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Avocado Pollination – by Honeybees or by Wind?

Gad Ish-Am
Tzafon Agricultural R & D,
and
Ohalo College, Katzrin, Israel

Emi Lahav
Acco Regional Experiment Station,
Israel

A major question remains re avocado pollination:

What is the relative contribution of wind *vs.* honeybees (and other insects)?

Or: is it necessary to introduce honeybee hives into avocado orchards to ensure pollination?

Davenport (2003 and more):
Wind is the major avocado pollination agent in Florida.

Ying, Davenport *et al.* (2009):
Wind, and not honeybees, is the main avocado pollinator also in California.

The purpose of this study was:

to determine the relative importance of honeybee activity and wind in the pollination of avocado trees under a Mediterranean climate

Methods (1)

Location

Avocado orchard, Western Galilee, Israel

Cultivars and trees

Five cultivars: Hass, Reed (flower group A) Ettinger, Fuerte, Nabal (flower group B)
Five trees in full bloom (next to a pollenizer tree) for each cultivar, per season.

Observation seasons and days

Seven seasons: 1982 – 1984, 1989 – 1992,
Nine days per season.

Meteorology data

Two stations: inside the orchard, and in an open field next to the orchard.

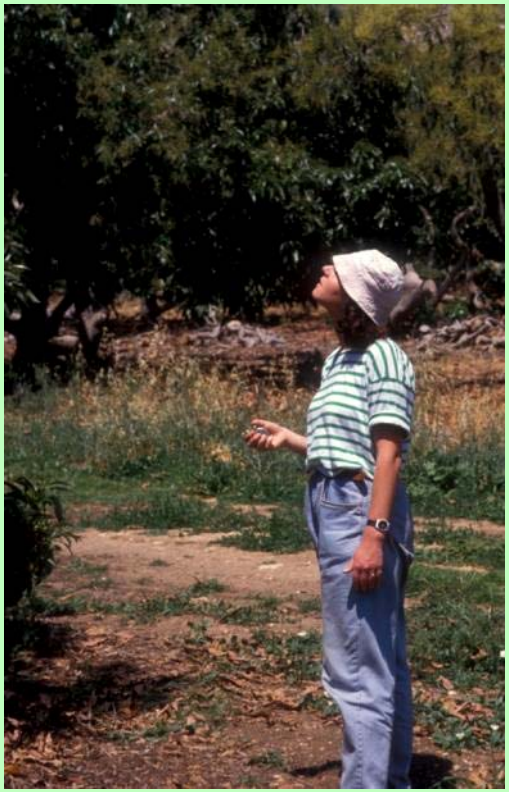
Methods (2)

Temperatures

Daily max, min and average.

Wind velocity

Measuring every 30 min, from 08:00 to 18:00.
Recording daily max and average.



Honeybee density

Number of bees per tree, counts every 30 min during the day, for each tree.
Recording daily "Max bee density" for each cv.

Flower stages

Recording open flower stages every 30 min for each tree.

Rates of pollination

Sampling 50 styles per cultivar every 60 min.
Checking "Percent pollination" under a light microscope.
Recording daily "max percent pollination" per cv.

Methods (3)

Simulation of wind effect

'Hass' & 'Fuerte' male flowers were subjected to changing wind velocities under lab condition. Pollen drift was recorded using a stereoscope.

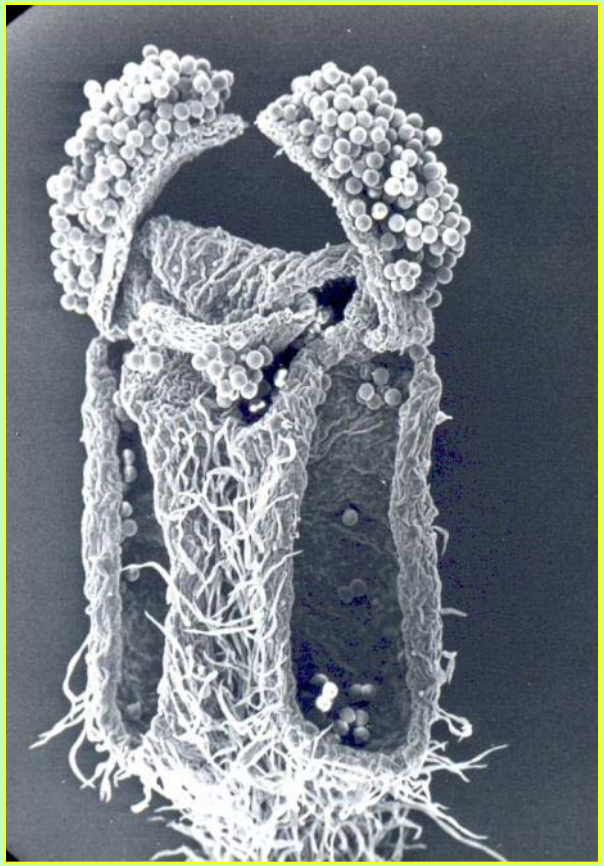
Statistical analysis

1. Data from the 7 years were pooled.
2. Daily "Max percent pollination" of the 5 cultivars was pooled and analyzed *vs.*:
   - Daily "max bee density"
   - Wind velocity (daily max or average)
   - Temperature (daily max or average)
   - Cultivar
3. "Max percent pollination" of each cultivar was also analyzed against "Max bee density" and wind velocity.

Results (1)

Wind velocity in the field

Maximum wind velocity (61 observation days):
Open field - 9.7 m/sec; Inside the orchard - 4.5 m/sec.



Anther of 'Hass' male flower

Simulation of wind effect

Wind velocity of up to 10 m/sec
No pollen dispersal from the male flowers.

Wind velocity of 10 to 14 m/sec
Few pollen dispersed from the male flowers.

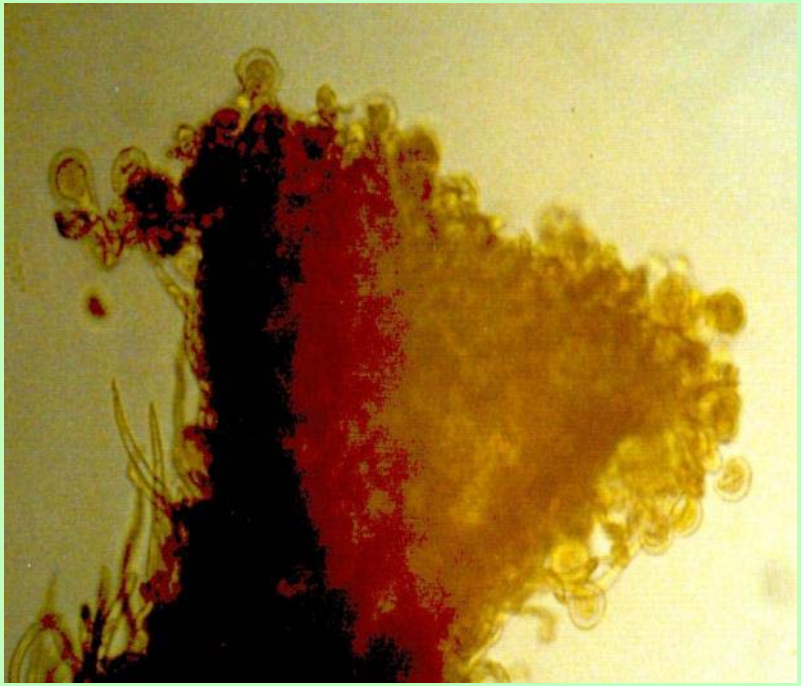
Wind velocity of 14 to 16 m/sec
Pollen dispersal from all male flowers.

High wind velocities caused pollen dispersal mainly in clusters.

Results (2)

Effects on "Percent pollination" of the 5 cultivars

"Honeybee density" – high significant positive effect ($P < 0.0001$).
"Wind velocity" – no effect, neither of max, nor of average velocity.
"Average daily temperature" – positive effect ($P = 0.020$).
"Cultivar" – significant effect ($P = 0.012$).



'Hass' female flower pollinated stigma

Effects on "Percent pollination" of each cultivar

Honeybee density: significant positive effects.

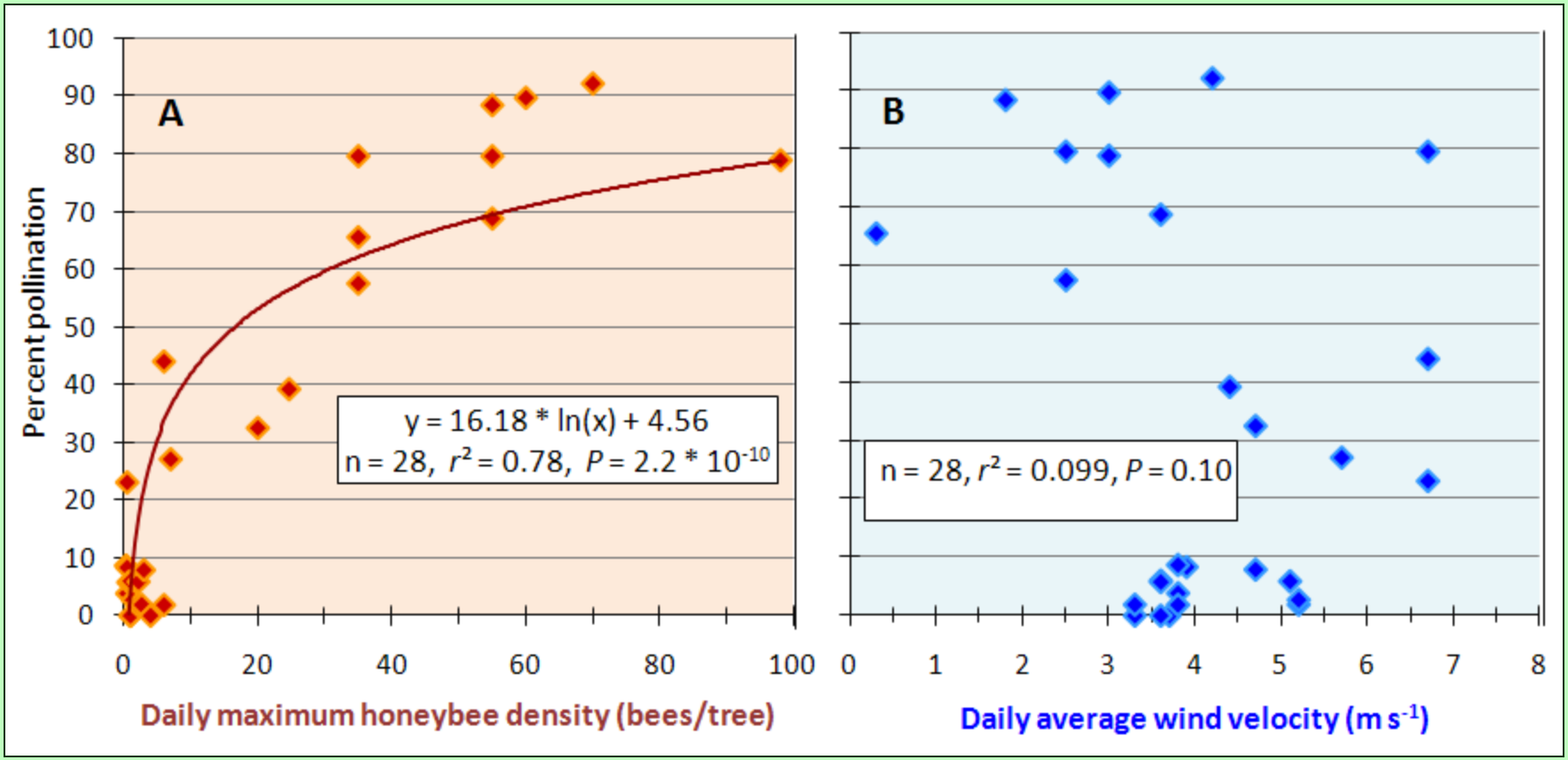
Wind velocity: neither daily max, nor average wind velocities had any effect.

Results (3)

"Percent pollination" of 'Hass' is affected by:

"Honeybee density" – a high significant positive effect ($P < 0.0001$).
"Wind velocity" – no effect ($P = 0.10$).

'Hass' percent pollination *vs.* honeybee density and wind velocity



Discussion

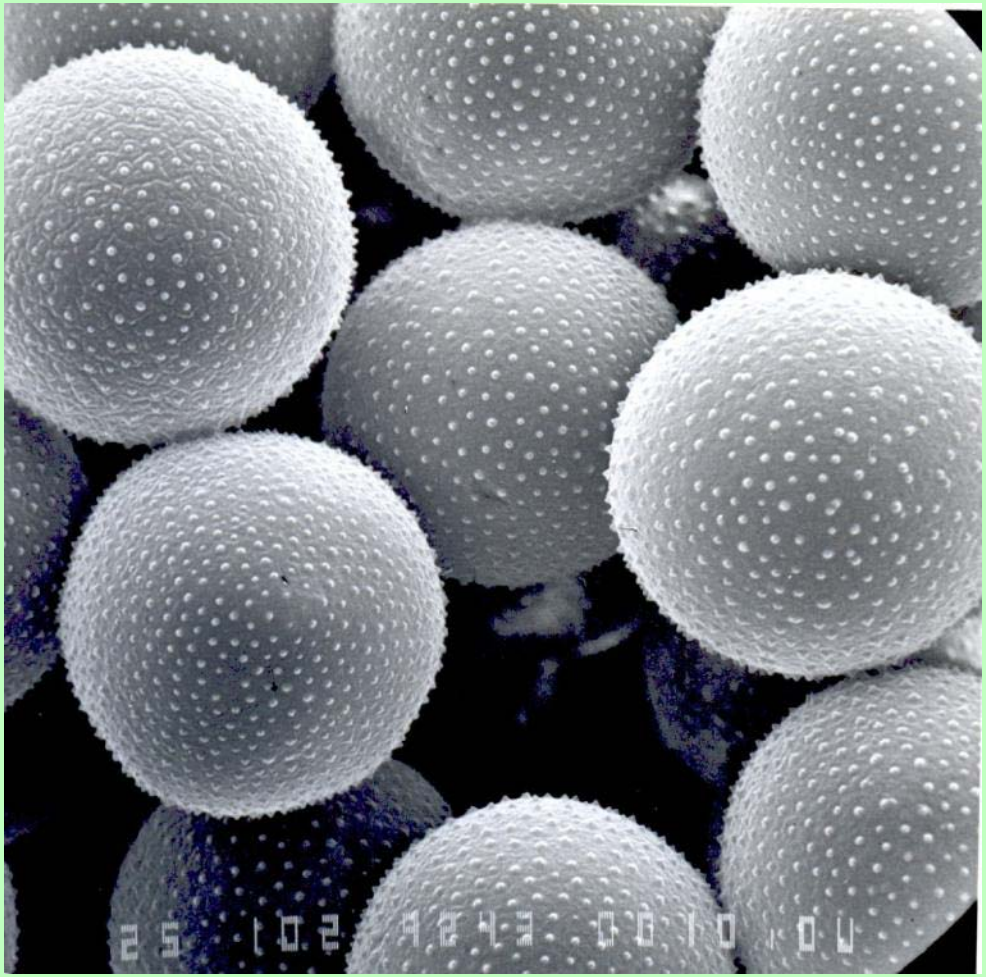
the avocado flower – a typical insect pollinated flower

- Nectar secretion by both gender flowers.
- Small stigma and small amount of pollen.
- Flowers are colorful and have scent.
- Large, sticky pollen grains.

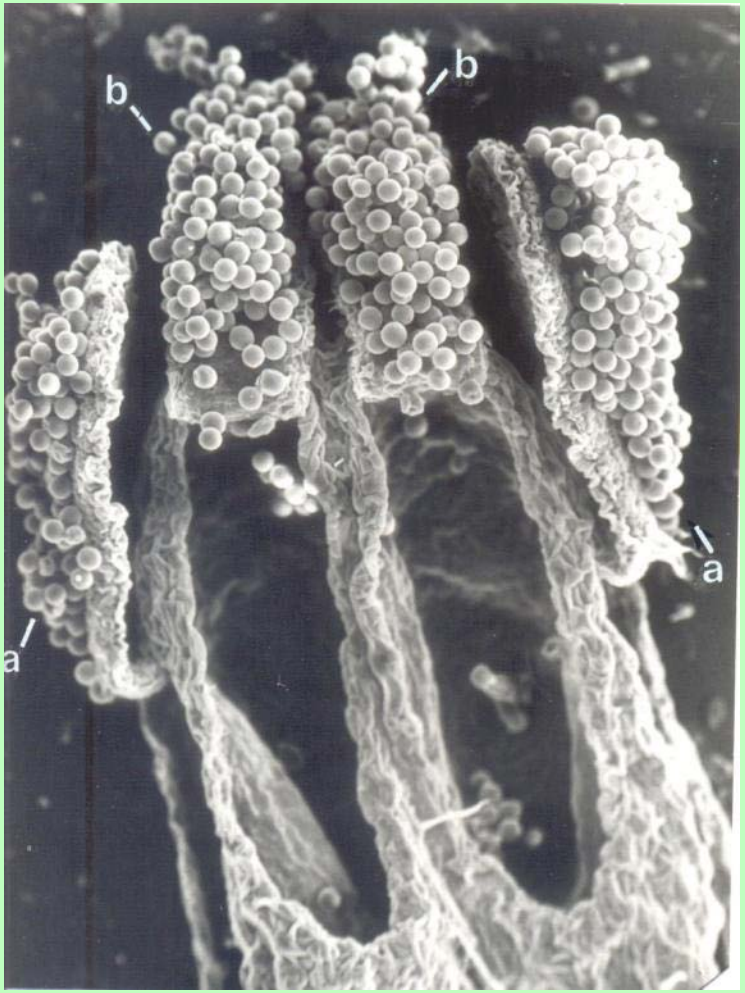
Female Phase (‘Reed’)

Male Phase (‘Fuerte’)

The avocado pollen grains are large and sticky



Ettinger pollen grains



Ettinger pollen grains attached to the open valves

Experiments of pollination under net

Flowering tree under net, with no bees: no fruits, or very few fruits (1-3% of un-caged trees).

Flowering tree + pollenizer tree under net, with no bees: few additional fruits (4-6% of un-caged trees).

Flowering tree under net, with bees: numerous fruits.

Sources: numerous works from California, Israel, South Africa, and Yucatán.

Flowering tree under net, with bees + pollenizer next to net: numerous fruits, of which only 7% (3-14%) are cross.

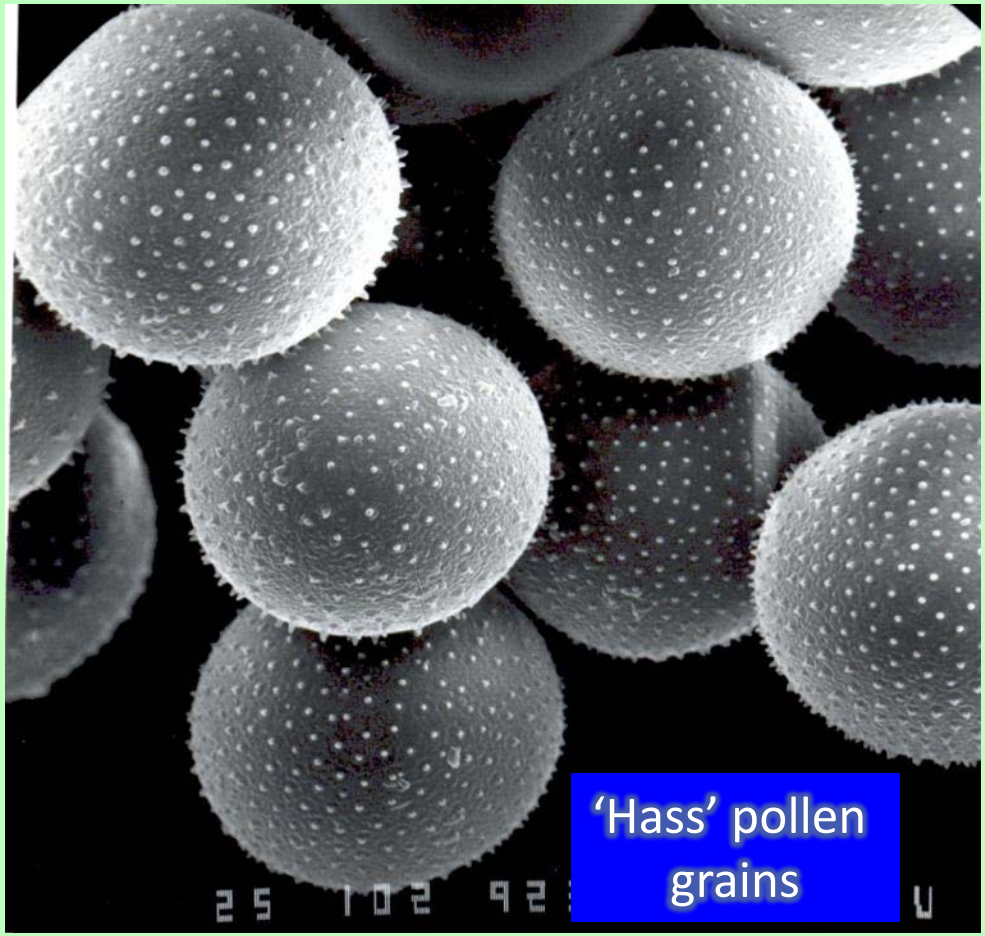
Source: Degani *et al.*, 2003

Measurements of avocado air-borne pollen

Very low quantities, mostly as clusters.

'Ettinger' pollen floats up to 25 m.

Source: Katz, 1995



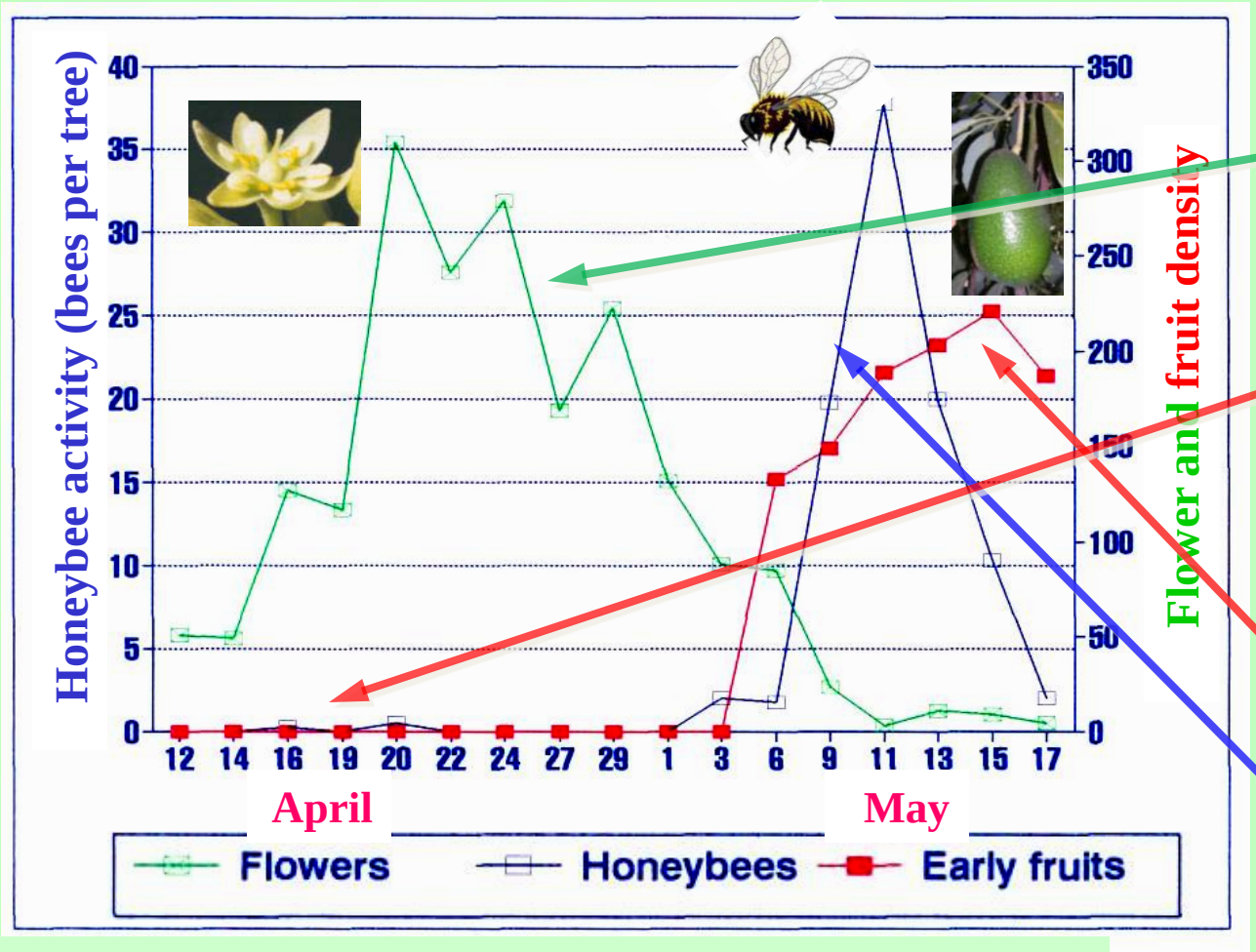
No correlation between wind velocity and air-borne avocado pollen amounts.

Air-borne pollination rates in caged trees:

2.5%-4.7% in trees next to a pollenizer tree.

0.6% pollination in a secluded 'Ettinger' tree.

'Hass' flowering, honeybee activity and fruit set - Israel, spring 1992



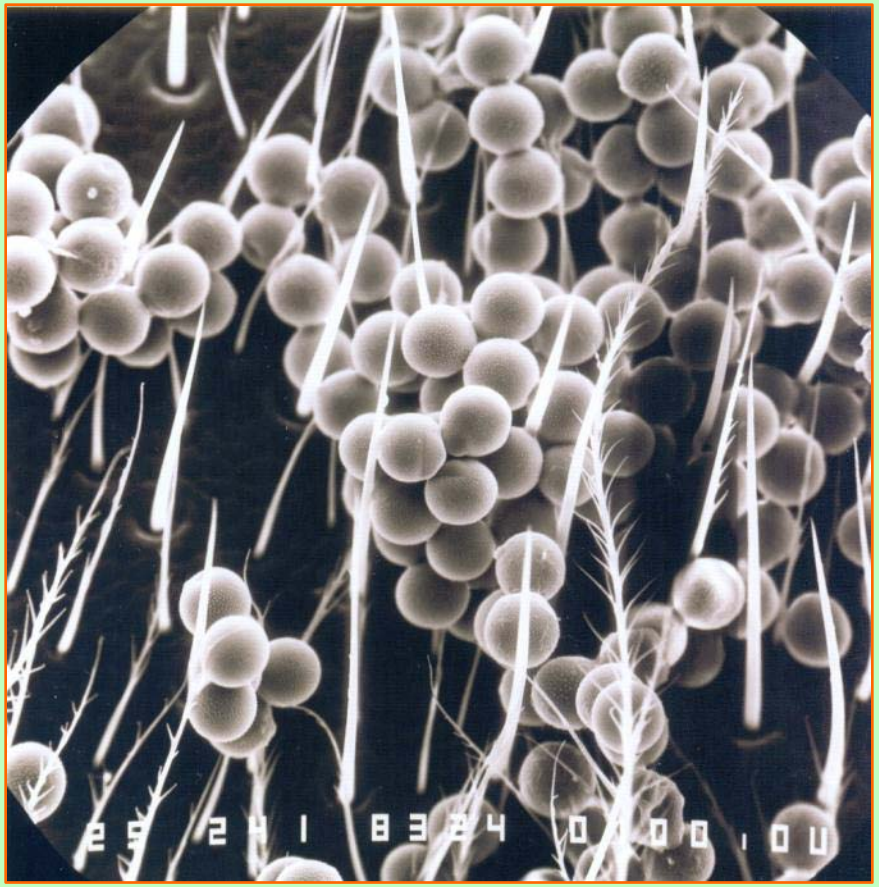
No fruit-set during 'Hass' peak bloom, while honeybee activity was very low

High fruit-set began when the bees visited the trees, at the end of bloom.

Source: Ish-Am and Eisikowitch, 1998

Honeybees transfer the pollen

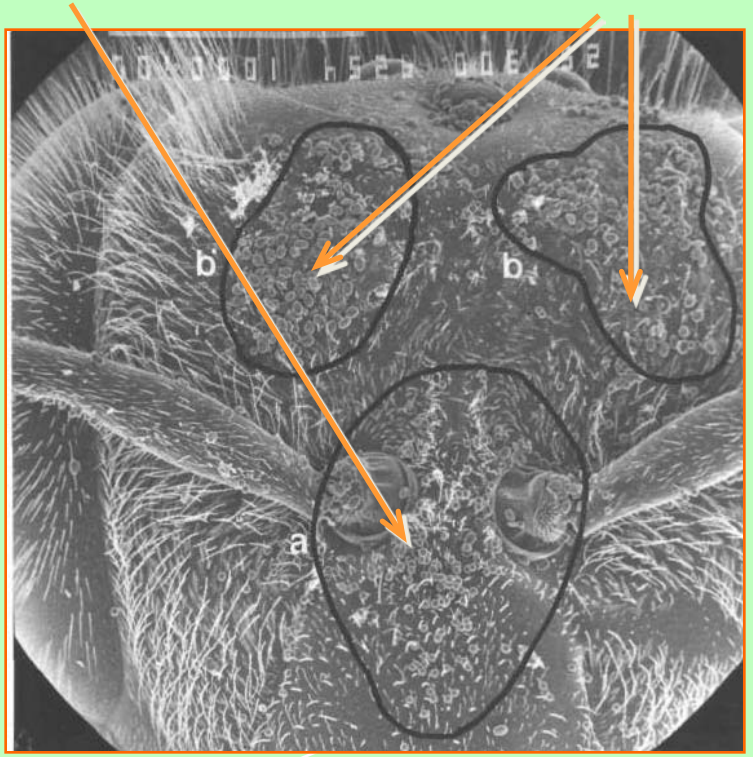
Avocado pollen carried on a honeybee's body



Head of a honeybee

Avocado pollen

Brassicaceae pollen



Source: Ish-Am and Eisikowitch, 1993

Pollen and stigma touch same locations

Male flower

Female flower

Forehead transfer

Ventral-thorax transfer

Honeybees are efficient pollinators, but…

Vithanage (South-West Australia, 1990):

Honeybees are the most available efficient avocado pollinator.

Two beehives/hectare increased yield (3.5-fold), comparing to no hives.

Three beehives/hectare further increased productivity by 20% to 38%.

Ish Am *et al.* (Israel, 2000):

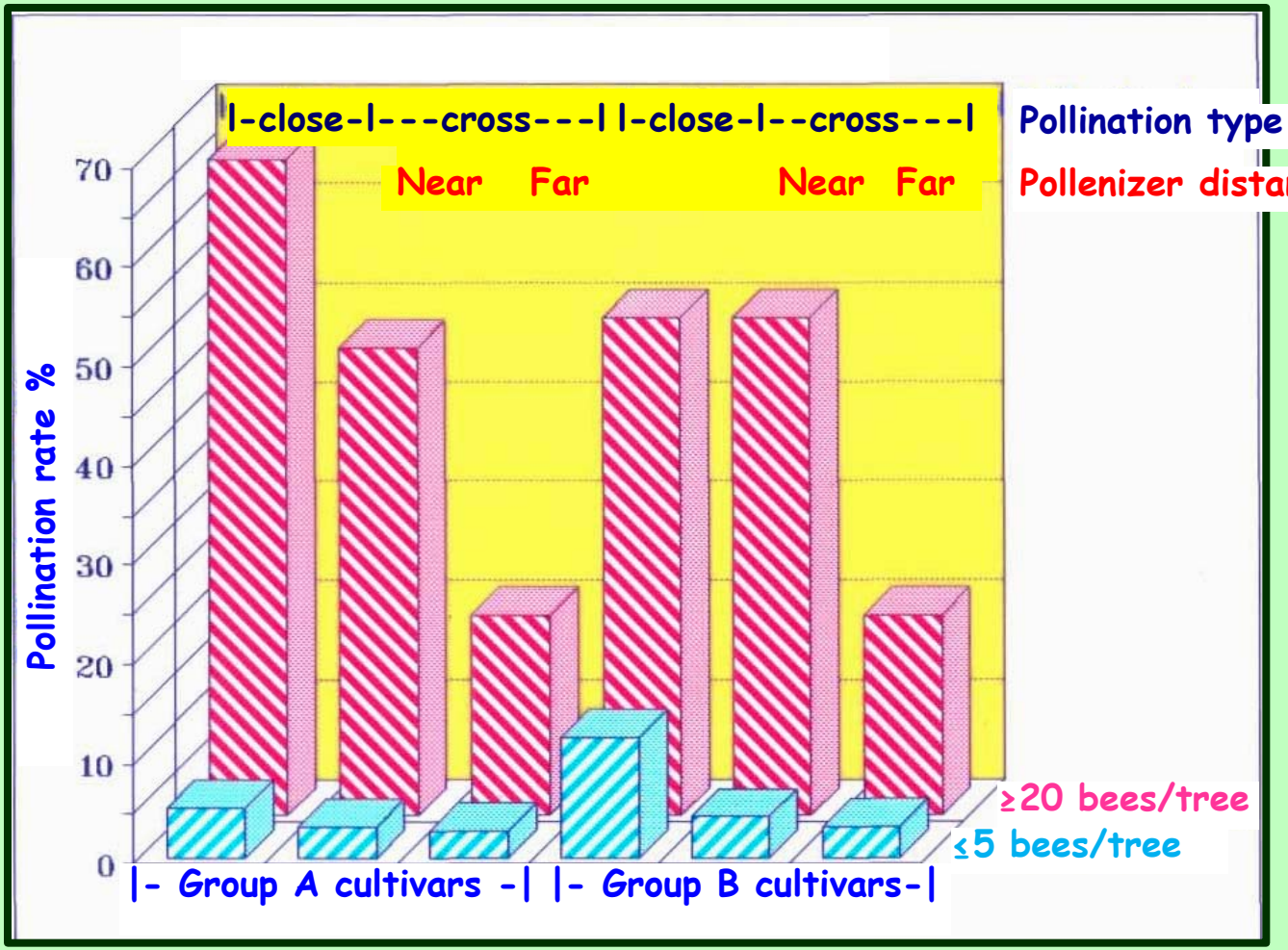
Adding bumblebee hives increased yield, and mainly increased cross-yield in trees that are distant from pollenizer.

Ish Am & Gazit (Mexico, 2002):

Eight local Meliponinae species are more efficient pollinators than honeybees.

Conclusion: the need for numerous honeybees.

Average pollination rates are affected by:



Source: Ish-Am and Eisikowitch, 1998

a. Number of bees per tree: Twenty may be sufficient.

b. Pollenizer distance: Near pollenizer induces better cross-pollination.

c. Pollination type: Close-pollination rate is mostly higher than cross-pollination.

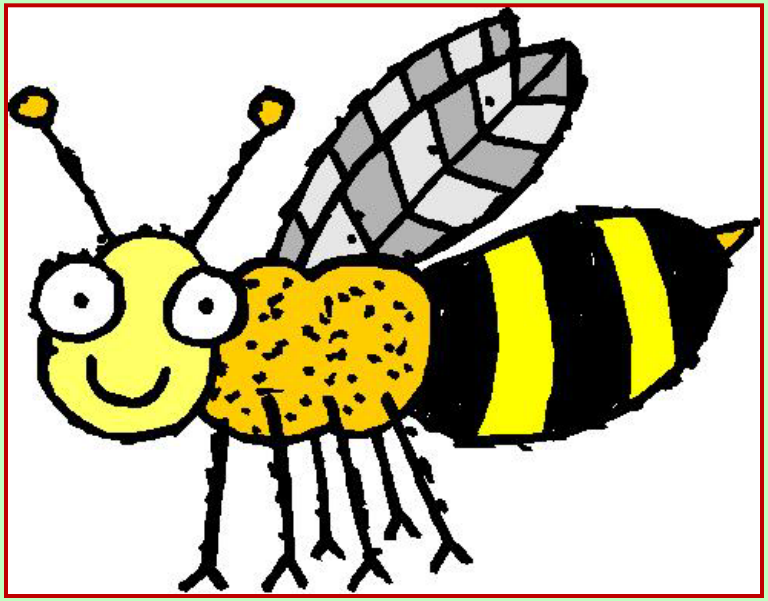
d. Flowering group: "Group A" cultivars get higher close-pollination rate.

Conclusion: our work, plus other works, invalidate the claims of Davenport and his colleagues.

Recommendation: monitoring honeybee activity, and adjusting honeybee-hive density accordingly:

Bees per tree	Close-fruit set	Cross-fruit set	Adding hives
0	none	none	necessary
1-4	Very few	none	necessary
5-9	few	none	necessary
10-25	many	few on the 1st row	recommended
26-55	many	on 1st and 2nd rows	may be helpful
More than 55	many	up to the 4th row	not needed

Source:
Ish-Am, 2005



Thank you...