**Identifying plant-pollinator relationships of the Riverside coastal sage scrub ecosystem for habitat and plant conservation**

Principal Investigator: C. Sheena Sidhu (Postdoctoral Researcher),

co-Principal Investigator: Erin E. Wilson Rankin (Assistant Professor),

Department of Entomology, UC Riverside

**Overview**

The coastal sage scrub ecosystem of Riverside County is threatened due to agriculture and increasing urbanization (Minnich & Dezzani 1998). This ecosystem provides habitat for many rare and native plant species, which are monitored for conservation (MSHCP 2013). For management to be effective, it is valuable to consider multiple interactions and relationships within the ecosystem, such as proposed through the Multiple Species Habitat Conservation Plan (MSHCP 2003). One interaction particularly critical for plant conservation is the plant-pollinator relationship (Waser & Ollerton 2006). Pollinators play the essential role in plant reproduction for ~75% of floral plants globally, and this propagates plant populations (Committee on the Status of Pollinators in North America 2007). Therefore, pollinator management and identifying plant-pollinator relationships is necessary for maintaining a healthy ecosystem.

**Research aims**

Our research aims to support coastal sage scrub habitat and plant conservation by examining pollinators, particularly bees, which provide the essential ecosystem service of pollination. Our research goals are to: 1) identifying plant-pollinator interactions in the coastal sage scrub ecosystem, and 2) measure the reproductive success of plants provided by the services of pollinators.

**Research methods and modifications**

Due to the ongoing severe drought and other minor factors, we made several strategic changes to the original proposed plan while still addressing our overall research goals. The following section outlines our revised research methods and explains modifications.

Objective 1) *Identifying plant-pollinator interactions in the coastal sage scrub ecosystem*

*Methods:* To first identify the pollinators present in the coastal sage scrub community (which has been understudied in southern California), we set out vane traps every three weeks during the winter season proceeding rainfall and continuing through peak bloom of several plant species. Vane traps are used to attract and collect insects (Rao et al. 2011). Vane traps were placed in 6 key sites in January (prior to peak bloom), and was expanded to 9 sites in subsequent sampling periods at Motte Rimrock Reserve in Perris, CA. The 9 sites were selected based on the dominate presence of key plant species we focused on for this study (see Table 1). The vane trap collections will allow us to correlate pollinator communities with plant species present at each site, via multivariate analysis.

**Table 1**: Sites sampled for pollinators at Motte Rimrock Reserve, and dominate flower species at each site.

|  |  |  |
| --- | --- | --- |
|   | **Site name** | **Dominant plant species** |
| 1 | CA broom patch\* | *Acmispon glaber* |
| 2 | Annual patch | *Calandrinia ciliata, Cryptantha sp.* |
| 3 | Buckwheat Gully | *Eriogonum fasciculatum* |
| 4 | Cactus patch\* | *Opuntia parryi* |
| 5 | Goldfield site | *Lasthenia californica* |
| 6 | Hilltop site | *Phacelia minor, Solanum xanti* |
| 7 | Poppy field\* | *Eschscholzia californica* |
| 8 | Sage site | *Salvia mellifera*  |
| 9 | Squash patch | *Cucurbita palmate* |

\* site added after January sampling

In addition, we collected pollinators directly from plants to record direct plant-pollinator interactions. This will be used to construct a plant-pollinator network to identify how the plant and pollinator community interacts with each other, and changes overtime (Bascompte & Jordano 2007).

*Modifications:* Due to the drought, we have focused on floral species proceeding the winter rain instead of monthly sampling throughout the year. We are currently in the middle of our field season. Although we have found a diversity of floral visitors at our research sites, overall bee abundance and visitation activity has been low. We have supplemented vane-trap samples with actively collected pollinators from plants when possible in order to identify plant-pollinator interactions and relationships. We foresee that continued research and long-term sampling will provide robust plant-pollinator network information.

Lastly, we had proposed to conduct our research at the Shipley-Skinner Reserve, however Motte Rimrock Reserve (a UC Reserve) is a similar habitat within Riverside County, has predictable floral diversity, and is located at a closer proximity to the UCR campus.

Objective 2) *Measure the reproductive success of plants provided by the services of pollinators.*

*Methods:* To measure the contribution of pollinators to plant reproduction, we excluded pollinators from flowers of select plants in the coastal sage scrub community. To exclude pollinators, ten flower buds were bagged using fine-meshed bags for medium to large flowers, or fine-mesh tents were erected over complete plants of small flowers (Kearns & Inouye 1993). Flowers were allowed to open and continue blooming within the bags. Upon plant seed-set, seedpods will be collected from bagged and adjacent unbagged plants to statistically compare seed set of pollinator-excluded and pollinator-accessible plants. This will allow us to evaluate the contribution of pollinators to reproductive success of coastal sage scrub plants. Reproductive success will be related to the pollinator community present at each site (as describe in Obj. 1) to identify potential pollinators.

*Modifications:* We originally planned to measure pollination efficiency by observing pollinators visiting flowers and subsequently limiting pollination (i.e. allowing 3, 6, or 12 pollinator visits before bagging flowers and relating visitation number to seed set). However, although we have found floral visitor diversity at our research sites, bee visitation activity has been low so we had to modify the methods to address our objective. Instead, we used the bagged vs. unbagged flower method described above to measure the value of insect-mediated pollination without measuring visitation rate, because of low bee activity at the sites.

We had also planned to focus on bumble bee species, as outlined in our proposal, but bumble bee abundance has been its lowest in decades, perhaps associated with the drought. Future, long-term sampling at the study-site and similar habitats can provide more information about bumble bee communities in coastal sage scrub ecosystems.

**Progress, to-date**

To-date, we have dispersed vane traps 4 times (Jan 14, Feb 19, March 2, March 15), with preliminary information from the first three sampling periods. We collected far fewer individuals in the vane traps in January, which was when fewer flowers were in bloom. Collections increased dramatically as plants began to flower in the subsequent months (Figure 1). Similarly we have observed an increase in total pollinator diversity since January, where average diversity per site has increased five-fold (2.6 ± 1 vs. 10.1 ± 4.3 morphospecies/site in January and February, respectively; March data not yet measured). We anticipate a decline in samples collected as floral resources decline throughout the spring and summer.

 **Figure 1:** Average number of pollinators collected from vane traps each month

While the overall abundance has increased after winter rains, the collection by site varies (Figure 2), likely due to floral phenology and floral availability. As we continue this study, future analyses will include connecting pollinator abundance and species diversity to floral availability in order to relate pollinator communities with the floral communities of the coastal sage scrub ecosystem.

We are continuing to collect samples at Motte Rimrock Reserve and process them (pin and label) at the Rankin Lab at UCR. Pollinators have been preliminarily categorized into morpho-species groups, and will later be identified to the species level prior to multivariate analyses (Table 2).

**Figure 2:** Pollinator abundance by site, each month

\*site added after January sampling

**Table 2:** Pollinators collected from vane traps (January and February), identified by morpho-species categories

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Order** | **Morpho-species ID** | **Common name** |
| 1 | Coleoptera | small Coleoptera | small black beetle |
| 2 | Diptera | small house fly | small house fly |
| 3 | Diptera | small Diptera | small fly |
| 4 | Diptera | small syriphid | small flower fly |
| 5 | Diptera | large Muscidae | house fly |
| 6 | Diptera | Diptera | fly |
| 7 | Hemiptera | Hemiptera | true bug |
| 8 | Hymenoptera  | *Anthidium* sp. | wool carder bee |
| 9 | Hymenoptera  | Vespidae | wasp |
| 10 | Hymenoptera  | Halictid | sweat bee |
| 11 | Hymenoptera  | small Halictid | small sweat bee |
| 12 | Hymenoptera  | Andrenidae | mining bee |
| 13 | Hymenoptera  | *Melissodes* sp. | long-horned bee |
| 14 | Hymenoptera  | *Apis mellifera* | honey bee |
| 15 | Hymenoptera  | green Halictid | green sweat bee |
| 16 | Hymenoptera  | *Xylocopa* sp. | carpenter bee |
| 17 | Hymenoptera  | *Diadasia* sp. | cactus bee |
| 18 | Hymenoptera  | *Bombus* sp. | bumble bee |
| 19 | Hymenoptera  | *Lasioglossum* sp. | small bee |
| 20 | Lepidoptera | Lepidoptera | moth |
| 21 | Lepidoptera | Sphingidae | hawk moth |
| 22 | Lepidoptera | *Vanessa* sp. | brush-footed butterfly |

Based on collecting pollinators directly from plants to document plant-pollinator interactions, we have completed preliminary network analyses to identify the interactions of the plant-pollinator community, see Figure 3 for example.

**Figure 3:** Plant-pollinator network of interacting species at Motte Rimrock. The network is constructed similar to a classic “food web” with only two levels. Here, pollinators are listed on left side of network, and plants listed on right side of network, where the length of the (purple) blocks represents the relative number of interactions observed per individual species (i.e. the larger the block, the more interactions observed. The (red-orange) lines connecting pollinators and plants represent the interactions observed 

Pollinator-excluded (bagged and tented), and pollinator-accessible (no bag or tent) flowers have been set up during peak bloom of several flower species (*Acmispon glaber, Calandrinia ciliate, Camissonia bistorta, Cryptantha sp, Lasthenia californica, Phacelia minor, Solanum xanti*)*.* Seedswill be collected approximately April-May 2015 once they have set. After seeds are processed and counted in the Rankin Lab, we will estimate the benefit of pollinator services by assessing differences in seed set between bagged and unbagged flowers.

All analyses will be completed following pollinator species-level identification and seed count to produce publications and species lists (see *Outputs* below).

**Outputs**

We will continue to analyze our data to produce the following outputs:

1. **Publication of bee and pollinator records and plant-pollinator interactions**
	* This will provide a published record of pollinators found in Riverside County
	* Published records of pollinator communities will help future coastal sage scrub management
	* We will highlight any new species records for Riverside County, and the unique inland coastal sage scrub community
2. **Bee species list for Motte Rimrock Reserve**
	* This will aid future researchers and is a valuable contribution to this relative young UC Natural Reserve
	* List will include observed floral relationships
3. **Present findings at scientific conferences and share results with conservation organizations**
	* This initial study may spark future research and collaborations
	* Plant-pollinator interaction information can be used by plant conservation organizations such as California Native Plant Society and insect conservation organizations, such as Xerces Society for Invertebrate Conservation to promote native floral plantings and habitat management to support pollinators, which contribute to a healthy ecosystem
4. **Training for UC Riverside undergraduates**
	* We will continue scientific training of 3-4 UC Riverside undergraduates
	* This concurrently provides mentoring and management experience for postdoctoral researcher (lead PI)

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