

## Mobility of honey bees (*Apidae*, *Apis mellifera* L.) during foraging in avocado orchards

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**Abstract** – The mobility of the honey bee (*Apis mellifera* L.) during foraging has a great influence on the effectiveness of the bees as cross-pollinators. In this work, honey bee mobility was measured in avocado orchards, between neighbouring trees and up to a distance of 15 rows. The average number of bees crossing between adjacent rows in a 10-min period was linearly correlated to bee density, and the corresponding percentage increased with the increase in wind velocity, from 30 % in a light wind (4 km/h) to up to 65 % in a strong wind (45 km/h). The bees tended to travel upwind, and this tendency increased with increasing wind velocity. Consequently, under strong-wind conditions, up to 100 % of the bees travelled to the adjacent upwind row in a 10-min period. The percentage of cross-pollinating bees decreased with increasing distance from the pollen source, following a hyperbolic curve, and reached 1–2 % of the bees at a distance of 10–15 rows. © Inra/DIB/AGIB/Elsevier, Paris

**honey bee / mobility / cross-pollination / *Persea americana* / avocado / wind velocity**

### 1. INTRODUCTION

Pollinator mobility is essential mainly to plants that require, or are benefited by cross-pollination (i.e. pollen transfer between plants of different cultivars within the same species). This need occurs in dioecious crop species (kiwi, some papaya cultivars), in self-incompatible mono-

ecious or hermaphroditic species (almond, cherry), and in crops which are partially self-incompatible (some apple and most avocado cultivars) [32]. In some of these species, such as apple and almond, cross-pollination is performed by honey bees both directly, during the foraging flight, and indirectly, by means of pollen transfer through body contact of bees inside the

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hive [10, 11, 22]. However, no efficient avocado pollen transfer occurs among the honey bees within hive, and avocado cross-pollination is totally dependent on bee mobility during foraging [27, 29].

Honey bee mobility during foraging is limited: a single bee usually forages within an area of no more than two or three neighbouring trees [1, 2, 5, 6, 8, 14, 18, 20, 21]. Nevertheless, foragers moving tens, or even hundreds of meters, have been observed. These bees stopped foraging before their loads of nectar or pollen were full, flew above the canopy, and landed elsewhere for continued foraging [4, 35]. This 'orientation flight' [13], which was later called 'sampling behaviour' [16, 17] or 'monitoring flight' [18], was assumed to be made by the 'scout bees', which are the only honey bees that perform long-distance cross-pollination during foraging [18].

The purpose of the current research was to measure honey bee mobility during foraging in an avocado (*Persea americana* Miller) orchard, between adjacent trees and in a larger range, and to correlate this mobility to bee density on the trees, to wind speed and direction, and to the distance from the pollen source.

## 2. MATERIALS AND METHODS

Observations and measurements were conducted in avocado plots in the western Galilee of Israel, using medium size trees (5–8 m high) of the cultivars 'Fuerte', 'Ettinger', 'Hass', 'Nabal' and 'Reed'. They took place in the 1982–1984 seasons in an orchard near kibbutz Eilon, and in the 1989–1993 seasons in orchards of Eilon, Rosh-Hanikra and Kabri.

Honey bee density (BPT = bees per tree) was assessed by counting the bees on a whole tree (five trees per cultivar), while circling it at a distance of about 1 m from the canopy for 1 min, using a manual counter [19, 31]. Calibration counts were performed at the beginning of each day, until the discrepancy among the workers was reduced to less than 10 %.

Wind velocity (WindVel) and wind direction were estimated in an open field beside the orchard. Beaufort scale for field estimation of wind velocity was used, to be later converted to km/h.

Honey bee mobility among adjacent trees was measured on four trees in full bloom: two neighbouring trees in a row and two trees next to them in the adjacent row. At the beginning of each measurement period, wind speed and direction, and bee density were recorded. Later, all the bees that crossed between the observation trees were counted, simultaneously in all directions, by an observer, who sat with his back to the sun, and used a multi-station counter with a marked station for each direction. Using these data, the average number of bees that had crossed in a 10-min period from one tree to the adjacent row (NoMob) was calculated. The percentage of bees which crossed between adjacent rows in 10 min (PrMob) was calculated as:

$$\text{PrMob} = (\text{NoMob}/\text{BPT}) * 100 \quad (1)$$

The ratio of wind-direction preference of the bees (UWMP = upwind mobility preference) was calculated for each measurement as:

$$\text{UWMP} = \frac{\text{no. of bees travelling upwind/}}{\text{no. of bees travelling downwind}} \quad (2)$$

Correlations of these variables with both bee density and wind velocity were examined.

The monitoring of honey bee mobility in a range greater than one row was possible owing to the exclusive flowering phenology of avocado. During 4–6 h in the morning, under normal temperature conditions [28], type-A avocado cultivars bear only female-stage flowers, while type-B cultivars carry male flowers exclusively, with a reversal of roles in the afternoon [34]. Therefore, bees that visit flowers of a cultivar in male-stage bloom 'mark' themselves by building pollen loads, which render them identifiable and subject to follow-up while crossing to a cultivar in female-stage bloom [27]. Measurements were taken in avocado plots with adjoining blocks of opposite flowering-type cultivars which bloom during the same season. Plots of 'Hass' contiguous to 'Ettinger' were selected in the orchards of Eilon, Rosh-Hanikra and Kabri, and a 'Reed' block bordering with a block of 'Nabal' was selected in Rosh-Hanikra orchard. Measurements were performed during the female bloom of type-A

cultivars ('Hass' or 'Reed'), and the pollen-releasing stage of type-B cultivars ('Ettinger' or 'Nabal', respectively), which occur in the morning on warm days and at midday on cool days [28]. At the onset of each measurement, wind direction and velocity and bee density of each cultivar were recorded. Later, pollen-load carrying bees and nonloaded bees were simultaneously counted in several rows by several observers. Each observer walked along one row for 15–20 min and used two counters. Counts were carried out in the two rows of the male-blooming cultivar facing the female bloom, and in several rows of the female-blooming cultivar (nos 1, 2, 4, 5, 7 and 15 away from the male bloom). For each row we performed two to five counts, pooled them and calculated the average percentage of pollen-load carriers, which was marked:

PPM(0) = percentage of pollen-load carriers on male-bloom trees

PPF(d) = percentage of pollen-load carriers on female-bloom trees, in 'd' rows away from the male bloom

We assumed that all the pollen-load-carrying bees on the female blooms had arrived from the adjacent male bloom during foraging flight. Also, we assumed that the mobility of pollen-load carriers is similar to that of the nonloaded bees, i.e. that the proportion of the pollen-load carriers among the bees visiting the male bloom is similar to that among the cross-pollinating bees on the female bloom. Therefore, the percentage of cross-pollinating bees in row 'd' of the female bloom, which was designated PCrBee(d), was calculated as:

$$\text{PCrBee}(d) = (\text{PPF}(d) / \text{PPM}(0)) * 100 \quad (3)$$

Take-off and landing directions were observed on three trees in full bloom: two flowering branches (branches which bear inflorescences in each leaf node) per tree were marked, one facing an adjoining tree within the row, and the other facing a parallel tree in the adjacent row. At the beginning of each observation, wind direction and velocity and bee density were measured. Later, all bees visiting the marked branches in a 10-min period were recorded, noting their landing and take-off directions. For improved accuracy, bee-movement directions were recorded by the eight major and secondary compass points. The secondary point counts were later proportionally divided between the adjacent major points.

Observations were made by one observer under light wind conditions (1 Beaufort = 3.7 km/h), and by three observers under mild wind conditions (4 Beaufort = 24.1 km/h). Each observer performed three observation periods of 10 min.

Data analysis was performed according to Sokal and Rohlf [33]. The statistical procedures are listed further below.

### 3. RESULTS

#### 3.1. Mobility between adjacent rows

The number of bees that crossed to the adjacent row in 10 min (NoMob) increased significantly with the increase in BPT, which explained 50 % ( $P < 0.0001$ ) of NoMob variance (*figure 1*), and increased only slightly (not significantly) with the increase in wind speed (*figure 2*). NoMob related to BPT and to WindVel by the multivariable regression function:

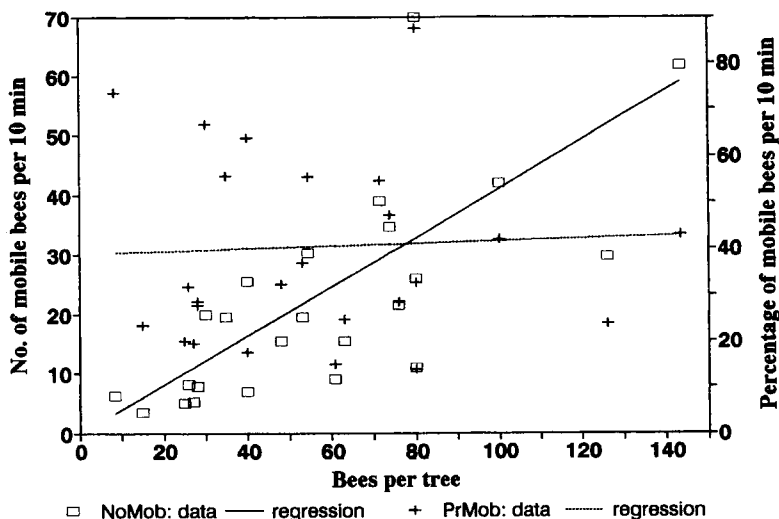
$$\text{NoMob} = 0.418 * \text{BPT} + 0.277 * \text{WindVel} - 4.02 \quad (4)$$

which explained 51.1 % ( $P = 0.0001$ ) of NoMob variability.

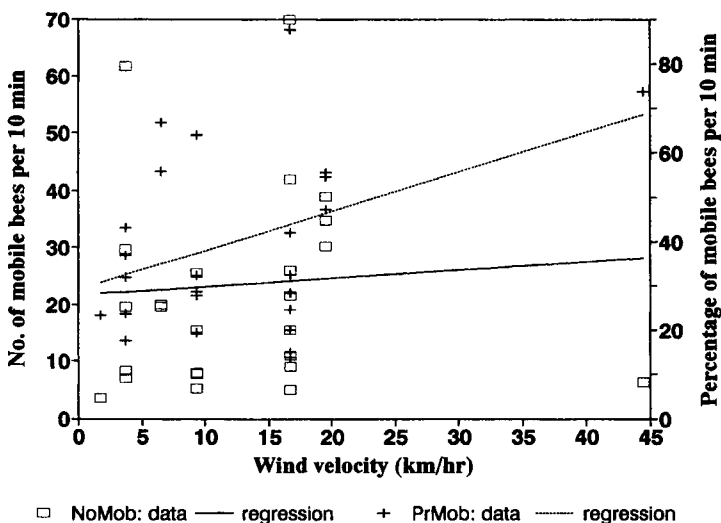
The percentage of bees crossing to an adjacent row in 10 min (PrMob) was found to be hardly influenced by bee density, and was varied around an average of 41% of the bees (*figure 1*). However, it rose with the increase of wind velocity (*figure 2*), from 30 % during a light wind to 60–70 % during a strong wind of 44.5 km/h (6 Beaufort, the strongest wind during which we observed bee activity), and wind velocity explained 13 % ( $P = 0.042$ ) of PrMob variance. PrMob related to BPT and to WindVel by the multivariable regression function:

$$\text{PrMob} = 0.0476 * \text{BPT} + 0.897 * \text{WindVel} + 26.2 \quad (5)$$

which explained 13.5 % ( $P = 0.073$ ) of PrMob variability. A parametric transformation of PrMob [ $\text{TPrMob} = \arcsin$



**Figure 1.** Number of honey bees crossing between parallel trees of neighbouring rows in a 10-min period (NoMob), and the corresponding percent (PrMob), as a function of bee density (BPT = bees per tree). Linear regressions are: NoMob =  $0.412 \cdot \text{BPT} - 0.146$ ,  $r = 0.70$ ,  $P < 0.0001$ ,  $n = 26$ ; PrMob =  $0.028 \cdot \text{BPT} + 38.8$ ,  $r = 0.04$ , ns,  $n = 26$ .



**Figure 2.** Number of honey bees crossing between parallel trees of neighbouring rows in a 10-min period (NoMob), and the corresponding percent (PrMob), as a function of wind velocity (WindVel, in km/h). Linear regressions are: NoMob =  $0.147 \cdot \text{WindVel} + 21.6$ ,  $r = 0.07$ , ns,  $n = 26$ ; PrMob =  $0.882 \cdot \text{WindVel} + 29.1$ ,  $r = 0.36$ ,  $P = 0.042$ ,  $n = 26$ .

$(PrMob/100)^{1/2}$  [33] related similarly to these variables ( $r^2 = 0.13$ ,  $P = 0.081$ ).

### 3.2. Preference for the upwind direction

In all measurements of honey bee mobility between adjacent trees, more bees travelled upwind than downwind (figure 3). The preference for the upwind direction (UWMP) was found to increase with the increase in WindVel, which explained 43 % ( $P = 0.0007$ ) of UWMP variability (figure 3).

### 3.3. Mobility to a range greater than one row

The percentage of pollen-load carriers was maximal during pollen shedding, and dropped gradually thereafter. It reached

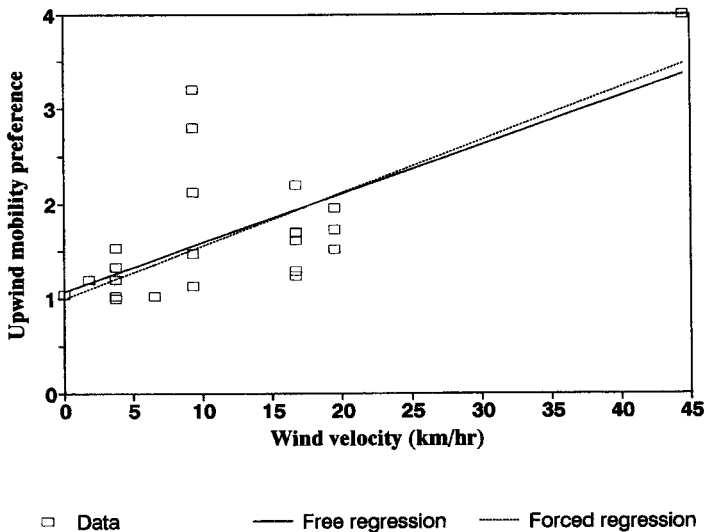
40–60 % on the male-blooming cultivars, and was much lower on the female bloom: during pollen shedding we recorded up to 8 % pollen-load carriers in rows adjacent to the male bloom, but in more remote rows, and at a later period, only 0–5 % of them were observed (figure 4). The best-fit function of regression of the averages of percentage of cross-pollinating bees on female bloom versus distance ('d' in rows) from the male bloom was:

$$PCrBee = 12.3/d + 0.323 \quad (6)$$

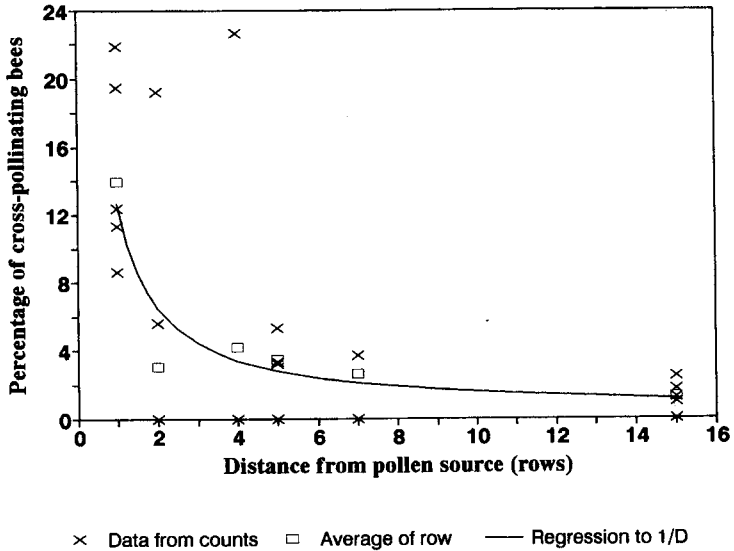
where 'd' explains 85.9 % ( $P = 0.0079$ ) of PCrBee variability (figure 4).

### 3.4. Take-off and landing directions

Under light wind conditions, no differences were found among the directions of either take-offs ( $P = 0.985$ ) or landings ( $P = 0.521$ ) (table I). However, at a mild



**Figure 3.** Honey bee preference of upwind direction (UWMP = upwind mobility preference), which is the ratio between the number of honey bees crossing to the nearest tree in the upwind direction and the corresponding number in the downwind direction, as a function of wind velocity (WindVel, in km/h). The free linear regression is:  $UWMP = 0.052 * WindVel + 1.08$ ,  $r = 0.65$ ,  $P = 0.0007$ ,  $n = 23$ , and the forced to [0,1] linear regression is:  $UWMP = 0.056 * WindVel + 1.00$ ,  $r = 0.65$ ,  $P = 0.0006$ ,  $n = 23$ .



**Figure 4.** Percentage of cross-pollinating bees on female-stage blooming trees (PCrBee), as a function of distance ( $D$ , in rows) from the male-stage trees. Honey bees carrying pollen loads and non-loaded bees were simultaneously counted on trees in male-stage and on trees in female-stage bloom. The counts of each row were pooled to calculate the average PCrBee per row (see Materials and methods). The best-fit function of regression of the averages to  $D$  is:  $\text{PCrBee} = 12.3/D + 0.323$ ,  $r = 0.93$ ,  $P = 0.0079$ ,  $n = 6$ .

wind velocity (about 24 km/h), a clear difference was recorded among take-off directions ( $P = 0.028$ ), with an even greater difference among landing directions ( $P = 0.0009$ ). Landings were mostly directed upwind ( $P = 0.0038$ ), whereas most of the take-offs were directed perpendicularly to the wind ( $P = 0.0030$ ).

#### 4. DISCUSSION

Two foraging strategies can be distinguished among social bees: fixed-course foraging ('triplining'), where the bee gathers food along a route which it returns to in subsequent flights and on subsequent days; and fixed-site-and-species foraging ('species and site constancy'), where the bee collects the food from one species in a small patch (1–3 trees or a similar field

area), to which it returns in subsequent flights and on subsequent days [24, 26].

Fixed-site-and-species foraging strategy is typical of honey bees, which sophisticatedly transfer information about food sources among the individual bees [24, 26]. According to this information, 'work groups' are formed in the hive, where all the bees visit the same food source. These workers show a high level of constancy to the food location and to the flower species, and hence their mobility during foraging is limited and their efficiency as cross-pollinators is low. The information gathering is effected by 'scouts', who visit several locations and flower species during a flight [24, 26], and perform efficient cross-pollination. The proportion of scouts among the foraging bees sets the cross-pollination efficiency of the colony [18].

**Table I.** Percentages of honey bee taking-off to, and landing from various directions, at two wind speeds.

Date	Wind speed	Wind direction	Honeybee activity	<i>n</i>	Direction of honey bee movement			
					N	E	S	W
27.4.90	3.7 km/h	East	take-off	91	25.7	23.2	24.2	26.9
			landing	114	17.8	31.5	24.8	25.9
28.4.90	24 km/h	West	take-off	150	12.8	25.9	36.4	24.9
			landing	180	16.9	20.9	16.4	45.7

Differences among the directions for each row were tested using a  $X^2$  test of homogeneity (see Results).

Our data show that the proportion of honey bee mobility to an adjacent row is not influenced by bee density (*figure 1*), which may be a result of zero energetic gain to the food collectors from increasing mobility of this type. Therefore, we assume that the reports about increase in bee mobility with increased bee density [4, 6, 12, 14, 30, 32, 35, 36] refer to growth in the number of bees crossing between adjacent trees, and not in their percentage. However, the percentage of short-range bee mobility seems to increase with an increase in wind velocity (equation (5), *figure 2*), as has been qualitatively observed previously [14, 23, 39]. This effect may result from the increase in upwind-directed movement of the bees with the increase in wind velocity (*figure 3*), and perhaps also from an expansion of their foraging area.

The 'tendency to forage upwind' [7], which we found to grow with increased wind velocity (*figure 3*), has been explained as the product of aerodynamic restrictions, since it is easier to take-off and land against the wind [39], or as the result of olfactory search for food [23, 39]. We found that bees tend to land against the wind (*table 1*), but they may change their flight direction beforehand. Nevertheless, strong evidence for the olfactory explanation has been provided [38], and it

appears that during foraging of either a food collector or a scout bee, food source location is aided by the sense of smell, and thus motion in the upwind direction is preferred. Another explanation is that the bees choose to forage in an upwind direction while loading, and to fly downwind back to the hive when they are full and heavy (D. Roubik, pers. comm.).

We found an average of 41 % of the bees crossing between adjacent rows of avocado medium-size trees in a 10-min period. Because under good avocado-pasture conditions honey bees fill their crop in about 10 min [27], we used this figure to estimate the percentage of bees crossing between adjacent rows during foraging. Both bee-mobility rate and the upwind-direction preference grew with increasing wind velocity (*figures 2 and 3*), and under a wind speed of about 45 km/h the upwind mobility to the adjacent row reached 100 % of the bees. This short-range mobility is higher than has been described before [1, 2, 5, 6, 8, 14, 18, 21], and may explain the high rate of both cross-pollination and fruits of cross-pollination that was found in rows adjacent to the pollen donor, and also the growth in production in these rows, compared to rows further away [2, 3, 9, 15, 20, 25, 27].

Our work indicates that the percentage of cross-pollinating bees stabilizes at about

1–2 % of the workers, at a distance of 10 to 15 rows away from the male bloom. This percentage conforms with the early assumption, that this value is about 1 % [17]. This low percentage of cross-pollinating honey bees should explain the reports of cross-pollination, and cross-pollinated fruit set, at long distances from the pollen source [9, 27, 37]. Nevertheless, a rise in the percentage of scouts among the foraging bees with an increase in competition [18] requires further study. The division of labour between food and information gatherers may be flexible, and, under increased-competition conditions, food collecting honey bees may switch to information gathering. Under such circumstances, an increase in cross-pollination efficiency of the honey bee population is expected.

An inconsistency was encountered with regard to the short-range bee mobility. Direct counts of bees resulted in an average of 40 % of the bees crossing to an adjacent row (*figure 1*), whereas counts of pollen-load carriers led to only 14 % cross-pollinating bees in the first female-blooming row (*figure 4*). This difference may stem from a low tendency of the bees that collect pollen and nectar on the male bloom, to cross to the female bloom, which carries nectar only.

## ACKNOWLEDGMENTS

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**Résumé – Mobilité des abeilles (*Apidae*, *Apis mellifera* L.) au cours du butinage dans les vergers d'avocatier.** La mobilité des abeilles au cours du butinage influence fortement l'efficacité des abeilles en tant qu'agents de la pollinisation croisée. Ceci est particulièrement important pour les cultures telles que l'avocatier (*Persea americana* Miller), qui requièrent la pollinisation croisée ou en bénéficient et pour lesquelles il n'y a pas de transfert de pollen entre abeilles à l'intérieur de la ruche. Nous avons quantifié la mobilité des abeilles dans des vergers d'avocatiers entre arbres adjacents et jusqu'à une distance de 15 rangées, en mesurant la densité des abeilles, la vitesse et la direction du vent. La densité des abeilles (nombre d'abeilles/arbre) a été comptée sur l'arbre entier à raison de cinq arbres par cultivar. La mobilité entre arbres adjacents a été mesurée en comptant les mouvements d'abeilles effectués dans toutes les directions entre quatre arbres adjacents. La mobilité sur une distance supérieure à une rangée a été calculée à partir du nombre d'abeilles avec et sans pelottes de pollen, à la fois dans les rangées d'avocatiers portant des fleurs mâles produisant du pollen et dans les rangées d'arbres portant seulement des fleurs femelles. et ce à différentes distances de l'arbre mâle en fleurs. Les directions d'envol et d'atterrissage des abeilles ont été enregistrées sur les branches d'avocatiers en fleurs et mises en relation avec la vitesse et la direction du vent. Le pourcentage moyen des abeilles qui, sur une période de dix minutes, sont passées d'une rangée à une autre rangée adjacente a été de 41 %. Ce chiffre n'est pas influencé par la densité d'abeilles, c'est-à-dire qu'il existe une corrélation linéaire entre le nombre d'abeilles passant d'une rangée à une autre adjacente et la densité des abeilles (*figure 1*). Néanmoins, ce pourcentage augmente avec la vitesse du vent : de 30 % par vent léger, il passe à 65 % par vent fort (*figure 2*). Les abeilles ont le plus souvent volé contre le vent et cette



tendance aussi s'est accrue avec la vitesse du vent (*figure 3*). Ainsi, par vent fort, près de 100 % des abeilles ont volé contre le vent d'une rangée à une autre adjacente en l'espace de dix minutes. Par vent faible, aucune différence n'a été trouvée entre les directions d'envol et d'atterrissage ; mais avec un vent de 24 km/h, les atterrissages se sont faits le plus souvent contre le vent, alors que la plupart des mouvements d'envol étaient perpendiculaires à la direction du vent (*tableau 1*). La mobilité sur une distance supérieure à une rangée s'est effectuée au-dessus de la canopée, apparemment comme une recherche d'autres sources de nourriture. Le pourcentage d'abeilles effectuant une pollinisation croisée à la suite de cette mobilité a diminué selon une courbe hyperbole quand la distance à la source de pollen augmentait, pour s'approcher de 1 à 2 % à la distance de dix à quinze rangées (*figure 4*). La plupart des butineuses ont fait preuve d'un niveau élevé de constance florale, à la fois à l'espèce de fleur et au lieu de nourriture. Leur mobilité au cours du butinage est donc limitée et leur efficacité en tant qu'agents de la pollinisation croisée est faible. Seules les éclairceuses, qui récoltent à la fois de la nourriture et de l'information, présentent une mobilité élevée et accomplissent avec efficacité la pollinisation croisée. Mais, comme elles ne représentent que 1 à 2 % des butineuses, on peut dire que l'efficacité des abeilles dans la pollinisation croisée de l'avocatier est faible. © Inra/DIB/AGIB/Elsevier, Paris

**Avocat / *Persea americana* / pollinisation croisée / efficacité pollinisatrice / butinage / vitesse vent**

**Zusammenfassung – Mobilität von Honigbienen (*Apidae, Apis mellifera* L.) während der Futtersuche in Avocadopflanzungen.** Die Effektivität der Honigbienen als Kreuzbestäuber hängt

stark von ihrer Mobilität während der Futtersuche ab. Dies ist bei den Anpflanzungen besonders wichtig, die wie Avocado eine Kreuzbestäubung benötigen oder davon begünstigt werden und bei denen die Übertragung des Pollen nicht in dem Bienenvolk erfolgen kann. Wir bestimmten die Mobilität von Sammlerinnen in Avocadopflanzungen zwischen benachbarten Bäumen und über einen Abstand von 15 Reihen in Abhängigkeit von der Bienendichte und der Richtung und Stärke des Windes. Die Dichte der Honigbienen (Bienen pro Baum) wurde entweder an einzelnen Bäumen bestimmt oder über 5 Bäume gemittelt. Zur Ermittlung der Mobilität wurden die Bienenflüge in allen Richtungen zwischen vier benachbarten Bäumen beobachtet. Die Mobilität in Entfernungen von mehr als einer Reihe wurde aus der Anzahl von Bienen mit und ohne Pollenladung berechnet. Diese wurde gleichzeitig in Pflanzreihen mit pollenproduzierenden männlichen Blüten und in benachbarten Reihen mit nur weiblichen Blüten in verschiedener Entfernung von den männlichen Blüten bestimmt. Auf blühenden Zweigen wurde die Richtung der Landung und des Abflugs der Bienen bestimmt und zu der Richtung und Geschwindigkeit des Windes in Beziehung gesetzt. Der mittlere Prozentsatz der Bienen, die innerhalb einer 10-minütigen Beobachtungszeit zwischen benachbarten Pflanzreihen wechselten, betrug 41 %. Dieser Prozentsatz war von der Bienendichte unabhängig, die Anzahl überwechselnder Bienen stieg daher linear mit der Bienendichte an (*Abb. 1*). Dagegen nahm dieser Prozentsatz mit zunehmender Windgeschwindigkeit von 30 % bei leichtem Wind bis auf 65 % bei starkem Wind zu (*Abb. 2*). Die Bienen flogen hierbei zumeist gegen die Windrichtung, eine Tendenz, die bei steigender Windgeschwindigkeit zunahm (*Abb. 3*). Dies führte dazu, daß bei starkem Wind annähernd 100 % der Bienen innerhalb von 10 min gegen die Windrichtung von einer zur nächsten Pflanz-

reihe wechselten. Bei schwachem Wind ergaben sich keine Unterschiede der Lande- oder Abflugrichtung der Bienen. Bei einer Windgeschwindigkeit von 24 km/h erfolgten die Landungen dagegen zumeist in Gegenwindrichtung, während die Abflüge quer dazu erfolgten (*Tabelle I*). Bienenbewegungen über einen Abstand von mehr als einer Pflanzreihe erfolgten oberhalb der Kronen, offensichtlich in der Suche nach anderen Futterquellen. Die auf Grund dieser Erhebung abgeschätzten Anteile von kreuzbefruchteten Bäumen nimmt nach gemäß einer hyperbolischen Kurve mit zunehmender Entfernung ab und erreicht in einer Entfernung von 10–15 Reihen 1 % bis 2 % (*Abb 4*). Die meisten der sammelnden Honigbienen zeigen einen hohen Grad an Konstanz bezüglich der Blütenart und des Sammelortes, daher ist ihre Mobilität gering und ihre Effektivität als Kreuzbestäuber begrenzt. Nur die Kundschafterbienen, die sowohl Nahrung als auch Information sammeln, zeigen während des Sammelns eine hohe Mobilität und damit hohe Effektivität in der Kreuzbestäubung. Da diese jedoch nur 1 % bis 2 % der Sammelbienen stellen, ist die Effektivität der Honigbiene als Kreuzbestäuber gering. © Inra/DIB/AGIB/Elsevier, Paris

### Honigbienen / Mobilität / Kreuzbefruchtung / Avocado / *Persea americana* / Windgeschwindigkeit

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