
Neuroptera, immature	Catherine A. Tauber, Cornell University

Table 2. (cont.)

Group	Resource
Neuroptera, adult	Norman Penny, Cal Academy
Orthoptera	David A. Nickle, SEL
Phasmida	SJSU collection
Psocoptera	Mockford, 1993
Thysanoptera	Mound & Kibby, 1998
<i>Heliothrips</i> (Thripidae)	Mound & Kibby, 1998; Mound & Monteiro, 1997

Statistical Analysis

To determine how species densities varied between shrubs and seasons, statistical analyses were computed for species in which at least six individuals appeared at four or more sites or at least ten individuals at three sites. A list of all species used in the analyses appears in Appendix 1. Insect densities were computed by dividing insect counts by leaf area. Since data for all species were highly skewed, frequency data were transformed to rank data prior to analysis. Two-factor ANOVAs (Zar, 1984), grouped by shrub and sampling period, were performed on insect densities using Systat 7.0 (1997). *A priori* tests were performed to test for species density differences between poison oak and the other shrubs, between toyon and coyote brush, between summer (June through August) and the rest of the year, and between spring (March - April) and winter (November - February).

Insects were also grouped into broad feeding guilds and statistically analyzed to investigate how functional differences in the fauna compared between shrubs and

seasons. Following Moran & Southwood (1982), the following guilds were used: chewers, sap suckers, epiphyte grazers, scavengers, predators, parasitoids, ants, and tourists. The fungivore families Corylophidae and Leioididae were included among the epiphyte grazers, since their niche is similar to many psocids which are included in that guild. Collembola were also included with the epiphyte grazers. Statistics were also computed for all insects collectively. Guild statistics included insects which were too rare to include in species statistics. Individuals from the same guild were totaled for each sample, and densities (insects per m² of leaf area) were computed. Data for sap suckers, ants, tourists, and all insects together were too highly skewed and so were transformed to rank data; data for other guilds were log transformed. As with species, all were analyzed by two-factor ANOVAs, grouped by shrub and sampling period.

To compare species composition between shrubs and seasons, species similarities between shrubs were computed using Systat 7.0 using multidimensional scaling of Bray-Curtis distances between samples (Krebs 1989). The distance data used the 20 herbivore species found at the most sites, allowing at most one species per genus. Community structure was also examined in terms of guild similarities, using the eight guilds described above instead of the 20 species but otherwise following the same computations.

To determine differences between samples from chaparral and mixed evergreen forest habitats, Mann-Whitney *U* tests (or *t*-tests, if variances were homogeneous), were performed on density data of all the common species and all guilds, grouped by habitat type. Habitat was classified as mixed evergreen forest if plant associates included at least

two tree species, including at least one of bigleaf maple (*Acer macrophyllum* Pursh), tanbark oak (*Lithocarpus densiflorus* (Hook. & Arn.) Rehder), black oak (*Quercus douglasii* Hook. & Arn. and *Q. kelloggii* Newb.), buckeye (*Aesculus californica* (Spach) Nutt.), hazelnut (*Corylus cornuta* Marsh.), willow (*Salix* spp.), Monterey pine (*Pinus radiata* D. Don), douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco), or redwood (*Sequoia sempervirens* (D. Don) Endl.). Habitat was considered chaparral if plant associates included *Adenostoma falciparum* Hook. & Arn., manzanita (*Arctostaphylos* spp.), *Ceanothus* spp., or *Eriodictyon* spp. Habitat was also considered chaparral if it included none of the mixed evergreen forest trees, had no *Acacia*, *Eucalyptus*, or *Platanus*, and had no continuous tree canopy. Sample sites which met neither or both criteria were not included in the analyses.

Results

Insect abundance and richness

A total of 826 species or morphospecies were collected: 505 on coyote brush, 441 on toyon, and 309 on poison oak. Appendix 1 lists the 182 insect species which were collected in large enough numbers for individual analysis. Unless otherwise specified, all Lepidoptera and Neuroptera listed in this and other tables are larvae, and all other holometabolous insects are adults.

Overall insect densities were relatively high and uniform on coyote brush, while densities on poison oak and toyon were lower but peaked in the spring or summer, resulting in a significant season $\times$ shrub interaction ($F_{14,192} = 2.232$; $P = 0.008$) (Fig. 3). Although insect densities on coyote brush peaked slightly in February, seasonal variation was not significant ($F_{7,64} = 0.816$, $P = 0.578$). In contrast, toyon and poison oak both showed significant seasonal variation ($F_{7,64} = 5.024$, $P < 0.001$ and $F_{7,64} = 4.361$, $P < 0.001$, respectively). Densities were highest on poison oak in April and on toyon in July, with dramatic density fluctuations throughout the year. Interestingly, insect density peaks and valleys were similar for both poison oak and toyon. Coyote brush supported the greatest overall insect density, and poison oak the lowest, for all months except July and April. The high density on toyon in April was mainly due to a single sample with 17200 *Frankliniella* sp. 1. (No other species exceeded 1000 individuals in a single sample.)

Several insect species showed significant season $\times$ shrub interactions, but most of these reflect seasonal fluctuations of insects found preferentially on one shrub. Most of the remaining cases (given in Appendix 2) appear to be statistical artifacts from small sample sizes; for example, aphid sp. 2 was collected from coyote brush twice in June and once from poison oak in July. A few cases appear to be related to flowering. For example, *Limonius ornatulus* (LeConte) appears on toyon in July and poison oak in April, both times when the shrubs are flowering. *Cryptorhopalum apicale* (Mannerheim), *Sericus silaceus* (Say), melyrid sp. 2, *Forficula auricularia* L., and aelothripid sp. 2 also occurred most often on flowering plants regardless of species. Only *Frankliniella* sp. 1

Fig. 3. Shrub $\times$ season interaction from 2-way ANOVA of rank insect density. The graph shows actual densities instead of ranks. The July value for toyon includes one sample with an outbreak of *Frankliniella* sp. 1; with that sample excluded, the density drops to 191.58.

showed any other clear trend, moving from toyon in the summer to coyote brush in the fall. With so few shrub-season interactions, shrub and season results will be treated independently hereafter.

Of the 182 insect species analyzed individually, 104 varied significantly ($P < 0.05$) by season (Appendix 3). Not surprisingly, most seasonal insects were at a minimum in the winter and late fall. However, there were a few exceptions. *Dicyrtoma beta* Christiansen & Bellinger (Collembola: Sminthuridae), chironomid sp. 3, and *Nysius tenellus* Barber (Heteroptera: Lygaeidae) all occurred in higher numbers during the winter, and *Lachesilla pacifica* Chapman (Psocoptera: Lachesillidae) occurred in the winter and fall. According to *a priori* tests, 25 species were most common during the summer; all but four of them were either sap-suckers or predators. Thirty-three other species were significantly more common in the spring than winter, including six of the ten thrips species.

All major orders with the exception of Psocoptera were found significantly more often on coyote brush (Table 3, Appendix 4). Toyon was the next most preferred shrub, particularly with psocids. Surprisingly, only five insect species were found preferentially on poison oak. In order of decreasing commonness on poison oak, these species were *Epitrix hirtipennis* (Melsheimer) (Coleoptera: Chrysomelidae), *Plagiognathus diversus* *cruralis* Van Duzee (Heteroptera: Miridae), *Pseudolesteva* sp. (Coleoptera: Staphylinidae), *Acroneura* sp. (Homoptera: Cicadellidae), and *Heliothrips haemorrhoidalis* (Bouché) (Thysanoptera: Thripidae).

Table 3. Number of species appearing preferentially on just one shrub, total and per order.

	Coyote brush	Poison oak	Toyon
Total	48	5	16
Coleoptera	6	2	3
Collembola	1	0	0
Diptera	2	0	0
Heteroptera	4	1	4
Homoptera	6	1	0
Hymenoptera	17	0	1
Lepidoptera	7	0	1
Phasmida	0	0	1
Psocoptera	1	0	5
Thysanoptera	4	1	1

The differences between species composition among shrubs are also illustrated by the species composition similarity calculations, which showed some apparent trends between shrubs (Fig. 4). Coyote brush is generally distinct, but poison oak and toyon are not well differentiated and overlap. The loadings (Table 4) indicate that no single species had a particularly large influence on the results. Dimension 1 is defined mostly by decreasing density of *Epitrix hirtipennis*; only coyote brush is well differentiated along that axis. Dimension 2 reflects the influence especially of three species found commonly only on coyote brush (*Elpiste marcescaria* Gueneé, *Empoasca* sp., and larva *Bucculatrix variabilis* Braun) and one species common on toyon (phlaeothripid sp. 2). Most of the differentiation between coyote brush and toyon occurs along dimension 2. Species composition similarity calculations showed no clear differentiation between seasons.

Fig. 4. Multidimensional scaling of insect species composition among the three shrubs coyote brush, toyon, and poison oak. Axis labels show the directionality of loadings for species with loadings of absolute value greater than 0.28.

Table 4. Species loadings in composition comparison. Loadings with absolute value greater than 0.28 are shown in bold.

species	Dim. 1	Dim. 2
<i>Diachus auratus</i>	-0.0001	0.0179
<i>Epitrix hirtipennis</i>	-0.2816	-0.1589
<i>Parthenicus brunneus</i>	0.2403	-0.1713
mirid sp. 3	0.0013	-0.0573
mirid sp. 4	0.0962	-0.2447
<i>Corythucha incurvata</i>	-0.0487	0.2078
<i>Brachycaudus helichrysi</i>	0.0226	-0.1456
cercopid sp. 1	-0.0766	-0.1084
<i>Empoasca</i> sp.	0.1233	-0.3656
<i>Philya californiensis</i>	0.1547	-0.2769
<i>Calinda longistylus</i>	0.0526	-0.1978
<i>Coleophora viscidiflorella</i>	0.0781	-0.2686
<i>Elpiste marcescens</i>	0.2494	-0.3502
<i>Sabulodes aegrotata</i>	0.0828	0.1408
larva <i>Bucculatrix variabilis</i>	0.0273	-0.3950
<i>Timema californica</i>	-0.1400	0.1398
<i>Aeolothrips</i> sp.	0.0088	-0.1548
phlaeothripid sp. 2	-0.2375	0.3131
<i>Frankliniella</i> sp. 1	-0.0232	-0.0054
thripid sp. 3	-0.0596	-0.0478

Species richness (number of species collected) followed the same general patterns as overall species abundance (Fig. 5). For each shrub, species richness was highest in April and fell to a minimum in the winter. Coyote brush consistently supported more species than toyon, which supported more species than poison oak.

Fig. 5. Richness (number of species) on each shrub over time.

Guilds

Results of 2-way ANOVAs showed that the chewer, sap sucker, predator, and parasitoid guilds all had a significant season $\times$ shrub interaction (chewer: $F_{14,192} = 3.488$, $P < 0.001$; sap sucker: $F_{14,192} = 3.285$, $P < 0.001$; predator: $F_{14,192} = 2.136$, $P = 0.012$; parasitoid: $F_{14,192} = 2.447$, $P = 0.003$). Chewers were most numerous on coyote brush during February and least numerous in late summer; poison oak and toyon chewer densities peaked during the spring and were lowest in November and mid-summer (Fig. 6a). Sap suckers showed a similar pattern on all shrubs of higher densities in late spring and summer and lower densities in winter, but poison oak showed a hundred-fold difference in sap sucker densities, while their density on coyote brush remained nearly constant (Fig. 6b). Predator densities dropped in winter on toyon and poison oak; on coyote brush they appeared to rise and fall with a general increase in the early spring. (Fig. 6c). Parasitoid densities on coyote brush peaked in February and declined in August, yet were found at constant low levels on poison oak and toyon (Fig. 6d).

Three of the remaining guilds, epiphyte grazers, ants, and tourists, showed significant changes between shrubs (Fig. 7). The epiphyte grazers were significantly ($F_{1,192} = 10.593$, $P = 0.001$) more common on toyon than coyote brush, but their densities on poison oak were not significantly different from the other two shrubs ($F_{1,192} = 1.940$, $P = 0.165$). Ants were significantly more common on coyote brush than on poison oak ($F_{1,192} = 17.892$, $P < 0.0001$) or toyon ($F_{1,192} = 20.105$, $P < 0.001$). Tourists were equally

Fig. 6. Shrub $\times$ season interaction from 2-way ANOVA of rank density for four guilds: (a) chewers, (b) sap suckers, (c) predators, (d) parasitoids. The graph shows actual densities instead of ranks. The July value for toyon sap suckers includes one sample with an outbreak of *Frankliniella* sp. 1; with that sample excluded, the density drops to 127.53.

Fig. 7. Insect densities per guild. Asterisks mark shrubs with significantly greater densities ($P < 0.05$). The asterisk in parentheses indicates that there was also a significant shrub $\times$ season interaction for the guild (see Fig. 6). The value for toyon sap suckers includes one sample with an outbreak of *Frankliniella* sp. 1; with that sample excluded, the density drops to 44.28.

common on toyon and coyote brush ($F_{1,192} = 0.090$, $P = 0.765$) but significantly less common on poison oak ($F_{1,192} = 9.220$, $P = 0.003$).

Scavengers, epiphyte grazers, ants, and tourists showed significant seasonal variation (Fig. 8). The *a priori* tests between summer and the rest of the year and between spring and winter were not significant ($P > 0.20$ in all cases) for scavengers and epiphyte grazers; both had population peaks in three different months (February, April, and July). Ants were significantly more common in summer ($F_{1,192} = 12.084$, $P < 0.001$) and more common in spring than in winter ($F_{1,192} = 24.935$, $P < 0.001$). Tourists were significantly less abundant in summer ($F_{1,192} = 9.777$, $P = 0.002$) and more abundant in spring than in winter ($F_{1,192} = 14.854$, $P < 0.001$).

There were a few significant correlations between seasonal guild densities. On coyote brush, the seasonal abundances of parasitoids were strongly correlated with leaf eaters ($r = 0.865$, $P = 0.005$) and negatively correlated with piercers/suckers ($r = -0.721$, $P = 0.044$), and there was a strong negative correlation between leaf eaters and piercers/suckers on coyote brush ($r = -0.865$, $P = 0.006$). Scavengers and predators on toyon were correlated ($r = 0.874$, $P = 0.005$). Leaf eaters on toyon were strongly correlated with those on poison oak ($r = 0.949$, $P < 0.001$). Other correlations between guilds were not significant or were caused by single outliers.

Multidimensional scaling of guild composition showed no clear trends. Neither guild composition by shrub nor by season showed any clear differentiation.

Fig. 8. Insect densities over time for the epiphyte grazer, scavenger, ant, and tourist guilds.

Habitat type

Species composition showed no differentiation between chaparral and mixed evergreen forest habitats. Epiphyte grazers occurred more frequently in mixed evergreen forest ($P < 0.001$, d.f. = 199), but no other guilds differed significantly by habitat type, and the guild composition analysis showed no clear differentiation between the two habitats. Only 23 species differed significantly by habitat type. Of these, 13 were more common in chaparral (Table 5).

Observations of other insects

Many species of insects occurred too infrequently to meet the criterion for inclusion in the statistical analysis. Some of these were observed to use the plants. For example, the geometrid *Dichorda illustraria* (Hulst) was found three times on poison oak in the course of the sampling, observed on it other times, and reared to adulthood on it from first instar larvae. Eggs hatched during the fall, and the later instar larvae passed the winter eating poison oak bark. An unidentified pyralid (subfamily Phycitinae) was found on toyon twice in April and twice in June; one caterpillar was reared to adulthood on toyon.

Because of the sampling method, insects such as leaf rollers, leaf miners, borers, and scales would be expected to be rare in the samples. At other times, leaf rollers (*Episimus argutatus* (Clemens): Lepidoptera, Tortricidae) were observed on poison oak.

Table 5. Species and guild which differed significantly between chaparral and mixed evergreen forest habitats. Probabilities marked with asterisks were computed with *t*-test; others were computed with Mann-Whitney *U* test. d.f. = 199 in all cases (75 samples in chaparral, 126 in forest).

	<i>P</i>	density (insects/m ²)	
		chaparral	mixed forest
chaparral species			
<i>Apion cribricolle?</i> LeConte	0.0172	0.204	0.007
<i>Diachus auratus</i> (Fabricius)	0.0150	0.454	0.115
<i>Scymnus (Pullus)</i> sp. 1	0.0013	0.164	0
<i>Agathidium rotundulum</i> Mannerheim	0.0311	0.153	0.073
entomobryid sp. 1	0.0090	0.174	0
<i>Bourletiella</i> n. sp. 2	0.0195	5.372	4.567
<i>Orthocladus</i> sp.	0.0318	0.260	0.144
<i>Corythucha incurvata</i> Uhler	0.0285	4.350	1.891
<i>Aphis</i> sp. 3	0.0181	0.101	0.011
cercopid sp. 1	0.0481	0.255	0.058
aphelinid sp. 1	0.0177	0.078	0.006
pteromalid sp. 3	0.0483	0.060	0.015
larva <i>Coniopteryx</i> spp.	0.0122	0.332	0.134
<i>Frankliniella</i> sp. 1	0.0017	178.530	5.450
mixed evergreen forest species			
<i>Psyllobora vigintimaculata</i> Say	0.0039	0.191	0.807
coccinellid larva sp. 1	0.0467	0.246	0.272
beetle larva sp. 1	0.0383	0	0.057
<i>Entomobrya suzannae</i> Scott	0.0278	0.104	0.726
<i>Dicyrtoma beta</i> Christiansen & Bellinger	0.0103	0.223	7.113
mirid sp. 7	0.0105	0.020	0.609
aleurodid sp. 1	0.0155	0.028	0.220
platygastid sp. 2	0.0465	0.014	0.086
caterpillar sp. 1	0.0068	0.009	0.447
<i>Graphopsocus cruciatus</i> (L.)	0.0192*	0.707	1.422
mixed evergreen forest guild			
epiphyte grazer	0.0008*	18.044	39.077

A *Ceroplastes* coccid appeared in two samples from coyote brush, but it seems to occur more frequently, sometimes covering the branches of entire plants. An unidentified armored scale was found on toyon. An agromyziid leaf miner (unidentified) and a cecidomyiid gall midge (*Rhopalomyia californica* Felt; see also Gagné & Boldt, 1995) were reared from coyote brush.

Discussion

The insects found on poison oak in this study are new host records. Habek (1989) reviewed the literature on insects associated with *Toxicodendron* and supplemented it with additional collecting, but most of the literature focuses on the eastern species *T. radicans* and *T. toxicarium*. Only six insect species have been reported from *T. diversilobum* in previous literature. One, *Caloptilia diversilobiella* Opler (Lepidoptera: Gracilariidae) may be a specialist herbivore (Opler, 1969); three other species, *Callimoxys sanguinicollis fuscipennis* (LeConte) (Coleoptera: Cerambycidae), *Pulvinaria rhois* Ehrhorn (Homoptera: Coccidae), and *Pseudococcus longisetosus* Ferris (Homoptera: Pseudococcidae) are generalist herbivores (Linsley, 1963; Steinweden, 1946; Lamiman, 1922); and two species are flower visitors, *Apis mellifera* L. and *Chrysura crescentis* Horning (Jepson, 1936; Horning, 1971). Of the five insects found preferentially on western poison oak in this study, at least four are new records to *Toxicodendron*. *Epitrix hirtipennis* (Coleoptera: Chrysomelidae) and *Heliothrips*

haemorrhoidalis (Thysanoptera: Thripidae) are often pests on other plants (White & Barber, 1974; Mound & Monteiro, 1997). New records for Miridae and Staphylinidae on *Toxicodendron* were discovered with the collection of *Plagiognathus diversus cruralis* and *Pseudolesteva* sp. The *Acroneura* sp. on poison oak may prove to be a new record if it is different from the *Acroneura* reported by Habek (1989).

Some insects which did not show a preference for any shrub were observed to feed on poison oak. The omnivorous looper *Sabulodes aegrotata* (Gueneé) and pyralid sp. 2 were both reared to adulthood on poison oak. Neither of these have been previously reported from poison oak. Poison oak flowers only briefly, and it was past full flowering at most of the sampled sites; hence many associates of poison oak flowers were likely to have been missed in this sampling. The staphylinid *Pseudolesteva* was only found on poison oak plants which were flowering, so it was most likely attracted to the flowers. In observations from other years, the following insects were seen visiting flowers:

Coleoptera: *Limonius ornatulus*, *Sericus silaceus* (Elateridae), *Callimoxys sanguinicollis fuscipennis* (Cerambycidae), *Cryptorhopalum apicale* (Dermestidae); Diptera: *Philia strigilata* McAfee (Bibionidae); Hemiptera: *Leptocoris trivittatus* (Say) (Rhopalidae); Hymenoptera: *Prenolepis imparis* (Say) (Formicidae), *Bombus* (*Pyrobombus*) *caliginosus* (Frison), *Apis mellifera* (Apidae), unidentified Andrenidae; Araneae: unidentified Thomisidae.

The status of *Heliothrips haemorrhoidalis* preferentially occurring more often on poison oak might not have biological significance. *Heliothrips haemorrhoidalis* was

found in small numbers (three or fewer) in six poison oak samples; single thrips were found in two toyon samples, and one toyon sample contained 96 thrips. At a 5% confidence level, we can expect about five of the 77 significant differences between shrubs to be due to type I errors; this might well be one of them. *Heliothrips haemorrhoidalis* has been reported from toyon by Swan (1952). However, it appears from this study that *H. haemorrhoidalis* does not associate with coyote brush.

Most of the insects reported as common on toyon by Swan (1952) and on coyote brush by Tilden (1948; see also Steffan, 1997) were verified to be associates in this study, but several less common insects which they reported as associates were found with equal likelihood on all three shrubs. New insect records include *Agathidium rotundulum* Mannerheim (Coleoptera) and *Ectopsocus briggsi* McLachlan, *Graphopsocus cruciatus* (L.), and *Trichopsocus acuminatus* Badonnel (Psocoptera) on toyon and *Entomobrya multifasciata* (Tullberg) (Collembola), *Contarinia* sp. and *Orthocladius* sp. (Diptera), *Camponotus vicinus* Mayr, *Formica moki* Wheeler, and *Tapinoma sessile* (Say) (Hymenoptera), and *Amphigerontia bifasciata* (Latreille) (Psocoptera) on coyote brush.

Of the six psocid species found in this study to specialize on one shrub, five specialized on toyon. It is possible that toyon has longer lived leaves, allowing for more algae and fungi growth. Toyon is also more tolerant of shade than coyote brush, which might also increase the microvegetation growth upon which psocids feed. This may also explain why the leiodid *Agathidium rotundulum*, the only other common fungivore, is also more common on toyon. The preference of epiphyte grazers in general for mixed

evergreen forest as well as for toyon suggests that greater humidity may be a factor in epiphyte grazer abundance, possibly because it allows more mosses, algae, fungi, and lichens to grow on the shrubs. Predators on toyon, however, appear to be more closely linked with the scavengers, since the two guilds were correlated seasonally.

Parasitoids are especially common on coyote brush and are possibly attracted by the large number of other insects which feed on the shrub. Homoptera and caterpillars are especially common on coyote brush and may provide hosts for many parasitoids (Yoshimoto, 1984). The positive seasonal correlation of parasitoids with leaf eaters on coyote brush and their negative correlation with piercers/suckers suggest that parasitoids feed more on leaf eaters than on piercing/sucking insects. Although no quantitative records were kept, rearing of *Bucculatrix variabilis* caterpillars showed high parasitism rates.

Leaf eaters are more common on coyote brush in the spring, and sucking insects are more plentiful in the summer and fall, giving a strong negative correlation between the two guilds. The leaf eaters are possibly attracted to the new foliage which grows mostly in the spring. Sucking insects possibly prefer the summer because plant phloem may accumulate more nitrogen through the growing season (Kramer & Kozlowski, 1979). This negative correlation does not appear on the other shrubs.

The seed bug *Nysius tenellus* occurred almost exclusively on coyote brush and was most common in November when the flowers had gone to seed. This suggests that *N. tenellus* feeds on coyote brush seeds. Tilden (1948) refers to *N. tenellus* as "one of the

common and characteristic insects” of coyote brush but says nothing of its feeding habits.

Mirid sp. 2 occurred exclusively on toyon, and it was found most often in July, when the toyon was flowering. This suggests a possible association between the mirid and toyon flowers.

Nocturnal insects were not sampled in this study, and beating samples may not include most leaf rollers, leaf miners, borers, scales, and insects on roots. Some of these insects have been previously reported from poison oak (Opler, 1969; Linsley, 1963; Steinweden, 1946; Lamiman, 1922); however, none appeared in the samples of this survey. As noted earlier, leaf rollers have been present on poison oak, scales were found on toyon and coyote brush, and leaf miners and gall makers were reared from coyote brush. Hence these insects may be more common than the beating samples indicate.

The results illustrate many of the advantages of a research design which compares the communities on different plants instead of focusing on only one plant. The large difference in number of insects preferring a given plant would not easily be spotted by examining different studies on the different plants. Furthermore, many insects which might appear to associate with a plant if that is the only plant examined are instead revealed to associate with the entire plant community. For example, both Swan (1952) and Tilden (1948) reported the earwig *Forficula auricularia* to be associated with the shrub they examined, but it appears instead simply to inhabit the area and everything in it. A comparative study can also reveal associations which a study of individual plants miss. For example, Tilden (1948) did not find that certain ants spend significantly more time on

Baccharis.

On the other hand, a comparative study alone does not distinguish between those insects which are incidental to the shrubs versus those generalists which use the shrubs. For example, the aphid *Myzocallis agrifolicola* Richards and the cecidomyiid *Polystepha* feed on oak and likely are simply incidental to other plants in the area, but *Sabulodes aegrotata* was seen to feed on all three shrubs.

The major finding of this study, the first to examine insect communities on chaparral plants seasonally and comparatively, was the large differences in both abundance and richness of the shrubs' insect communities. The relatively few species which favored chaparral or mixed evergreen forest habitat indicates that the differences in shrubs have a much larger effect than the differences in where they grow. Overall insect density on coyote brush was almost twice that on toyon, which in turn was almost twice that on poison oak. Richness was consistently higher on coyote brush than on toyon and higher on toyon than on poison oak. The number of species preferring coyote brush was much higher than those preferring poison oak, again with toyon intermediate. Several general theories have been proposed to explain such patterns, and many of them may apply here.

The lower richness on poison oak might in part reflect sampling artifact. Because of poison oak's architecture, only 71% as much leaf area was sampled from it as was sampled from the other shrubs when poison oak was in leaf, and because of its deciduousness, only 17% as much branch area was sampled from poison oak in winter.

These differences are roughly comparable to the differences in richness between poison oak and toyon, but even adjusting for area, the richness on poison oak is still less than on coyote brush. Furthermore, the richness statistics reflect richness per branch, which may better reflect richness per shrub than a measure of richness per area does.

Species-specific plant defenses probably account for much of the difference.

Toyon has a chemical defense against herbivores (Dement & Mooney, 1974; Dahlman & Johnson, 1980). Poison oak might have a chemical defense, but nobody has established that the urushiol which causes poison oak dermatitis serves to discourage arthropod herbivores. Toyon also has sclerophyllous leaves, which are an effective physical defense. Coyote brush has slightly sticky leaves, especially in the summer, which probably help defend it against aphids and other small insects. Poison oak has no obvious physical defenses, but their long, flexible branches might reduce herbivore loads by dislodging the herbivores when the branches rub against each other in the wind, as proposed by Moran & Southwood (1982) for *Salix*.

An important factor in species abundance and distribution is carrying capacity based on available energy resources, which appears to vary greatly among the different shrubs. A main adaptation of coyote brush appears to be rapid growth. With sufficient water, it can produce foliage year-round (Tilden, 1948). In contrast, toyon and poison oak only produce new growth in the spring and early summer, and poison oak is completely leafless all winter. On toyon and perhaps on poison oak, chemical and physical defenses make the leaf resources unavailable for most herbivores for much of the year. Coyote

brush thus provides much greater available energy resources, which may account for the much greater abundance and richness of the insect community on it.

Abundance-distribution relationships are not likely to apply to the results of this study because all three shrubs have similar ranges within California (Hickman, 1993). Poison oak was probably the most common shrub in the study area, while toyon and coyote brush were roughly comparable in frequency. Although patch size was not measured, patch sizes of the three shrub species appeared roughly comparable as well.

There is some evidence for plant architecture having an influence on insect abundance and perhaps richness. Since the three shrubs are roughly the same size, species richness is not likely to be influenced by plant size (Lawton, 1983). However, insect densities on both toyon and poison oak were highest by far when the plants were flowering. Richness peaks were less pronounced; on toyon the richness peak during flowering in July was lower than the richness during new leaf growth in April, and on poison oak the increase in richness during flowering might be explained by a general overall richness increase in the spring. No increase in abundance or richness was found associated with fruiting. As noted above, a few insects were found more often on flowering plants. Since insects are likely attracted by the pollen and nectar resources, it is arguable whether to attribute increases to plant architecture or to resource availability.

Habitat diversity over time due to seasonal leaf production did not increase richness. Only a few insect species appeared primarily in the winter, and all of these appeared at least as commonly on coyote brush as on toyon or poison oak. It is possible

that some insects specialize for winter existence on seasonal plants, but that they were too rare to appear in the species statistics. Indeed, *Dichorda illustraria* appears to be an example of such an insect. However, greater seasonal variation of shrubs corresponded with less faunal richness overall. By requiring that insects adapt to different conditions, changing resources probably create broader niches which support fewer species. The more stringent requirements to occupy such a niche may also keep more of the niches empty.

An unpredictable food source can be expected to support fewer specialists because many organisms would adapt by migrating to other food sources, and specialists would be more subject to local extinction and thus be less common. Our results support this contention. Poison oak had only a third as many species preferring it as preferred toyon, and only a ninth as many as coyote brush. Furthermore, at least two of the species found more often on poison oak in this study are generalists which attack other plants, as are three of the four herbivores previously reported from poison oak. The greater degree of specialization on steady resources would also account for a more distinctive community, as is seen on coyote brush.

This study indicates that seasonality of the host plant affects insect communities in several ways. Abundance and richness are roughly inversely proportional to the degree of seasonality of the host plant. Coyote brush, which grows year-round with little seasonal variation, showed no seasonal variation in overall insect abundance and supported the greatest insect densities, greatest richness, and most insect specialists. Poison oak, which

is deciduous, supported the smallest and most variable insect densities, lowest richness, and the fewest insect specialists. Toyon was intermediate between these two both in the growth pattern of the plant (evergreen, but producing new growth only in the spring and early summer) and in the variability, abundance, richness, and degree of specialization of the insects it supports. An unpredictable food source may account for such results by affecting overall resource availability, potential for specialization, and niche breadth. These results support previous studies which have found richer fauna on steady resources. For example, perennial herbs were found to have a richer fauna on them than annual herbs (Lawton & Schröder, 1977; Strong & Levin, 1979), and herbivory on leaves of Australian *Eucalyptus*, which have indeterminate leafing schedules, was greater than on North American *Quercus*, which have determinate leafing (Morrow & Fox, 1989).

More studies are needed comparing evergreen versus deciduous plants and comparing evergreen plants with determinate versus indeterminate leafing. Root and stem insects on such plants might provide further useful comparisons, since they would be less affected by leafing schedules. Generalists versus specialists should also be examined in stable versus fluctuating communities. Other communities which might be useful objects for seasonal comparisons are temporary versus permanent ponds, intermittent streams, and perhaps even some microbial communities on a diurnal scale.

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Appendix 1. Insect species included in 2-way ANOVA analysis, with their total density (individuals per m²) and probability of nonrandom distribution by shrub and season.

	Species	insects/m ²	Shrub		Season		Shrub × Season	
			<i>F</i> _{2,192}	<i>P</i>	<i>F</i> _{7,192}	<i>P</i>	<i>F</i> _{14,192}	<i>P</i>
Coleoptera								
	Anthicidae							
	Apionidae							
	Bruchidae							
	Byturidae							
	Cantharidae							
Chrysomelidae	<i>Anthicus nitidulus</i> LeConte	0.137	2.021	0.1353	2.207	0.0353	0.717	0.7556
	<i>Apion cribricolle?</i> LeConte	0.080	4.700	0.0102	1.579	0.1437	0.890	0.5705
	<i>Stator limbatus</i> (Horn)	0.058	0.509	0.6018	1.439	0.1917	0.494	0.9348
	<i>Byturellus griseus</i> (Jayne)	0.092	0.376	0.6871	5.971	0.0000	0.405	0.9721
	<i>Cantharis</i> sp. 1	0.049	1.068	0.3457	2.458	0.0195	1.077	0.3812
	<i>Malthodes bicurvatus</i> Fall	0.093	0.317	0.7285	3.650	0.0010	1.600	0.0820
	<i>Podabrus modulator</i> Fall	0.042	2.417	0.0919	4.969	0.0000	1.505	0.1120
	<i>Crepidodera</i> sp. 1	0.051	1.000	0.3698	0.714	0.6600	1.000	0.4549
	<i>Diabrotica undecimpunctata</i> Mannerheim	0.029	1.873	0.1565	2.420	0.0214	0.951	0.5057
	<i>Diachus auratus</i> (Fabricius)	0.251	2.842	0.0608	2.428	0.0210	1.375	0.1684
Coccoonellidae	<i>Epitrix hirtipennis</i> (Melsheimer)	0.459	28.625	0.0000	8.151	0.0000	8.991	0.0000
	larva <i>Trirhabda flavolimbada</i> (Mannerheim)	0.403	8.913	0.0002	2.685	0.0113	2.685	0.0013
	adult <i>Trirhabda flavolimbada</i> (Mannerheim)	0.050	5.560	0.0045	1.503	0.1683	1.503	0.1129
	chrysomelid larva sp. 2	0.057	0.250	0.7791	2.302	0.0283	0.242	0.9979
	<i>Coccinella californica</i> Mannerheim	0.025	0.913	0.4030	3.722	0.0008	1.986	0.0207
	<i>Coccinella trifasciata subversa</i> LeConte	0.029	0.879	0.4170	1.906	0.0705	1.095	0.3643
	<i>Cycloneda polita</i> Casey	0.043	0.361	0.6977	1.811	0.0871	1.928	0.0257
	<i>Hyperaspis quadrioculatus?</i> Motschulsky	0.034	2.193	0.1144	2.468	0.0190	2.216	0.0086
	<i>Psyllobora vigintimaculata</i> Say	0.603	11.937	0.0000	1.471	0.1798	0.789	0.6808
	<i>Scymnus (Pullus)</i> sp. 1	0.063	2.390	0.0943	1.204	0.3023	0.851	0.6135
	<i>Scymnus (Pullus)</i> sp. 2	0.069	5.999	0.0030	0.286	0.9589	0.286	0.9949
	<i>Zagloba ornata</i> (Horn)	0.040	6.836	0.0014	0.678	0.6905	1.104	0.3567
	coccinellid larva sp. 1	0.307	8.687	0.0002	3.500	0.0015	2.352	0.0050

Appendix 1 (cont.)

	Species	insects/m ²	Shrub $F_{2,192}$	P	Season $F_{7,192}$	P	Shrub × Season $F_{14,192}$	P
Curculionidae	<i>Sibinia maculata</i> (LeConte)	0.032	0.257	0.7736	0.572	0.7786	1.106	0.3545
	weevil sp. 2	0.027	4.269	0.0154	1.225	0.2906	1.225	0.2595
Dermeestidae	<i>Cryptorhopalum apicale</i> (Mannerheim)	0.115	0.163	0.8499	2.125	0.0428	3.509	0.0000
Elaterridae	<i>Limoniis ornatus</i> (LeConte)	0.046	1.091	0.3380	1.610	0.1345	1.922	0.0262
	<i>Sericus silaceus</i> (Say)	0.055	1.102	0.3343	1.619	0.1320	1.930	0.0255
Leiodidae	<i>Agathidium rotundulum</i> Mannerheim	0.162	6.085	0.0027	1.107	0.3604	1.525	0.1050
Melyridae	<i>Listrus canescens</i> (Mannerheim)	0.094	1.146	0.3201	2.676	0.0115	1.398	0.1571
	melyrid sp. 1	0.061	0.119	0.8882	2.088	0.0467	0.575	0.8823
	melyrid sp. 2	0.044	0.970	0.3811	3.739	0.0008	2.047	0.0164
Prinidae	<i>Pinus interruptus</i> LeConte	0.073	2.556	0.0802	1.751	0.0994	1.166	0.3047
Scydmaenidae	scydmaenid sp. 1	0.079	1.513	0.2229	0.970	0.4546	0.429	0.9638
	scydmaenid sp. 2	0.049	1.567	0.2113	0.708	0.6655	1.379	0.1663
	scydmaenid sp. 3	0.067	0.148	0.8628	1.727	0.1048	0.724	0.7487
Staphylinidae	<i>Pseudolesteva</i> sp.	0.136	4.000	0.0199	4.000	0.0004	4.000	0.0000
Undetermined	beetle larva sp. 1	0.033	4.774	0.0095	0.871	0.5302	1.267	0.2308
Collembola								
Entomobryidae	<i>Entomobrya atrocincta</i> Schött	0.139	1.552	0.2146	3.727	0.0008	1.417	0.1482
	<i>Entomobrya multifasciata</i> (Tullberg)	3.052	4.601	0.0112	2.669	0.0117	1.391	0.1603
	<i>Entomobrya suzannae</i> Scott	0.459	1.814	0.1657	3.044	0.0046	2.396	0.0042
	entomobryid sp. 1	0.066	1.454	0.2361	2.368	0.0242	0.736	0.7367
Hypogastridae	hypogastruid sp. 1	0.037	1.567	0.2114	1.102	0.3636	1.182	0.2916
Sminthuridae	<i>Bourletiella</i> n. sp. 1	0.840	0.161	0.8515	2.542	0.0159	0.484	0.9399
	<i>Bourletiella</i> n. sp. 2	4.410	0.196	0.8220	4.567	0.0001	0.555	0.8970
	<i>Dicyrtoma beta</i> Christiansen & Bellinger	4.255	3.415	0.0349	47.040	0.0000	0.953	0.5029
Dermoptera								
Forficulidae	<i>Forficula auricularia</i> L.	0.068	0.560	0.5723	1.270	0.2673	1.969	0.0220
Diptera								

Appendix 1 (cont.)	Species	insects/m ²		Shrub		Season		Shrub × Season	
				<i>F</i> _{2,192}	<i>P</i>	<i>F</i> _{7,192}	<i>P</i>	<i>F</i> _{14,192}	<i>P</i>
Cecidomyiidae	<i>Contarinia</i> sp.	0.208	12.886	0.0000	2.242	0.0325	2.363	0.0048	
	<i>Polystepha</i> ? sp.	0.018	0.250	0.7791	1.154	0.3316	0.816	0.6510	
	<i>Porricondyla</i> sp.	0.048	1.090	0.3384	1.567	0.1473	1.429	0.1427	
Chironomidae	<i>Orthocladius</i> sp.	0.185	5.220	0.0062	6.603	0.0000	2.838	0.0007	
	chironomid sp. 2	0.125	0.359	0.6990	2.905	0.0066	0.938	0.5189	
	chironomid sp. 3	0.274	5.984	0.0030	12.480	0.0000	2.210	0.0087	
Heteroptera									
Anthocoridae	<i>Orius insidiosus</i> ? (Say)	0.116	6.549	0.0018	3.358	0.0021	4.674	0.0000	
	<i>Nysius tenellus</i> ? Barber	0.421	11.231	0.0000	4.470	0.0001	2.582	0.0020	
	<i>Irbisia</i> sp. 1	0.089	1.891	0.1537	1.831	0.0834	1.273	0.2275	
Miridae	<i>Parthenicus brunneus</i> Van Duzee	1.759	103.121	0.0000	7.496	0.0000	6.411	0.0000	
	<i>Plagiognathus diversus</i> Van Duzee	0.343	12.790	0.0000	5.482	0.0000	5.482	0.0000	
	mirid sp. 1	0.330	2.278	0.1052	5.429	0.0000	2.423	0.0038	
	mirid sp. 2	0.085	5.894	0.0033	2.142	0.0411	2.142	0.0114	
	mirid sp. 3	0.330	4.783	0.0094	5.526	0.0000	1.157	0.3115	
	mirid sp. 4	1.055	46.288	0.0000	0.838	0.5567	0.956	0.4999	
	mirid sp. 5	0.155	0.413	0.6620	8.641	0.0000	0.252	0.9974	
	mirid sp. 6	0.101	3.072	0.0486	1.742	0.1015	1.380	0.1661	
	mirid sp. 7	0.385	6.061	0.0028	9.567	0.0000	2.705	0.0012	
	mirid sp. 8	0.254	0.609	0.5447	2.563	0.0151	1.391	0.1607	
Reduviidae	<i>Empicoris rubromaculatus</i> (Blackburn)	0.032	4.999	0.0076	0.429	0.8835	0.429	0.9641	
	immature reduviid sp. 2	0.040	0.243	0.7844	1.148	0.3348	0.820	0.6470	
Rhopalidae	<i>Leptocoris trivittatus</i> (Say)	0.110	0.264	0.7682	0.572	0.7786	1.105	0.3554	
	<i>Corythucha incurvata</i> Uhler	2.679	28.907	0.0000	1.795	0.0902	0.593	0.8687	
Homoptera									
Aleurodidae	aleurodid sp. 1	0.142	1.346	0.2627	9.627	0.0000	0.727	0.7462	
	aleurodid sp. 2	0.072	2.537	0.0818	1.205	0.3018	1.173	0.2991	

Appendix 1 (cont.)

	Species	insects/m ²	Shrub		Season		Shrub × Season	
			<i>F</i> _{2,192}	<i>P</i>	<i>F</i> _{7,192}	<i>P</i>	<i>F</i> _{14,192}	<i>P</i>
Aphididae	aleurodid sp. 3	0.051	2.984	0.0529	2.734	0.0100	1.199	0.2786
	<i>Aphis baccharicola</i> Hille Ris Lambers	5.355	8.234	0.0004	2.517	0.0169	1.373	0.1692
	<i>Aphis spiraeicola</i> Patch	0.080	2.184	0.1154	2.839	0.0077	3.231	0.0001
	<i>Aphis</i> sp. 3	0.041	0.530	0.5895	2.803	0.0084	1.159	0.3103
	<i>Aphis</i> sp. 4	0.064	1.757	0.1754	0.572	0.7786	0.892	0.5686
	<i>Brachycaudus helichrysi</i> Kaltenbach	0.998	20.244	0.0000	7.073	0.0000	1.992	0.0202
	<i>Dactynotus</i> sp. 1	0.248	2.989	0.0527	3.708	0.0009	0.718	0.7546
	<i>Dactynotus</i> sp. 2	0.324	2.297	0.1033	3.763	0.0008	0.844	0.6207
	<i>Hyadaphis foeniculi</i> Passerini	0.410	2.647	0.0734	13.644	0.0000	0.945	0.5122
	<i>Myzocallis agrifolicola</i> Richards	0.131	2.566	0.0795	4.311	0.0002	0.813	0.6543
	<i>Myzus persicae</i> Sulzer	0.205	2.757	0.0660	1.905	0.0706	0.819	0.6476
	<i>Ovatus</i> sp.	0.106	0.493	0.6116	2.715	0.0105	0.504	0.9292
	<i>Tuberculatus</i> sp. 1	0.044	1.482	0.2298	4.355	0.0002	0.486	0.9385
	<i>Tuberculatus</i> sp. 2	0.054	1.550	0.2149	3.539	0.0013	1.049	0.4070
Aphrophoridae	aphid sp. 1	0.043	0.000	0.9999	1.476	0.1778	0.762	0.7093
	aphid sp. 2	0.056	1.091	0.3380	1.610	0.1345	1.922	0.0262
	aphrophorid sp. 1	0.025	0.502	0.6061	1.905	0.0707	0.901	0.5587
	cercopid sp. 1	0.141	4.454	0.0129	4.079	0.0003	1.116	0.3461
Cercopidae	cercopid sp. 2	0.256	1.202	0.3029	6.741	0.0000	0.673	0.7991
	<i>Acroneura</i> sp.	0.070	11.541	0.0000	6.172	0.0000	6.172	0.0000
Cicadellidae	<i>Empoasca</i> sp.	4.404	286.552	0.0000	1.643	0.1254	0.936	0.5209
	<i>Neocoelidiana obscura</i> (Baker)	0.059	2.264	0.1067	3.357	0.0021	1.426	0.1439
	<i>Pagaronia tredecimpunctata</i> Ball	0.153	0.396	0.6733	4.096	0.0003	0.762	0.7093
	<i>Stragania</i> sp.	0.038	8.154	0.0004	1.678	0.1164	1.678	0.0629
	immature cicadellid sp. 1	0.042	0.497	0.6091	1.092	0.3701	1.296	0.2127
	immature cicadellid sp. 2	0.032	3.108	0.0470	2.155	0.0400	2.553	0.0022
	<i>Philya californiensis</i> (Goding)	3.296	182.058	0.0000	6.159	0.0000	6.168	0.0000
Membracidae								

Appendix 1 (cont.)

	Species	insects/m ²	Shrub		Season		Shrub × Season	
			<i>F</i> _{2,192}	<i>P</i>	<i>F</i> _{7,192}	<i>P</i>	<i>F</i> _{14,192}	<i>P</i>
Psyllidae	<i>Psylla</i> sp.	0.025	0.511	0.6010	1.977	0.0601	1.581	0.0873
Triozidae	<i>Calinda longistylus</i> Crawford	0.360	34.078	0.0000	2.733	0.0100	2.733	0.0011
Hymenoptera								
Aphelinidae	aphelinid sp. 1	0.030	0.505	0.6045	0.660	0.7059	0.884	0.5773
	aphelinid sp. 2	0.025	3.764	0.0249	1.968	0.0613	1.114	0.3477
Cynipidae	cynipid sp. 1	0.049	0.222	0.8009	5.554	0.0000	0.222	0.9987
Encyrtidae	encyrtid sp. 1	0.026	0.829	0.4380	1.412	0.2026	1.303	0.2084
Eulophidae	Tetrastichinae sp. 1	0.031	1.004	0.3682	1.183	0.3142	1.037	0.4182
	Tetrastichinae sp. 2	0.056	0.141	0.8688	0.918	0.4939	1.326	0.1949
	euolphid sp. 3	0.043	5.262	0.0060	0.932	0.4826	0.932	0.5251
	euolphid sp. 4	0.022	5.881	0.0033	2.117	0.0436	2.117	0.0125
Eupelmidae	Eupelminae sp. 1	0.030	5.881	0.0033	2.117	0.0436	2.117	0.0125
Formicidae	<i>Camponotus hyatti</i> Emery	0.091	1.991	0.1394	2.416	0.0216	0.693	0.7796
	<i>Camponotus vicinus</i> Mayr	0.052	6.269	0.0023	0.712	0.6621	0.712	0.7611
	<i>Crematogaster coarctata</i> Mayr	1.158	2.041	0.1327	3.392	0.0019	0.314	0.9919
	<i>Formica moki</i> Wheeler	0.217	6.705	0.0015	2.297	0.0286	1.358	0.1773
	<i>Leptothorax gallae</i> M.Smith	0.037	0.878	0.4172	0.942	0.4751	1.569	0.0909
	<i>Linepithema humile</i> (Mayr)	8.354	5.616	0.0043	1.842	0.0814	0.786	0.6838
	<i>Monomorium ergatogyna</i> Wheeler	0.409	1.009	0.3664	1.469	0.1804	0.621	0.8455
	<i>Prenolepis imparis</i> (Say)	2.270	0.476	0.6217	9.166	0.0000	0.448	0.9564
	<i>Tapinoma sessile</i> (Say)	0.726	6.966	0.0012	0.898	0.5089	1.123	0.3395
Mymaridae	Mymarinae sp. 1	0.042	0.211	0.8098	1.800	0.0893	0.427	0.9647
	Mymarinae sp. 2	0.043	1.506	0.2244	1.100	0.3648	1.160	0.3089
	mymarid sp. 3	0.022	2.732	0.0676	0.918	0.4938	1.278	0.2239
Platygasteridae	platygastrid sp. 1	1.229	82.982	0.0000	7.401	0.0000	4.493	0.0000
	platygastrid sp. 2	0.055	0.390	0.6775	2.376	0.0238	0.728	0.7445
	platygastrid sp. 3	0.021	2.566	0.0794	0.429	0.8835	0.776	0.6941

Appendix 1 (cont.)

	Species	insects/m ²	Shrub <i>F</i> _{2,192}	<i>P</i>	Season <i>F</i> _{7,192}	<i>P</i>	Shrub × Season <i>F</i> _{14,192}	<i>P</i>
Pteromalidae	platygastriid sp. 4	0.135	4.704	0.0101	6.428	0.0000	4.284	0.0000
	pteromalid sp. 1	0.064	4.272	0.0153	1.232	0.2871	1.232	0.2549
	pteromalid sp. 2	0.201	39.335	0.0000	3.692	0.0009	3.692	0.0000
	pteromalid sp. 3	0.030	5.549	0.0045	1.481	0.1761	1.481	0.1211
	pteromalid sp. 4	0.101	14.756	0.0000	1.410	0.2032	1.410	0.1513
	pteromalid sp. 5	0.034	5.265	0.0059	0.937	0.4789	0.937	0.5200
	pteromalid sp. 6	0.061	10.136	0.0001	1.000	0.4329	1.000	0.4554
	pteromalid sp. 7	0.031	4.269	0.0154	1.225	0.2906	1.225	0.2595
Torymidae	torymid sp. 1	0.032	3.789	0.0243	1.147	0.3354	1.541	0.0997
Lepidoptera								
Coleophoridae	<i>Coleophora lynosyridella</i> Walsingham	0.278	40.652	0.0000	7.114	0.0000	7.114	0.0000
	<i>Coleophora viscidiflorella</i> Walsingham	1.849	23.123	0.0000	5.282	0.0000	3.821	0.0000
Geometridae	<i>Elpiste marcescens</i> Gueneé	1.498	159.320	0.0000	3.240	0.0029	3.168	0.0002
	<i>Prochoerodes truxaliata</i> Gueneé	0.035	7.208	0.0010	2.187	0.0371	2.187	0.0096
	<i>Sabulodes aegrotata</i> (Gueneé)	0.133	0.575	0.5634	1.786	0.0922	0.628	0.8398
	geometrid sp. 1	0.023	2.773	0.0650	1.414	0.2016	1.055	0.4014
	geometrid sp. 2	0.036	3.997	0.0199	2.981	0.0054	1.404	0.1540
	geometrid sp. 3	0.296	3.524	0.0314	1.446	0.1892	0.833	0.6325
Lyoniidae	larva <i>Bucculatrix variabilis</i> Braun	12.191	417.318	0.0000	6.661	0.0000	3.534	0.0000
	adult <i>Bucculatrix variabilis</i> Braun	0.410	38.736	0.0000	1.366	0.2217	1.191	0.2850
Pyralidae	pyralid sp. 1	0.029	2.702	0.0697	1.413	0.2019	1.058	0.3987
	pyralid sp. 2	0.027	1.466	0.2335	1.407	0.2044	1.214	0.2674
Tortricidae	tortricid sp. 1	0.038	2.700	0.0697	0.928	0.4863	1.293	0.2145
Undetermined	caterpillar sp. 1	0.264	28.949	0.0000	5.365	0.0000	5.365	0.0000
	caterpillar sp. 2	0.029	2.184	0.1154	2.839	0.0077	3.231	0.0001
Neuroptera								
Chrysopidae	<i>Chrysoperla carnea</i> (Stephens)	0.330	1.197	0.3044	5.757	0.0000	0.573	0.8838

Appendix 1 (cont.)

	Species	insects/m ²	Shrub $F_{2,192}$	Season $F_{7,192}$	Shrub × Season $F_{14,192}$
			P	P	P
	<i>Pseudomallada sierra</i> (Banks)	0.042	2.486	0.0859	0.903
Coniopterygidae	larva <i>Coniopteryx</i> spp.	0.214	8.193	0.0004	1.312
	adult <i>Coniopteryx</i> spp.	0.089	3.181	0.0437	1.903
Hemerobiidae	<i>Hemerobius</i> sp. 1	0.156	1.593	0.2059	3.209
Orthoptera				0.0031	1.494
					0.1162
Gryllidae	<i>Oecanthus californicus</i> Saussure	0.089	2.625	0.0750	7.666
Rhaphidophoridae	<i>Gammarotettix bilobatus</i> Thomas	0.289	2.114	0.1236	4.214
Tettigoniidae	<i>Microcentrum</i> sp.	0.027	0.189	0.8278	1.817
Phasmida				0.0860	0.422
					0.9666
Timemidae	<i>Timema californica</i> Scudder	0.662	18.640	0.0000	5.904
Psocoptera				0.0000	1.889
					0.0296
Caeciliidae	<i>Caecilius burmeisteri</i> ? Brauer	0.036	2.700	0.0697	1.903
	<i>Caecilius maritimus</i> Mockford	0.286	7.320	0.0009	3.287
Ectopsocidae	<i>Ectopsocus briggisi</i> McLachlan	2.778	8.476	0.0003	1.401
	<i>Ectopsocus californicus</i> (Banks)	1.777	16.775	0.0000	4.012
	<i>Elipsocus hyalinus</i> (Stephens)	0.127	0.685	0.5054	0.419
Elipsocidae	<i>Lachesilla pacifica</i> Chapman	0.115	1.668	0.1914	2.114
Lachesillidae	<i>Philotarsus picicornis</i> (Fabricius)	0.048	0.259	0.7719	4.264
Philotarsidae	<i>Amphigerontia bifasciata</i> (Latreille)	0.284	6.082	0.0027	3.987
Psocidae	<i>Indiopsocus</i> sp.	0.110	1.891	0.1537	1.831
	<i>Loensia maculosa</i> (Banks)	0.150	0.267	0.7662	1.828
Stenopsocidae	<i>Graphopsocus cruciatus</i> (L.)	1.113	20.745	0.0000	6.798
Trichopsocidae	<i>Trichopsocus acuminatus</i> Badonnel	0.651	8.889	0.0002	3.754
Trogiidae	<i>Cerobasis guestfalica</i> (Kolbe)	0.303	1.135	0.3237	2.943
Thysanoptera				0.0060	0.655
					0.8158
Aeolothripidae	<i>Aeolothrips</i> sp.	0.471	7.448	0.0008	5.357
	aeolothripid sp. 2	0.040	0.135	0.8739	2.254
				0.0317	2.112
					0.0128

Phlaeothripidae	<i>Leptothrips</i> sp.	3.076	16.644	0.0000	7.586	0.0000	1.139	0.3262
	phlaeothripid sp. 2	1.954	33.330	0.0000	0.807	0.5821	0.869	0.5937
Thripidae	<i>Frankliniella</i> sp. 1	65.313	10.070	0.0001	29.238	0.0000	3.984	0.0000
	<i>Frankliniella</i> ? sp. 2	0.783	0.136	0.8734	12.187	0.0000	0.270	0.9963
	<i>Heliothrips haemorrhoidalis</i> (Bouché)	0.629	3.271	0.0401	0.940	0.4772	1.478	0.1224
	thripid sp. 2	0.325	0.385	0.6810	11.318	0.0000	0.218	0.9988
	thripid sp. 3	6.225	11.205	0.0000	6.722	0.0000	0.990	0.4650
	thripid sp. 4	0.168	0.407	0.6665	2.777	0.0090	1.338	0.1880
	thripid sp. 5	0.318	0.729	0.4839	1.604	0.1363	1.266	0.2320
	thripid sp. 6	0.071	0.102	0.9028	0.882	0.5217	1.318	0.1994
	thripid sp. 7	0.131	7.616	0.0007	5.210	0.0000	3.369	0.0001
	thripid sp. 8	0.092	2.137	0.1208	3.984	0.0004	1.385	0.1636

Appendix 2. Insect densities (individuals per m²) by shrub and season, where there is a significant season × shrub interaction ($P < 0.05$) and no significant insect specialization on just one shrub. (C = coyote brush, P = poison oak, T = toyon)

Species	$F_{14,192}$	P		Insects per meter ²								
				Jun	Jul	Aug	Sep	Nov	Feb	Mar	Apr	
Coleoptera												
Coccinellidae												
<i>Coccinella californica</i> Mannerheim	1.986	0.0207	C	0.272	0	0	0	0	0	0	0	0
			P	0.222	0	0	0	0	0	0	0	0
			T	0	0	0	0.098	0	0	0	0	0
<i>Cycloneda polita</i> Casey	1.923	0.0257	C	0	0.362	0	0	0	0	0	0	0.124
			P	0	0.097	0	0.202	0	0	0	0	0
			T	0.168	0	0	0	0	0.088	0	0	0
<i>Hyperaspis quadrioculatus?</i> Motsch.	2.216	0.0086	C	0	0.091	0	0	0	0.428	0	0	0
			P	0	0	0	0	0	0	0	0	0
			T	0	0.191	0	0	0.095	0	0	0	0
coccinellid larva sp. 1	2.352	0.0050	C	2.436	0.170	1.713	1.760	0.143	0	0	0	0
			P	0	1.014	0	0	0	0	0	0	0
			T	0	0.124	0	0	0	0	0	0	0
Dermestidae												
<i>Cryptorhopalum apicale</i> (Mannerheim)	3.509	0.0000	C	0.227	0	0	0	0	0	0.102	0	0
			P	0	0	0	0	0	0	0	1.919	0
			T	0	0.518	0	0	0	0	0	0	0
Elateridae												
<i>Limonius ornatus</i> (LeConte)	1.922	0.0262	C	0	0	0	0	0	0	0	0	0
			P	0	0	0	0	0	0	0	0	0.633

Appendix 2 (cont.)

Species	$F_{14,192}$	P	Jun	Jul	Aug	Sep	Nov	Feb	Mar	Apr
<i>Insects per meter²</i>										
<i>Sericus silaceus</i> (Say)										
	1.930	0.0255	T 0	0.482	0	0	0	0	0	0
			C 0.082	0	0	0	0	0	0	0
			P 0	0	0	0	0	0	0	1.239
			T 0	0	0	0	0	0	0	0
Melyridae										
melyrid sp. 2	2.047	0.0164	C 0	0.081	0	0	0	0	0	0
			P 0.106	0	0	0	0	0	0	0
			T 0	0.870	0	0	0	0	0	0
Collembola										
Entomobryidae										
<i>Entomobrya suzannae</i> Scott	2.396	0.0042	C 0.075	0	0	0.358	0	0.281	0.292	0.367
			P 1.550	0.311	0	0	0	2.651	0	0
			T 0.149	0.245	0	0.203	0	3.329	0.316	0.896
Dermaptera										
Forficulidae										
<i>Forficula auricularia</i> L.	1.969	0.0220	C 0	0	0.106	0	0	0	0	0.560
			P 0	0	0	0	0	0	0.100	0.101
			T 0	0.645	0	0	0.110	0	0	0
Diptera										
Cecidomyiidae										
<i>Contarinia</i> sp.	2.363	0.0048	C 0.180	0	0	0.286	0	0.586	0.360	3.148
			P 0	0.325	0	0	0	0	0	0.101
			T 0	0	0	0	0	0	0	0
Chironomidae										
chironomid sp. 3	2.210	0.0087	C 0	0	0	0	0	2.313	0.115	0
			P 0	0	0	0	0	0.747	0	0
			T 0	0	0	0	0.138	2.711	0.563	0

Appendix 2 (cont.)			Insects per meter ²								
Species	$F_{14,192}$	P	Jun	Jul	Aug	Sep	Nov	Feb	Mar	Apr	
Heteroptera											
Miridae											
mirid sp. 1	2.423	0.0040	C 0.224	3.839	3.061	0	0	0	0	0	
			P 0.120	0	0	0	0	0	0	0	
			T 0	0.495	0.171	0	0	0	0	0	
mirid sp. 7	2.705	0.0012	C 0.311	0	0	0	0	0	0	0	
			P 1.069	0	0	0	0	0	0	0.521	
			T 2.634	0.112	0	0	0	0	0	4.587	
Homoptera											
Aphididae											
<i>Aphis spiraeicola</i> Patch	3.231	0.0001	C 0	0	0	0	0	0	0	1.704	
			P 0	0	0	0	0	0	0	0	
			T 0.210	0	0	0	0	0	0	0	
aphid sp. 2	1.922	0.0262	C 1.065	0	0	0	0	0	0	0	
			P 0	0.291	0	0	0	0	0	0	
			T 0	0	0	0	0	0	0	0	
Cicadellidae											
immature cicadellid sp. 2	2.553	0.0022	C 0	0.096	0	0	0	0	0	0	
			P 0	0	0	0	0	0	0	0	
			T 0.105	0	0	0	0	0	0	0.559	
Hymenoptera											
Platygastridae											
platygastriid sp. 4	4.284	0.0000	C 0.114	0	0	2.834	0	0	0	0	
			P 0	0	0	0.157	0	0	0	0	
			T 0	0	0.133	0	0	0	0	0	
Lepidoptera											
Undetermined											

Appendix 2 (cont.)		Insects per meter ²									
Species	$F_{14,192}$	P	Jun	Jul	Aug	Sep	Nov	Feb	Mar	Apr	
caterpillar sp. 2	3.231	0.0000	C 0	0	0	0	0.600	0	0	0	
			P 0	0	0	0	0	0	0	0	
			T 0	0	0	0	0	0	0.100	0	
Orthoptera											
Gryllidae											
<i>Oecanthus californicus</i> Saussure	1.881	0.0305	C 0	0	0	0.109	0	0	0	0	
			P 0	0	0.735	0.485	0	0	0	0	
			T 0	0	0.218	0.589	0	0	0	0	
Psocoptera											
Psocidae											
<i>Amphigerontia bifasciata</i> (Latreille)	2.644	0.0015	C 2.126	0	0.419	0	0.566	0	0	1.879	
			P 0	0	0	0	0	1.537	0	0	
			T 0.281	0	0	0	0	0	0	0	
Thysanoptera											
Aeolothripidae											
aeolothripid sp. 2	3.091	0.0128	C 0	0.081	0.105	0	0	0	0.146	0	
			P 0	0	0	0	0	0	0	0.238	
			T 0	0.399	0	0	0	0	0	0	
Thripidae											
<i>Frankliniella</i> sp. 1	3.984	0	C 0.210	1.546	10.961	78.231	20.724	0.150	0.423	0.447	
			P 0.240	1.359	6.189	4.065	1.389	0	0.131	0.995	
			T 0.075	1398.789	30.236	9.026	0.787	0.240	0.120	1.176	

Appendix 3. Species with significant ($P > 0.05$) seasonal variation, and their average densities per season. The last columns give results of *a priori* tests; Su = summer (June-August), rest = nonsummer (September-April), Sp = spring (March - April), W = winter (November - February)

Species	$F_{7,192}$	P	Insects per meter ²							<i>a priori</i> results	
			Jun	Jul	Aug	Sep	Nov	Feb	Mar	Apr	
Coleoptera											
Anthicidae											
<i>Anthicus nitidulus</i>	2.207	0.0353	0.246	0.027	0	0.272	0	0.177	0.103	0.267	
Byturidae											
<i>Byturrellus grisescens</i>	5.971	0.0000	0	0	0	0	0	0.083	0.617	0.037	rest>Su Sp>W
Cantharidae											
<i>Cantharis</i> sp. 1	2.458	0.0195	0.026	0.368	0	0	0	0	0	0	Su>rest
<i>Malthodes bicurvatus</i>	3.650	0.0010	0.396	0.164	0	0	0	0	0.038	0.146	Su>rest Sp>W
<i>Podabrus modulatus</i>	4.969	0.0000	0.025	0	0	0	0	0	0	0.315	Sp>W
Chrysomelidae											
chrysomelid larva sp. 2	2.302	0.0283	0	0	0	0	0	0	0.033	0.423	Sp>W
<i>Diabrotica undecimpunctata</i>	2.420	0.0214	0.140	0	0	0.095	0	0	0	0	
<i>Diachus auratus</i>	2.428	0.0210	0	0.057	0.025	0.715	0.456	0.081	0.522	0.151	rest>Su
<i>Epitrix hirtipennis</i>	8.151	0.0000	0.302	0	0	0.059	0	0	0.719	2.594	Sp>W
larva <i>Trirhabda flavolimbata</i>	2.685	0.0113	0.055	0	0	0	0	0	0.170	2.996	Sp>W
Coccinellidae											
coccinellid larva sp. 1	3.500	0.0015	0.812	0.436	0.571	0.587	0.048	0	0	0	Su>rest
<i>Coccinella californica</i>	3.722	0.0008	0.165	0	0	0.033	0	0	0	0	Su>rest
<i>Hyperaspis quadrioculatus?</i>	2.468	0.0190	0	0.094	0	0	0.032	0.143	0	0	W>Sp
Dermestidae											
<i>Cryptorhopalum apicale</i>	2.125	0.0428	0.076	0.173	0	0	0	0	0.034	0.640	Sp>W
Melyridae											
<i>Listrus canescens</i>	2.676	0.0115	0.286	0.259	0	0	0	0	0	0.208	

Appendix 3 (cont.) Species	$F_{7,102}$	P	Insects per meter ²							<i>a priori</i> results	
			Jun	Jul	Aug	Sep	Nov	Feb	Mar	Apr	
melyrid sp. 1	2.088	0.0467	0.122	0.284	0.034	0	0	0	0	0.045	Su>rest
melyrid sp. 2	3.739	0.0008	0.035	0.317	0	0	0	0	0	0	Su>rest
Staphylinidae											
<i>Pseudolesteva</i> sp.	4.000	0.0004	0	0	0	0	0	0	0	1.085	Sp>W
Collembola											
Entomobryidae											
<i>Entomobrya atrocincta</i>	3.727	0.0008	0.065	0	0	0	0	0.939	0.111	0	
<i>Entomobrya multifasciata</i>	2.669	0.0117	0.894	0.622	0.803	0.179	0.045	17.940	2.534	1.396	
<i>Entomobrya suzannae</i>	3.044	0.0046	0.591	0.185	0	0.187	0	2.087	0.203	0.421	
entomobryid sp. 1	2.368	0.0242	0	0	0	0	0.219	0	0	0.306	
Sminthuridae											
<i>Bourletiella</i> n. sp. 1	2.542	0.0159	0	0	6.337	0	0.263	0	0.120	0	
<i>Bourletiella</i> n. sp. 2	4.567	0.0001	4.917	17.169	10.010	0.877	0	0	0.553	1.753	Su>rest Sp>W
<i>Dicyrtoma beta</i>	47.040	0.0000	0	0	0	0	0.070	33.232	0.738	0	rest>Su W>Sp
Diptera											
Cecidomyiidae											
<i>Contarinia</i> sp.	2.242	0.0325	0.060	0.108	0	0.095	0	0.195	0.120	1.083	Sp>W
Chironomidae											
<i>Orthocladius</i> sp.	6.603	0.0000	0.115	0	0	0.026	0	0	0.372	0.970	rest>Su Sp>W
chironomid sp. 2	2.905	0.0066	0.024	0	0	0	0	0.593	0.347	0.037	
chironomid sp. 3	12.480	0.0000	0	0	0	0	0.046	1.924	0.226	0	rest>Su W>Sp
Heteroptera											
Anthocoridae											
<i>Orius insidiosus</i> ?	3.358	0.0021	0	0.037	0.028	0.233	0.592	0	0	0.041	W>Sp

Appendix 3 (cont.) Species	$F_{7,192}$	P	Insects per meter ²							<i>a priori</i> results	
			Jun	Jul	Aug	Sep	Nov	Feb	Mar	Apr	
Lygaeidae											
<i>Nysius tenellus</i> ?	4.470	0.0001	0	0	0	0.027	2.637	0.577	0.127	0	rest>Su W>Sp
Miridae											
<i>Parthenicus brunneus</i>	7.496	0.0000	1.798	2.735	2.861	4.319	1.812	0.047	0	0.498	Su>rest
<i>Plagiognathus diversus cruralis</i>	5.482	0.0000	0	0	0	0	0	0	2.079	0.661	rest>Su Sp>W
mirid sp. 1	5.429	0.0000	0.115	1.445	1.077	0	0	0	0	0	Su>rest
mirid sp. 2	2.142	0.0411	0.070	0.570	0.039	0	0	0	0	0	Su>rest
mirid sp. 3	5.526	0.0000	0.283	0.215	0.364	0.761	0.031	0	0.512	0.471	Sp>W
mirid sp. 5	8.641	0.0000	0.097	0	0	0	0	0	0	1.143	Sp>W
mirid sp. 7	9.567	0.0000	1.338	0.037	0	0	0	0	0	1.703	Sp>W
mirid sp. 8	2.563	0.0151	1.681	0.112	0	0	0	0	0	0.237	Su>rest
Homoptera											
Aleurodidae											
aleurodid sp. 1	9.627	0.0000	0.152	0	0.205	0	0	0	0.077	0.704	Sp>W
aleurodid sp. 3	2.734	0.0100	0	0.091	0	0	0.277	0	0.037	0	
Aphididae											
<i>Aphis baccharicola</i>	2.517	0.0169	2.789	18.947	20.683	0.424	0	0	0	0	Su>rest
<i>Aphis spiraeicola</i>	2.839	0.0077	0.070	0	0	0	0	0	0	0.568	Sp>W
<i>Aphis</i> sp. 3	2.803	0.0084	0.212	0	0	0.119	0	0	0	0	
<i>Brachycaudus helichrysi</i>	7.073	0.0000	5.670	1.052	0.109	0.115	0.516	0	0.253	0.272	Su>rest
<i>Dactynotus</i> sp. 1	3.708	0.0009	0.473	0.202	0.031	0	0.774	0	0	0.507	
<i>Dactynotus</i> sp. 2	3.763	0.0008	0	0.880	0.209	0.942	0.565	0	0	0	Su>rest
<i>Hyadaphis foeniculi</i>	13.644	0.0000	0.353	0	0	0.035	0	0	0.275	2.617	Sp>W
<i>Myzocallis agrifolicola</i>	4.311	0.0002	0	0.854	0.029	0.061	0.071	0	0	0.037	Su>rest
<i>Ovatus</i> sp.	2.715	0.0105	0.758	0.063	0	0.029	0	0	0	0	Su>rest
<i>Tuberculatus</i> sp. 1	4.355	0.0002	0.052	0	0.224	0	0	0	0	0.076	Su>rest

Appendix 3 (cont.) Species	$F_{7,192}$	P	Insects per meter ²							<i>a priori</i> results	
			Jun	Jul	Aug	Sep	Nov	Feb	Mar	Apr	
<i>Tuberculatus</i> sp. 2	3.539	0.0013	0	0.378	0.053	0	0	0	0	0	Su>rest
Cercopidae											
cercopid sp. 1	4.079	0.0003	0.112	0	0	0	0.074	0.173	0.434	0.339	Sp>W
cercopid sp. 2	6.741	0.0000	0.376	1.601	0.035	0.035	0	0	0	0	Su>rest
Cicadellidae											
<i>Acroneura</i> sp.	6.172	0.0000	0	0	0	0.416	0	0	0.144	0	rest>Su
<i>Neocoelidiana obscura</i>	3.357	0.0021	0	0	0	0.317	0.155	0	0	0	rest>Su
<i>Pagaronia tredecimpunctata</i>	4.096	0.0003	0.342	0	0	0	0	0.296	0.085	0.501	
immature cicadellid sp. 2	2.155	0.0400	0.035	0.032	0	0	0	0	0	0.186	Sp>W
Membracidae											
<i>Philya californiensis</i>	6.159	0.0000	11.896	3.882	2.321	3.641	0.200	0	2.400	2.028	Su>rest Sp>W
Triozidae											
<i>Calinda longistylus</i>	2.733	0.0100	0.356	0.403	0.115	0.037	0	0.049	0.287	1.629	Sp>W
Hymenoptera											
Cynipidae											
cynipid sp. 1	5.554	0.0000	0	0	0	0	0	0	0	0.396	Sp>W
Eulophidae											
eulophid sp. 4	2.117	0.0436	0.108	0.030	0	0	0	0	0	0.039	Su>rest
Eupelmidae											
Eupelminae sp. 1	2.117	0.0436	0	0.027	0.087	0.128	0	0	0	0	
Formicidae											
<i>Camponotus hyatti</i>	2.416	0.0216	0.482	0.041	0	0.064	0	0	0.050	0.091	
<i>Crematogaster coarctata</i>	3.392	0.0019	1.537	4.938	1.330	0.523	0	0	0.903	0.037	Su>rest Sp>W
<i>Formica moki</i>	2.297	0.0286	0.645	0.165	0	0.036	0	0	0.524	0.366	Sp>W
<i>Prenolepis imparis</i>	9.166	0.0000	0.516	5.747	0	0	0.677	0.041	0.519	10.660	Sp>W
Platygastridae											

Appendix 3 (cont.) Species	$F_{7,192}$	P	Insects per meter ²							<i>a priori</i> results	
			Jun	Jul	Aug	Sep	Nov	Feb	Mar	Apr	
platygastroid sp. 1	7.401	0.0000	1.217	0.265	0	0.111	0.254	6.005	1.259	0.721	rest>Su
platygastroid sp. 2	2.376	0.0238	0	0.038	0.181	0	0	0.065	0.041	0.113	
platygastroid sp. 4	6.428	0.0000	0.038	0	0.044	0.997	0	0	0	0	
Pteromalidae											
pteromalid sp. 2	3.692	0.0009	0.235	0.121	0	0	0.351	0.043	0.448	0.408	Sp>W
Lepidoptera											
Coleophoridae											
<i>Coleophora lynosyridella</i>	7.114	0.0000	0.570	0.172	0	0.043	0.079	0.110	0	1.250	Sp>W
<i>Coleophora viscidiflorella</i>	5.282	0.0000	0.038	0.057	0	0	0.044	13.844	0.775	0.036	rest>Su
Geometridae											
<i>Elpiste marcescens</i>	3.240	0.0029	0.404	2.370	1.878	1.963	2.241	1.959	0.136	1.035	W>Sp
<i>Prochoerodes truxaliata</i>	2.187	0.0371	0	0	0.153	0	0	0.096	0.034	0	
geometrid sp. 2	2.981	0.0054	0	0	0	0	0	0.221	0.023	0.046	rest>Su
Lyonetidae											
larva <i>Bucculatrix variabilis</i>	6.661	0.0000	7.279	2.874	1.305	0.844	5.920	38.430	36.504	4.373	W>Sp
Undetermined											
caterpillar sp. 1	5.365	0.0000	0.365	0	0.044	0	0	1.346	0.169	0.185	rest>Su
caterpillar sp. 2	2.839	0.0077	0	0	0	0	0.200	0	0.033	0	
Neuroptera											
Chrysopidae											
<i>Chrysoperla carnea</i>	5.757	0.0000	0.480	0.210	0.335	0.423	0.105	0	0.068	1.020	Su>rest Sp>W
Hemerobiidae											
<i>Hemerobius</i> sp. 1	3.209	0.0031	0.390	0.216	0.079	0	0	0.135	0.038	0.387	
Orthoptera											

Appendix 3 (cont.) Species	$F_{7,192}$	P	Insects per meter ²						<i>a priori</i> results	
			Jun	Jul	Aug	Sep	Nov	Feb	Mar	Apr
Gryllidae										
<i>Oecanthus californicus</i>	7.666	0.0000	0	0	0.318	0.394	0	0	0	0
Rhaphidophoridae										
<i>Gammarotettix bilobatus</i>	4.214	0.0002	0.117	0	0	0	0	1.218	0.380	0.599 rest>Su
Phasmida										
Timemidae										
<i>Timema californica</i>	5.904	0.0000	0.244	0	0	0	0.840	0.265	2.201	1.748 rest>Su
Psocoptera										
Caeciliidae										
<i>Caecilius maritimus</i>	3.287	0.0025	0.079	0.088	0.099	0.101	0.171	0.383	0	1.369
Ectopsocidae										
<i>Ectopsocus californicus</i>	4.012	0.0004	0.868	2.317	2.639	1.710	0.600	0.726	2.271	3.085 Sp>W
Lachesillidae										
<i>Lachesilla pacifica</i>	2.114	0.0439	0.037	0	0.127	0.108	0.466	0.180	0	0 W>Sp
Philotarsidae										
<i>Philotarsus picicornis</i>	4.264	0.0002	0	0	0	0	0	0	0	0.384 Sp>W
Psocidae										
<i>Amphigerontia bifasciata</i>	3.987	0.0004	0.802	0	0.140	0	0.189	0.512	0	1.441
Stenopsocidae										
<i>Graphopsocus cruciatus</i>	6.798	0.0000	1.297	2.344	1.750	0.977	0.587	0.561	0.321	1.069 Su>rest
Trichopsocidae										
<i>Trichopsocus acuminatus</i>	3.754	0.0008	1.107	0.595	0.256	0.805	0.031	0.060	0.083	2.266 Sp>W
Trogiidae										
<i>Cerobasis guestfalica</i>	2.943	0.0060	0.182	0.128	0.282	1.290	0.411	0.060	0	0.074

Appendix 3 (cont.)		$F_{7,192}$	P	Insects per meter ²							<i>a priori</i> results		
Species				Jun	Jul	Aug	Sep	Nov	Feb	Mar	Apr		
Thysanoptera													
Aeolothripidae													
<i>Aeolothrips</i> sp.		5.357	0.0000	0.068	1.143	0.044	0	0	0	1.676	0.834	Sp>W	
aeolothripid sp. 2		2.254	0.0317	0	0.160	0.035	0	0	0	0.049	0.079		
Phlaeothripidae													
<i>Leptothrips</i> sp.		7.586	0.0000	1.020	2.139	2.797	5.256	0.220	3.866	4.620	4.690	Sp>W	
Thripidae													
<i>Frankliniella</i> sp. 1		29.238	0.0000	0.175	67.231	15.795	30.441	7.633	0.130	0.225	0.873	Su>rest	
<i>Frankliniella</i> ? sp. 2		12.187	0.0000	0.296	0	0	0	0	0	0	5.969	rest>Su Sp>W	
thripid sp. 2		11.318	0.0000	0	1.824	0.772	0	0	0	0	0	Su>rest	
thripid sp. 3		6.722	0.0000	0.624	0.364	0.097	0.044	0.326	0.101	0.526	47.716	Sp>W	
thripid sp. 4		2.777	0.0090	0.274	0.160	0	0.067	0	0	0	0.845	Sp>W	
thripid sp. 7		5.210	0.0000	0	0	0	0	0	0.727	0.320	0	rest>Su	
thripid sp. 8		3.984	0.0004	0.071	0	0	0	0	0	0.632	0.037	Sp>W	

Appendix 4. Insects with nonrandom distribution between shrubs ($P < 0.05$). Insects are grouped by the shrub they were found on most often, if any. An asterisk after the probability of significance for insects on coyote brush and toyon indicates that the *a priori* test found no significance between poison oak and the other two shrubs combined.

	Species	$F_{2,192}$	P	Insects per meter ²		
				coyote brush	poison oak	toyon
On poison oak						
Coleoptera						
Chrysomelidae	<i>Epitrix hirtipennis</i> (Melsheimer)	28.625	0.0000	0	1.356	0.022
Staphylinidae	<i>Pseudolesteva</i> sp.	4.000	0.0199	0	0.407	0
Heteroptera						
Miridae	<i>Plagiognathus diversus cruralis</i> Van Duzee	12.790	0.0000	0	1.028	0
Homoptera						
Cicadellidae	<i>Acroneura</i> sp.	11.541	0.0000	0	0.210	0
Thysanoptera						
Thripidae	<i>Heliothrips haemorrhoidalis</i> (Bouché)	3.271	0.0401	0	0.189	1.698
On coyote brush						
Coleoptera						
Apionidae	<i>Apion cribricolle</i> ? LeConte	4.700	0.0102*	0.152	0	0.088
Chrysomelidae	larva <i>Trirhabda flavolimbada</i> (Mannerheim)	8.913	0.0002	1.208	0	0
	adult <i>Trirhabda flavolimbada</i> (Mannerheim)	5.560	0.0045*	0.149	0	0
Coccinellidae	coccinellid larva sp. 1	8.687	0.0002*	0.778	0.127	0.016
	<i>Psyllobora vigintimaculata</i> Say	11.937	0.0000	1.297	0.216	0.297
	<i>Scymnus (Pullus)</i> sp. 2	5.999	0.0030*	0.208	0	0
	beetle larva sp. 1	4.774	0.0095*	0.088	0.012	0
Undetermined						
Collembola						
Entomobryidae	<i>Entomobrya multifasciata</i> (Tullberg)	4.601	0.0112*	8.126	0.540	0.489

Appendix 4 (cont.)		Species	$F_{2,192}$	P	coyote brush	Insects per meter ²	
						poison oak	toyon
Diptera							
Cecidomyiidae		<i>Contarinia</i> sp.	12.886	0.0000*	0.570	0.053	0
Chironomidae		<i>Orthocladus</i> sp.	5.220	0.0062	0.418	0.062	0.076
Heteroptera							
Anthocoridae		<i>Orius insidiosus</i> ? (Say)	6.549	0.0018	0.309	0	0.040
Lygaeidae		<i>Nysius tenellus</i> ? Barber	11.231	0.0000	1.239	0	0.024
Miridae		<i>Parthenicus brunneus</i> Van Duzee	103.121	0.0000	5.265	0	0.011
		mirid sp. 4	46.288	0.0000	3.151	0	0.013
Homoptera							
Aphididae		<i>Aphis baccharicola</i> Hille Ris Lambers	8.234	0.0004	15.922	0.133	0.011
		<i>Brachycaudus helichrysi</i> Kaltenbach	20.244	0.0000	2.805	0.072	0.118
Cicadellidae		<i>Empoasca</i> sp.	286.552	0.0000	11.300	0.111	0.077
		<i>Sragania</i> sp.	8.154	0.0004	0.114	0	0
Membracidae		<i>Philya californiensis</i> (Goding)	182.058	0.0000	9.871	0	0.017
Triozidae		<i>Calinda longistylus</i> Crawford	34.078	0.0000	1.079	0	0
Hymenoptera							
Eulophidae		eulophid sp. 3	5.262	0.0060*	0.130	0	0
		eulophid sp. 4	5.881	0.0033*	0.066	0	0
Eupelmidae		Eupelminae sp. 1	5.881	0.0033*	0.091	0	0
Formicidae		<i>Camponotus vicinus</i> Mayr	6.269	0.0023*	0.155	0	0
		<i>Formica moki</i> Wheeler	6.705	0.0015*	0.582	0.044	0.026
		<i>Linepithema humile</i> (Mayr)	5.616	0.0043	23.653	0.305	1.105
		<i>Tapinoma sessile</i> (Say)	6.966	0.0012*	1.819	0.333	0.027
Platygasteridae		platygastriid sp. 1	82.982	0.0000	3.344	0.330	0.013
		platygastriid sp. 4	4.704	0.0101*	0.368	0.020	0.017
Pteromalidae		pteromalid sp. 1	4.272	0.0153*	0.191	0	0
		pteromalid sp. 2	39.335	0.0000	0.602	0	0

Appendix 4 (cont.)

	Species	$F_{2,192}$	P	Insects per meter ²		
				coyote brush	poison oak	toyon
Torymidae						
Lepidoptera						
Coleophoridae						
	<i>ptermalid</i> sp. 3	5.549	0.0045*	0.090	0	0
	<i>ptermalid</i> sp. 4	14.756	0.0000	0.303	0	0
	<i>ptermalid</i> sp. 5	5.265	0.0059*	0.102	0	0
	<i>ptermalid</i> sp. 6	10.136	0.0001	0.184	0	0
	<i>ptermalid</i> sp. 7	4.269	0.0154*	0.094	0	0
	<i>torymid</i> sp. 1	3.789	0.0243*	0.079	0	0.017
	<i>Coleophora lynosyridella</i> Walsingham	40.652	0.0000	0.834	0	0
	<i>Coleophora viscidiflorella</i> Walsingham	23.123	0.0000	5.422	0.126	0
Geometridae	<i>Elpiste marcescens</i> Guenée	159.320	0.0000	4.459	0.009	0.025
	<i>Prochoerodes truxaliata</i> Guenée	7.208	0.0010*	0.106	0	0
	<i>geometrid</i> sp. 3	3.524	0.0314	5.069	0.177	0.137
Lyonetiidae	larva <i>Bucculatrix variabilis</i> Braun	417.318	0.0000	36.513	0.013	0.048
	adult <i>Bucculatrix variabilis</i> Braun	38.736	0.0000	1.188	0	0.042
Undetermined	<i>caterpillar</i> sp. 1	28.949	0.0000	0.791	0	0
Psocoptera						
Psocidae	<i>Amphigerontia bifasciata</i> (Latreille)	6.082	0.0027*	0.624	0.192	0.035
Thysanoptera						
Aeolothripidae	<i>Aeolothrips</i> sp.	7.448	0.0008	0.928	0.043	0.441
Phlaeothripidae	<i>Leptothrips</i> sp.	16.644	0.0000	5.688	1.334	2.206
Thripidae	<i>thripid</i> sp. 3	11.205	0.0000*	1.055	17.445	0.173
	<i>thripid</i> sp. 7	7.616	0.0007	0.380	0	0.012
On toyon						
Coleoptera						
Coccinellidae	<i>Zagloba ornata</i> (Horn)	6.836	0.0014	0.014	0	0.106
Curculionidae	<i>weevil</i> sp. 2	4.269	0.0154*	0	0	0.081

Appendix 4 (cont.)

	Species	$F_{2,192}$	P	coyote brush	poison oak	toyon
Leiodidae	<i>Agathidium rotundulum</i> Mannerheim	6.085	0.0027	0.042	0	0.445
Heteroptera						
Miridae	mirid sp. 2	5.894	0.0033*	0	0	0.255
	mirid sp. 7	6.061	0.0028*	0.039	0.199	0.917
Reduviidae	<i>Empicoris rubromaculatus</i> (Blackburn)	4.999	0.0076*	0	0	0.095
Tingidae	<i>Corythucha incurvata</i> Uhler	28.907	0.0000	0.219	0.024	7.794
Hymenoptera						
Aphelinidae	aphelinid sp. 2	3.764	0.0249*	0.017	0	0.058
Lepidoptera						
Geometridae	geometrid sp. 2	3.997	0.0199*	0.019	0	0.091
Phasmida						
Timemidae	<i>Timema californica</i> Scudder	18.640	0.0000	0.313	0.042	1.631
Psocoptera						
Caeciliidae	<i>Caecilius maritimus</i> Mockford	7.320	0.0009	0.071	0.212	0.577
Ectopsocidae	<i>Ectopsocus briggisi</i> McLachlan	8.476	0.0003*	1.305	1.502	5.526
	<i>Ectopsocus californicus</i> (Banks)	16.775	0.0000	0.978	0.887	3.467
Stenopsocidae	<i>Graphopsocus cruciatus</i> (L.)	20.745	0.0000*	0.361	0.884	2.095
Trichopsocidae	<i>Trichopsocus acuminatus</i> Badonnel	8.889	0.0002*	0.219	0.368	1.365
Thysanoptera						
Phlaeothripidae	phlaeothripid sp. 2	33.330	0.0000	0.072	0.713	5.078
On coyote brush and toyon						
Collembola						
Sminthuridae	<i>Dicyrtoma beta</i> Christiansen&Bellinger	3.415	0.0349	3.246	6.616	2.902
Diptera						
Chironomidae	chironomid sp. 3	5.984	0.0030	0.304	0.093	0.427
Heteroptera						

Appendix 4 (cont.)		Species	Insects per meter ²			
			$F_{2,192}$	P	coyote brush	poison oak
Miridae		mirid sp. 3	4.783	0.0094	0.452	0.158
Homoptera						0.379
Cercopidae		cercopid sp. 1	4.454	0.0129	0.228	0.043
Neuroptera						0.154
Coniopterygidae		adult <i>Coniopteryx</i> spp.	3.181	0.0437	0.092	0.031
		larva <i>Coniopteryx</i> spp.	8.193	0.0004	0.441	0.025
Thysanoptera						0.175
Thripidae		<i>Frankliniella</i> sp. 1	10.070	0.0001	14.086	1.796
						180.056
No a posteriori significance						
Heteroptera						
Miridae		mirid sp. 6	3.072	0.0486	0	0.122
Homoptera						0.181
Cicadellidae		immature cicadellid sp. 2	3.108	0.0470	0.012	0
						0.083