

**AGRICULTURAL RESEARCH FOUNDATION
FINAL REPORT
FUNDING CYCLE 2015 – 2017**

TITLE: Oregon Crop Pollinators: Evaluation of Pollen Carrying Capacity and Crop Loyalty for Yield Enhancement

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COOPERATORS: Oregon growers of bee pollinated crops

SUMMARY:

Many Oregon growers are dependent on bees for pollination which can be a critical factor as it can influence the quality and quantity of the product that is marketed. Native bees such as bumble bees are efficient pollinators of some Oregon crops such as blueberries and red clover seed but their abundance is unpredictable and they are not commercially available. In contrast, honey bees can be rented but they are believed to be poor pollinators of these crops. The current study was conducted to determine the value, of honey bees as pollinators of these crops. Our studies showed that in red clover, honey bees were abundant during early and mid-bloom after which bumble bee abundance increased. In blueberries, ~ 96% of the pollinator visits were made by honey bees. Thus, honey bees are the dominant bee in both crops. However, when honey bee hives are placed in blueberry fields, the workers do not return to the hive with blueberry pollen. This has led to the belief that while honey bees forage on the crop, they are not contributing to crop pollination. To determine the contribution of honey bees to pollination of blueberries, further studies were conducted. Honey bees foraging on blueberries were collected and pollen on parts of the body that are traditionally not believed to be involved in pollination were examined. An unexpected discovery was made that different body parts were covered with blueberry pollen. While the quantities were small, the amount present was many times greater than what is needed for effective pollination. These observations, along with evidence of high abundance of foragers on blueberry flowers provide strong evidence that honey bee are key contributors of blueberry pollination. Oregon farmer rent 2-4 honey bee hives/acre and achieve very high yields compared to other blueberry growing regions in the United States; this further documents that honey bees are much better pollinators of this crop than has been believed earlier.

OBJECTIVES:

The objectives of the study were to:

1. Pollen carrying capacity of bees foraging on Oregon crops
2. ‘Loyalty’ of bee species foraging on Oregon crops

PROCEDURES:

The studies were focused on two Oregon crops in which bumble bees are believed to be better pollinators compared with honey bees:

1. Blueberries – Blueberries require buzz pollination (flowers have to be shaken to release the pollen), which honey bees are unable to do; bumble bees have a strong muscular body and can buzz pollinate.
2. Red Clover Seed - The corolla tube in red clover flowers is long and is believed to present a challenge for honey bees to access nectar as they have shorter tongue lengths than bumble bees.

However, in both crops, honey bees were observed to be the dominant forager. In blueberries, ~96% of the pollinator visits were made by honey bees.

The blueberry study yielded interesting and remarkable new insights on the role of honey bees, and hence further investigations were focused on this crop. In particular, pollen on parts of the body that are traditionally not believed to be involved in pollination were examined.

Thirty honey bees were collected from blueberries flowers and transported to the lab. Honey bees were dissected into four main body regions: head, body, legs, and tarsi (feet). Each body part was visually divided into sub-regions and the percentage of total regional pollen located on sub-regions was estimated. The identity of the pollen was also determined.

Pollen was next separated from the body parts using a solvent, sonicator, and centrifuge, and loaded onto a hemocytometer for estimating pollen grains extracted from each body part.

The pollen load data was analyzed using appropriate statistical analysis.

SIGNIFICANT ACCOMPLISHMENTS:

Our studies showed that, contrary to what is generally believed, honey bees are key contributors to pollination of Oregon blueberries. While bumble bees may be more efficient in blueberries, their life cycle is not well synchronized with blueberry bloom in the varieties examined in this study, and abundance is low. In contrast, honey bee density is high with the hive rentals. Also, while honey bees are unable to buzz pollinate, they can still collect adequate pollen while foraging on flowers for nectar, and thereby serve as efficient pollinators. In red clover, bumble bee abundance is low during early and mid-bloom when honey bee abundance is high; this could be due to competition between the two species. Solitary bees including halictids and blue orchard bees do not appear to contribute much to pollination in both blueberries and red clover seed crops.

In addition, the study documented behaviors of bees that are integral to crop pollination that have never been observed before. These behaviors show that pollination by bees in blueberries can be achieved by pollen inadvertently collected on diverse body parts including the legs and feet. The study highlights the need for examination of pollen carried over all body parts of the bee for assessing contribution of a bee species to crop pollination and crop loyalty.

Observations and data documenting the contribution of honey bees to blueberry pollination:

Overall, less than 10% of honey bees carried pollen balls on the pollen basket – the part which has traditionally been examined by researchers for determining the contribution of a bee species to pollination. The remaining pollen was present on other body parts, and was identified as being

primarily blueberry pollen. The greatest percentage blueberry pollen was carried on the head and parts of the tarsi (feet) of the bees – including the basitarsi and tarsal claws on the rear legs (Figure 1), with slightly smaller percentages carried on the body and other parts of the legs (Table 1). The feet of the bees (tarsi) carried most of the pollen.

For a closer examination, we divided the feet into four sub-regions: the tarsi of the front legs, the tarsi of the middle legs, the pollen comb (basitarsi) of the rear feet, and the segments 2-5 (the remainder of the rear feet). Most of the pollen was carried on the basitarsi, which is not surprising because it is covered with bristles and hairs which are efficient at combing pollen off other parts of the body (Table 2; Figure 1).

Table 1. Percent of the total pollen load that are blueberry tetrads on the four major body parts

Body Part	% Blueberry Pollen	Tetrad Counts
Head	87.9 ±1.6 a	131.2 ± 23.6 bc
Tarsi (feet)	81.9 ±2.1 ab	740.5 ± 40.4 a
Body	79.6 ±2.6 b	69.8 ± 12.8 c
Legs	77.8 ±2.6 b	219.8 ± 40.4 b

Body Parts ordered in descending order based on the value of % Blueberry Pollen.

Means followed by different letters are significantly different at $P < 0.05$

Table 2. The number of blueberry tetrads carried on the four tarsal regions: fore-tarsi, mid-tarsi, the basitarsi of the rear foot, and the segments 2-5 of the rear foot.

Body Part	Mean	SE
Basitarsi (rear foot)	399.9	64.1 a
Mid-tarsi	162.6	26.1 b
Fore-tarsi	89.6	14.4 c
Rear segments 2-5	39.0	6.3 d

Means followed by different letters are significantly different at $P < 0.05$

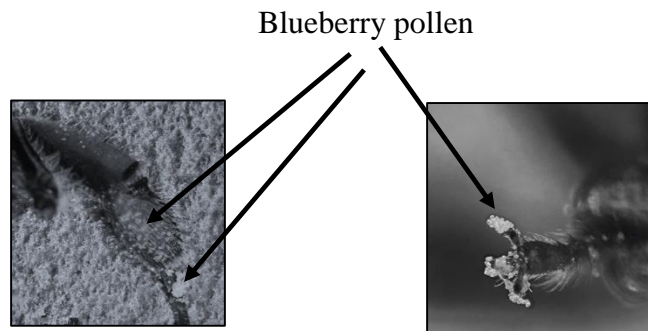


Figure 1. Blueberry pollen on different parts of the leg and feet of a honey bee worker – basitarsus on the left and tarsal claw on the right.

The study documented that honey bees do collect blueberry pollen and are thus able to serve as efficient pollinators of the crop. Thus, the study showed that pollination can be achieved via pollen carried on various body parts not just the pollen basket.

Presentations in which the above research was included:

- The Oregon ICP Experience. USDA-SCRI Integrated Crop Pollination (ICP) Project, Fifth Annual Meeting, East Lansing, MI, November 2016.
- Honey bee pollination behavior and effectiveness in relation to blueberry variety flower shape. Oregon Blueberry Commission, Research Committee meeting, Salem, OR, January 2017.

Publication related to the study:

- Lande, C., Hoffman, G., and Rao, S. 2016. Pollen collected by honey bees foraging in blueberry fields: Distribution on body parts. Proceedings 75th Annual PNW Insect Management Conference, Portland OR, pp 28-30.

Manuscript in preparation:

- Hoffman, G. D., Lande, C E.H., Rao, S. Honey Bee Study Reveals Unusual Pollination Mechanism in Blueberries

BENEFITS & IMPACT:

As indicated above, bumble bees are believed to be more efficient in pollinating blueberries and red clover seed crops and thus likely to contribute more to yield in both crops compared with honey bees. The bell shaped blueberry flower with a small opening in the corolla (fused petals) is difficult for a honey bee to access and extract pollen. Some native bees such as bumble bees can access pollen by shaking ('buzzing') flowers and thereby releasing pollen thus enabling them to be efficient as pollinators. However, native bumble bee abundance is unpredictable and dependent on many factors including weather. Unlike other regions in the country, commercial bumble bee colonies are banned as the species being sold are not native to the region. Hence, growers have depended on honey bees for crop pollination but data were lacking in terms of their contribution to crop pollination in these crops.

The benefits of the current study are the evidence provided that honey bees are key contributors for crop pollination of both blueberries and red clover. In blueberries, honey bees do not shake pollen by buzzing flowers, and limited blueberry pollen has been documented to be present in pollen basket loads taken to hives – these have led to the belief that honey bees are not efficient as blueberry pollinators. This has been proven to be incorrect by the current study. While foraging for nectar, honey bees inadvertently collect pollen on other hairy body parts such as the tarsi of legs and this can be transferred to other flowers for pollination. These observations, along with observations that ~ 96% of the pollinator visits to blueberry flowers are made by honey bees, provide strong evidence that growers benefit by stocking honey bee hives for blueberry pollination. There are many native pollinators of Oregon blueberries, particular several species of

bumble bee, but these are not present in large enough numbers to be a reliable source of pollinators. Our studies have shown that blueberries require pollination by bees to get a good fruit set and berry size which are necessary for high yields. Oregon farms get very good yields compared to other blueberry growing regions in the United States, which further documents that honey bees are much better pollinators of this crop than has been believed earlier.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM:

The following funding was received in 2016 for related projects:

- USDA-NIFA: \$ 35,000 for developing sustainable pollination strategies for blueberries
- Oregon Blueberry Commission: \$ 8,668 for follow up studies on examination of honey bee pollination behavior and effectiveness in relation to blueberry variety flower shape.

FUTURE FUNDING POSSIBILITIES:

Oregon Blueberry Commission, USDA SCRI and FFAR (Foundation for Food and Agriculture Research) depending on results of the ongoing follow up studies.