Project Report – January 2017
Understanding the effects of nutrition and juvenile hormone on reproductive output in alkali bees (Nomia melanderi) and Characterizing microbial associates of alkali bees

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Health and reproduction are critical aspects of native pollinator biology, because the number of pollinators available each year is limited by the survival and number of offspring produced the previous year. Furthermore, pollination by bees is mostly the result of female bees collecting nectar and pollen to provision their developing offspring. Understanding the factors that influence bee health and reproductive output, as well as the dietary needs of female bees during different stages of their reproductive cycle is thus a crucial element of maintaining pollinator populations.

Alkali bees (Nomia melanderi) are important native pollinators of alfalfa (Medicago sativa), and thus are a valuable resource for alfalfa seed growers. I have proposed experiments to investigate the reproductive biology of female alkali bees, and to survey the bacterial and fungal associates of alkali bees throughout their life cycle. Below is a summary of my findings so far, based on two field seasons in Touchet Valley, WA in 2015 and 2016. In the case where these results are published, I will pass along the publication to the WASGA to keep on file.

1. Describe emergence patterns of alkali bee nests

   Introduction
   The first step in understanding factors that influence reproductive output is understanding how much natural variation there is in reproductive success among nesting females. This information is not currently available for alkali bees. The number of brood cells in alkali bee nests have been previously reported (Bohart and Cross, 1955, Johansen, et al., 1982), but it is unknown how many of these progeny survive to emergence the following spring. Mayer and Miliczky (1998) tracked emergence patterns over the entire season with traps that covered several nests, but did not provide information about the variance in number and sex ratio of bees emerging from individual nests. This is potentially important information for growers, because it provides information about the variation in reproductive output among their bee population. Female alkali bees make only one nest (Bohart and Cross, 1955). Variance in the number and sex ratio of progeny emerging from each nest thus represent variance in reproductive success among nesting females. I intend to describe this variation, and the results below represent a first step toward meeting this objective.

   Methods
   I developed methods for capturing female alkali bees as they emerge from their natal nest following the completion of development. I used methods similar to those of Mayer and Miliczky (1998), but modified the size of trap and frequency of census in order to track emergences of individual nests, using three different trap types (Figure 1). I placed these traps on soil that was free of any holes, and checked them for newly emerged bees each morning between 0700-1100. In most cases, there ended up being several nests within the area covered by the trap, so the number and sex of emerging bees was averaged across the number of holes in each trap.
Figure 1 Three types of traps used to capture alkali bees as they emerge from their natal nests for the first time after completing development.

I tracked nest emergences between 05 June and 13 June 2015 from 51 traps, though only 8 of these traps were tracked for the entire 9 day period. Due to unforeseen circumstances, this was approximately 10-14 days after emergences had begun (personal comm., Mike Ingham). Thus, the patterns reported below likely reflect the end of the emergence season, and do not give a clear picture of the total variance in reproductive output among nesting females. In 2016, I tracked nest emergences across the entire emergence period, from 26 May through 17 June, in 101 traps across 3 beds.

Results and Discussion

Johansen, et al. (1982) reported that alkali bee nests in Washington have 9-16 brood cells. The mean (± 1 standard deviation) number of bees emerging in 2015 was 4.42 ± 3.43 and in 2016 was 3.39 ± 1.90 (Table 1).

This suggest that bees I surveyed are either laying fewer eggs or many of the eggs laid in the previous season are not surviving to spring emergence.

Table 1 Number of bees emerging from traps on three bee beds.

<table>
<thead>
<tr>
<th>year</th>
<th>bed</th>
<th>mean ± sd</th>
<th>range</th>
<th>% male</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>1</td>
<td>4.42 ± 3.43</td>
<td>0.33-10</td>
<td>56</td>
<td>15</td>
</tr>
<tr>
<td>2016</td>
<td>1</td>
<td>3.59 ± 2.12</td>
<td>0-10</td>
<td>54</td>
<td>32</td>
</tr>
<tr>
<td>2016</td>
<td>2</td>
<td>3.59 ± 2.07</td>
<td>0-7.5</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>2016</td>
<td>3</td>
<td>3.65 ± 1.65</td>
<td>0.5-7.5</td>
<td>59</td>
<td>49</td>
</tr>
</tbody>
</table>

Sex ratio of alkali bees is reported to be 1.4 males to 1 female (Johansen, et al., 1982). In 2015, I observed an average sex ratio of 0.56 males to 1 female when including only traps that were surveyed for at least 7 days after the first emergence (n = 15 traps). In 2016, I observed an average sex ratio of 1.33 males to 1 female. Overall, the numerical sex ratio is slightly male-biased (Table 1). The female bias sex ratio observed in 2015 is likely due to sampling during the latter part of the emergence period.

Although the average emergence numbers were fairly consistent across bee beds and years, there was a lot of variation in the number and sex ratio of bees emerging in each trap (Figure 2). Both males and females emerged from nests in most traps, but some nests apparently produce all females or all males
In bees, sex is determined based on whether the egg is fertilized or not. Nesting females thus determine the sex ratio of their progeny.

*These data suggest there may be variation in sex ratio strategies among alkali bees.*

![Figure 2](image)

**Figure 2** Histograms showing frequency of emergence patterns from individual nests. Left: Distribution of number of bees emerging per hole in each trap; Right: Distribution of sex ratio of bees emerging per hole in each trap; (A) Bed 1 - 2015, (B) Bed 1 - 2016, (C) Bed 2 - 2016, (D) Bed 3 - 2016

2. Identify hormonal and nutritional factors that influence variation in reproductive potential in female alkali bees

*Introduction*

Variation in nutrition and hormone cycling during development and in the early stages of adulthood influence reproductive activity in other bees, but this relationship is untested for alkali bees. I will test these factors by treating females with juvenile hormone (JH), which is well known for its role in insect
gonad development (Nijhout, 1994), and by manipulating the protein content of food resources provided to bees.

Methods

I tested the effects of JH and nutrition on reproductive development among newly emerged alkali bee females. I used newly emerged females for two reasons. First, this is an especially sensitive time for reproductive development among bees. Females of a bee species related to alkali bees emerge with undeveloped ovaries, and protein consumption is required for their eggs to develop (Kapheim, et al., 2012). Other bee species emerge from development with very low levels of endogenous JH, which then increase during the course of ovary development (Smith, et al., 2013, Bloch, et al., 1996, Robinson, et al., 1991). Second, this is a practical way to standardize age among experimental bees. It is also a phase of the life cycle that can be easily recognized by seed growers, should practical applications arise from this research.

Newly emerged females were collected from emergence traps that had been placed over undisturbed surfaces by gently coaxing them into 15 ml conical tubes, and the tube was placed in a cooler with an ice pack for transport to the laboratory. Upon returning to the lab, we randomly assigned each bee to one of five treatments:

1. sugar water only
2. sugar water + pollen + alfalfa flowers
3. sugar water + pollen
4. sugar water + pollen + JH-III
5. sugar water + pollen + solvent

For treatments, JH-III (product E589400, Toronto Research Chemicals, Inc., Toronto, ON, Canada) was dissolved in dimethylformamide (DMF) (Fisher Scientific, Fair Lawn, NJ, USA) at a concentration of 100 μg μl⁻¹. This dose was chosen because it has significant effects on ovary size in bumble bees (B. terrestris), which are slightly larger than N. melanderi (Amsalem, et al., 2014). We applied the treatments with a pipette tip to the thorax of each bee while they were secured in their harnesses. Bees in the JH and solvent groups received 1 μl of JH-III dissolved in DMF or DMF only, respectively. Bees in the all other groups were touched lightly with a clean pipette tip. The treatment procedure was repeated 5 d later.

After treatment, bees were placed in perforated plastic deli containers (72 mm h x 90 mm lower diameter x 113 mm upper diameter). Bees in all groups except ‘sugar water only’ were fed a mixture of sterilized sucrose and pollen: 30 ml of 35% (w/v) sucrose mixed with 2.5 g of finely ground honey bee pollen (Betterbee, Greenwich, NY, USA), and food was replaced daily. Bees in the ‘sugar water only’ group received sterile 35% (w/v) sugar solution. Cages were kept at 22-28°C, 40-85% RH, and 13 h light:11 h dark with full spectrum lighting. When bees reached 10 d of age, they were chilled at 4°C for 5 min, placed in individually-labeled tubes, and flash-frozen in liquid nitrogen. Samples were stored in liquid nitrogen until return to Utah State University, where they were transferred to a -80°C freezer. The 10 day period provides enough time for ovary development, as alkali bees typically lay their first egg on the third day after emergence (Bohart and Cross, 1955). Dissections were completed at Utah State University.

Some of the newly emerged females were flash-frozen immediately so that I could compare reproductive development in the lab to reproductive development when females emerge from over-wintering. I also collected actively nesting females, by selecting females returning to the bee bed with a full load of pollen on their legs. This indicated that the females were reproductive and ensured that they
were at a similar stage of the cell building/egg-laying cycle. All bees were collected at the same time of day. I used compared these reproductively active females to the females we reared in the lab.

Results and Discussion
Females treated with JH or solvent and reared in the lab for 10 d had higher mortality than those in the sham control group (treatment 3 above), though this difference was not statistically significant (JH: 53%, DMF: 57%, sham: 34%; $\chi^2 = 3.62$, $p = 0.16$, $n = 30$ JH, 30 DMF, 32 sham).

JH has a positive effect on reproductive physiology in young, non-reproductive female alkali bees. The maximum longest terminal oocyte and Dufour’s gland size, measured jointly, were significantly larger in JH-treated females than in females in either control group (MANOVA: $F_{(6,80)} = 9.42$, $p < 0.001$, $n = 45$). Follow-up regression analysis of each reproductive measurement revealed that the JH treatments led to a marginally significant increase in maximum oocyte length (overall model: $F_{(2,42)} = 2.88$, $p = 0.07$; DMF vs sham: $p = 0.56$, sham vs JH: $p = 0.06$, DMF vs JH: $p = 0.03$, $n = 45$; Figure 3A) and a highly significant increase in Dufour’s gland length (overall model: $F_{(2,42)} = 30.87$, $p < 0.001$; DMF vs sham: $p = 0.37$, sham vs JH: $p < 0.001$, DMF vs JH: $p < 0.001$, $n = 45$; Figure 3B).

One of the primary functions of the Dufour’s gland in alkali bees is to secrete chemicals (Batra, 1972). It is connected to the sting, and thus plays a lubricating role in egg-laying. Most importantly, ground nesting bees line the inside of their cells with secretions from this gland, and it thus serves a prominent reproductive role.

These results suggest that treatments of JH at emergence may have a positive effect on several facets of reproductive development.

![Figure 3](image)

Figure 3 Effect of JH on (A) ovary and (B) Dufour’s gland development in alkali bees. Each bar represents the mean size of reproductive gland for each treatment group. Error bars are ± 1 standard error of the mean. Letters represent significantly different groups at $\alpha = 0.05$.

Alkali bees do not require protein for short-term survival in the lab. The primary source of protein for bees is pollen. Survival for 10 days post-eclosion was not significantly different among bees reared on different diets, though bees fed alfalfa pollen had the lowest survival rates ($\chi^2 = 1.51$, $p = 0.47$, $n = 93$; sugar only – 60%, sugar + pollen – 68.6%, sugar + pollen + alfalfa – 53.6%). This marginal decrease in survival when feeding on alfalfa flowers may be due to exposure to toxins or pathogens on the flowers or in the nectar and pollen.

Protein in the diet does not appear necessary to initiate reproductive development. The maximum longest terminal oocyte and Dufour’s gland size, measured jointly, were dependent on treatment group (MANOVA: $F_{(10,198)} = 25.05$, $p < 0.001$, $n = 106$). Follow-up regression analysis of each reproductive
measurement revealed that the females reared in the lab for 10 d developed significantly longer oocytes than newly emerged females, but terminal oocytes of lab-reared females were significantly smaller than those of nesting (overall model: $F_{(4,101)} = 86.67, p < 0.001$; Table 2; Figure 4A). Among the lab-reared females, diet treatment did not have a significant effect on ovary development ($p > 0.3$). Regression analysis of Dufour’s gland development revealed a similar pattern. Dufour’s glands were significantly larger among lab-reared females than newly emerged females, but actively nesting females had significantly larger Dufour’s glands than lab-reared females (overall model: $F_{(4,101)} = 45.68, p < 0.001$; Table 2; Figure 4B). There were no significant differences in Dufour’s gland size among lab-reared females on different diets ($p > 0.24$).

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Longest terminal oocyte (mm)</th>
<th>Dufour’s gland length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newly emerged females</td>
<td>36</td>
<td>0.77 ± 0.54</td>
<td>3.80 ± 0.46</td>
</tr>
<tr>
<td>Lab-reared females</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar-water only</td>
<td>14</td>
<td>1.81 ± 0.42</td>
<td>4.47 ± 0.52</td>
</tr>
<tr>
<td>Sugar + pollen</td>
<td>22</td>
<td>1.98 ± 0.64</td>
<td>4.66 ± 0.47</td>
</tr>
<tr>
<td>Sugar + pollen + alfalfa</td>
<td>14</td>
<td>2.01 ± 0.47</td>
<td>4.50 ± 0.60</td>
</tr>
<tr>
<td>Nesting females</td>
<td>20</td>
<td>3.35 ± 0.30</td>
<td>5.55 ± 0.30</td>
</tr>
</tbody>
</table>

This suggests that access to a protein source, such as pollen, is not necessary to initiate oocyte or Dufour’s gland development, but other cues, such as mating or access to nesting substrate, may be necessary to complete reproductive development.

Although most females that were collected immediately upon emergence had small, undeveloped reproductive organs, there were a few exceptions. Two newly emerged females had oocytes that were nearly as long as the smallest terminal oocyte found among nesting females (Figure 4A). These results suggest that female alkali bees emerge from overwintering with undeveloped ovaries and Dufour’s glands, but that they are able to initiate development of these glands very rapidly. Diet does not seem to be the limiting factor in developing these reproductive organs.

**Figure 4** Reproductive development under different nutritional treatments. Boxes represent the interquartile range (25% of the data lies below the box values and 25% of the data lie above the box values; open circles are outliers. Letters in boxes represent significant differences ($p < 0.001$).
3. Identify how reproductive potential corresponds to dietary preferences

Introduction

Bees use floral nectar to provision their cells for egg-laying and as energy to fuel flight during foraging. In honey bees, sensitivity to the sugar concentration of nectar changes with experience and reflects nutritional needs (Pankiw and Page, 2003, Pankiw and Page Jr, 1999). Based on results from a 2014 pilot study, I aimed to test the hypothesis that bees in different phases of reproductive development have different sensitivity to sucrose.

Methods

We placed emergence traps over dense clusters of nesting holes early in the morning, before the bees had emerged to begin foraging. Bees were gently coaxed into 15 ml conical tubes upon emergence, and the tube was placed in a cooler with an ice pack for transport to the laboratory.

Upon returning to the lab, we chilled each bee at 4°C for 5 min, and then harnessed it by securing a thin filament of cotton twine around the thread-waist, and attaching it to a plastic drinking straw, following the previously used “belt method” (Vorel and Pitts-Singer, 2010). The plastic straws had been cut in half lengthwise, such that harnessed bees were facing forward in a vertical position.

We randomly assigned each bee to one of three treatments: JH, solvent control, sham. JH-III (product J2000, Sigma-Aldrich, St. Louis, MO, USA) was dissolved in dimethylformamide (DMF) (Fisher Scientific, Fair Lawn, NJ, USA) at a concentration of 100 μg μl⁻¹. This dose was chosen because it has significant effects on ovary size in bumble bees (B. terrestris), which are slightly larger than N. melanderi (Amsalem, et al., 2014). We applied the treatments with a pipette tip to the thorax of each bee while they were secured in their harnesses. Bees in the JH and solvent groups received 1 μl of JH-III dissolved in DMF or DMF only, respectively. Bees in the sham treatment group were touched lightly with a clean pipette tip. The bees were then left to rest at 23-26°C for 4 h. This time period was chosen to give bees ample time to recover from handling stress, and is typical of PER assays performed with honey bees (Bitterman, et al., 1983, Giurfa and Sandoz, 2012). The mean ± 1 standard deviation time between capture and treatment was 2.04 ± 0.02 h. Alkali bees cease foraging activity by 19:00 pm (Cane, et al., 2016), and do not store food in their nests (Batra, 1970). All bees had thus experienced a natural starvation period of at least 19 h at the time of testing.

The sucrose response of each bee was tested following established protocols (Page Jr, et al., 1998, Gonalons, et al., 2016), with the exception that we targeted our stimulation to the gustatory sensilla on the mouthparts (i.e., the galea on the maxillae and the labial palps) while they were folded against the head in the resting position (see Fig. 3 in de Brito Sanchez, 2011 for detailed description of the mouthparts) and the foretarsi. The antennae are a more common target of stimulation in honey bees, but stimulation of tarsi and mouthparts have also been previously used (Giurfa and Sandoz, 2012). Bees must fully extend the glossa from inside the rest of the labium to ingest food (de Brito Sanchez, 2011). Thus, stimulating the mouthparts does not allow the bees to ingest any sucrose solution without a full extension of the proboscis. Bees were presented with a toothpick saturated with each of 7 concentrations of sucrose solution (0.1, 0.3, 1, 3, 10, 30, and 50% w/v) for a 60 s period, and their response was recorded. Bees that responded in this way were able to lick the toothpick briefly. Bees were presented with water (0%) for 60 s between each concentration of sucrose solution to control the potential for sensitization or habituation that could occur with repeated exposure to sucrose. Each concentration was presented to each bee before moving on to the presentation of water. The mean amount of time it took to complete a round of testing was 12 minutes (m). Thus, an average of 12 m passed between each presentation of sucrose solution and the following presentation of water, and an average of 24 m passed between each presentation of sucrose solution and the next presentation of sucrose. A response was recognized as a full extension of the proboscis, including the glossa. Partial
proboscis extensions were noted, but were not counted as a response. The investigators administering the PER test were blind to the JH treatment group of each bee. Upon completion of the assay, bees were placed in individually-labeled tubes and flash-frozen in liquid nitrogen. Samples were stored in liquid nitrogen until return to Utah State University, where they were transferred to a -80°C freezer.

A gustatory response score (GRS) was calculated for each bee as the total number of responses to sucrose recorded for each bee. A high GRS (7) indicates high responsivity to sucrose, and a low GRS (0) indicates low responsivity to sucrose.

Results and Discussion

> Short-term effects of JH on reproductive females

JH does not have short-term effects on reproductive physiology in reproductive female alkali bees. Bees treated with JH or DMF prior to the PER assay had higher mortality than those in the sham group, though this difference was not statistically significant (JH: 32%, DMF: 40%, sham: 18%; $\chi^2 = 4.89$, $p = 0.09$, $n = 41$ JH, 43 DMF, 44 sham). The maximum longest terminal oocyte and Dufour’s gland size were not statistically different between treatment groups (MANOVA: $F_{(20,136)} = 1.15$, $p = 0.31$, $n = 80$). These results were unchanged when we excluded the 4 females for which yellow bodies were not visible (MANOVA: $F_{(20,128)} = 1.11$, $p = 0.35$, $n = 76$).

This suggests that JH is not an effective means by which to “boost” reproductive performance among adult alkali bees that are already actively nesting.

> Sucrose response in alkali bees

Across all treatment groups, a higher percentage of bees responded to higher concentrations of sucrose (Figure 5). There were no significant differences between treatment groups in the probability of a proboscis extension response at any of the sucrose concentrations (logistic regression at each concentration: $p > 0.10$ before Bonferroni correction, $n = 23-31$ per group; Figure 5). Across all females ($n = 81$), the mean ($\pm$ 1 s.d.) GRS was $3.62 \pm 2.13$. Nearly 10% ($n = 8$) of bees did not respond to any concentration of sucrose, and more than 13% ($n = 11$) of bees responded to all sucrose concentrations. This reflects a large amount of variation in nectar preference and response.

This suggests that alkali bees generally prefer nectar in higher concentrations, but there is variation among bees in these preferences.

![Figure 5 Percent of bees responding to increasing concentrations of artificial nectar](image)
Reproductive status was correlated with sucrose response in unexpected ways. Maximum oocyte length was not a significant predictor of GRS in alkali bees (p = 0.43; Table 3; Figure 6A). JH treatments also did not have a significant effect on GRS (p = 0.72; Table 3). However, a different aspect of reproductive physiology, Dufour’s gland size, was a significant predictor of GRS (p = 0.001; Table 3; Figure 6B). Females with the longest Dufour’s glands were the most responsive to sucrose. Identity of the investigator administering the PER test was also a significant predictor of GRS (p < 0.001; Table 3). These results were unchanged when the 4 females without noticeable yellow bodies were excluded from the analysis.

Table 3 Results of a Poisson regression on gustatory response (GRS). Intertegular width was included in the model, because although the overall model was not significant, results of the MANOVA analysis on reproductive physiology revealed that body size is a significant predictor of Dufour’s gland length and maximum oocyte length; overall model: p < 0.001, n = 80.

<table>
<thead>
<tr>
<th></th>
<th>coefficient</th>
<th>s.d.</th>
<th>z</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>JH treatment group</td>
<td></td>
<td></td>
<td></td>
<td>0.72</td>
</tr>
<tr>
<td>Sham vs DMF</td>
<td>0.06</td>
<td>0.15</td>
<td>0.38</td>
<td>0.70</td>
</tr>
<tr>
<td>Sham vs JH</td>
<td>0.12</td>
<td>0.14</td>
<td>0.82</td>
<td>0.41</td>
</tr>
<tr>
<td>Maximum oocyte length</td>
<td>0.07</td>
<td>0.09</td>
<td>0.79</td>
<td>0.43</td>
</tr>
<tr>
<td>Dufour’s gland length</td>
<td><strong>0.52</strong></td>
<td><strong>0.16</strong></td>
<td><strong>3.31</strong></td>
<td><strong>0.001</strong></td>
</tr>
<tr>
<td>Intertegular width</td>
<td>-0.88</td>
<td>0.51</td>
<td>-1.73</td>
<td>0.08</td>
</tr>
<tr>
<td>PER observer</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Observer 2</td>
<td>-0.31</td>
<td>0.14</td>
<td>-2.23</td>
<td>0.03</td>
</tr>
<tr>
<td>Observer 3</td>
<td>-0.91</td>
<td>0.20</td>
<td>-4.53</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>constant</td>
<td>0.93</td>
<td>1.16</td>
<td>0.80</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Figure 6 Relationship between sucrose response (GRS) and reproductive physiology in reproductive females – (A) longest terminal oocyte length (p = 0.43, n = 80; Table 3), (B) Dufour’s gland length (p = 0.001, n = 81; Table 3).

These results suggest that proper functioning of the Dufour’s gland may depend on access to adequate dietary needs. Nectar preferences may vary with reproductive status, and reproductive females may be more likely to collect dilute nectar.
4. Characterize microbial associates of alkali bees

Introduction

Alkali bees have many microbial enemies which can lead to disease or spoil pollen provisions in the nest (Johansen, et al., 1982, Batra and Bohart, 1969, Batra, et al., 1973), but bees also associate with many beneficial microorganisms (Vasquez, et al., 2012). Some bacteria found in bee nests function to prevent food spoilage, including pollen balls provided to larvae (McFrederick, et al., 2012, Anderson, et al., 2014). Other bacteria found in the guts of honey bees and bumble bees have been shown to decrease infection rates when exposed to pathogens or parasites (Vasquez, et al., 2012, Koch and Schmid-Hempel, 2011, Forsgren, et al., 2010).

Advances in DNA sequencing technology have provided a means for studying the entire community of bacterial and fungal microorganisms in a given environment, without the need for culturing-based techniques. This technology was first used to characterize the microbial community associated with honey bees (Cox-Foster, et al., 2007, Martinson, et al., 2011), and was a major breakthrough in understanding the role of microorganisms in bee health. A potential outcome of characterizing the microbial communities associated with bees is the development of probiotic treatments to improve the health of commercially managed species. However, administering probiotics that are not endogenously associated with the bee can cause weakened immune systems and increase mortality (Ptaszyńska, et al., 2016). A first step toward developing probiotic treatments is thus identifying the microbes that naturally associate with each species. Nesting in the ground may expose alkali bees to a unique set of microbes that have not been previously characterized in other bees (none of whom are ground-nesting), and this may be an important source of microbial acquisition and function.

I proposed to characterize the diversity and relative abundance of bacterial and fungal associates of alkali bees throughout their life cycle, and to determine the how these microbes are acquired and maintained. This work will establish a foundation upon which future studies of beneficial and harmful microbes can be manipulated to investigate impact on alkali bee health.

Methods

I have collected samples for this project and completed dissections. DNA extractions are currently underway.

References


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