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Kiwifruit flowers: anther dehiscence and daily collection of pollen by honey bees

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Abstract The start of the daily collection of kiwifruit (*Actinidia deliciosa* (A. Chev.) C. F. Liang & A. R. Ferguson var. *deliciosa*) pollen by honey bees (*Apis mellifera* L.) was dependent on the timing of anther dehiscence. Anthers from both staminate and pistillate kiwifruit flowers usually dehisced early in the morning and pollen collection began soon after. The anthers on the staminate flowers released pollen each morning for 3 days and the anthers on the pistillate flowers released pollen for 5 days.

Keywords *Apis mellifera;* honey bees; *Actinidia deliciosa;* kiwifruit; pollen collection; anther dehiscence; pollination

INTRODUCTION

Kiwifruit vines (*Actinidia deliciosa* (A. Chev.) C. F. Liang & A. R. Ferguson var. *deliciosa*) are dioecious. The flowers do not produce nectar (Palmer-Jones & Clinch 1974). However, both staminate and pistillate flowers produce pollen. Pollen from pistillate flowers is not viable but honey bees (*Apis mellifera* L.) still collect it and thus visit flowers of both sexes. The collection of kiwifruit pollen is reported to begin about 0800 h (Jay & Jay 1984a), and to decrease in the afternoon when the pollen is thought to become dry and difficult to collect and, hence, unattractive to foragers (Palmer-Jones & Clinch 1974). Attempts have been made to encourage honey bees to collect kiwifruit pollen earlier in the day and thus extend the period in which they visit the flowers with a consequent increase in pollination effectiveness.

Such management techniques have included feeding colonies sugar syrup in an outdoor feeder a few metres from the hive at 0630 h (Rope 1984) and placing hives on stands well off the ground (Jay & Jay 1984a, b). In raising hives off the ground to keep them warmer, it is assumed that the start of kiwifruit pollen collection depends on the ambient temperature affecting honey bee activity. This assumption is supported by the observation that colonies frequently delay their foraging until late in the morning after a cool night or after a rainy period, although ambient temperatures are high enough for flight to occur (Jay & Jay 1984b).

Another factor that may control the start of kiwifruit pollen collection is the availability of kiwifruit pollen. Pollen cannot usually be collected from flowers by honey bees until the anthers have dehisced. The dependence of pollen collection on pollen presentation has been reported for several plant species (Synge 1947; Percival 1949, 1955).

Kiwifruit anthers dehisce by a longitudinal split (McKay 1977; Schmid 1978). The timing of dehiscence — usually rigidly controlled for a plant species (Percival 1965) — is unreported for kiwifruit anthers. In a few plant species, dehiscence occurs before flower opening, in which instance the timing of flower opening (and not of dehiscence) would control the start of pollen collection.

The purpose of this study was to establish whether temperature (hence, honey bee activity) or anther dehiscence controls the timing of honey bee collection of kiwifruit pollen.

MATERIALS AND METHODS

The study was conducted during the 1983 and 1984 flowering seasons in a kiwifruit orchard in Kumeu, north-west of Auckland. The orchard comprised c. 12 ha of mature kiwifruit vines and was surrounded by kiwifruit orchards and several market gardens. The orchard had a stocking rate of eight hives/ha during both flowering seasons. Six honey bee colonies were monitored during the 1983 season, and three colonies during the 1984 season. The colonies were housed in two-super Langstroth hives fitted with pollen traps which removed about 16% of the kiwifruit pollen pellets (Goodwin 1986).

The pollen traps were emptied hourly during 26 days over the two flowering seasons (74 pollen trap days), and the pollen frozen until analysis. An unbiased subsample of c. 200 pollen pellets was taken from each hourly sample to determine the

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number of pollen pellets from the different flower species. The subsample and the total samples were then weighed to calculate the total number of pollen pellets from each species of flower (Goodwin 1986). The flower species that the pellets came from were identified by colour by comparing them with pellets taken from honey bees collecting pollen from flowers in the area and verified using light microscopy. The colour comparison was made with pollen pellets taken from foraging honey bees and not pollen taken directly from flowers because of slight changes in colour when the pollen is packed into the honey bee's pollen baskets. Very few pollen pellets had pollen from more than one species of flower. Staminate and pistillate kiwifruit pollen pellets were not separated. Hourly recordings were also taken of the air temperature underneath the vines.

The time that the anthers from kiwifruit flowers first dehisced was established from hourly examinations of anthers of flowers that were still on the plants. Thirty newly opened staminate and pistillate flowers were marked at c. 0600 h each morning for 24 days. Dehiscence was defined as having occurred when 50% of the anthers on 50% of the flowers had dehisced. To establish if pollen was being liberated from staminate flowers on the days subsequent to their opening, a petri dish was held under the flowers and the anthers were lightly brushed. Samples of staminate and pistillate pollen grains were taken from foraging honey bees, air dried, and viewed with a scanning electron microscope.

The average time of dehiscence and the start of kiwifruit pollen collection was calculated using radial statistics (Batschelet 1965).

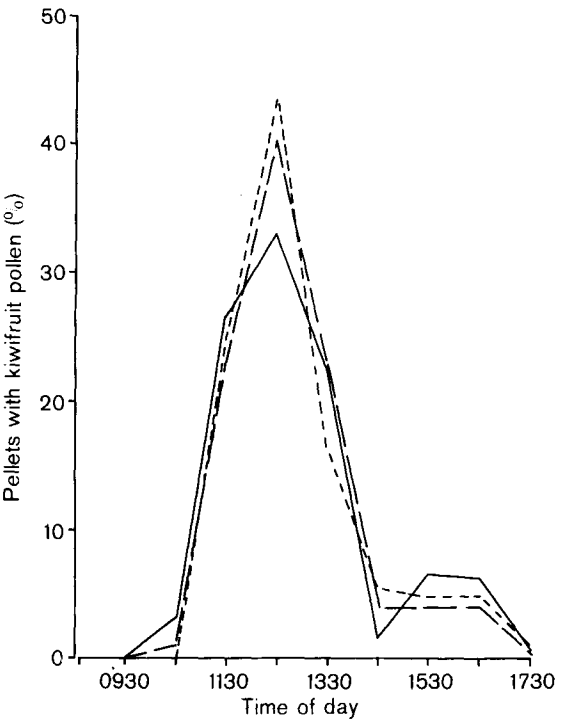

Fig. 1 The amount of kiwifruit pollen trapped each hour from three colonies on the same day. The hourly totals for each colony have been expressed as a percentage of the total amount of pollen trapped from that hive on that day.

RESULTS

Anther dehiscence

Staminate flowers

The anthers from the staminate kiwifruit flowers did not dehisce until after flower opening which normally occurred before 0700 h (Goodwin unpublished data). All the anthers on a flower dehisced on the day that the flower opened with usually >1 h between the time the first and last anther of the flower dehisced. The staminate anthers dehisced by a longitudinal split which reached about half way down the anther. The staminate pollen was dry and powdery and readily fell (when knocked) from the anthers as soon as the split had started. Although there did not appear to be any significant increase in the length in the split on the mornings succeeding the day of opening, more pollen was liberated from the anthers on the following two days. This occurred at the same time that newly opened flowers were dehiscing. The mean time of staminate anther dehiscence was 0920 h (angular deviation = 77 min) and at a mean temperature of 18.7°C (95% C.I. = 0.88°C).

Pistillate flowers

The anthers on the pistillate flowers dehisced by a slightly different method. Like the staminate, the pistillate anthers dehisced by a longitudinal split in the anther wall, but split only about 1/5 of the way down the wall on the first day the flowers were open. The splits lengthened each successive morning until the anthers were completely open on the fifth morning. The pistillate pollen adhered in clumps to the anther walls so that it had to be scraped off by the foraging honey bees. Only the pollen that had been exposed by the splits was available for collection.

It was not possible to place an accurate time on the pistillate anther dehiscence because the split occurred slowly and, unlike the staminate flowers, the only pollen available to be collected was that

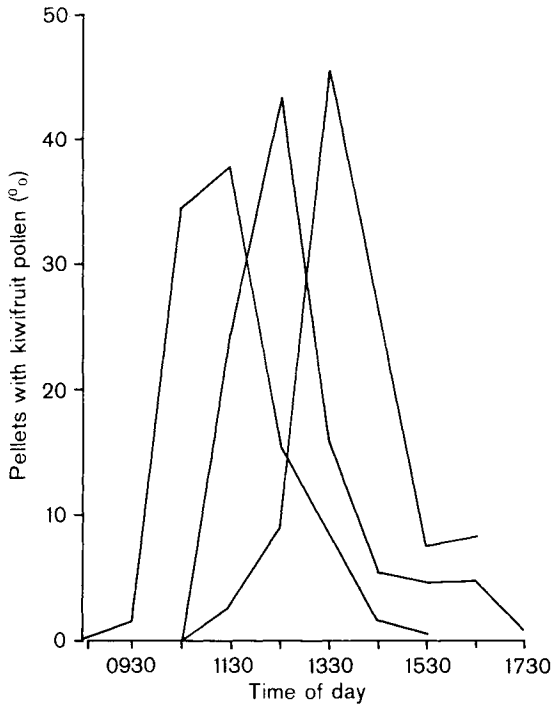

Fig. 2 The amount of kiwifruit pollen trapped each hour from the same colony on three different days. Data calculated as in Fig. 1.

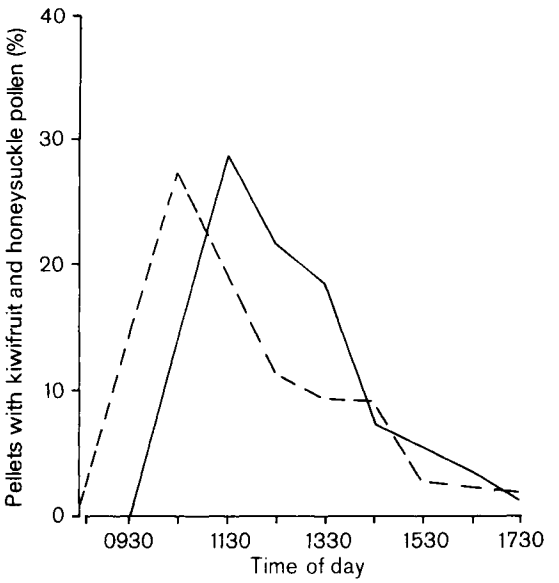

Fig. 3 The amount of kiwifruit pollen and honeysuckle (*Lonicera* spp.) pollen trapped each hour from the same colony on the same day. Data calculated as in Fig. 1.
——— kiwifruit;
— — — honeysuckle.

exposed by the split. There did not, however, appear to be any pollen made available by the split before the staminate pollen dehisced.

Pollen collection

Each colony started to collect kiwifruit pollen at approximately the same time on any one day (e.g., Fig. 1) but the time of the start of kiwifruit pollen collection did vary between days (e.g., Fig. 2). When investigating the collection of pollens other than kiwifruit, it was found that colonies collected other types of pollen before they started collecting kiwifruit pollen (Fig. 3). 74 records taken over 26 days during the two seasons showed that colonies collected other types of pollen — mainly honeysuckle (*Lonicera* spp.) — before kiwifruit pollen 56 times, started collecting other types of pollen at the same time as kiwifruit 17 times, and collected kiwifruit pollen first on only 3 occasions. Most instances of colonies collecting kiwifruit pollen before or at the same time as the other pollens occurred during their first few days in the orchard. The mean time of the start of kiwifruit pollen collection was 0937 h (angular deviation = 43 min) and the mean temperature at the start was 18.65°C (95% C.I. = 0.93°C). On none of the 24 days when pollen dehiscence and the start of collection were investigated did kiwifruit pollen collection precede anther dehiscence. On one very humid day dehiscence and the subsequent honey bee foraging was delayed until 1400 h.

DISCUSSION

Although the start of kiwifruit pollen collection varied on different days (Fig. 2), each colony started collecting kiwifruit pollen at the same time of day on any one day (Fig. 1). This synchrony suggests that factors outside the hives were controlling the timing of kiwifruit pollen collection. The honey bees often collected other types of pollen before kiwifruit (Fig. 3) which suggests that the start of kiwifruit pollen collection is not related simply to the start of foraging activity. If the delay in kiwifruit pollen collection resulted from the effect of temperature on honey bee activity, as suggested by Jay & Jay (1984a, b), the collection of other pollens should have been equally affected. This is also supported by the observation that the average temperature at the start of kiwifruit pollen collection (18.65°C) was far above the minimum temperature needed for normal flight activity (10°C in Lundie 1925; 9°C in Burrill & Dietz 1981).

The start of kiwifruit pollen collection was very closely related to the time of anther dehiscence. Because dehiscence is affected by environmental

conditions (Percival 1965), the effect of cold, wet nights in delaying the start of kiwifruit pollen collection could be explained by an indirect effect on the honey bees through the timing of anther dehiscence, and not directly as assumed by Jay & Jay (1984a, b). The dehiscence pattern of kiwifruit anthers may also explain why honey bees show a preference for foraging on the warmer east side of the vines in the morning (Jay & Jay 1984b), where dehiscence would occur earlier.

The observations suggest that the start of kiwifruit pollen collection is regulated by the availability of pollen. Hence, attempts to encourage bees to forage earlier in the morning are unlikely to be successful except in situations where kiwifruit pollen availability is not limiting.

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