THE USE OF BEES FOR THE PURPOSE OF INTER-MATING IN POTATO[1]

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Abstract

The pollination behavior of bumblebees and honey bees was studied on potato flowers in screened enclosures and in the field. In enclosures, the domestic honey bee (*Apis mellifera* L.) and the bumblebee species, *Bombus fervidus* Fabricius, seemed to lack any "cue" to initiate visitation of the flowers. When honey was placed on a few flowers, visitation was stimulated. The honey bee tore and chewed at the anther cone to collect pollen, while *B. fervidus* probed for nectar which was not present. Shortly afterward, both species ceased visitation and could not be induced to visit further, regardless of the honey stimulus. Neither species was effective as a pollinator.

It is concluded that neither species will be useful for large-scale crossing of potato populations. However, another bumblebee species, *Bombus impatiens* Cresson, is very effective in pollinating potatoes in the field. Manipulating the behavior of such indigenous populations of bumblebees is likely to be the most effective method of exploiting insect pollination in the potato.

Resumen

La acción polinizadora de abejorros y abejas meliferas ha sido estudiada en flores de papa adentro de jaulas de malla y en el campo. Bajo condiciones de encierro la abeja doméstica (*Apis mellifera* L.) y los abejorros de la especie, *Bombus fervidus* Fabricius, aparentemente no recibieron "estimulo alguno" que los indujera a iniciar a las flores. Al colocarse miel de abeja sobre unas cuantas flores, se logró estimular visitas. La abeja melifera desgarró y masticó el cono de anteras con el objeto de colectar polen mientras *B. fervidus* buscó nectar inexistente. Al poco tiempo, ambas especies, suspendieron las visitas y no se las pudo inducir a reiniciarlas a pesar del estimulo de la miel de abeja. Ninguna de las dos especies resultó efectiva como polinizadora.

Se concluye que ninguna de las dos especies será útil en la polinización cruzada de poblaciones grandes de papa. Sin embargo, *Bombus impatiens* Cresson, otra especie de abejorro, es muy efectiva como polinizadora de

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papa en el campo. La manipulación del compartamiento de este tipo de población indigéna de abejorros será posiblemente el método más efectivo de explotar la polinización de papa por medio de insectos.

Introduction

The large-scale inter-mating of tuber-bearing Solanums is becoming increasingly valuable for population improvement, for new mass-screening breeding methods (6), and may be particularly important in the production of botanical seed for commercial potato production in developing countries (5). At present, large-scale inter-mating must be done by hand or by the uncontrolled activity of indigenous bee populations. The use of bumblebees or domestic honey bees, under controlled conditions, would facilitate controlled, large-scale inter-mating.

Materials and Methods

Domestic honey bees and bee cages were supplied by Dr. E. H. Erickson of the USDA, SEA-AR Bee Lab, Madison, Wisconsin. In the greenhouse during the late winter months, *Solanum tuberosum* Group Phureja-Group Tuberosum diploids, which were flowering and fertile, were placed in two bee cages which were 1.83 m h × 0.91 m w × 2.44 m l. A small hive or "nucleus" of bees was placed in each cage. The behavior of the bees was observed before and after a few drops of honey were applied to some of the potato flowers (where anthers and petals converge).

Two larger bee cages, which were 1.83 m h × 3.05 m w × 3.05 m l, were used outdoors during the summer months. A variety of plant types, all fertile, including various floral colors, and both diploids and tetraploids, were placed in these cages. Two weeks before bees were introduced into the cages, the plants were sprayed with malathion for aphid control, the only chemical control used. A nucleus of bees was placed in one cage, with the other cage acting as a control. After two weeks, the old nucleus was replaced with a new one. Bee activity was observed before and after placing honey on some of the flowers.

After the domestic honey bees were removed, a nest of bumblebees was introduced into the cage. The bumblebees were observed before and after honey was placed on some of the flowers.

A sample of the bumblebees, as well as a sample of bumblebees freely foraging potato fields at the University of Wisconsin Peninsular Branch Experiment Station, Sturgeon Bay, were collected. These samples were identified by Dr. J. T. Medler of the Department of Entomology, University of Wisconsin, Madison. The bumblebees used in the cage were *Bombus fervidus* Fabricius. The bumblebees responsible for fruit set in the potato fields were *Bombus impatiens* Cresson.

Results

In the greenhouse, the domestic bees indicated no interest in the potato plants or their flowers, and only sought to escape the enclosure. When honey was applied to some of the flowers, there was a flurry of bee visitation to all flowers. This visitation was of a very unusual nature, wherein the bees tore apart the anther cones chewing open the inner sides of the anthers and thereby collecting pollen and filling their pollen sacs. This aggressive behavior ended after one or two days, after which no further activity could be induced using honey. Most of the bees retreated to their hive and no fruit set resulted.

When a similar experiment was conducted outdoors, using larger cages, a similar pattern of behavior was observed. Bees only sought to escape from the cage and actually seemed to be repelled by the potato plants. After nearly two weeks, honey was applied to some flowers, but by this time, the bees had largely retreated to their hive and were not attracted to the flowers.

When a fresh hive of bees replaced the first, and honey was immediately placed on some flowers, the bees were induced to aggressively visit all flowers for a short period, as observed in the greenhouse. However, as before, the bees quickly learned not to visit the flowers further and could not be "tricked" with the honey a second time. No fruit developed in either the bee cage or the control, although the plants were fertile and were later used for crossing. The only subsequent bee activity was the visitation of a few clover flowers growing in the bottom of the cage.

When the bumblebees, *B. fervidus,* were placed in the cage, there was no initial visitation of the flowers. When honey was applied to some of the flowers, the bumblebees were induced to visit the flowers. However, these bumblebees did not collect pollen but only probed for nectar, which was absent. Few fruit resulted, and the bumblebees soon stopped visiting the potato flowers.

Discussion

It is clear from these results that domestic honey bees are not suitable for inter-mating potato species. The enclosures which were used are commonly used for such purposes and therefore it is not likely that they were the cause of the erratic behavior of the bees. Potato flowers seem to lack a stimulus for inducing honey bee visitation. Even when "cued into" the flowers by the presence of honey, bee visitation soon stopped and could not be induced again by any amount of honey.

Solanum pollination ecology involves a specific plant-insect mechanism called "buzz pollination" (1, 2), requiring a large-bodied bee which can grasp the anther cone and violently shake it. Even when honey bees were "fooled" into working the flowers, they did not employ buzz pollination to collect the pollen and were ineffective in causing pollinations. Buchmann

(2) believes that *Apis* is physiologically or behaviorally incapable of vibrating poricidal flowers for pollen.

Honey bees have been observed in the potato fields at Sturgeon Bay and may even approach a brightly colored potato flower. However, they have never been seen by the authors to work a potato flower and only seem interested in the flowering weed species in the field. These observations indicating the inability of the honey bee to pollinate the potato are supported by the field studies of Dr. D.R. Glendinning, Scottish Plant Breeding Station, Edinburgh, Scotland (personal communication), and by cage studies of Dr. M.T. Jackson, International Potato Center, Lima, Peru (personal communication).

If bees are to be used to effect potato pollination, it seems this will have to be done using bumblebees or other non-*Apis* species. Furthermore, certain bumblebee species are equally ineffective. The caged bumblebee, *B. fervidus,* did not effect pollinations and seemed to be a "staminal milker" rather than a "buzzer." Given an effective pollinator species, such as *B. impatiens,* there remains the considerable problem of domestication. Domesticating bumblebees is very difficult (7), although there has been some progress in this area (4, 9). It would be particularly difficult to domesticate *B. impatiens* with its underground domiciles and a temperament which has been characterized as "vicious" (8).

Even if it is not practical to domesticate the appropriate bumblebee species, it should still be possible to have greater control over the pollination ecology of wild populations. Normal bumblebee behavior does not ensure random mating in bulk populations. Self-pollination is rarely a problem among diploid Solanums, which are nearly all self-incompatible, but in tetraploid potatoes bee pollination can result in up to 80% selfing (3). Outcrossing in such tetraploids could be achieved by employing male-sterile plants as females. However, it would seem that such male-sterile plants must still shed their nonfunctional pollen, since the authors have observed that bumblebees usually avoid pollen-barren flowers. Another factor reducing effective inter-mating is the tendency for bees to work up and down rows (E.H. Erickson, personal communication), preventing or reducing mating between rows of different parents. Planting designs might be made to encourage between row cross-pollination by planting intermittent barrier rows of a species such as corn, perpendicular to the potato rows. Innovations such as this, in conjunction with male sterility or self-incompatibility, might make potato hybrid seed production, using indigenous bumblebees, practical.

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