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Newhall Ranch Investigation of the San Fernando Valley Spineflower

Chorizanthe parryi S. Watson var. *fernandina* (S. Watson) Jepson

Prepared by

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INTRODUCTION

The San Fernando Valley Spineflower (SFVS), *Chorizanthe parryi* var. *fernandina* (Polygonaceae), is an herbaceous plant thought to be extinct (Hickman 1993) until rediscovered by a team of biologists led by Tony Bomkamp and Rick Reifner on the Ahmanson Ranch in Ventura County, California on May 1, 1999. It was last recorded in 1929 from Lake Elizabeth and near Castaic (Skinner and Pavlik 1994). Since its rediscovery in May 1999, this low-growing annual has also been found on the Newhall Ranch, in Los Angeles County, 17 miles northeast of the Ahmanson Ranch (California Natural Diversity Data Base 2001). Although the Ahmanson Ranch and the Newhall Ranch both support large populations of the SFVS, fewer than 20 acres of habitat are known to be occupied (Meyer 2003).

Historically, this taxon is reported to have had a range that extended from Lake Elizabeth in Los Angeles County to near Del Mar in San Diego County (Munz and Keck 1959; Glenn Lukos Associates, Inc. 1999; Jones, *et al.* 2002). Currently, it is designated as a List 1B plant (Rare, Threatened, or Endangered in California or Elsewhere) by the California Native Plant Society and is State-listed endangered and a Federal candidate for listing (CNPS 2004).

Following the rediscovery of the SFVS, a series of surveys and directed research activities were undertaken to determine the size and extent of the on-site populations, any off-site occurrences, and factors important to its survival. These initial studies were reported in Sapphos Environmental, Inc. (2001). Included in that report is a summary of the known information regarding the pollination biology of this plant. On the basis of an apparently abundant seed set and a brief field observation, Jones (1999) suggested that the SFVS might be ant pollinated, but that pollinators were probably not limiting the reproduction of this plant.

A knowledge of the reproductive biology of rare plants is often critical to any management plan developed to ensure the long-term survival of a plant (Kearns, *et al.* 1998). Such studies involve a detailed analysis of all aspects of plant reproductive biology, including the breeding system, pollination interactions, fruit/seed set studies, dispersal and germination studies, growth and survival investigations, etc. (Kearns and Inouye 1993). The present study will investigate only the pollination of the SFVS on the Newhall Ranch. Specifically, we set out to determine: 1) the spectrum of floral visitors to the SFVS over the course of the day between the hours of 9:00 a.m. and 7:00 p.m.; 2) the invertebrate community in the vicinity of the SFVS and how it is related to the actual floral visitors collected on the SFVS; 3) the identification of the purity or lack thereof of the pollen being carried by the floral visitors to the SFVS; and 4) the effectiveness of native ants as pollinators of the SVFS. Further, data collected carrying out tasks 1 ,3 and 4 will be compared to that previously found at the Ahmanson Ranch (Jones, *et al.* 2002). No comparable data were collected at the Ahmanson Ranch for task 2.

METHODS

Study Site

Studies of the SFVS were carried out at the Newhall Ranch, Los Angeles County, California (Figure 1). The specific locations of our studies can be seen in Figure 2. Global Positioning System (GPS) coordinates for each of the study sites, including the subpopulations, can be found in Table 1. These readings were taken using a Garmin "etrex" 12-channel GPS unit.

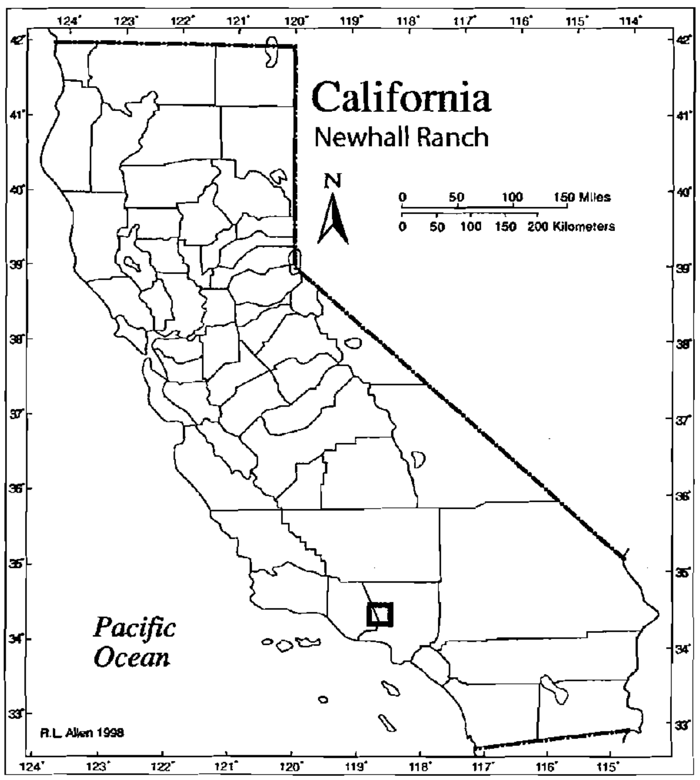


Figure 1. Location of the Newhall Ranch in Los Angeles County.

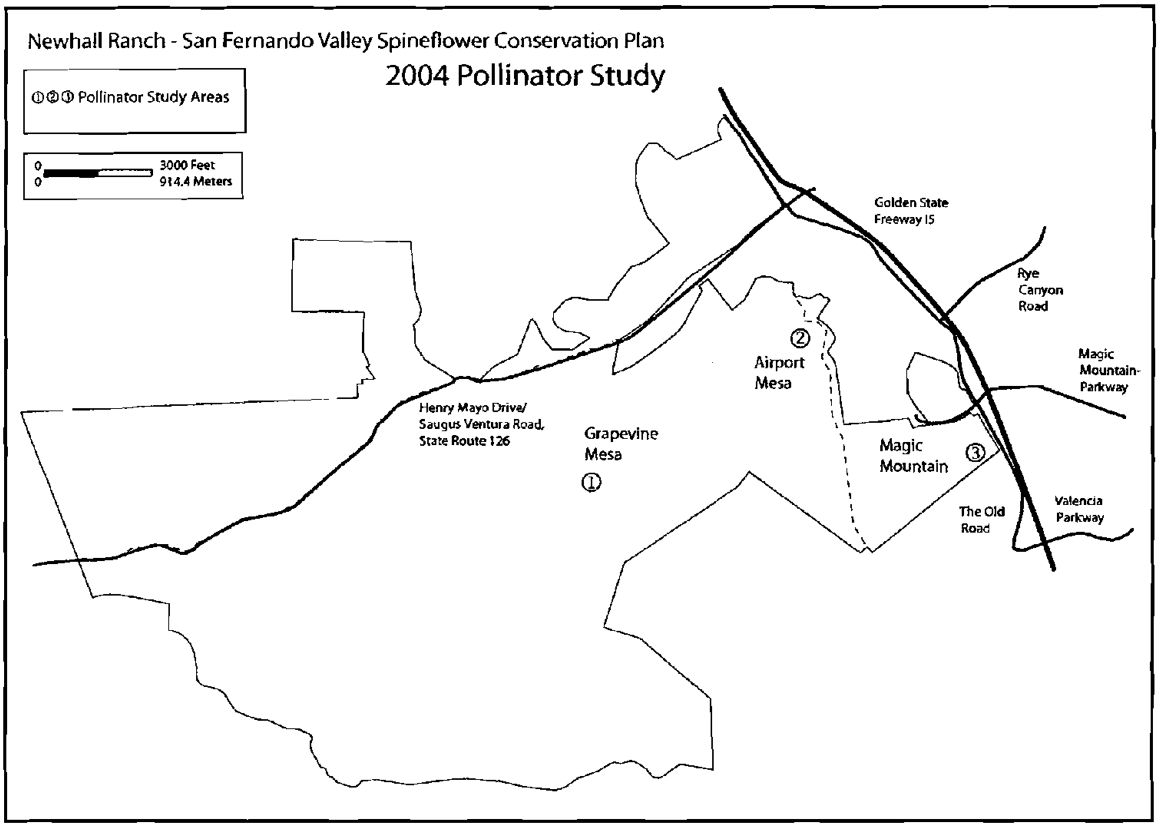


Figure 2. Specific locations of sites investigated on the Newhall Ranch in Los Angeles County. Names for the Study Sites are as follows: 1 is Grapevine Mesa Site, 2 is Airport Mesa South Site, and 3 is Magic Mountain Site (see Appendix I for photos of these sites). Specific GPS coordinates for each of the three subpopulations studied at each of the three sites can be found in Table 1.

Table 1. GPS coordinates for each of the three study sites at the Newhall Ranch (see Figure 2).

Study Site	GPS Coordinates
1a	34° 24.743' N, 118° 37.786' W
1b	34° 24.796' N, 118° 37.800' W
1c	34° 24.799' N, 118° 37.823' W
2a	34° 25.701' N, 118° 36.272' W
2b	34° 25.711' N, 118° 36.269' W
2c	34° 25.706' N, 118° 36.272' W
3a	34° 24.970' N, 118° 35.041' W
3b	34° 24.965' N, 118° 35.039' W
3c	34° 24.975' N, 118° 35.044' W

Flowers of SFVS

The sessile flowers of this species (see Figure 3) are 2.5-3mm long with a greenish white tube and 6 white, sparsely hairy lobes, occurring in two series of 3 (Reveal 1989, Hickman 1993). Filaments and anthers of the 9 stamens vary in color from white to pink (Reveal 1989 and Jones, et al., 2002). The ovary is glabrous (Jepson 1925) and bears 3 styles with dry stigmas (Reveal 1989). Nectar is present around the base of the ovary and between the filaments. The flowers are protandrous (Taft 2003) and are produced in late spring – April-June (Munz and Keck 1959).

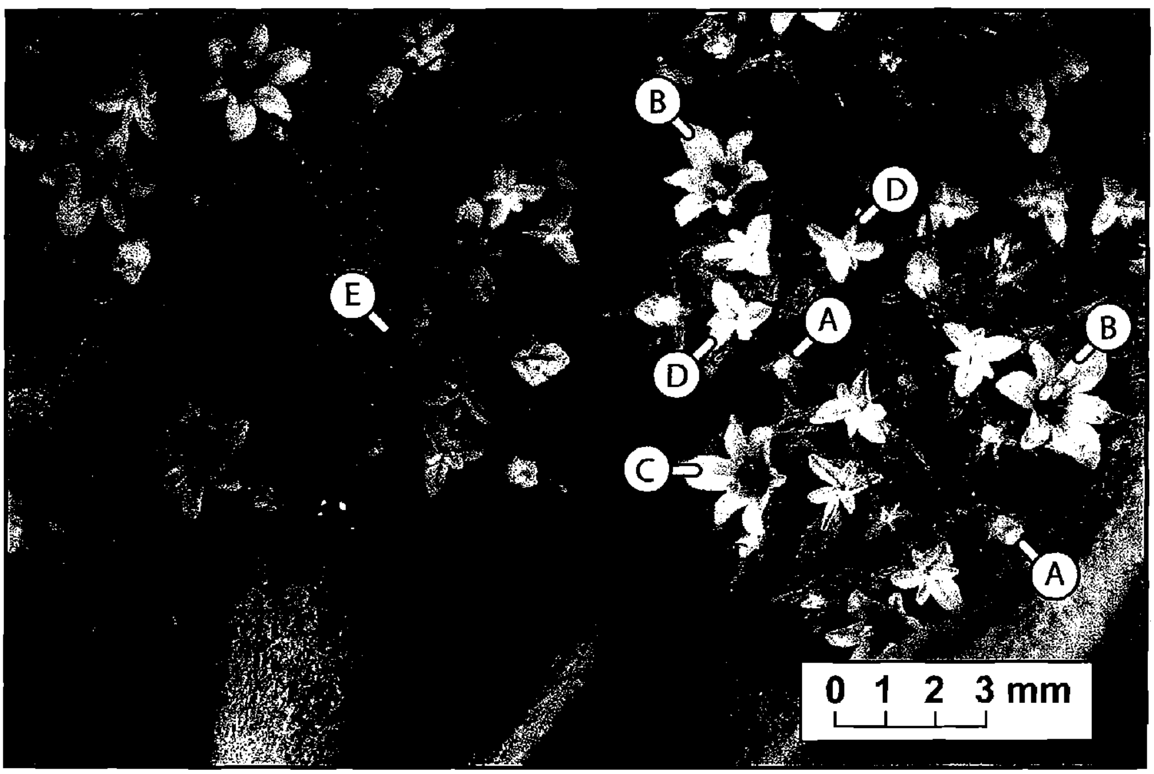


Figure 3. Photo of the SFVS with pollinator. A. Unopened flower bud; B. Open flower with dehiscing anthers – flowers protandrous; C. Open flower with receptive stigma; D. Post-pollinated flower – kept on plant to increase visual display for flying insects (see Jones and Cruzan, 1999); E. Pollen of the SFVS on head of Pyramid Ant, *Dorymyrmex insanus*.

Spectrum of SFVS Floral Visitors

Dawn-to-Dusk Observations

To determine pollinator behavior, diversity, and the relative importance of each of the major pollinator groups, we carried out a series of dawn-to-dusk surveys. These surveys were conducted twice during the blooming period (from 23 April through 25 April 2004 and 7 May through 9 May 2004) of the SFVS at three separate study sites (1, 2, and 3 - see Figure 1C). Field observations were made during the mid and late-blooming periods of the SFVS. In this study, mid-bloom was defined as the time when between 50% and 75% of the SFVS plants were in flower and late bloom was defined as the time when approximately 75% of the SFVS plants had completed flowering. We were unable to do an early bloom observation period since the contract was not completed in time to do so.

Based on the results of SFVS investigations at the Ahmanson Ranch, dawn-to-dusk observations were conducted at the Newhall Ranch between the hours of 9:00 a.m. and 7:00 p.m. (Jones, et al., 2002). Dawn-to-dusk means that we observed the possible pollinators that visited SFVS plants for at least 10 minutes out of each hour beginning on the hour at 9:00 a.m. and continuing throughout the day until 50 minutes after the hour of 6:00 p.m. As mentioned, these surveys were carried out twice during the blooming of the SFVS on the Newhall Ranch. Each survey involved three consecutive days of observation.

At each of the three study sites, three subpopulations (e.g. 1A, 1B, and 1C) were selected on the basis of ease with which one person could observe a sizeable number of plants at one time. One observer was assigned to each of the three separate study sites (1, 2, and 3). That person observed and recorded the visitors to the SFVS plants in the initial subpopulation (e.g.,1A) during the first 10 minutes of each hour. That same observer then had 10 minutes to move to the second subpopulation (1B) where he/she observed and recorded the visitors from 20 minutes after the hour until half past the hour. Finally, that same observer then rotated to the third subpopulation (1C) and repeated the process from 40 minutes after the hour until 50 minutes after the hour. We usually had two people working each site so that they could spell one another, allowing each observer to have a break. This was done to keep the observers fresh and alert.

A visitor was defined as an organism (taxon) that actually landed on and came into contact with the anther(s) and/or the stigma(s) of the flower of the SFVS. Visits were defined as the number of times that a visitor landed on a SFVS flower and probed that flower for nectar and/or pollen. Data were analyzed with respect to number of invertebrate visitors and visits in five general categories: beetles, flies, bees, ants, and others.

Invertebrate Community in the Vicinity of the SFVS and Potential Pollinators of the SFVS

Pollinator Collection and Identification

A time based sampling method was utilized to capture potential pollinators. Individual insects that were on or in the area of the SFVS were collected using aspirators and nets. Samples were collected for a total of 30 person minutes (i.e., if there were two people, we sampled for 15 minutes) at each site and each captured individual was placed into a glassine envelope. Collections were primarily conducted at a location (subpopulation) near, but not within, the dawn-to-dusk study subpopulations at each of the three sites. This was done in order to eliminate the possibility of decreasing pollinator visitations as a result of collection. One sample was collected on April 23rd, three on May 7th, and three on May 8th. For analysis, these were pooled for a single site for a single day. For each insect collected, we noted whether it was found on or near the SFVS.

Ground Dwelling Arthropod Sampling

Pitfall traps were used to sample ground dwelling arthropods. Each trap consisted of a single 16 oz plastic cup filled with approximately 4 oz of propylene glycol to act as a preservative. Three traps were placed at each site, each covered with hardware mesh to prevent the capture of vertebrates. Traps were removed when not in use. A single pitfall sample consisted of approximately 48 h of continuous trapping (from Friday afternoon until Sunday afternoon). Pitfall traps were open from the 23rd until the 25th of April and from the 7th until the 9th of May.

Arthropod Identification

All captured arthropods were identified to order and morphospecies, the latter being essentially a recognizable taxonomic unit (Oliver and Beattie 1993). Hymenopteran samples were taken to Roy Snelling at the Los Angeles County Museum for identification to species and Sean Walker, Robert Allen, and Frances Shropshire of California State University, Fullerton also participated in the identification of the floral visitors present during study observations. Our morphospecies of hymenopterans corresponded with Snelling's hymenopteran species identifications. This type of correspondence is expected (e.g. Oliver and Beattie 1996).

Visitor Floral Constancy

Pollen Analysis

Glassine envelopes with floral visitors collected for identification and pollen sampling were returned to the lab. Each visitor was examined under a Bausch and Lomb dissecting scope to see if pollen was present on the visitor and, if so, where it was located. A 3 cm piece of double sided Scotch tape was then removed from the dispenser, one end cut to a point, and the pointed end then used to pick up any available pollen from the visitors under the dissecting scope. Once the pollen had been transferred from the visitor to the double sided tape, the tape was placed on a 3" x 1" x 1mm glass microscope slide. One or two drops of cotton blue (1% aniline blue in lactophenol) was then added to stain the pollen grains and the slide allowed to sit for at least 24 hrs before examination. Slides were viewed under a Leitz compound microscope and were identified using reference slides (prepared with known SFVS pollen using the same staining technique). Types and numbers of pollen grains found on each individual were used to determine which pollinators carry the pollen of SFVS and how constant they are to the SFVS. Pollinator constancy is defined on a percentage basis. The higher the percentage of one pollen species in a sample the more specific that pollinator is to that particular plant species. For the purpose of this study, a pollinator will be considered to be "constant" to a given plant species when that pollinator visits that species at least 95% of the time during a single foraging flight; i.e., for SFVS, 95% of the pollen grains collected from a visitor's body would be from that species. Since most of the pollinators carried fewer than 200 pollen grains, we report only the number of different pollen species being carried by each of the visitors examined.

Effectiveness of Ants as Pollinators

The ant species *Dorymyrmex insanus* was chosen as the model ant for our experiments to determine if ants can serve as effective pollination vectors for the SFVS. This species was selected because it was the dominant ant visitor to the flowers of the SFVS on the Ahmanson Ranch (Jones, et al., 2002) and because, on our preliminary visits to the Newhall Ranch, colonies of this ant were found near the populations of the SFVS that we hoped to investigate.

To determine if *Dorymyrmex insanus* is a viable pollination vector of the SFVS, the following was done: Two hundred seeds were taken from the Ahmanson Ranch samples held in refrigeration at California State University, Fullerton (we were unable to use seeds of the SFVS from the Newhall Ranch for this portion of the study because we did not receive that seed from Rancho Santa Ana Botanic Garden until the 29th of June 2004, which was too late for use in these experiments) and planted in a tray filled with premium grade potting soil (Green All Premium Potting Mix), which was top layered with commercially produced sterile sand. Germination took place after 9 days and was considered complete after 14 days. A total of 122 seedlings resulted from this germination period.

These seedlings were allowed to grow for an additional 10 days before being transferred to their respective experimental enclosures. The wooden enclosures were 36" in length, 24" in width, and 6" in height each with a lid constructed of molding bead supporting a screen top. Each enclosure was mounted on 4 cedar posts serving as legs and elevated 3 feet above the ground. The screen used was metal 1/16th inch aluminum screening, which was large enough to keep out winged pollinators but not small enough to keep contained the suspected ant vectors. However, containment of the ant vectors was further accomplished using "Cooks Ant Barrier" (a commercially available insect repellent). The sides of the enclosures were sponged with the solution until the wood was heavily saturated. This treatment was repeated regularly and was effective in keeping the ants from escaping as well as preventing entry to the containers by other arthropods.

Equal numbers of plants were transplanted into each enclosure. When small flower buds began to appear on the inflorescences, approximately 500 workers from a single nest of *Dorymyrmex insanus* were collected from the Newhall Ranch study site across the street from the Hilton Hotel (Study Site 3 – Magic Mountain Site – See Figure 3 for location and Table 1 for GPS coordinates). Ants were collected using an aspirator connected to small plastic vials, as well as by sponges soaked with sugar solution.

The ants were introduced to Enclosure 1 (Experimental) and immediately began to tunnel. They also immediately began to inspect their surroundings as well as visit the plants. A sugar water solution (Cornell University hummingbird mixture: one part sugar to four parts water) was supplied to the ants regularly each morning and evening using a saturated sponge. Ants continued to visit the plants throughout the flowering period. The colony experienced a die-off of workers until approximately 200 workers were left after the first two weeks and none were left at the end of week 4.

SFVS plants were also transferred to a second identical container (Enclosure 2 – Control), but no ants were introduced and an attempt was made to exclude all possible floral visitors through the use of "Cooks Ant Barrier".

Plants in each enclosure were allowed to mature and set fruit. Plants were then harvested and the number of fruits/seeds produced per treatment were counted. Seeds from plants in each enclosure were removed from the dried flower buds by soaking them over a large bowl filled with water and applying rotating hand pressure in a household kitchen strainer to release them into the water-filled bowl. Left-over plant material from the strainer was placed on paper toweling to dry and inspected for any additional seeds not released into the bowl.

RESULTS

Spectrum of SFVS Floral Visitors

The results of the dawn-to-dusk series of observations for 23-25 April (mid-season) and 7-9 May 2004 (late season) are presented in Figures 4 through 19. Each set of figures graphically illustrates the visits or visitors to the SFVS by the major groups of potential insect pollination vectors during the mid- and late blooming periods at each of three observation sites as well as the combined totals for each series of observations.

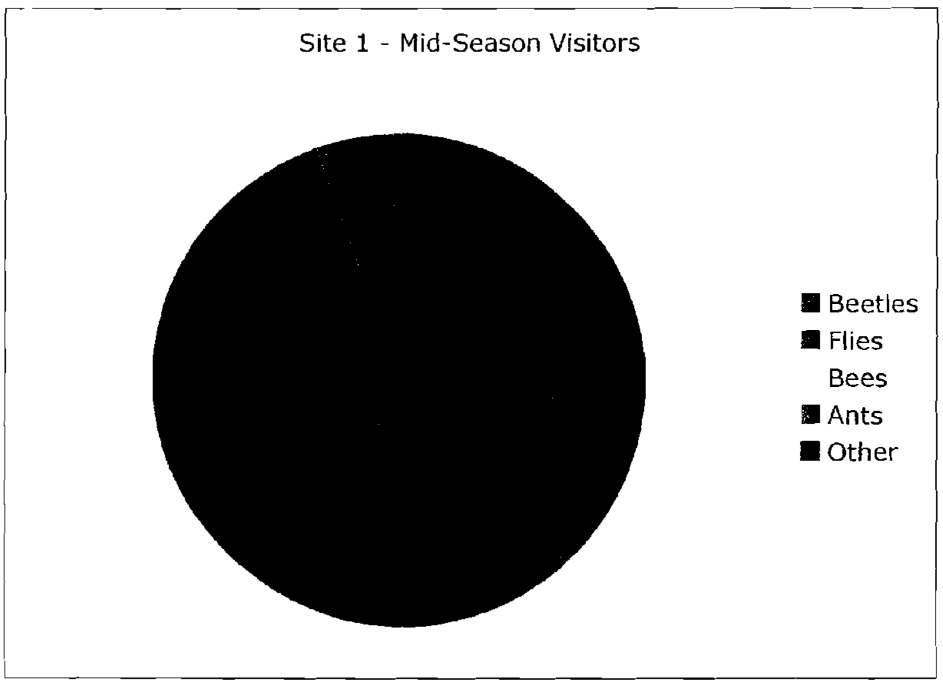


Figure 4. Combined data for all visitors to the SFVS at Site 1 for 23-25 April 2004.

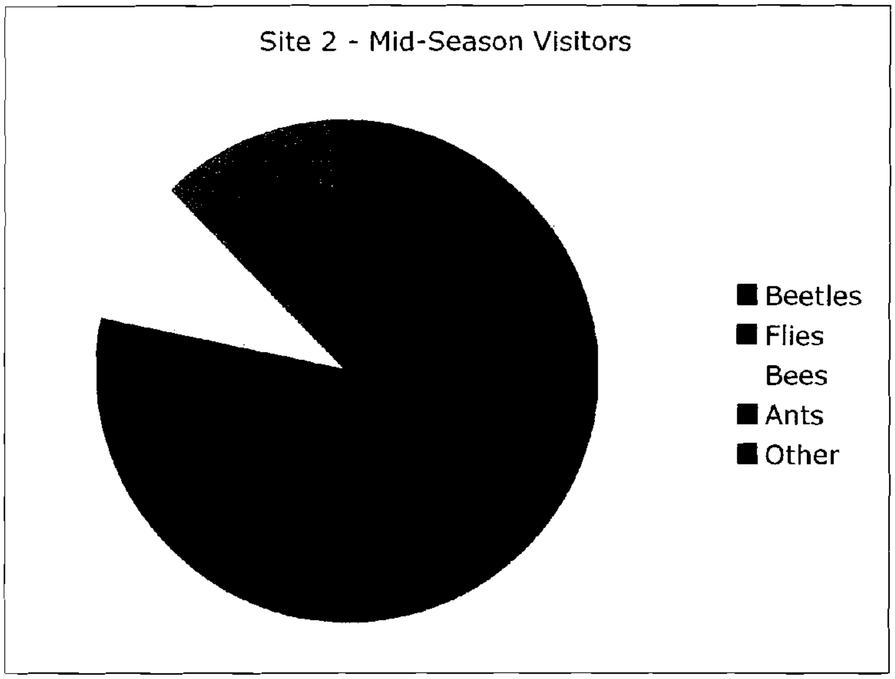


Figure 5. Combined data for all visitors to the SFVS at Site 2 for 23-25 April 2004.

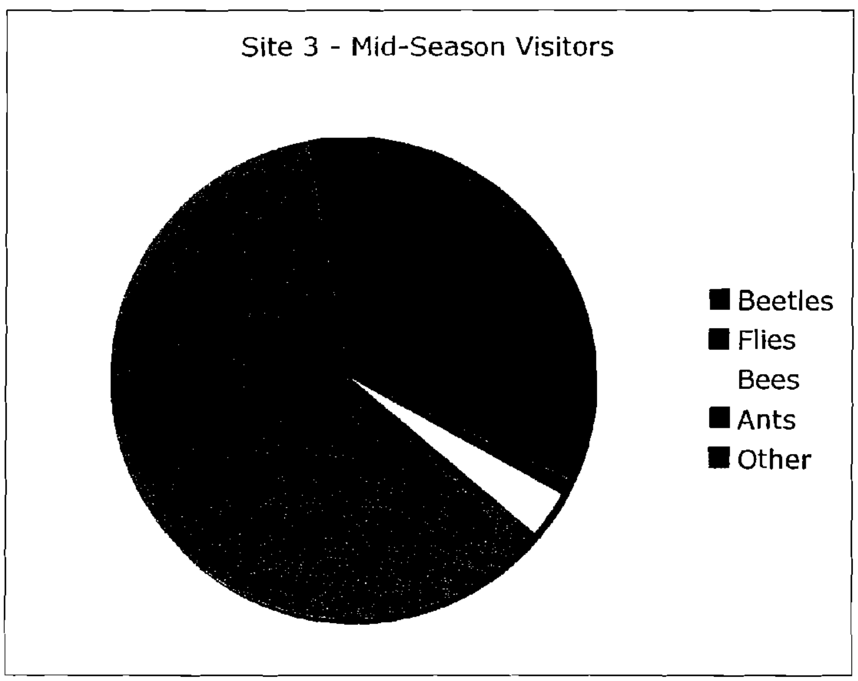


Figure 6 .Combined data for all visitors to the SFVS at Site 3 for 23-25 April 2004.

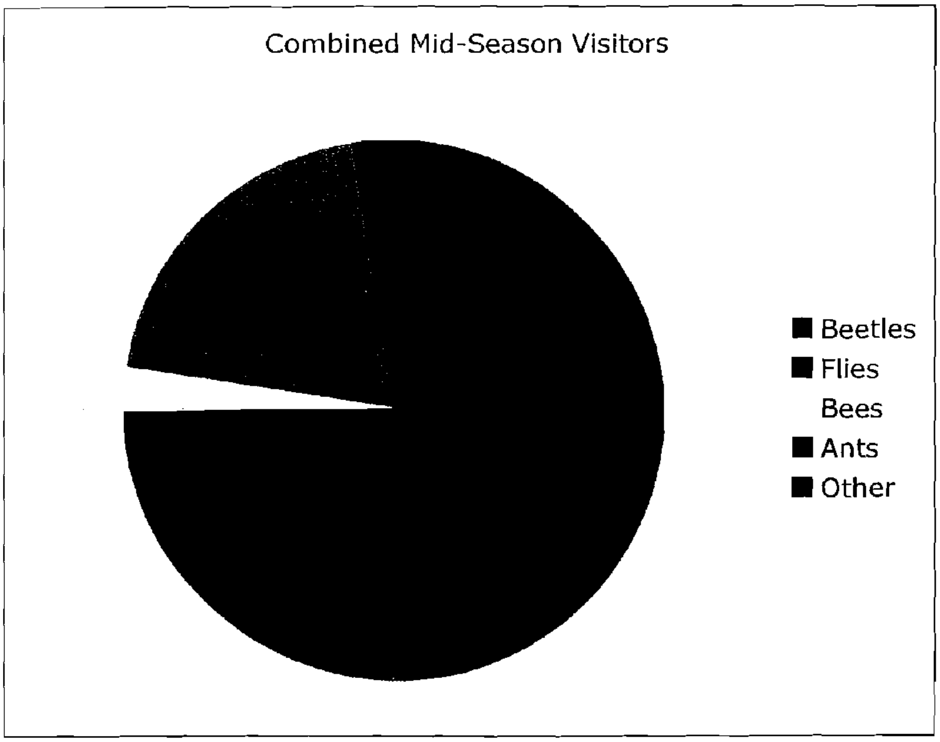


Figure 7. Combined data for all visitors to the SFVS at Sites 1, 2, and 3 for 23-25 April 2004.

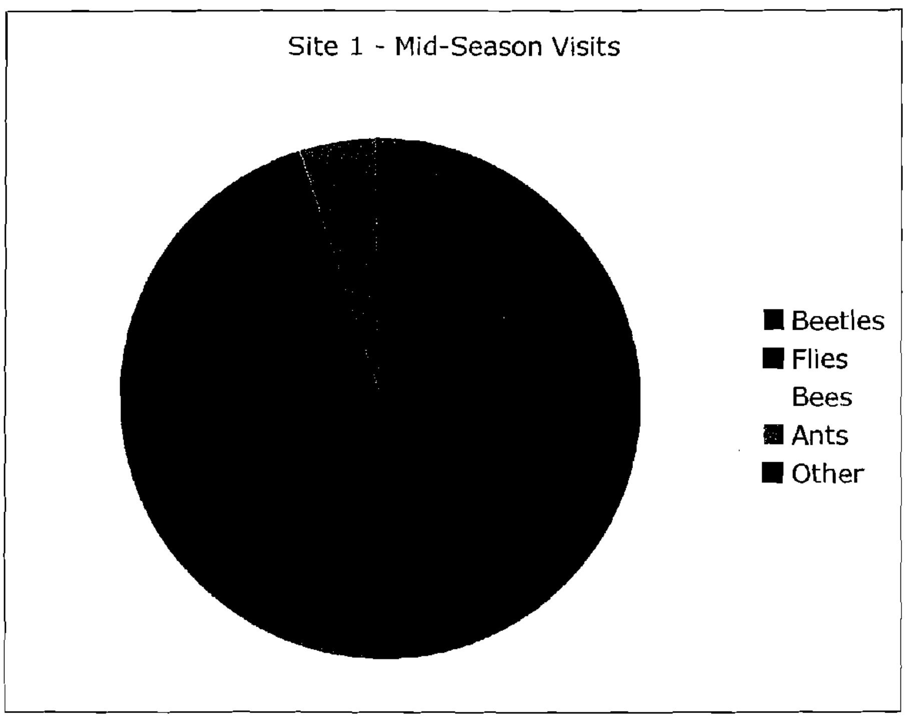


Figure 8. Combined data for all visits by visitors to the SFVS at Site 1 for 23-25 April 2004.

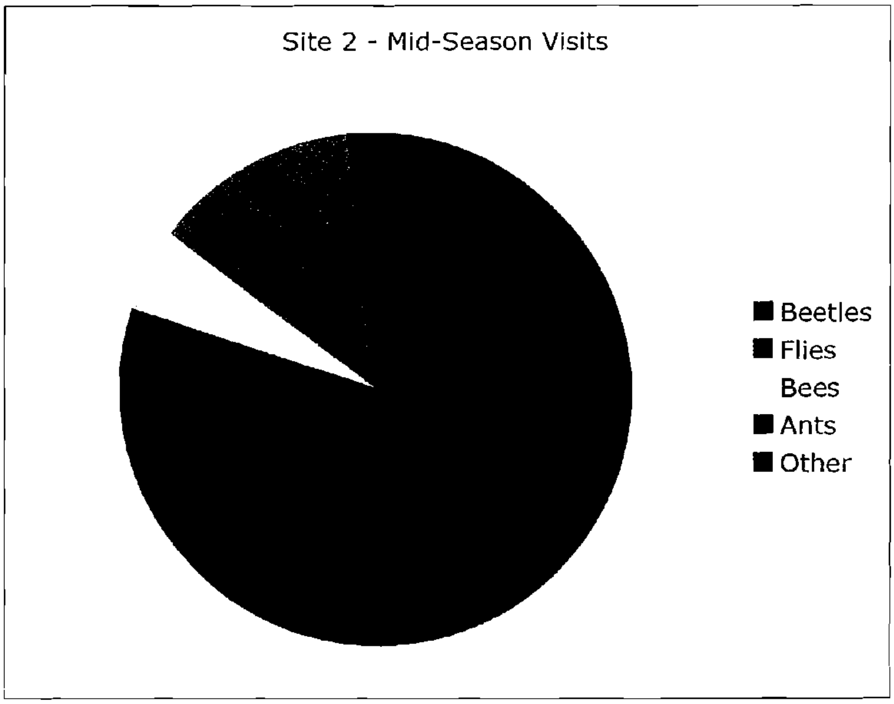


Figure 9. Combined data for all visits by visitors to the SFVS at Site 2 for 23-25 April 2004.

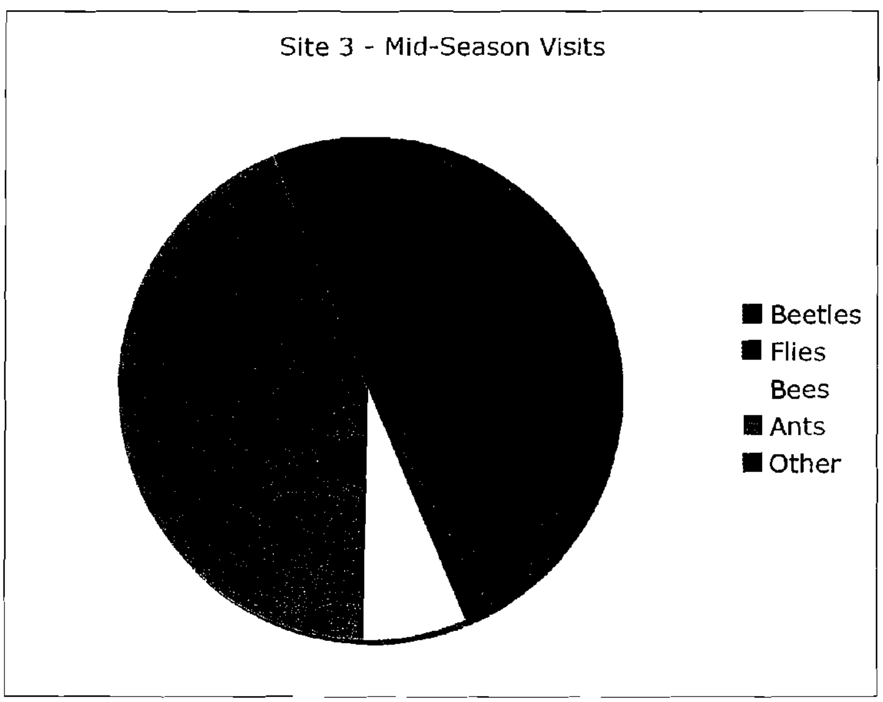


Figure 10. Combined data for all visits by visitors to the SFVS at Site 3 for 23-25 April 2004.

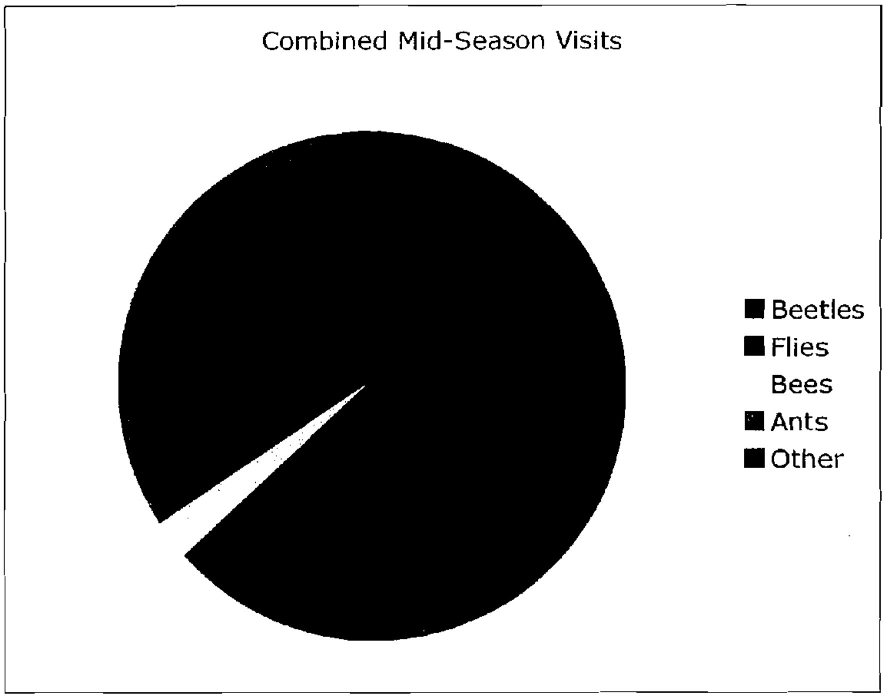


Figure 11. Combined data for all visits by visitors to the SFVS at Sites 1, 2, and 3 for 23-25 April 2004.

Visitors to the flowers of the SFVS varied substantially from site to site during our mid-season observations conducted from 23 – 25 April 2004. Flies (67%) and beetles (27%) dominated the visitors at Site 1 (Figure 4) and at Site 2 (58.5% for flies and 21.5% for beetles, Figure 5), whereas flies were replaced by ants (43%) as dominant visitors along with beetles (42%) at Site 3 (Figure 6). Total visitors also varied considerably among the sites, with 722 visitors at Site 1, 130 at Site 2, and 483 at Site 3. Overall, 1335 visitors were observed on the flowers of the SFVS during the mid-season flowering period. During this period, flies (42.5%) beetles (32%), and ants (20%) were the dominant floral visitors to the SFVS (Figure 7).

An examination of the visits made by each of the visitor groups shows that flies (79%) greatly outnumbered beetles (16%) in terms of the number of flowers actually visited by the individual visitors at Site 1 (Figure 8). Flies (67%) also dominated the visits at Site 2 (Figure 9), followed by beetles (11.5%) and ants (11%). Ants (61%) made the most numerous visits at Site 3 (Figure 10) followed by beetles (32%). Total visits varied among the three sites from 2021 at Site 1, 633 at Site 2, and 2488 at Site 3. Overall 5142 visits were made by the visitors to the flowers of the SFVS during the mid-season flowering period. During that time, flies (40%), ants (33%), and beetles (23%) dominated the floral visits (Figure 11).

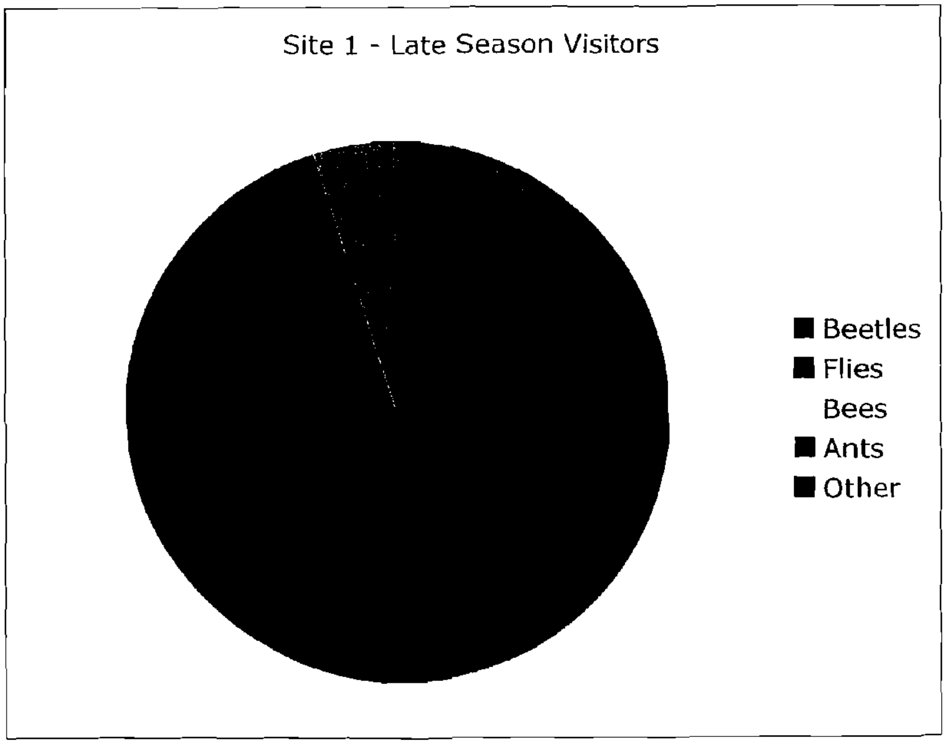


Figure 12. Combined data for all visitors to the SFVS at Site 1 for 7-9 May 2004.

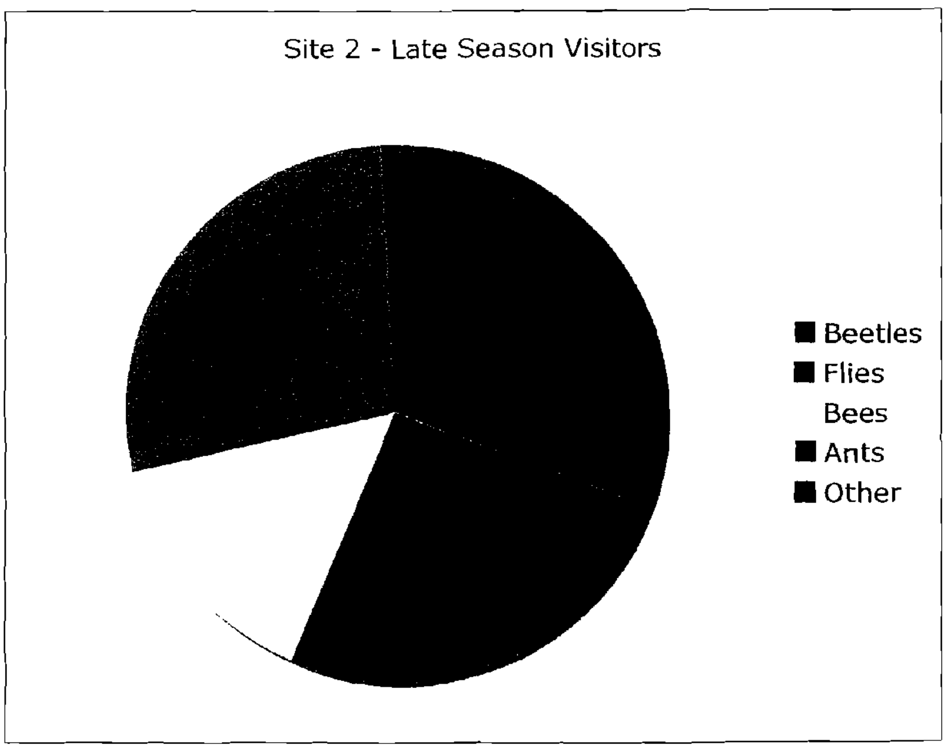


Figure 13. Combined data for all visitors to the SFVS at Site 2 for 7-9 May 2004.

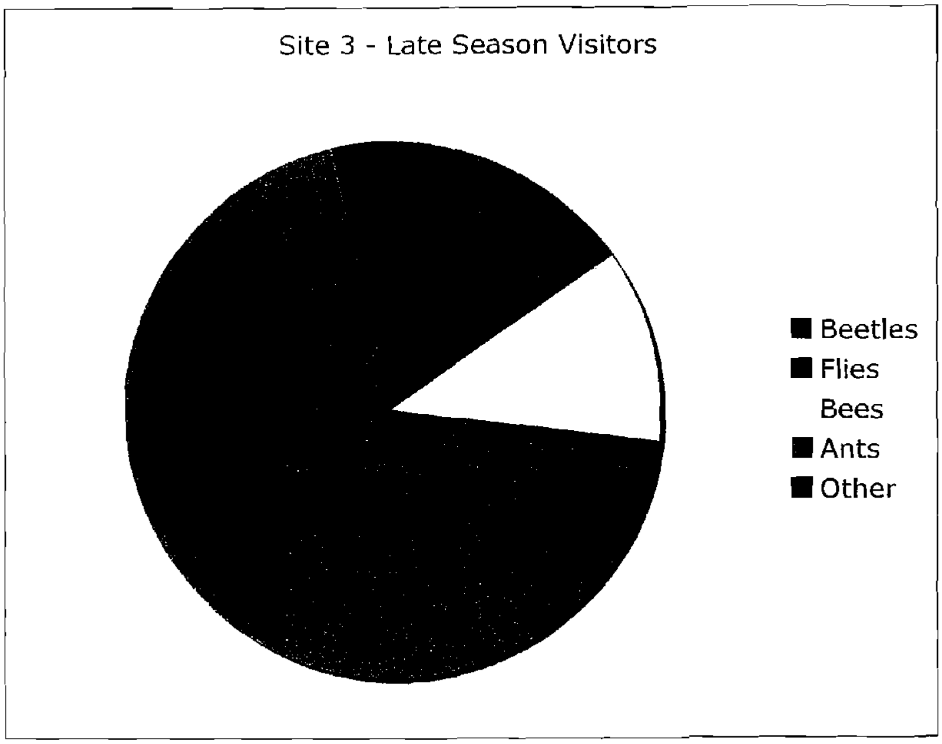


Figure 14. Combined data for all visitors to the SFVS at Site 3 for 7-9 May 2004.

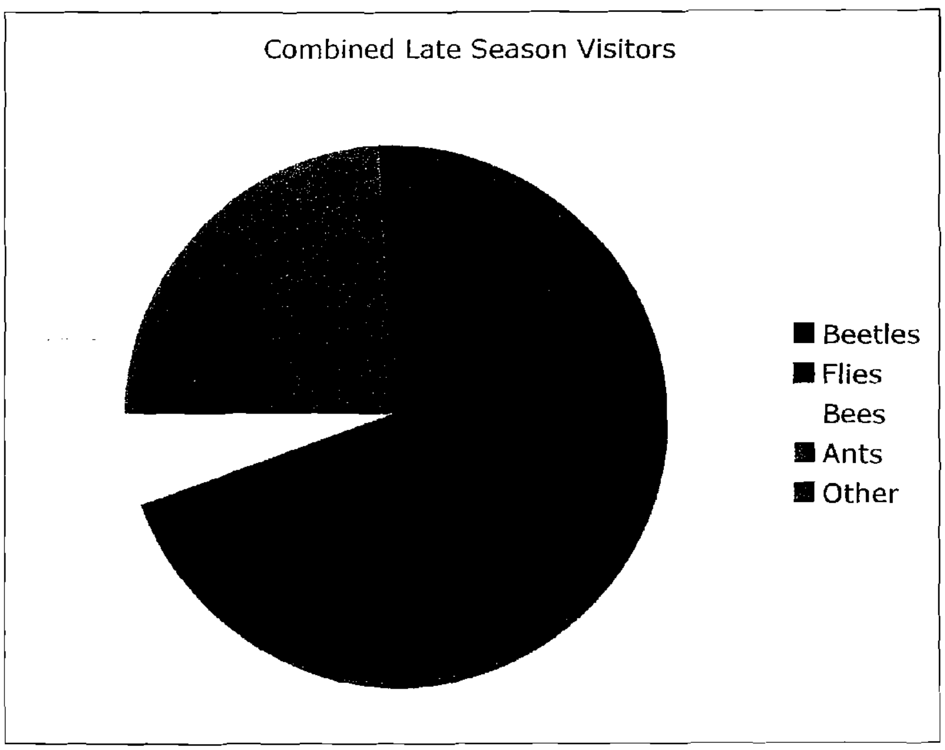


Figure 15. Combined data for all visitors to the SFVS at Sites 1, 2, and 3 for 7-9 May 2004.

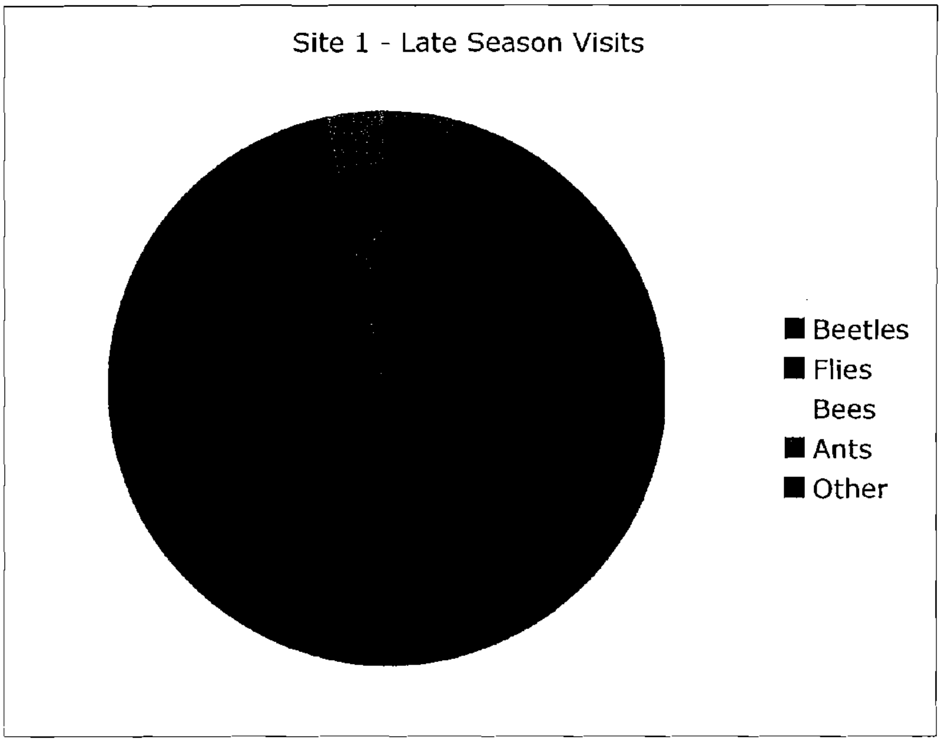


Figure 16. Combined data for all visits to the SFVS at Site 1 for 7-9 May 2004.

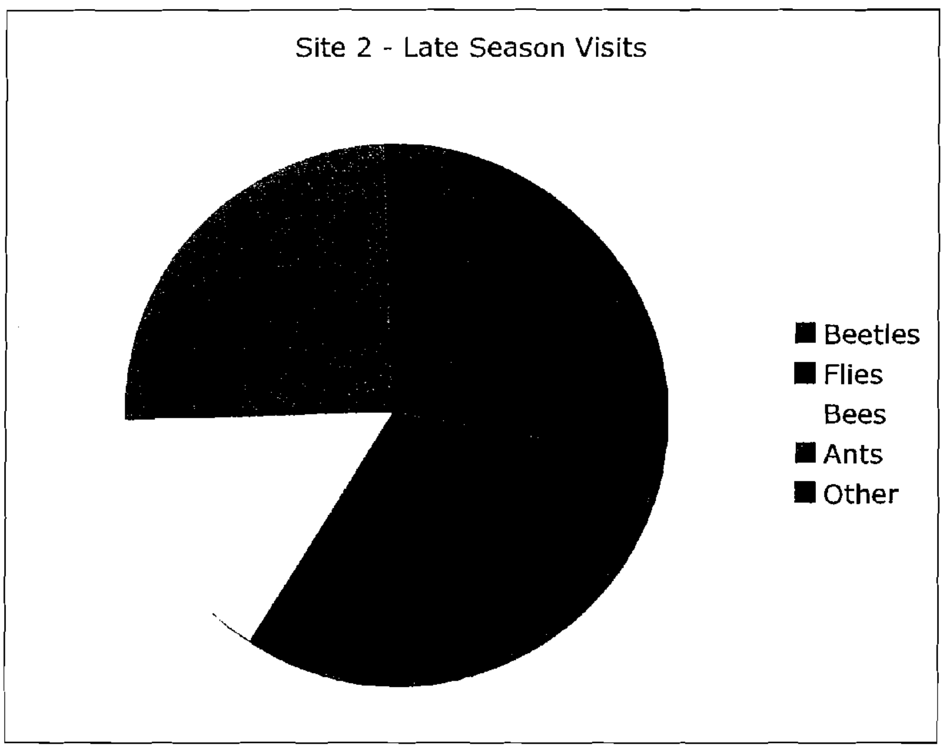


Figure 17. Combined data for all visits to the SFVS at Site 2 for 7-9 May 2004.

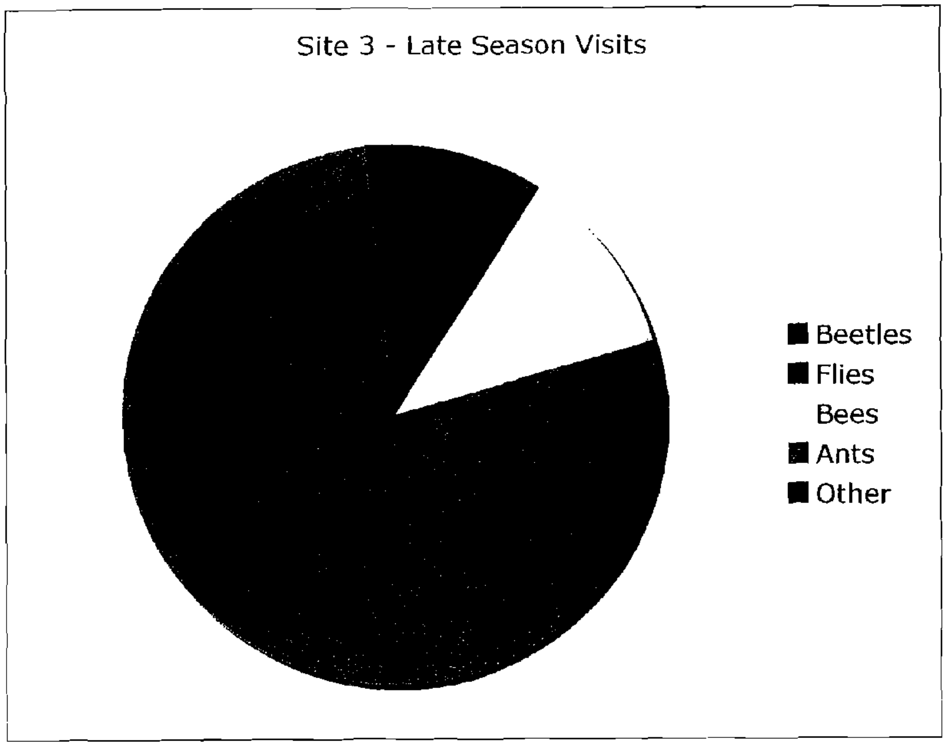


Figure 18. Combined data for all visits to the SFVS at Site 3 for 7-9 May 2004.

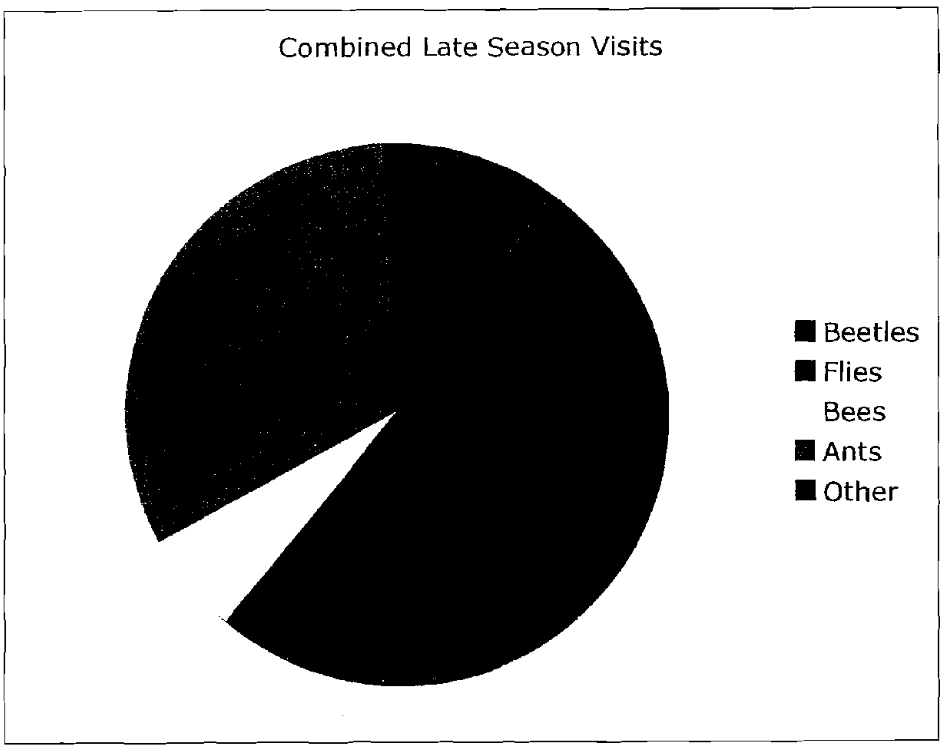


Figure 19. Combined data for all visits to the SFVS at Site 1, 2 and 3 for 7-9 May 2004.

Visitors to the flowers of the SFVS also varied substantially from site to site during our late-season observations conducted from 7-9 May 2004. Flies (83%) dominated the visitors at Site 1 (Figure 12), followed by beetles (12%). At Site 2 (Figure 13), there was a more equal distribution of visitors with beetles (31%), ants (28%), flies (25.5%) being the dominant visitors, whereas ants (70%) were by far the dominant visitors at Site 3 (Figure 14). Total visitors also varied considerably among the sites, with 429 visitors at Site 1, 133 at Site 2, and 171 at Site 3. Overall, 733, or about half the number of visitors seen during the mid-season, were observed on the flowers of the SFVS. During this late season, flies (54%), ants (24%), and beetles (16%) were the dominant floral visitors to the SFVS (Figure 15).

An examination of the number of flowers visited by each of the visitor groups shows that flies (90%) greatly outnumbered beetles (6.5%) at Site 1 (Figure 16). Flies (31%), beetles (28%), ants (25%), and bees (15%) almost equally dominated the visits at Site 2 (Figure 17). Ants (78%) made the most numerous visits at Site 3 (Figure 18), followed by bees (11%) and beetles (9%). Total visits varied among the three sites with 1483 at Site 1, 372 at Site 2, and 1009 at Site 3. Overall 2864 visits, or about half the number of visits seen during the mid-season, were made by the visitors to the flowers of the SFVS during the late season flowering period. During this late season, flies (51%), ants (32%), and beetles (10%) dominated the floral visits (Figure 19).

Invertebrate Community in the Vicinity of the SFVS and Potential Pollinators of the SFVS

General Patterns of Arthropod Abundance

We captured 4223 individuals consisting of 12 different insect orders, two arachnid orders (Acarina and Araneae), one myriapod (Chilopoda), one crustacean (Isopoda), and a large number of Collembola (Figure 20). Non-insect taxa made up a large portion of the sample. In particular, 45% of the sample was made up of Collembola.

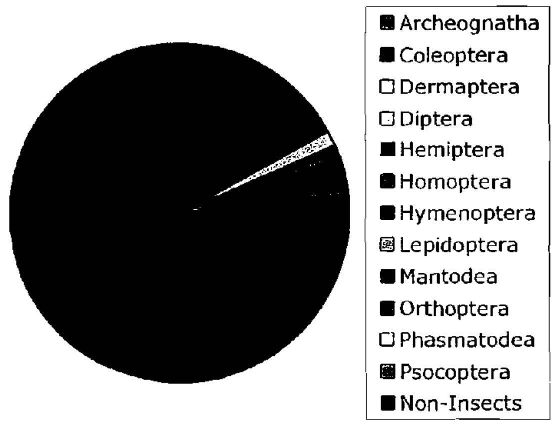
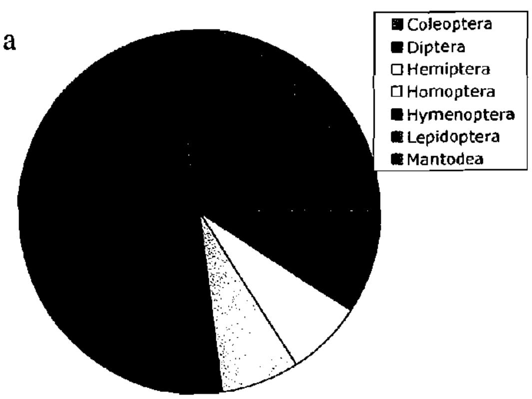


Figure 20. Relative abundance of different invertebrate taxa captured at Newhall Ranch.

Of the taxa captured during our sampling, 7 different orders of insect were captured on the SFVS (Figure 21a) and their relative abundance largely reflected their relative abundance in the community (Figure 21b).

a



b

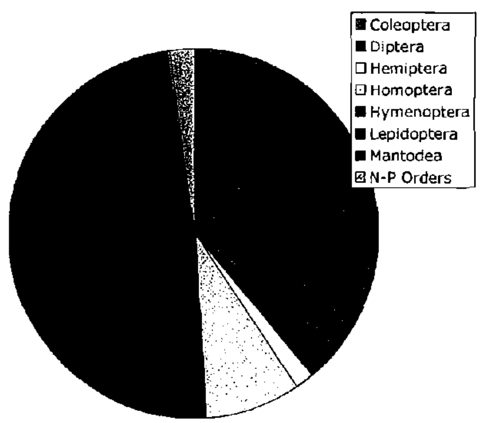


Figure 21 a & b. Insect community composition (relative abundance) of different insect orders captured on flowers (a) and near flowers (b). The near flowers sample includes data from pitfall traps and hand collected individuals. Non-Pollinator (NP) orders includes groups that were never observed on SFVS (Archeognatha, Dermaptera, Phasmatodea, Orthoptera, and Psocoptera). This group makes up only 3% of the entire sample.

In addition, the relative abundance of pollinator orders was correlated with their relative abundance in the community (Figure 22).

Order	Number of Morphospecies
Hymenoptera	31
Diptera	18
Coleoptera	15
Hemiptera	14
Homoptera	7
Orthoptera	6
Lepidoptera	3
Archeognatha	2
Psocoptera	1
Phasmatodea	1
Dermaptera	1

Table 3. Distribution of morphospecies across insect orders.

Patterns of Insect Species Diversity at Newhall Ranch

We identified 101 different morphospecies of insect. Hymenopterans (bees and ants) were the most diverse order of insects, followed by Dipterans (flies), Coleopterans (beetles), and Hemipterans (true bugs) (Table 3). The most abundant orders were generally the most diverse. Of the 101 different morphospecies, 49% are represented by a single specimen and 16 % by two specimens. Only in 7 morphospecies did we collect 50 or more individuals (Figure 23). These data indicate that there are number of infrequent species present and very few abundant species.

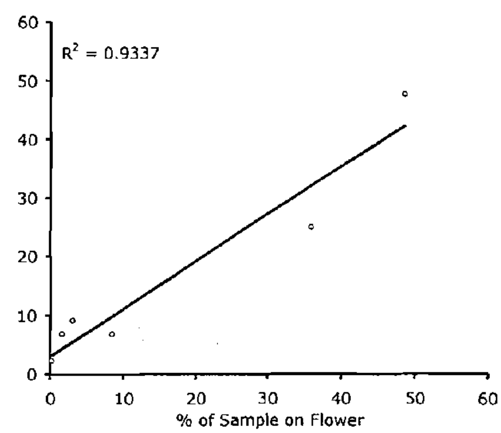


Figure 22. Relationship between the relative abundance of taxa captured on the spine flower and their relative abundance in the community (r=0.9663, P<0.05).

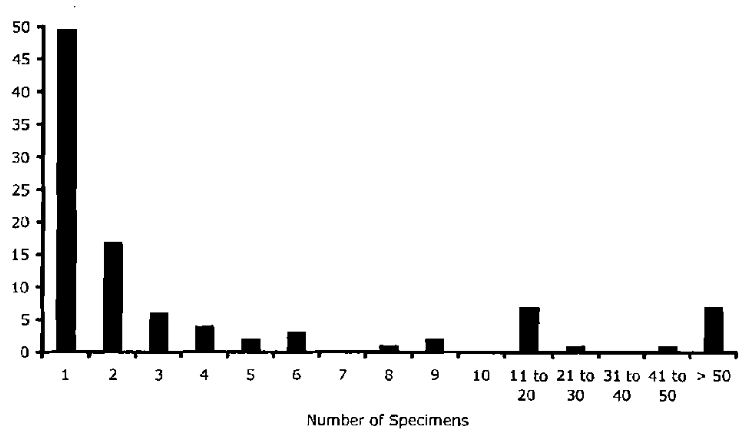


Figure 23. Number of individuals collected of each species.

Effects of Sampling Method

We sampled using two different methods. We used pitfall traps and, also, performed hand collections to catch species that were potential SFVS visitors. Pitfall traps primarily capture active ground- dwelling arthropods and will underestimate the abundance of inactive or non-ground dwelling species (e.g., Adis 1979; Spence and Niemelä 1994; Work, *et al.* 2002). We captured 1665 individuals from 69 different morphospecies using pitfalls and from hand- collecting we captured 291 individuals from 51 different morphospecies. Results of the two sampling methods share only 21 species in common (Jaccard Coefficient=0.21). In addition, based on species accumulation curves (Colwell and Coddington 1994), we have sampled the species captured with pitfall traps much more thoroughly than the species we collected by hand (Figure 24). This is evident since the species accumulation curve for the hand collection is essentially linear whereas the pitfall species accumulation curve is hyperbolic and the rate of species accumulation has decreased. Since we only estimated pollinator diversity using hand-collected individuals, it is possible that we have underestimated the number of pollinator species.

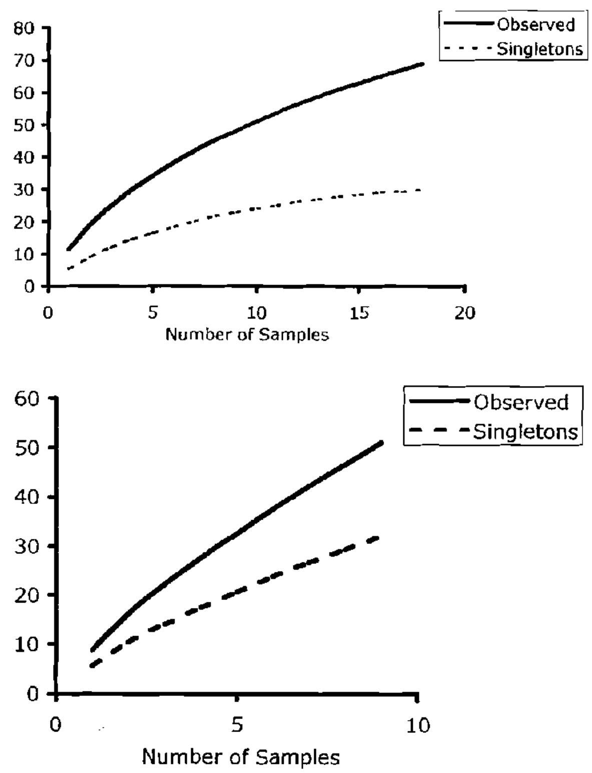


Figure 24. Species accumulation curves for pitfall trap (upper) and hand collected (lower) samples. Singletons are species represented by a single specimen.

Visitor Floral Constancy

Floral visitors collected on the flowers of the SFVS are listed in Table 4.

Table 4. List of all floral visitors captured on the flowers of the SFVS during the course of this study. Orders are abbreviated as follows: COL = Coleoptera; DIP = Diptera; HEM = Hemiptera; HOM = Homoptera; HYM = Hymenoptera; LEP = Lepidoptera; and MAN = Mantodea. The Hymenoptera were identified by Roy Snelling, an expert on that order of insects. All others were identified only to family due to the difficulty of identifying insects beyond that level (unless done by an expert in that group). All individuals captured during this study, whether on the flowers or in the vicinity of the plants, were grouped together into morphospecies (i.e. ones that looked alike and were assumed to be members of the same taxon) and given a number.

Order	Family	Genus	Species or Morphospecies	With Pollen	SFVS Pollen	Other Pollen	% SFVS
COL	Bruchidae	Unknown	MS-107	NO	0	0	
COL	Bruchidae	Unknown	MS-107	YES	1	0	100
COL	Bruchidae	Unknown	MS-107	NO	0	0	
COL	Bruchidae	Unknown	MS-107	NO	0	0	
COL	Melyridae	Unknown	MS-10	YES	1	0	100
COL	Melyridae	Unknown	MS-10	NO	0	0	
COL	Melyridae	Unknown	MS-10	NO	0	0	
COL	Melyridae	Unknown	MS-10	NO	0	0	
COL	Melyridae	Unknown	MS-10	YES	11	7	61
DIP	Bombyliidae	Unknown	MS-106	NO	0	0	
DIP	Bombyliidae	Unknown	MS-106	YES	2	0	100
DIP	Bombyliidae	Unknown	MS-106	YES	2	2	50
DIP	Bombyliidae	Unknown	MS-108	YES	5	5	50
HEM	Lygaeidae	Unknown	MS-78	YES	1	0	100
HEM	Lygaeidae	Unknown	MS-78	NO	0	0	
HEM	Lygaeidae	Unknown	MS-78	NO	0	0	
HOM	Cicadellidae	Unknown	MS-2	YES	5	0	100
HOM	Cicadellidae	Unknown	MS-2	NO	0	0	
HOM	Cicadellidae	Unknown	MS-2	NO	0	0	
HYM	Braconidae	Unknown	MS-18	NO	0	0	
HYM	Braconidae	Unknown	MS-109	YES	1	0	100
HYM	Braconidae	Unknown	MS-111	YES	1	0	100
HYM	Formicidae	Forelius	Mccooki	YES	1	0	100
HYM	Formicidae	Forelius	Mccooki	NO	0	0	
HYM	Formicidae	Forelius	Mccooki	NO	0	0	
HYM	Formicidae	Forelius	Mccooki	YES	1	0	100
HYM	Formicidae	Forelius	Mccooki	YES	1	2	33
HYM	Formicidae	Forelius	Mccooki	YES	1	0	100
HYM	Formicidae	Forelius	Mccooki	YES	16	0	100
HYM	Formicidae	Forelius	Mccooki	NO	0	0	
HYM	Formicidae	Forelius	Mccooki	YES	4	1	80
HYM	Formicidae	Forelius	Mccooki	YES	1	1	50
HYM	Formicidae	Forelius	Mccooki	YES	13	0	100

HYM	Formicidae	Forelius	Mccooki	YES	2	2	50
HYM	Formicidae	Forelius	Mccooki	NO	0	0	
HYM	Formicidae	Forelius	Mccooki	YES	11	0	100
HYM	Formicidae	Forelius	Mccooki	YES	8	0	100
HYM	Formicidae	Forelius	Mccooki	YES	1	0	100
HYM	Formicidae	Forelius	Mccooki	YES	2	0	100
HYM	Formicidae	Unknown	MS-110	YES	1	0	100
HYM	Formicidae	Unknown	MS-100	YES	3	0	100
LEP	Pyralidae	Unknown	MS-92	NO	0	0	
MAN	Mantidae	Unknown	MS-6	NO	0	0	

Of the 17 individuals of the small red ant species (*Forelius Mccooki*) caught on the SFVS flowers and sampled for pollen, 13 (76.5%) carried one or more pollen grains of the SFVS. Of the 13 that carried pollen, 9 (69%) carried only SFVS pollen and were 100% constant to the SFVS. The remainder (4) carried mixed loads, but all included some pollen of the SFVS.

The 43 insect floral visitors caught while visiting the SFVS represented at least 14 different species of potential pollinators. Of those 43, 25 (58%) carried pollen loads of one or more pollen grains. The 25 floral visitors that carried pollen loads represented at least 10 different taxa of potential pollinators for the SFVS. Of the 25 floral visitors with pollen loads, 18 (72%) carried only SFVS pollen, whereas the rest (7 or 28%) carried mixed pollen loads, but all included some pollen from the SFVS.

Effectiveness of Ants as Pollinators

The plants in Enclosure 1 produced a total of 2,977 flowers, whereas the plants in Enclosure 2 produced 2,480 flowers. This indicates that the number of flowers produced per enclosure was substantial and represented a good food source for potential pollinators.

Of the original plants in the two enclosures, 32 survived in Enclosure 1 and 27 in Enclosure 2 by the end of the experimental period. Fruits were produced by plants in both enclosures. The 2977 flowers found on the plants in Enclosure 1 produced a total of 1922 (64.6% fruit-set) one-seeded triangular achenes (fruit), whereas the 2480 flowers recorded in Enclosure 2 produced 723 (29.2% fruit-set) triangular achenes.

DISCUSSION

The reproductive biology of rare and endangered plants has been of great interest to biologists in developing management strategies (Purdy *et al.* 1994; Schemske *et al.* 1994; Luijten *et al.* 1996; Bernardello *et al.* 1999; Kaye, 1999; Timmerman-Erskine and Boyd1999). The conservation or reintroduction of rare species involves not only understanding factors affecting seed production, but also factors affecting long-term successful propagation (Giblin and Hamilton 1999). In order for a population to remain stable, the plants must flower and receive sufficient pollinators to produce viable seeds. Those seeds must receive enough nutrients and also avoid predation in order to establish and continue to grow to produce the next generation. Interference with any of these steps inhibits reproduction and, if consistent over time, may result in reduced populations (Kaye 1999).

It was the objective of this study to determine the pollination vectors of the SFVS on the Newhall Ranch, to determine if the plant was pollinator limited, to evaluate the arthropod community in the vicinity of populations of the SFVS, to determine how constant given SFVS flower visitors are to that plant, to investigate the effectiveness of ants as pollinators of the SFVS, and to compare the results of this study to those of the SFVS on the Ahmanson Ranch.

SFVS exhibits 9 of the 10 characteristics associated with ant pollination (Hickman, 1974), and at the Ahmanson Ranch ants were the dominant visitors (Jones, et al., 2002). However, it is quite obvious from the dawn-to-dusk observations done during this current study, as well as those carried out at the Ahmanson Ranch (Jones, et al., 2002), that there is substantial diversity in the visitors to SFVS flowers. There is a strong correlation at the level of insect orders between the insect visitors captured on the flowers of the SFVS and those insects captured in the community in the vicinity indicating that the SFVS is not pollinator limited and can be pollinated by a rather large diversity of pollinators. In fact, the dominant floral visitors found during our studies at the Newhall

Ranch were flies (especially beeflies), beetles, and ants, especially a little red ant, *Forelius Mccooki,* whereas the dominant floral visitors at the Ahmanson Ranch (Jones, et al., 2002) were two species of ants (*Dorymyrmex insanus* and *Solenopsis xylonii*), the honeybee (*Apis mellifera*), and a small beetle (*Zabrotes* sp.).

The insect community was quite diverse and both sampling methods captured a number of infrequent species as evidenced by the high percentage (~50%) of species represented by only a single specimen (singletons). Given this and the fact that the species accumulation curves did not reach an upper asymptote, it is very likely that we have underestimated the insect diversity in this community. However, these results are not unlike other studies of arthropod communities in coastal sage scrub (CSS). Burger, *et al.* (2003) found that approximately 51% of their 169 morphospecies were represented by a single specimen. Their results and ours suggest that the terrestrial arthropod community in CSS is very diverse and adequately sampling the terrestrial arthropod diversity will require a much greater sampling effort than that represented in this study.

We found that 14 of 101 insect morphospecies were captured on the flowers of the SFVS and might be potential pollinators. Of these 14 species, 10 carried grains of SFVS pollen. Interestingly, our sample of potential pollinators contained 8 singletons, which also suggests that there is a number of species with very low abundance in this community and again potentially indicates that we have probably under-estimated the insect diversity in this community. Regardless of these issues, it is clear that the most abundant orders of insects in our sample (e.g., Hymentoptera, Coleoptera) also represent the largest number of potential pollinators. In addition, it is unequivocally clear that numerous species, representing a diversity of insect orders, are potential pollinators in this system.

Forty-three total visitors were captured on the flowers of the SFVS. Of those, 58% were found to be carrying pollen loads and, of that 58%, 72% carried only pollen of the SFVS, indicating that many of the visitors to the flowers of the SFVS were constant to that species and did not visit other species in bloom in the area on that foraging bout.

This level of constancy means that these species are relying on the resources provided by the flowers of the SFVS (pollen and nectar) as a significant part of their food intake or food for their developing larva.

By far the most common insect captured on the flowers of the SFVS (17 of 43 or 39.5%) was the small red ant, *Forelius Mccooki*, of which 13 of 17 (76.5%) carried one or more pollen grains. Carrying even one pollen grain of the SFVS is significant since the flowers of the SFVS have only a single ovule in the ovary of the flower; therefore, one pollen grain could affect a successful reproductive event if properly transferred to the stigmatic surface. From these data, it appears that this ant species is a significant pollinator of the SFVS on the Newhall Ranch.

The results from the study of the possible effectiveness of native ants as pollinators of the SFVS suggest that *Dorymyrmex insanus,* a dominant ant visitor to the SFVS on the Ahmanson Ranch, is an effective pollination vector. These results are quite preliminary since there has not been time (we did not get the seed to do this study from RSABG until the end of June 2004 and that late date would have prohibited us from doing any studies where mature plants had to be used. Luckily, we had some seed from the Ahmanson Ranch project and we used that seed for these preliminary studies) to do any germination studies of the seed produced by the plants in the enclosure with ants (Experimental) versus the one without ants or any other pollination vectors (Control). We plan to conduct these germination studies this coming spring (to 2005). The results from these germination studies will provide us with additional information regarding the fertility of the seeds set in both enclosures, especially seed set in the enclosure where every effort was made to exclude all possible pollination vectors. If the seeds from this latter enclosure are viable, it will be an indication that the plants set viable selfed seed without vector assistance.

In our study of the SFVS at the Ahmanson Ranch (Jones, *et al.*, 2002), we did find approximately 25% fruit/seed set when all pollinators were excluded (selfing without a vector) compared to approximately 55% fruit/seed set in the open pollinated controls.

However, no viability studies of those seeds were conducted. These seed set percentages compare favorably with those found in the current study (64.6% when only ants were permitted to visit the plants compared to 29.2% fruit/seed set when all pollinators were excluded), but the current study used different methods and was carried out under more controlled circumstances. If the seeds set in the absence of pollinators prove to be viable, it will further indicate that this plant is not pollinator limited and could reproduce in very "bad" years (e.g. those with very low rainfall) even in the absence of or the severe reduction of its pollination vectors.

There is no way to be absolutely sure that all pollination vectors other than the introduced ant species were excluded. The results of this experiment, however, do indicate that exclusion was sufficient enough to show that ants do, indeed, function as effective pollination vectors of the SFVS, especially when compared to seed set in plants where pollinators were excluded (suggested by the very low seed count from the control).

SUMMARY AND RECOMMENDATIONS

1. It is clear from our data that the SFVS is not pollinator limited. This conclusion is supported by the dawn-to-dusk data taken at the Newhall Ranch and at the Ahmanson Ranch. Further, there is a significant correlation, at the level of insect orders, between the spectrum of floral visitors and the spectrum of insects captured during this study in the habitat surrounding the dawn-to-dusk study plots, indicating that if the insect is found in the area where the SFVS grows, it may very well use the flowers of the SFVS as a source of food.
2. Our data demonstrate that ants are effective pollinators. This conclusion is supported by the comparison of fruit/seed set between plants exposed only to ants as possible pollination vectors versus those plants where all pollinators were excluded.
3. It appears from our data from the current study and those from the Ahmanson Ranch (Jones, et al., 2002) that the SFVS can and does set fruit/seed without the aid of any pollination vectors. Although this needs further verification by growing the plants in indoor exclusion enclosures in growth chambers (where we can completely restrict the possible entrance of other pollinators), we feel that this ability to self and set fruit/seed without a pollination vector demonstrates two things. First, that even under extreme conditions of drought where both plant and pollinator populations are greatly reduced in numbers, plants of the SFVS that do germinate, survive to maturity and flower, will set some fruit/seed (it appears to be around 25%), thus ensuring the continuity of the species through this limited reproductive success. Secondly, given the fact that the SFVS is pollinated by a myriad of possible pollinators, but that the vast majority of them are small, rather sedentary insects, pollen dispersal would seem to be quite limited. This would tend to decrease gene (pollen) flow between or among the many populations that occur on the Newhall Ranch. This limited pollen dispersal, coupled with the rather high percentage

of selfing found here and at the Ahmanson Ranch, indicates that any given population of the SFVS may accumulate unique alleles. Conserving such alleles would be important in maintaining the genetic flexibility required to successfully adjust to any future environmental changes.

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Site 2. Airport Mesa South – photo of area showing the habitat in which the data were collected for this site.

Site 3. Magic Mountain - photo of area showing the habitat in which the data were collected for this site.