

## Research Article

# A Survey of Bee Species Found Pollinating Watermelons in the Lower Rio Grande Valley of Texas

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Using a combination of flower traps and visual observations, we surveyed three watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) fields in the Lower Rio Grande Valley to determine what bees inhabit this crop in this region. No managed honey bee (*Apis mellifera* L.) hives were in any of the fields; however, two contained managed hives of the common eastern bumble bee, *Bombus impatiens* (Cresson). A total of 15 species were collected or observed from all three fields combined. Of these species, only four were found to be very abundant: *Agapostemon angelicus* Cockerell/texanus Cresson, *A. mellifera*, *Lasioglossum coactum* (Cresson), and *Melissodes thelypodii* Cockerell. *Apis mellifera* comprised 46% of all bees collected from all three fields combined and was highly abundant in two of the three fields. In the third field, however, *A. mellifera* and *Agapostemon angelicus/texanus* were equally abundant. Surprisingly, *B. impatiens* comprised only 1% of the total bees surveyed in all three fields combined, despite two of the fields having several managed hives each. As *B. impatiens* is not native to this region, it was not surprising that none were collected or observed in the field with no managed hives.

## 1. Introduction

Watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai; Cucurbitaceae] is a crop that has been well documented for its dependence on insect pollinators for fruit and seed set due to its monoecious flowering condition of separate staminate (male) and pistillate (female) flowers [1, 2]. In fact, numerous studies have even shown that watermelon plants in exclusion cages will not set fruit [1–3]. Each female watermelon flower also requires approximately 500 to 1000 or more viable pollen grains for complete fertilization of ovules [1, 4]. Therefore, each female watermelon flower has been found to require at least 6–8 honey bee (*Apis mellifera* L.; Hymenoptera: Apidae) visits for successful pollination [1, 5].

Historically, *A. mellifera* has been generally recognized as the most important pollinator for commercial crop production [4, 5], including watermelon. Due to their manageability and large perennial colonies, *A. mellifera* is easily transported

to different fields as needed [4–6]. Recently, however, many *A. mellifera* colonies have been significantly weakened or lost due to exotic parasites, diseases, loss of bee-keeping subsidies, colony collapse disorder, Africanization, and pesticide exposure [3–8]. In fact, the supply of *A. mellifera* colonies has been reduced more than 50% since the 1950s despite a growing demand for *Apis* pollination services [4].

In response to declining *A. mellifera* populations, watermelon growers are now pollinating their fields using commercial bumble bees (*Bombus* spp.; Hymenoptera: Apidae). Although *Bombus* spp. have small annual colonies made up of fewer workers than *A. mellifera* hives have and they are also labor-intensive to produce, *Bombus* colonies require far less maintenance in the field. Moreover, their workers are active at lower temperatures and fly in higher winds than *A. mellifera* do. On a per-bee basis, *Bombus* spp. are also more efficient watermelon pollinators than *A. mellifera* are [6]. In USA, the primary commercial *Bombus* species is the common eastern bumble bee, *B. impatiens* (Cresson).

Researchers and growers have recently turned their focus to evaluating wild bee species as pollinators in crop production, especially in crops that are heavily dependent on insect pollinators, such as watermelon, for example [4, 7, 8]. In certain crops, some wild bee species are more effective pollinators than are *A. mellifera* workers [4]. Also, wild bees provide their pollination services free of charge [7]. Kremen et al. [7] found that organic farms in California located near native habitat (defined as having  $\geq 30\%$  native habitat within a 1 km radius of the farm) could receive adequate pollination from wild bees alone. However, as agricultural intensification increases, pollination services decrease by 3- to 6-fold [7].

Watermelon is one of many important crops grown in the Lower Rio Grande Valley of Texas. In an attempt to better understand watermelon pollination in the Lower Rio Grande Valley, bee species, both wild and managed, were surveyed at flowering watermelon in this region.

## 2. Materials and Methods

Observations and collections were undertaken in three fields located in Hidalgo County, TX, during Spring 2011. Two fields, designated as Mile 13 Field (26.38881° N, 98.23451° W) and Mile 14 Field (26.40230° N, 98.23282° W), located northwest of Edinburg, TX, were the larger of the three fields at 3.237 ha and 7.284 ha, respectively. Both fields are owned by a local watermelon grower and were planted in mid-Feb. 2011 with both seeded and seedless varieties interplanted within each row. While neither of these fields had managed *A. mellifera* hives placed in them, they both did have multiple managed hives of *B. impatiens*. Native vegetation consisting predominantly of common sunflower (*Helianthus annuus* L.; Asteraceae) was allowed to grow along the field edges as a refuge for beneficial insects. Both of these fields had adjacent citrus orchards and grassy fields with remnant citrus trees and mesquite.

The third field (ARS Field) was a small solid planting (0.352 ha) of a seeded variety (Legacy) located on the USDA-ARS property in Weslaco, TX (26.15850° N, 97.96364° W). This field was established a month later on 8 Mar. 2011. Native vegetation along the field edges was kept mowed, except for a 30 m strip of golden crownbeard (*Verbesina encelioides* (Cav.) Benth. & Hook. f. ex A. Gray; Asteraceae) growing along a fence  $\sim 30$  m from the field's western edge. ARS Field was also bordered on the south side by a corn field. No managed *A. mellifera* or *B. impatiens* hives were placed in this field.

To target just the bees visiting watermelon flowers, flower traps were used primarily [9]. Traps consisted of clear 4.5 oz. Falcon specimen cups filled with approximately 80 mL of soapy water solution (3 mL of liquid dishwashing soap/3.785 L of water). A single male watermelon flower was submerged in each trap during trap placement. A total of 10 points approximately 6 m apart were marked in each field along three 60 m transects for a total of 30 points per field. Transects began approximately 6 m from the field edge following the row. During peak watermelon flowering, traps were placed at each point between 0900 HR and 1000 HR and removed between 1400 HR and 1430 HR. Contrary

to findings in North Carolina where watermelon flowers opened around 0700 HR [10], watermelon flowers in our study were just opening at the time of trap placement and were just about to close at the time of trap removal. All samples were brought back to the lab for processing and identification. Due to the short flowering period, Mile 13 Field and Mile 14 Field were sampled weekly a total of three times (31 Mar., 7 Apr., and 14 Apr.), and ARS Field was sampled weekly a total of five times (19 Apr., 26 Apr., 3 May, 10 May, and 17 May). A single trap was placed beside a single hive quad (Koppert Biological Systems, Inc.; Michigan, USA) at Mile 13 Field and Mile 14 Field (2 traps total) to see if traps would collect worker *B. impatiens*.

Trap samples were supplemented with visual observations and hand collections. During trap placement and removal, the surrounding flowers were scanned for the presence of bees. If a bee could be identified by sight, its identity and the location it was observed were recorded. If a bee could not be identified by sight, it was collected using a Dirt Devil Detailer (Model CV 2000) and brought back to the lab for processing and identification. To eliminate counting nonvisiting bees, only bees observed in watermelon flowers were recorded or collected. Approximately 1.5 h after trap placement on 14 Apr., sample points of Mile 13 Field were each visually surveyed for an additional period; however, additional visual observations were not made at either of the remaining fields.

All identifications were made by one of us (CSH) primarily using the identification keys provided on the Discover Life website (<http://www.discoverlife.org/mp/20q?search=Apoidea>). In cases where the Discover Life key to species for a specific genus did not cover the Lower Rio Grande Valley, an appropriate published key was used. Identification of *Lasioglossum coactum* (Cresson) (Hymenoptera: Halictidae) was aided with correspondence with Jason Gibbs, who also confirmed this identification after viewing representative specimens.

Due to morphological similarities between *Agapostemon angelicus* Cockerell and *A. texanus* Cresson (Hymenoptera: Halictidae), a definitive identification cannot be made without molecular testing [11]. Based on species collection records for both species mapped on the Discover Life website, it is likely that the correct identification is *A. texanus*. However, no males of either species, which are distinctly different, were collected to support this assumption.

## 3. Results

A total of 15 species of bees were collected from our watermelon fields in the Lower Rio Grande Valley (Table 1). ARS Field was found to be the most diverse field with 11 species. Eight and nine species of bees were collected from Mile 13 Field and Mile 14 Field, respectively. ARS Field had a higher overall abundance of bees than the other two fields, possibly a result of this field being sampled two more times than Mile 13 Field and Mile 14 Field.

Only four species were found to be abundant: *A. angelicus/texanus*, *A. mellifera*, *L. coactum*, and *Melissodes thelypodii* Cockerell (Hymenoptera: Apidae). *Apis mellifera* was

TABLE 1: Bee species collected from three Lower Rio Grande Valley watermelon fields during 2011.

Species	ARS		Mile 13		Mile 14	
	Traps	Obs.	Traps	Obs.	Traps	Obs.
<i>Agapostemon angelicus/texanus</i> *	1	—	12	1	38	—
<i>Apis mellifera</i>	2	67	10	44	11	28
<i>Augochlorella aurata</i>	—	—	—	—	1	—
<i>Augochlorella bracteata</i>	—	1	—	—	—	—
<i>Bombus impatiens</i>	—	—	—	3	1	1
<i>Exomalopsis snowi</i>	1	—	—	—	—	—
<i>Florilegus condignus</i>	1	—	—	—	—	—
<i>Halictus ligatus</i>	3	2	—	—	1	1
<i>Lasioglossum coactum</i>	38	—	5	—	6	1
<i>Lasioglossum viridatum</i>	—	—	—	—	3	—
<i>Lasioglossum</i> sp. 1	—	—	1	—	—	—
<i>Lasioglossum</i> sp. 2	3	—	8	—	3	—
<i>Lasioglossum</i> spp.	—	2	—	—	—	—
<i>Melissodes thelypodii</i>	19	1	18	1	8	1
<i>Nomada crucis</i>	—	1	—	—	—	—
<i>Triepeolus helianthi</i>	3	1	1	—	—	—
Unknown Halictid	—	1	—	—	—	—
Total:	71	76	55	49	72	32
Overall Total:	147		104		104	

\* Females of *A. angelicus* and *A. texanus* are morphologically identical and cannot be separated where the distribution of the two species overlap [11].

the most abundant bee, comprising 46% of the overall total number of bees collected and observed from all three fields combined. *Agapostemon angelicus/texanus*, *L. coactum*, and *M. thelypodii* each comprised 13% to 15% of the overall total number of bees surveyed. The remaining 11 species collectively comprised the remaining 11%. Despite Mile 13 Field and Mile 14 Field having approximately 3-4 managed hives of *B. impatiens* each, only 5 workers from these colonies were collected or observed from both fields. *Bombus impatiens* workers comprised only 1% of the overall total of bees surveyed from the three fields.

*Apis mellifera* was the most abundant pollinator in ARS Field and Mile 13 Field, while *A. angelicus/texanus* was equally abundant to *A. mellifera* in Mile 14 Field. Only one individual of *A. angelicus/texanus* was collected at ARS Field. However, *A. angelicus/texanus* numbers began to decline as the season progressed (Figure 1). Conversely, ARS Field had 3x the abundance of *L. coactum* than either of the two other fields combined, with a large peak in abundance on the last sample date (17 May) (Figure 1).

#### 4. Discussion

Our results were similar to those found in a small survey near Leesburg, FL [12]: the most abundant species was *A. mellifera*, followed by three fairly abundant species and other less common species. In total, Goff [12] collected eight species of bees, which is approximately the number of species that were found in our study fields. However, with the exception of *A. mellifera*, the bees Goff [12]

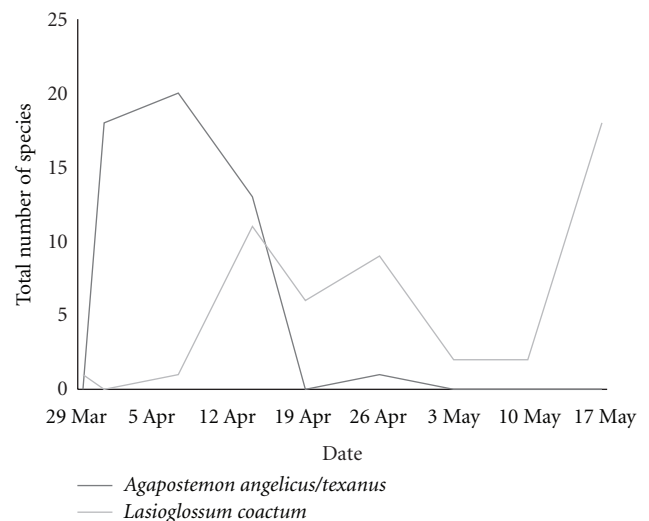


FIGURE 1: Seasonality of *Agapostemon angelicus/texanus* and *Lasioglossum coactum* collected from three Lower Rio Grande Valley watermelon fields during 2011.

collected were solely from the family Halictidae. Our study found roughly equal number of species from Halictidae and Apidae, including a few cleptoparasites presumably oudrinking nectar.

As no managed hives of *A. mellifera* were placed in any of these fields, the high number of this species collected and observed likely derives from feral colonies living nearby.

Grassy habitats located in close proximity to our fields were observed to contain suitable nesting sites for feral *A. mellifera*. It is equally likely that some of these bees may have originated from managed hives that were observed in a grassy field approximately 1 to 2 km east of Mile 13 Field and Mile 14 Field. Previous studies have indicated that this distance is well within the typical foraging range of *A. mellifera*, for example [13, 14]. In fact, Visscher and Seeley [13] found the radius surrounding 95% of their observation colony's foraging sites to be 6 km. Beekman and Ratnieks [14] found that 95% of the bees from their observation colony foraged within an even greater distance of 10 km.

Porter [15] noted that *A. texanus* was frequently found in fields and open places in scrub and woodland, such as abandoned citrus groves in the Lower Rio Grande Valley. Populations of *A. texanus* most likely occur year-round, but its population appeared to peak in December and January before becoming scarce by March and May [15]. This seasonality may explain the relative lack of *A. angelicus/texanus* in ARS Field compared to Mile 13 Field and Mile 14 Field as ARS Field was sampled a month later than the other two fields due to a later planting date. Porter [15] also noted that the main nectar and pollen source for *A. texanus* was common sunflower, which may, again, contribute to the low abundance of *A. angelicus/texanus* in ARS Field. While Mile 13 Field and Mile 14 Field both had common sunflower growing abundantly along the edges, ARS Field did not.

Life history information is lacking for *L. coactum*, which belongs to the predominantly primitively eusocial subgenus *Dialictus* [16, 17]. *Dialictus* contains numerous, commonly collected, "morphologically monotonous" species [17, 18]. In fact, a recent molecular study revealed that the easily identified species *Lasioglossum tegulare* (Robertson) (Hymenoptera: Halictidae) was instead a species complex containing several cryptic species, including *L. coactum* [17]. Gibbs [17] notes that the range of *L. tegulare* is more restricted to the northeast than previously reported and that records from Texas are probably *L. coactum*. As *Dialictus tegularis*, Mitchell [19] records a flight season of March or April through October for *L. coactum*.

The apparent higher abundance of *L. coactum* at ARS Field than Mile 13 Field and Mile 14 Field is likely a reflection of the later sampling at ARS Field than Mile 13 Field and Mile 14 Field. Primitively eusocial species tend to start with a single, solitary female completing all necessary nesting tasks. Upon emergence of her offspring, division of labor between queen and workers arises [20]. The lower number of *L. coactum* at both Mile 13 Field and Mile 14 Field are likely females just emerging from winter diapause at the beginning of the flight season. The increase at ARS Field likely reflects the natural increase in population as the season progresses. The drop in *L. coactum* abundance seen during early May could be attributed to residues from insecticides targeting whiteflies in late April. As we did not test for this, nor was this pesticide used on either of the two other fields, this relationship could also be coincidental.

Such a low abundance of *B. impatiens* both in the traps and during visual observations was surprising when considering the presence of multiple colonies at Mile 13

Field and Mile 14 Field. This was contrary to a study in North Carolina [10] looking at watermelon and cucumbers, which compared the diurnal activity, floral visitation rate, and pollen deposition rate of *B. impatiens* to *A. mellifera* to determine the most efficient pollinator of the two. Because *B. impatiens* was found to be out foraging earlier and longer, visited more flowers/minute and deposited more pollen grains, it was found to be the most efficient pollinator. However, no distinction was made in this study between managed and feral *B. impatiens* [10].

*Bombus impatiens* has a published distribution of Ontario and Maine, south to Florida, and west to Michigan, Illinois, Kansas, and Louisiana [21, 22]. The low abundance of *B. impatiens* in our study compared to the North Carolina study may be due to the fact that *B. impatiens* is not native to Texas or the Lower Rio Grande Valley as it is to North Carolina. Therefore, the managed colonies brought in from Michigan may not have been adequately adapted for the Lower Rio Grande Valley climate. In North Carolina, *B. impatiens* was found to be out foraging in watermelon flowers approximately 30 min. earlier than *A. mellifera* and, in some cases, even attempting to forcibly enter unopened watermelon flowers. Both species were observed foraging until the watermelon flowers closed for the day [10]. While our traps were placed in the field later in the morning than those in North Carolina, we do not feel we missed early morning *B. impatiens* foraging in watermelon as our traps were placed at the time of flower opening. In fact, on at least one occasion, trap placement was delayed until the male flowers were open enough to be used in the traps.

Colored pan traps are a passive collection method with the advantage of limiting potential sampling biases associated with the sampler's observational and netting skills. However, they have been known to have several biases, one of which is that they catch fewer individuals of *Bombus* spp. than expected [23]. In an attempt to avoid these biases as well as target our catches to bees attracted to watermelon, we employed flower traps, which shift the attractant from bowl color to the target flower. While this study did not specifically test the traps for any biases, we do not believe that trap biases, if any, were a contributing factor in the low *B. impatiens* abundance at both Mile 13 Field and Mile 14 Field. Visual observation data as well as unrecorded observations made in these fields during nonsampling times also indicated low *B. impatiens* abundance.

This study was conducted solely with the intent to establish baseline knowledge of the bees present in Lower Rio Grande Valley watermelon fields. As no major surveys of the Lower Rio Grande Valley bee fauna had been undertaken previously, our prior expectations were limited to *A. mellifera*, based on surrounding vegetation types as well as *Peponapis pruinosa* (Say) (Hymenoptera: Apidae), due to its dependence on the flowers of other cucurbits (i.e., squash). Therefore, the relatively high abundance of *A. mellifera* was not very surprising. Neither was the relatively high abundance of *L. coactum* as the genus *Lasioglossum* is globally occurring, commonly collected, and well known to dominate faunas with its abundance [18]. The most surprising finding of this study was the low abundance of



*B. impatiens* at Mile 13 Field and Mile 14 Field despite having managed hives within these fields.

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