Migration Study Planning and Protocol

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Objectives:

1. *Proof of Concept -* do passive audio monitors accurately estimate hummingbird density/abundance/activity? (Methods in Ecology & Evolution)
2. *Hummingbird occurrence and phenology* – What drives hummingbird migration: Is migration driven by plant phenology (flowering plants and nectar abundance)? Is bird abundance related to nectar abundance and patch size? Do weather events drive bird migration?

**Dates, Table 1:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sun** | **Mon** | **Tues** | **Weds** | **Thurs** | **Fri** | **Sat** |
| **11**  set up | **12**  set up  @SWRS | **13**  set up  4 top sites  @SWRS  training | **14**  set up  @El Coro.  Supplies in Douglas | **15**  set up  @El Coro. | **16**  sites  ST/MR  @El Coro. | **17**  sites  CP  @El Coro. |
| **18**  sites  OS1/OS2  @Onion Saddle | **19**  sites  LP/TC  @Portal | **20**  data/supplies in Douglas  @El Coro. | **21**  day off  @El Coro. | **22**  Sites  ST/MR  @El Coro. | **23**  sites  CP  @El Coro. | **24**  El Coronado HMN bird banding  @SWRS |
| **25**  SWRS  HMN bird banding  @SWRS | **26**  sites  LP/TC  @Onion Saddle | **27**  sites  OS1/2  @El Coro. | **28**  data/supplies in Douglas  @El Coro. | **29**  day off  @El Coro. | **30**  sites  CP/ST  @El Coro. | **31**  sites  MR  @El Coro. |
| **1**  sites  OS1/OS2  @Onion Saddle | **2**  sites  LP/TC  @El Coro. | **3**  data/supplies in Douglas  @El Coro. | **4**  day off  @El Coro. | **5**  sites  ST/MR  Take-down  @El Coro. | **6**  sites  CP  Take-down  @El Coro. | **7**  El Coronado HMN bird banding  @SWRS |
| **8**  SWRS  HMN bird banding  @Sunny Flats | **9**  sites  LP/TC/  OS1/OS2  Take-down  @Patagonia | **10**  Patagonia  Wrap-up | **11**  Patagonia wrap-up | **12**  Drive to Tucson  Sarah head home | **13**  Sierra Vista meeting | **14**  Gaby, Andrea, & Susan wrap-up |

**Sites, Table 2:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Site Name** | **Site Code** | **Dominant floral species** | **Location in Chiricahuas** |
| Coal Pit | CP | *Bouvardia ternifolia* | West |
| Saulsbury Trail | SB | *Bouvardia ternifolia* | West |
| Mormon Ridge | MR | *Bouvardia ternifolia, Stachys coccinea* | West |
| Onion Saddle 1 | OS1 | *Castilleja austromontana* | Saddle |
| Onion Saddle 2 | OS2 | *Penstemon barbatus, Salvia lemmonii, Silene laciniata* | Saddle |
| Long Park | LP | *Delphinium parishii, Mertensia franciscana* | Peak |
| Turkey Creek | TC | *Mimulus cardinalis, Delphinium parishii, Mertensia franciscana* | Peak |

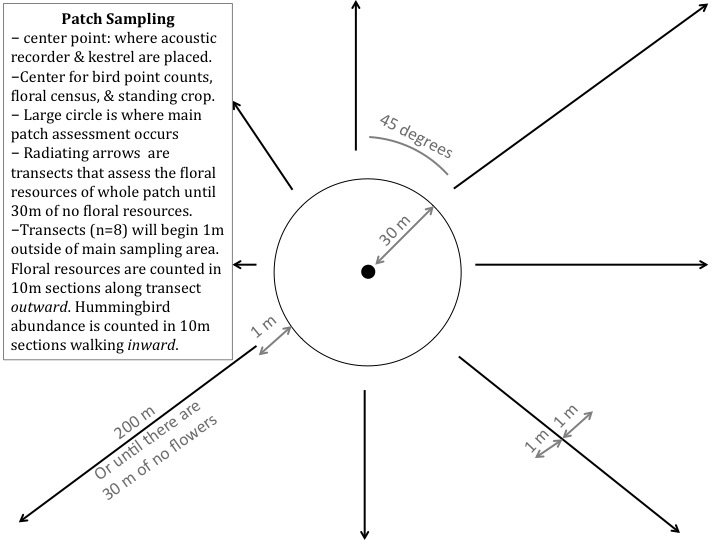
**Field Protocol:**

1. **Establishing the sites and the points**

To meet the project objectives of 1) calibrating Song Meters to estimate hummingbird activity/abundance and 2) determining the role of plant phenology, nectar abundance, and weather in influencing hummingbird occurrence and abundance during migration, we identified 7 floral patches in the Chiricahua Mountains (Table 2) during peak hummingbird migration (mid August – mid September). A monitoring point was placed near the center of a floral patch, in an area of suitable resources for hummingbirds. An acoustic recorder (AR; Song Monitor 2M+) was mounted at this point, and we returned weekly to conduct point counts, floral census, and nectar census at this point (w/30 m radius) for approximately 4 weeks. A Kestrel weather station was hung near the AR and continuously recorded weather information. For each site, we recorded latitude, longitude and elevation at the center sampling point. Data from the 8 transects were used to estimate patch area, perimeter, resource abundance and density, and hummingbird activity.

To estimate habitat heterogeneity and overall floral abundance around the focal point, we established 8 evenly spaced transects radiating out from the central point, beginning 1 m from the edge of the main census area and continuing for 200 m, or until no floral resources were encountered for 30 m. At this point, we made the assumption that we had left the focal patch. Walking the transect *outward*, we conducted a secondary floral census, and recorded the number of flowering plants of each hummingbird resource species within 1 meter of either side of the transect (see figure below) in 10 meter sections. For example: the number of plants of each species were recorded for meters 0-10, 10-20, 20-30, etc.

Each patch was visited 4 times (weather permitting). Sites were located as close to roads as possible to minimize travel time (driving, hiking), and so that sites could be censused often.



1. **Methods and data**

At each patch, we studied the hummingbird and resource abundance using four methods: acoustic recorders, point counts, standing crop measurements and floral censuses. On field days, we collected point count and standing crop data in the morning, within the first 5 hours after dawn. Floral census data was collected during daytime hours after the other data collection was been completed, because it was less temperature sensitive. We conducted a second mid-day or afternoon point count and transect count for hummingbird activity during each site visit as weather conditions allowed. The methods and their description are explained below.

* 1. **Acoustic Recorder**

We placed an acoustic recorder (AR) to passively monitor the acoustic landscape at each site. We replaced batteries and SD cards weekly to eliminate gaps in the data. AR batteries needed be replaced within 10 days to minimize the chance that it ran out of power and stop recording. During each visit we transferred the AR data from the SD cards to an external hard drive. The hard drive was backed up on a second external hard drive after each data transfer. Acoustic data was analyzed using Song Scope software. Sampling rate should be no more than 2xs the frequency desired (set other important parameters, See Song monitor software handbook). The recorder was placed in the center of a patch, near suitable floral resources.

* 1. **Point counts**

The aim of the point count is to collect data on hummingbird activity/abundance and diversity. We conducted two sets of point counts during each weekly visit to a site, morning (within 5 hours of sunrise) and afternoon (3 pm – dusk). Each point count included two measurements, *inward* and *outward* from the central point. **1)** Two observers stood at the AR point for each patch, and recorded hummingbird data for 1/2 each of the radius *outward*. When standing near a recorder, each announced presence with names. Distance to each observed bird was estimated by eye or using a range-finder. At each point, we set the chronometer to zero, and then waited 2 minutes before collecting data to account for disturbing the birds. For the next 10 minutes, we recorded each individual observed (species, sex, detection method, estimated distance, and observed behavior). If a bird crossed the peripheral vision (between the two people) it was flagged on the data sheet, indicating that it may be a double-counted bird. As long as the observer could see an individual, it was counted as only one bird. If the observer lost track of an individual, then the next bird seen was counted as a new individual. The nature of counting migrating hummingbirds is that there *will* be some double-counted birds. Our point count is designed to get an estimate of activity or abundance and is limited by the difficulty of accurately tracking and counting small, flying animals. **2)** Two observers stood 30 m away from the point, at opposite cardinal directions, and observed *inward* toward the AR. This was an attempt to minimize user interference with recorders, and still get data for calibration. As time and weather permitted, we conducted a second hummingbird census around the point and on transects in mid-day or late afternoon.

* 1. **Floral census**

We applied this method once per visit, usually in the morning. The phenology census was carried out within the 30 m radius of the point count location for each site. The objective was to count all individual flowering plants that are potential hummingbird resources. (Note: flowering plants that are not used by hummingbirds were not counted, and plants that did not have any buds, flowers, or fruits were not counted.) For a subset of each species, we recorded the number of fruits, flowers, and buds, and flower stage (phenology of flowers). We randomly chose 15 plants in the patch to count buds, fruits, and flowers, and to estimate plant height and width. This data was used to extrapolate the resource abundance for the whole patch. If there were fewer than 15 plants of a species, all individual phenology was censused.

The number of flowers, buds and fruits (f/b/f) for **each flowering plant** can be estimated by one of the following three methods.

* **Total f/b/f method**

If there were easily countable numbers of f/b/f, we counted all of the f/b/f on the plant.

* **Inflorescences**

If there were clearly defined inflorescences in a species (e.g., *Ocotillo*), and too many inflorescences per plant for all to be estimated, the number of f/b/f for **10 randomly chosen** inflorescences per plant were counted. The total number of inflorescences in every plant that is counted must also be recorded. The information was used to estimate the total number of f/b/f.

* **Section within a plant**

In large plants, which have dense clusters of f/b/f (e.g., *Penstemon*), this method was used. Each plant was divided into sections (each section must cover the vertical height of the plant/cluster). Within a section, count the number of f/b/f, and recorded the number of sections per plant. The information was used to estimate total f/b/f.

It must be noted that there are two sets of methods here. **1)** Count all the flowering plants of a given species in an area. **2)** Within a plant, there are three possible ways of counting the numbers of f/b/f. You could **a)** count all the f/b/f on a plant, or **b)** count f/b/f for 10 inflorescences and record total inflorescences in the plant, or **c)** count f/b/f in a section, and record total number of sections on the plant.

* 1. **Standing crop**

We applied this method within 5 hrs of daybreak weekly. The standing crop method was used to estimate the nectar abundance and quality that was potentially available to hummingbirds. For each flower, the flower stage was also recorded.

Nectar was taken from a sub-sample of flowers for every plant species within the 30 m radius of the point count that was a potential hummingbird resource. The number of flowers taken for standing crop measurement was dependent upon the total number of flowers for each species within the patch. Flower number was visually estimated, and if flowers were abundant, we took 30 flowers for each species (<= 5 flowers per single plant). If 30 flowers represented more than 20% of the flowers present for a species, we took 20 or 15 flowers. If flowers were relatively rare, we took as few as 10 flowers for a species. If there were very few flowers, and 10 flowers represented more than 20% of the total number of flowers for the species, we did not collect nectar for standing crop.

To characterize nectar resources, techniques described in Kearns & Inouye (1993) were used. Both nectar volume and sugar concentration of a flower were measured. Below is a summary of this procedure:

We used micro-capillary tubes to remove flower nectar. The flower was broken off at the base of the pedicel (stalk of the flower). It was turned upside down and squeezed gently so that the nectar rises and forms a bubble, which was collected using the micro-capillary tubes. [Note: If the flower’s corolla was wide and it is possible, a capillary tube is inserted into through the corolla to the nectar chamber, and the nectar is extracted by capillary action].

Once all the nectar in the flower was extracted, we measured the length of nectar in the tube. Then, to quantify the concentration of sugar, we use a manual field refractometer (ATAGO, 0-32% Brix, calibrated for temperature). The nectar was manually blown out of the capillary tube onto the measuring surface of the refractometer, and the Brix level was recorded. At the beginning of each sampling day, the refractometer was cleaned using distilled water and calibrated.

Later, we determined the volume in microliters (ul) with the following formula:

Using a formula in MS Access, we calculated the Molarity corresponding to the % sucrose (Brix reading from refractometer). The formula was found in R by matching it to the data reported in the conversion table from Kearns & Inouye (1993) pp. 172. Where x = the Brix reading for % sucrose:

Molarity = 2.92e-02x + (1.097e-04x2) + (4.761e-07x3) + (4.310e-10x4)

Then, the calories in a flower are calculated using the following formula:

The constant is the number of calories per mL of 1 Molar sucrose solution.

**2.5 Transects**

**2.5.1 Floral census**

The 8 transects allowed us to assess floral abundance and heterogeneity of the larger patch, define patch extent, better represent the resources that detected hummingbirds have access to, and determine the overall quality of the patch with regards to nectar and floral abundance.

Starting 1 m from the edge of the 30 m radius, we walked outwards in a straight line. For each 10 meters paced out along the transect, we counted the number of flowering plants of each species within 1 meter of each side. When we walked 30 m and had not recorded any plants, we ended the transect. Mark the end of the transect with a GPS point, so it can easily be relocated for afternoon focal observations.

**2.5.2 Focal observations**

From the end of the transect, we walked towards the center point. We recorded hummingbird presence along the transect, distance to each bird, and if feeding, which flowers they visited. In the afternoon, we returned to each patch to repeat the observations, but not the floral census, along the transects.

**2.6 Nectar Production**

Nectar production may give us a proxy for nectar amount/quality. Nectar production was done on a per species basis. Flowers were covered with a bag so pollinators could not reach them. After approximately 24 hours, we returned to the bagged plants and collected the nectar produced during that period. We took data once for each species. Nectar production was taken near to, but *not* at sampling sites.

**2.7 Pollen Collection**

This was a side project that may be used to identify pollen found on hummingbirds during banding/trapping events. For each plant species, we collected pollen on several slides to be examined later in the lab.

**2.8 Building the Recognizer**

We made several recordings at feeders at El Coronado and at SWRS as a way to guarantee getting good recognizer data and to test the distance at which the recorder may be picking up calls/wingbeats. Unfortunately, this data was lost due to an unknown technical failure of our SD card or AR.

We may also use Xeno Canto, Cornell Birds of North America, and other bird sound databases to build recognizers. Record time of observation, and write bird species names (age, sex if possible) next to time of sound. We can listen to these in the lab.

**5. Supplies:**

* Kestrel weather monitoring station
* Song Meter SM2+ station
* Extra SD or SDHC cards
* Screws (for mounting)
* Field guides (wildflower, grass, herb, and tree – Chiricahuas/Chihuahuan)
* Datasheets
* Clipboards
* Tape measures
* Binoculars
* Range finder
* Chronometer
* Anemometer
* Refractometer
* Clinometer
* Calipers
* Micro-capillary tubes
* Handheld Kestrel
* GPS
* Compass
* Flagging tape
* Chargers (laptop, phone, equipment)
* Lots of batteries (D, AA)
* Laptop
* Ziploc bags
* Headlamps
* First aid kit
* Campstove
* Basic set of dishes/pots/utensils for camping
* Garbage bags
* Tents/sleeping bags/mats
* Mini plant press

**REFERENCES**

Kearns, C. A. and Inouye, D. W. 1993. *Techniques for Pollination Biologists*. University Press of Colorado, Niwot, CO.