Legs covered with pollen, squash bee shows effectiveness as pollinator for squashes, gourds and pumpkins.

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Bees are essential . . .

POLLINATION

Of Squashes, Gourds and Pumpkins

SQUASH AND RELATED PLANTS of the genus *Cucurbita* are monoecious, having both male (staminate) and female flowers (pistillate) on the same plant. To insure fertilization under natural conditions, pollen from the male flower must be carried to the stigma of the female flower by insects. Although other insects, including cucumber, scarab, and meloid beetles, flies and moths are also involved, bees are the major pollinators.

Both wild bees and the honey bee play an active role. Wild bees belonging to the genera *Peponapis* and *Xenoglossa* are the most important. Because they are so closely associated with the ecology of squash, pumpkin and gourds, they are known as squash bees. These bees are solitary in habit and obtain their entire supply of pollen from squash or closely related plants. The pollen from this group of plants is large, and squash bees are ideally equipped to manipulate and gather it. The nectar of both male and female cucurbit flowers is most attractive to the bees, although they may seek nectar from other sources. As a result, a perfect relation exists between the cucurbit host and squash bees: the bees obtain pollen and nectar, and pollination of the host is insured.

There are other features that add to the effectiveness of this association of squash and bee. Depending upon season and weather conditions, flowers of the host open sometime before daylight to shortly thereafter. The flight of squash bees, depending upon species, season, elevation and weather conditions, begins before dawn or somewhat later and may continue at least until noon. However, under hot weather conditions the flowers wither and close by 8 or 9 in the morning and squash bee activity ceases at an early hour. Bee activity is in near perfect synchronization with the opening of the flowers. This allows bees to obtain pollen and nectar, and to pollinate the flowers before the flowers have been disturbed by other organisms that usually appear at a later hour in the morning.

Another advantage to the early morning activity can be observed in Mexico and Central America during the rainy season. Little rain occurs during the early morning hours, allowing bees to visit dry flowers. This is a distinct advantage, because flowers filled or partly filled with water appear to be unattractive to squash bees. The fact that squash bees are available over a good portion of the growing season, along with their abundance, also adds materially to their value as pollinators.

Other bees

Other wild bees that are occasionally important in pollination of squash are bumble bees, carpenter bees, halictid bees and stingless bees. Under some conditions one of these may become more important than another and account for most of the pollination that takes place. However, where conditions are favorable for squash bees, the others usually play a secondary role. They are of distinct value during the period of the year when squash bee activity is at a low ebb or in regions where squash bees do not occur. Some of these bees, such as bumble bees, carpenter bees and certain species of halictid bees may be active in the early morning hours. None of these bees is restricted to the pollen of squash, pumpkin or gourd. As a result, they might neglect the flowers of these hosts if more preferred pollen sources occur in the vicinity. For this reason they would appear to be less reliable as pollinators of squash than are squash bees.

The importance of honey bees as pollinators of squash, pumpkin and gourd should not be minimized, even though they are poorly adapted for this purpose as compared with squash bees. They experience difficulty in manipulating the large grain squash pollen, and are likely to avoid this pollen source if more preferred supplies are available. Honey bees usually visit the flowers much later in the morning than squash bees, although in the summer and particularly in desert regions and in warmer climates they may appear at dawn or shortly thereafter.

However, the abundance of honey bees and ease of manipulation allows them to serve as pollinators under many situations. They often play a dominant role, particularly when squash bees are scarce or absent. Where other pollen sources are not readily available, honey bees have been observed to gather large quantities of pollen from squash, pumpkin and gourds. Under these conditions the pollen supply may be all but depleted.

A squash bee survey was conducted in the Coachella and Borrego areas of southern California in November, 1962. No squash bees were observed, but fair numbers of honey bees were found visiting the flowers of the wild gourd, *Cucurbita palmata*. In the uncultivated desert regions, this plant was probably the sole source of pollen, and often the flowers were nearly denuded of pollen. To make certain that squash bees were not involved, dawn observations were made of plants in the vicinity of Borrego Springs on November 13 starting at 6 a.m. The temperature was 14° C. There was no evidence of pollen disturbance. Honey bees started visiting the flowers by 6:25 a.m., and by 7:20 a.m. most of the pollen had been removed. The survey was ended at 8 a.m. The stamens were nearly free of pollen, although there was still some dislodged pollen at the base of the stamens in the corolla. Once honey bees became active, they were abundant during the entire survey period.

Cucumber beetle, seen on leaf of wild gourd, contributes to pollination, but value is offset by damage to the plants and disease transmission.

Other insects

Flies are occasionally attracted to squash flowers. This is especially true of drosophilid and syrphid flies, which sometimes become covered with pollen while seeking nectar.

At Wendover, Utah, an area where squash bees apparently do not occur, an interesting case of pollination by the white-lined sphinx moth, *Celerio lineata* (Fabr.) was observed. The moths were seen flying from flower to flower seeking nectar and, in so doing, distributed pollen. Other smaller moths have frequently been seen in flowers, but their importance as pollinators is unknown.

There are a number of beetles closely associated with the flowers of squash, pumpkin and gourd. Cucumber beetles are probably the most common, followed by scarabs and meloids. These beetles are capable of transferring pollen from the male to female flowers and thus may play a role in pollination. However, they are more destructive than beneficial, and pollination would best be left to bees. Further, cucumber beetles have been associated with the transmission of virus disease.

In general, squash bees have been able to survive in satisfactory numbers in diversified agricultural areas. However, under certain conditions, an adverse influence has been observed. In Mexico, El Salvador and Nicaragua, a greatly reduced bee population has been observed in regions devoted extensively to cotton production. On occasion, dead bees have been taken in the flowers. In these same areas, it has been observed that the cucumber beetle population dropped to very low levels. Apparently the pest control program directed against cotton pests in these areas is highly injurious to squash bees.

Distribution

Squash bees are limited to the western hemisphere with the greatest concentration of species occurring in Mexico. Eleven species are known to be present in the United States. Some species are wide-ranging, while others are quite limited in their distribution. They are all closely associated with wild gourds, and some appear to be restricted to certain species of gourds, while others visit the flowers of several species—including cultivated squash and pumpkins. Distribution is restricted by host suitability and availability, climate, topography and man. There are species apparently limited to upland regions and others that occur at low elevations. Limited distribution can be associated with restricted suitability of the host.

Man has modified conditions in favor of extending the distribution of several species of squash bees. Indians utilized gourds in their economy and introduced gourds into their campsites. This had the tendency to increase the distributional ranges of several species of squash bees. In California it is believed that native gourds did not exist to any extent north of the Tehachapi Mountains. Today, through the action of man, certain species are widespread north of this area. The common gourd *Cucurbita foetidissima* has been taken as far north as Cottonwood at the northern end of the Sacramento Valley.

Probably more important than the spread of wild gourd by man, is the cultivation of squash and pumpkin. It is believed that the cultivation of these crops has permitted certain species of squash bees to extend their distribution in the United States to the eastern seaboard. In the West, the species that has greatly extended its northern distribution due to the activity of man is *Peponapis pruinosa* and its California form *angelica*. In the

Great Basin area *P. pruinosa* has worked its way at least as far north as the southern limits of the Snake River Valley in Idaho. The form *angelica* occurs in abundance north of the Tehachapi Mountains throughout a large portion of California and has been taken as far north as Susanville.

During 1963 a poor set of squash and pumpkin in some northern regions and isolated areas was attributed to a lack of squash bees. It is believed that further investigation might show possibilities for introduction and establishment of *P. pruinosa* or its form *angelica* in some of these areas. However, surveys have indicated that the northernmost limit of squash and pumpkin growing extends beyond the climatic range of this species.

Although the habits of squash bees follow a general pattern, there is apparently considerable variation in the response of the several species to environment. Comparative ecological studies (particularly at critical levels) are needed to analyze the magnitude of these interactions.

Surveys conducted in Mexico and Central America during 1963 indicate that the abundance of squash bee species was probably associated with abundance of gourds. The center of this complex appeared to be in the Colima to Oaxaca area of Mexico. Squash bees are so intimately associated with the ecology of squash and gourds that they may well furnish a clue to the parents and region where aboriginal man developed the ancestors of our domestic products.

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141

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MALEIC HYDRAZIDE

Retard Topping Regrowth

Lemon Tests

Spraying young regrowth shoots of mechanically top-pruned lemon trees with Maleic hydrazide (MH) resulted in a significant inhibition of growth for almost a year after treatment in tests reported in this article. Top growth was retarded without appreciably affecting fruit quality or yield through use of a concentration of about 400 ppm of MH.

Mechanically cutting the tops of lemon trees has been a commercial practice in California for a number of years. The expense of cutting and hauling away the brush or brush shredding and spreading, suggests a possible economic advantage by using a growth inhibitor, such as Maleic hydrazide (MH). In 1959 the Ventura Coastal Lemon Company conducted promising trials with MH sprays on recently-topped lemon trees. The experiments reported here were made to further measure the growth inhibition and to evaluate possible effects of MH on yield and quality of lemons.

In 1960, an orchard of vigorous six-year-old Frost nucellar Eureka lemon trees on Sweet orange rootstock were selected for uniformity at Ventura. The orchard was mechanically topped to a height of 9 ft on March 28. The trees were sprayed on May 27 when top regrowth was approximately 8 inches in length. MH sprays of 500 and 1,000 parts per million (ppm) active ingredient were applied for comparison with unsprayed controls. The 30% diethanotamine salt of MH was used with 50 milliliters (ml) of X-77 wetting agent per 100 gallons of spray mixture. Only the top growth was sprayed and this was done with a mist to minimize runoff. A randomized block experimental design was used with six tree plots and eight replications.

Ten months after spraying, measurements showed a significant reduction of top growth and shoot length. Three days after measurements, the tops were mowed to a height of 9½ ft above ground, and the brush was collected and weighed for each tree. Large reductions in the weight of top growth were found for both MH concentrations.

No MH sprays were applied after the second topping March 9, 1961. On August 2, 1961, the regrowth measurements averaged: Control, 3.5 ft; 500 ppm, 3.0 ft; and 1,000 ppm, 3.1 ft. These differences, although significant, are slight and of no commercial importance. However, they do show a persistent growth inhibition the year following treatment.

INHIBITING EFFECT OF MH SPRAYS ON REGROWTH OF TOPPED LEMON TREES

Treatments	Regrowth in Feet		Weight lbs/tree
	Tallest shoot	Bush top	
0	7.29	5.83	15.10
500 ppm	4.84	3.74	8.64
1,000 ppm	3.94	2.87	5.71

Topped March 28, 1960; sprayed May 27, 1960; measurements March 6, 1961; topped again and growth weighed March 9, 1961.

Vegetative response

Two weeks after spraying, the young leaves were bent downward with the leaf margins rolling toward the midrib. After one month, the malformed leaves and young shoot tips in the treated area fell off. Leaf curl chlorosis and abscission were limited to tops of MH-sprayed trees. Normal top growth started three months after spraying on the 500 ppm MH-treated trees and after four months for those receiving 1,000 ppm MH.

Fruit quality

Previous work on oranges and grapefruit showed that an undesirable effect of MH was an increase in rind thickness. In these tests, lemon samples were se-