

Honey Bees as Pollinators of Pickling Cucumbers in Wisconsin¹

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ABSTRACT

Honey bees, *Apis mellifera* L., were shown to improve cucumber fruit yields and quality. Thirty-seven other species of insects were collected from cucumber flowers and leaves, but their importance to the plant was not determined. Six native plants growing in the area of the test fields had lower concentrations of sugar in their nectar than the cucumbers but apparently had some other floral characteristics that attracted some honey bees.

INTRODUCTION

EDGECOMBE (1946) used honey bees, *Apis mellifera* L., to produce hybrid cucumber seed by cross pollination of deflorated rows of male and female cucumbers. Alex (1957) showed that yields of cucumbers in Texas were 5-6 times greater in cages containing honey bees than in those without them; however, he noted a species of small halictid bee that entered the cages that contained no honey bees and set 89 bushels of cucumbers per acre. Warren (1961) also obtained increased yields in fields where honey bees were placed at the rate of one colony per acre though the yields were not as great as those reported by Alex. Steinhauer (1971) had similar favorable results in Maryland. Szabo and Smith (1970) tested *Megachile rotundata* (F.) in the greenhouse and found it was equal to honey bees as a pollinator of cucumbers though it required more light and higher temperatures to perform satisfactorily. Martin (1970) showed that the use of honey bees increased yields and the numbers of seeds required for perfect fruit; in addition, he found that honey bees gathered nectar rather than pollen and that the concentration of sugars in the nectar of cucumber flowers ranged from 20 to 50%.

The more progressive producers of cucumbers in the United States place colonies of honey bees, *Apis mellifera* L., in or near their fields. However, machine harvesting of picking cucumbers, a recent development, requires a heavy uniform set of fruits for a single harvest if costs of production are to be competitive with hand-harvested crops. Thus larger fields of cucumbers must be planted to obtain the volume needed. However, the cultivation necessary to prepare these large fields has resulted in the destruction of the nesting sites of many native pollinators, which has increased the pollination requirements. We therefore need more detailed knowledge about the habits of honey bees as pollinators of cucumber flowers.

The objective of this present study was threefold, viz., (1) to show the effectiveness of honey bees in the pollination of cucumber, (2) to collect and identify other insects that compete with honey bees as pollinators of cucumbers or are visitors on the crop for unknown reasons, and (3) to measure the concentrations of sugars in the nectar of other crops and native plants that might compete for the attraction of the foraging honey bees introduced into the fields to pollinate the cucumber flowers. The investigation was made during the summer months of 1967 at the University of Wisconsin Experiment Station Farm at Hancock and in commercial cucumber fields near Wautoma, Wisconsin. Since the investigation was preliminary, treatments were not randomized and replicated for statistical analysis.

MATERIALS AND METHODS

Effectiveness of bees as pollinators.

The effectiveness of native insects and honey bees in pollinating cucumbers was tested by placing four 16- x 22-foot (1/124-acre) fiberglass screen cages (1/8-inch mesh) over field-grown cucumbers at the Hancock Experiment Station Farm. These cages excluded the potential pollinating insects in the area. Populations of honey bees in the cages were varied as follows: no bees in one cage; one small nucleus hive

(4,000 honey bees plus queen, the equivalent of 1/10 of a standard 2-story Langstroth hive of honey bees) in one cage; two small nuclei hives in one cage; and three small nuclei hives in the fourth cage. Also, four uncaged cucumber plots (16 x 22 ft.) were designated in the same 1-acre field, and two standard 2-story Langstroth hives (40,000-60,000 honey bees and queens) were placed adjacent to the test plots to augment the native population of pollinators.

In addition, we selected three commercial fields about 2 miles apart at Wautoma and placed 25 standard 2-story Langstroth hives of honey bees in the 4.9-acre field, none in the 7.5-acre field, and 36 cardboard cartons each with 3 pounds (about 11,000) of honey bees in the 7.6-acre field.

Cucumber plots.

The test plots at the Hancock Farm and commercial fields at Wautoma had the same soil type, were fertilized at similar rates, and were planted with the same gynecious hybrid cucumber variety; also the cultivation practices were similar. However, at the Hancock Farm, the cucumber plants were planted 6 inches apart within rows and in sets of two rows 12 inches apart with 5 feet between row sets. Approximately 40,000 plants were in an acre so that these plots typified a commercial field arranged for machine harvest (cucumbers were picked by hand). In the three commercial fields near Wautoma, the plants were planted approximately 12 inches apart within the rows with the rows 4 feet apart, and the fruit was hand picked.

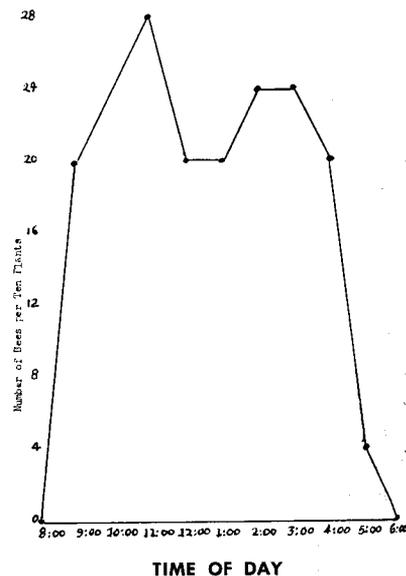


Figure 1. Daily activity of honey bees in cucumber fields (averages of 31 observations made for 15-minute periods each hour each day for 10 days).

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Insect visitation to cucumber plants.

Insect visitors to the cucumber plants and flowers were surveyed by making 10 sweeps with an insect net in each of the four field plots. The collections were then preserved and identified.

The relative attractiveness of various crop and wild flowers to honey bees was determined by placing paired colonies of bees in three settings, an intensively cultivated prairie-like area containing few woodlots that might have colonies of honey bees in trees; a mixed wooded and agricultural area with about 50% of the land under cultivation and the rest in scrub-oak forest; and a heavily wooded area with scattered small fields of cucumbers. Pollen traps were attached to the entrances of each of these hives so the pollen gathered each day by the foraging bees could be collected and identified as to flower species.

We also collected nectar samples from the honey stomachs of 10 to 20 honey bees found foraging on the flowers of cucumbers and on the six principal sources of nectar in the vicinity of the test plots. Concentrations of sugar in the nectar of each flower were read in the field with an Abbé refractometer and average values then computed.

The foraging habits of honey bee visitations on cucumber flowers were investigated by making counts during 15-minute periods per each hour of a day (8 a.m. to 6 p.m.) between July and September. The results were then tabulated, plotted, and used to determine the daily foraging cycle of honey bees on cucumbers in central Wisconsin.

Yields.

The cucumbers from the caged and uncaged field plots at the Hancock Farm were picked every other day, graded by U.S. Standards, and weighed to determine the quality and quantity of fruit produced. The cucumbers at the three commercial fields at Wautoma were picked by laborers, were graded by U.S. Standards, and were

weighed by the cooperating pickle company shed personnel. (Grade standards are based on diameter, length, shape, and appearance of the fruit). Crop value was computed from the prevailing prices at the company pickle sheds.

RESULTS AND DISCUSSION

Effectiveness of honey bees as pollinators.

In the cages at the Hancock Experiment Station Farm that contained no pollinators, only 33 pounds of misshapen fruit were produced (attributed

to the sensitivity of cucumber plants to a depression in light. Other possibilities are that the additional visits by native insect pollinators made a difference or that plot size was a factor.

The data in Table 1 indicate that in the two commercial fields near Wautoma, where honey bees were used to supplement native pollinators, including honey bees in hollow trees, the yields of cucumber per acre were 37.5% and 47.5% greater than in fields where no supplemental honey bees were provided. However, the use of five colonies per acre produced a cash return

Table 2. Concentration of sugar in nectar and approximate acreage of 6 species of flowers growing within a mile radius of cucumber fields in the vicinity of Hancock and Wautoma, Wisconsin.

Common Name	Latin Binomial	Approx. acreage	% sugar in nectar*
Cucumber†	<i>Cucumis sativus</i> L.	5	36
Cucumber‡	<i>Cucumis sativus</i> L.		41
White Sweet Clover	<i>Meiblotus alba</i> Dear.	25	13
Catnip	<i>Nepeta cataria</i> L.	4	23
Horsemint	<i>Monarda fistulosa</i> L.	3	20
Milkweed	<i>Asolepias syriaca</i> L.	7	16
Blazing Star	<i>Liatris</i> sp.	4	30
Blue Vervain	<i>Verbena hastata</i> L.	1½	25

* Average of 10-20 readings with refractometer for soluble solids in honey stomach of bee. All readings were taken on clear days.

† Day of rain and mist; 99% relative humidity.

‡ Sunny day; 50% relative humidity.

either to parthenocarpic development or possibly to ants observed visiting the flowers for nectar). The cages that contained 1, 2, and 3 nuclei hives had yields of 150, 137, and 138 pounds of well-formed fruit, respectively. The differences in yields between the cage without and those with honey bees were highly significant, which verified the reports of Alex (1957), Martin (1970), Steinhauer (1971) and others, but the differences between cages with different populations were not significant though they varied some. The yields (182 pounds of cucumbers) in the field plots with two standard colonies per acre were 29% greater than the yields in caged plots containing one or two nuclei hives. This difference may have resulted because of cage effects, which often reduce the effectiveness of honey bee foraging, or because

only 10.9% higher and a total average weight of fruit only 16% higher than the use of 5 packages (55,000 bees per acre, each with 3 pounds (11,000) of honey bees, equivalent to one strong colony (60,000 bees) per acre). Thus, the additional cost in rental fees for a large number of colonies (above one or two per acre) may be greater than the returns from the extra colonies.

Cucumber nectar sugar concentration.

Table 2 shows the concentrations of sugar determined for six species of plants growing in the vicinity that were possible competitors of cucumbers for honey bee visits. The sugar in cucumber nectar is more concentrated than the sugar in the other plants in the vicinity, even on rainy days. The concentration of sugar in nectar has been shown to be a factor in flower visita-

Table 1. Total and average yields and cash values of cucumbers produced on three commercial fields near Wautoma, Wisconsin.

Treatment	Field size (acre)	* Grades, percentages of yield, and weights in pounds							Total weight	Avg. wt. /acre	Avg. cash /acre
		1	2	3	4	5	6	7			
No bees	7.5	16.0%	20.6%	15.3%	15.6%	16.0%	9.9%	5.6%	46,137	6,152	\$133.33
		7,710	9,529	7,102	7,209	7,386	4,612	2,589			
15 pkg./A	7.6	11.0%	17.4%	14.3%	16.0%	19.8%	12.9%	6.9%	74,786	9,840	393.15
		9,280	13,072	10,756	11,992	14,848	9,654	5,184			
5 col./A	4.9	10.9%	13.4%	15.2%	19.5%	21.7%	11.7%	7.2%	56,833	11,718	441.23
		6,225	7,635	8,672	11,139	12,389	6,672	4,101			

* USDA Standard Grades vary with diameter, length, shape, and appearance of fruits.

† Five packages are equivalent to one strong two-story standard Langstroth hive of honey bees.

tions of honey bees (Shuel 1955 and Kauffeld and Sorensen 1971).

Native insect visitors to cucumber flowers.

The native insect visitors to the cucumber flowers belonged to five principal orders and included 38 species as follows: hundreds of honey bees *Apis mellifera*; 3 species of bumblebees, *Bombus vagans* F. Smith, *B. impatiens* Cresson, *B. griseocollis* Degeer; 1 *Megachilidae*, *Megachile latimanus* Say; 1 Mellissodes, *M. bimaculata bimaculata* (Lepelletier); 2 species of *Halicitidae*; 4 unidentified wasps; 1 unidentified species of ant; 4 species of *Syrphidae*; 1 *Bombyliidae*, and 3 other unidentified Diptera; 5 species of beetles, *Diabrotica porracea* Harold, *Diabrotica undecimpunctata* Mannerheim, *Coccinellidae* sp., *Mordellidae* sp., *Chrysomelidae* sp. and 2 unidentified species of beetles; 3 species of *Miridae*, *Lygaeidae*, *Cercopidae*; and 5 unidentified species of Lepidoptera. Since the honey bees were the predominant species visiting the cucumber flowers, this species presumably was responsible for most of the pollination. No study was made of the competitiveness of the other species in obtaining nectar from the flowers.

Foraging habits of honey bees on cucumbers.

Some honey bees were observed on the cucumbers soon after sunrise, but most began foraging when the temperature was above 70 F. and the plants were dry. Activity peaked near 11 a.m., and a second peak occurred between 2 and 3 p.m.; then foraging decreased until about 5 p.m. when only a few honey bees remained on the crop (Fig. 1). Favorable conditions for cucumber pollination by honey bees were therefore: temperature above 70 F., relative humidity below 70%, winds less than 15 mph, and bright sunshine. When weather conditions were otherwise, the number of bees working the cucumbers decreased, perhaps because on cool, cloudy days, few flowers opened completely and flower parts may have been inaccessible. Pollen collections from the pollen traps indicated that honey bees were collecting only very small pellets of cucumber pollen, about 1% of the total pollen collected. Pollen samples have not been analyzed as yet as to other plant sources.

Shuel (1955) showed that increased relative humidity usually reduces the concentration of sugar in the nectar. In this test, concentrations of sugar in the nectar of cucumber plants ranged from 36 to 41%, during a rain or in

sunshine, respectively. When humidity was high shortly after a rain, bees were observed to skip from one area of the field to another after visiting only one or two flowers. On a clear sunny day with low humidity, they foraged on several flowers (5-10) in a relatively small area before returning to the hive. However, during a rain, the honey bees hesitated to change rows and continued collecting nectar by flying down the rows under the canopy of cucumber leaves. Thus they revisited flowers they had visited before. The reduced number of bees observed working on cloudy or wet days undoubtedly decreased the amount of cucumber fruits set. Factors that affect soil or plant moisture should be considered when planning irrigation schedules.

DISCUSSION

Although large-scale use of honey bees in conjunction with fields of cucumbers planted for machine harvesting is in its infancy, food processing industries could undoubtedly profit by using honey bees for pollination of various crops. Further investigation is needed to ascertain more reliably the ideal concentrations of bees needed at different locations having dissimilar environmental conditions throughout the United States.

The following statements can be drawn from the data collected in this preliminary study, viz.,

(1) Cage studies with and without honey bees showed that yields and quality of cucumbers were improved with bees. Results were the same from three commercial fields.

(2) A small percentage of cucumber fruit developed in the cage without bees which could have been caused by ants or development of parthenocarpic fruit.

(3) The number of insect species collected on the cucumber flowers and plants requires further study to determine the amount of benefit or damage each does to cucumbers. Perhaps in some areas of the United States, wild insects, other than honey bees, would greatly affect the necessity for honey bees for cucumber pollination.

(4) In the Hancock and Wautoma, Wisconsin areas, six plants, that bloomed at the same time as cucumbers, were attractive to honey bees. Their approximate individual acreages were less to several times greater than the cucumber. The reduced sugar concentrations of these six plants indicate that some other floral factors such as aroma, color, etc., are more attractive (competitive) to honey bees than cucumber characteristics.

(5) Very small amounts of cucumber pollen were collected since honey bees were primarily gathering nectar.

(6) Honey bees were active throughout the day and showed two peaks of activity, one around 11 o'clock and the other between 2 and 3 o'clock in the afternoons.

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Footnotes

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⁴ After preparation of this manuscript, the occurrence of chalk brood disease in California was reported in the following publication: Thomas, G. M. and Luce, A. 1972. An epizootic of chalk brood, *Ascospaera apis* (Maassen ex Claussen) Olive and Spiltoir in the honey bee, *Apis mellifera* L. in California. *Amer. Bee J.* 112(3): 88-90.

⁵ Hymenoptera: Apidae.