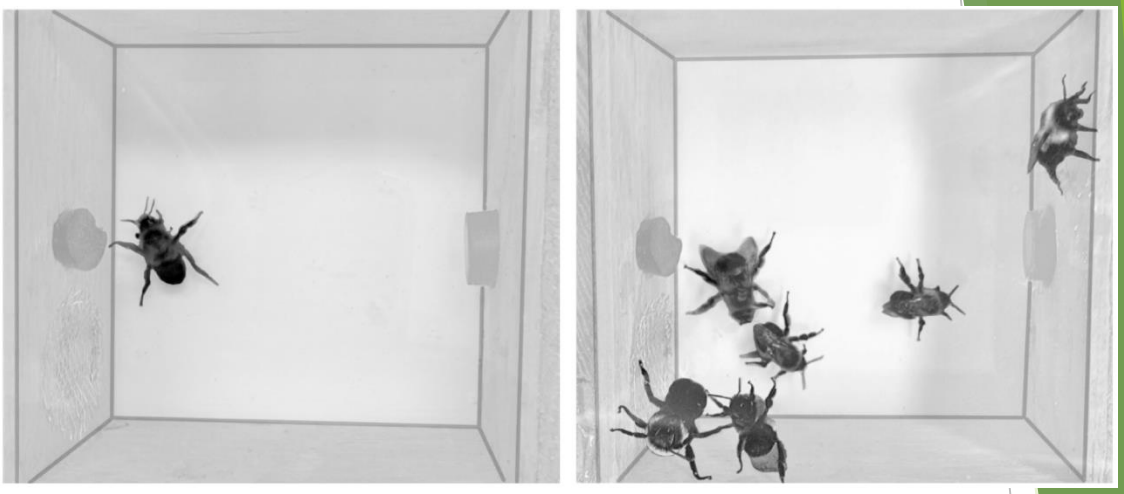


To a rough approximation, and setting aside vertebrate chauvinism, it can be said that essentially all organisms are insects . Robert May, 1988)

Floral choices by bumblebees: what they do and how they do it

Catherine Plowright
School of Psychology uOttawa

R. Christopher Plowright
Professor Emeritus, University of Toronto

NSERC CRSNG

First things first: Bumblebees ≠Honeybees

- Different *genus* (*Bombus*, *Apis*)
- No waggle dance
- Much smaller colonies
- No huge surplus of honey
- Only young queens overwinter
- Smooth stingers
- “Buzz” pollination

BUMBLEBEE BEHAVIOUR

- 1. Why knowing about bumblebees is important
- 2. Basic bumblebee biology and ecology
- 3. Studying bees in the lab
  - (a) Identifying individuals
  - (b) Presenting artificial flowers
- 4. Some results on floral choices.
  - (a) Learning a preference for symmetry
  - (b) Use of social cues
- 5. Bees in gardens

BUMBLEBEE BEHAVIOUR

- 1. Why is research on bumblebees are important?

.....*because*

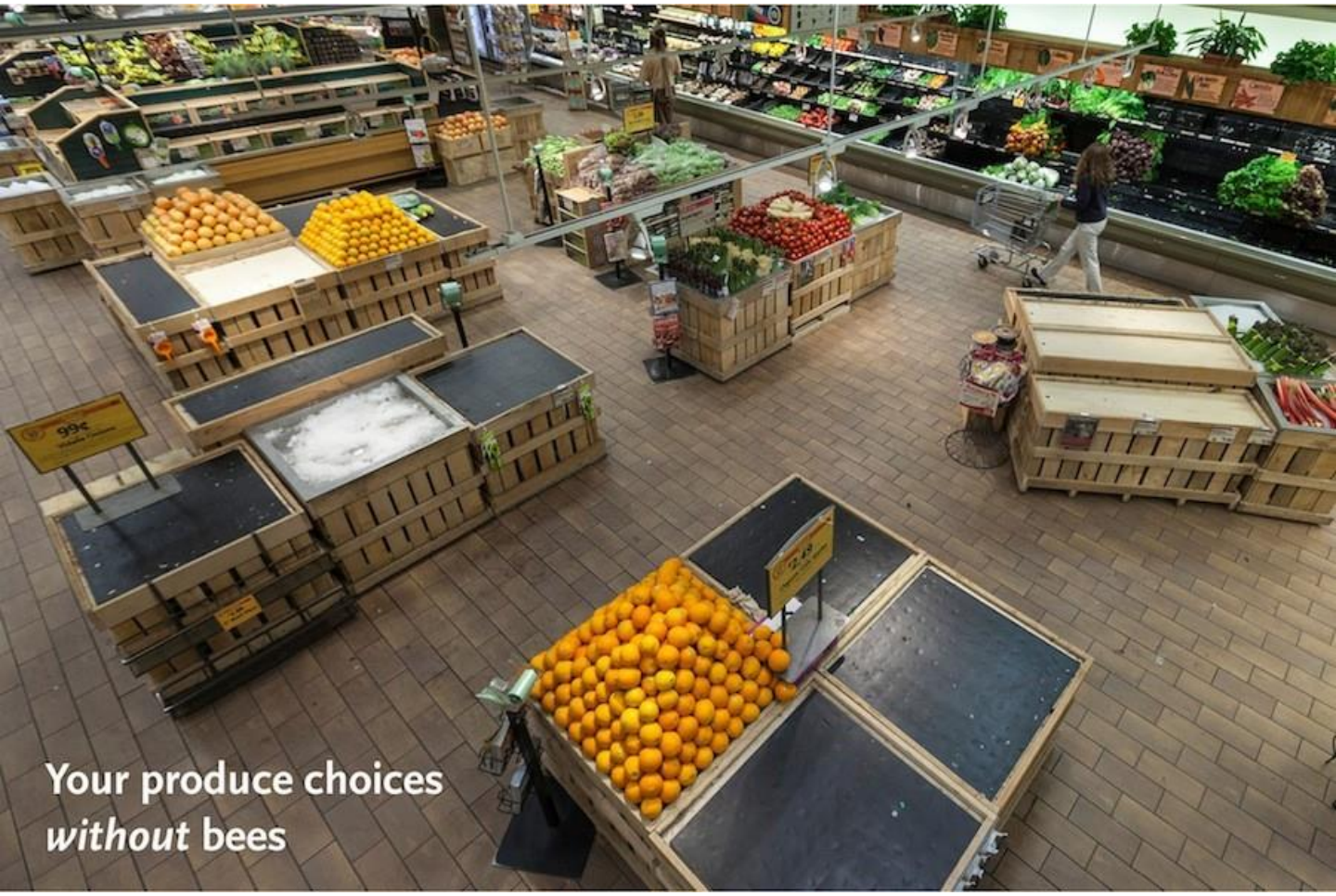
- (1) The "plight of the bumblebee" (Goulson et al. 2015): Bumblebees are in decline *world-wide*
  - ❖ Pesticides
  - ❖ Climate change
  - ❖ Destruction of habitat
  - ❖ Disease

…….and because

- (2) *One out of three* mouthfuls we eat depends on insect pollination (Buchmann & Nabhan 1996).

Your produce choices *with* bees

Your produce choices *without* bees



Photos from Whole Foods

.....*and also because*

- (3) They are economic drivers. Used in for pollination of greenhouse crops—especially tomatoes
- Value of 12 000 million Euros in 2004. (Velthuis & van Doorn, 2006)

Buzz pollination by bumblebees

- Cheaper than hand pollination
- Quality of fruit improved
- Improved use of *biological* pest control

Rearing bumblebees commercially

- *Lots* of basic research on mating, colony initiation, pollen use etc.
- "Rearing bumblebees in captivity" (Plowright and Jay, 1966)
- First commercial company (Bees-Under-Glass) in North America to sell colonies to greenhouses, mostly in Québec, in 1990
- Koppert and Biobest now dominate markets in Europe, North and South America & Asia and have expanded into China.

KOPPERT
BIOLOGICAL SYSTEMS

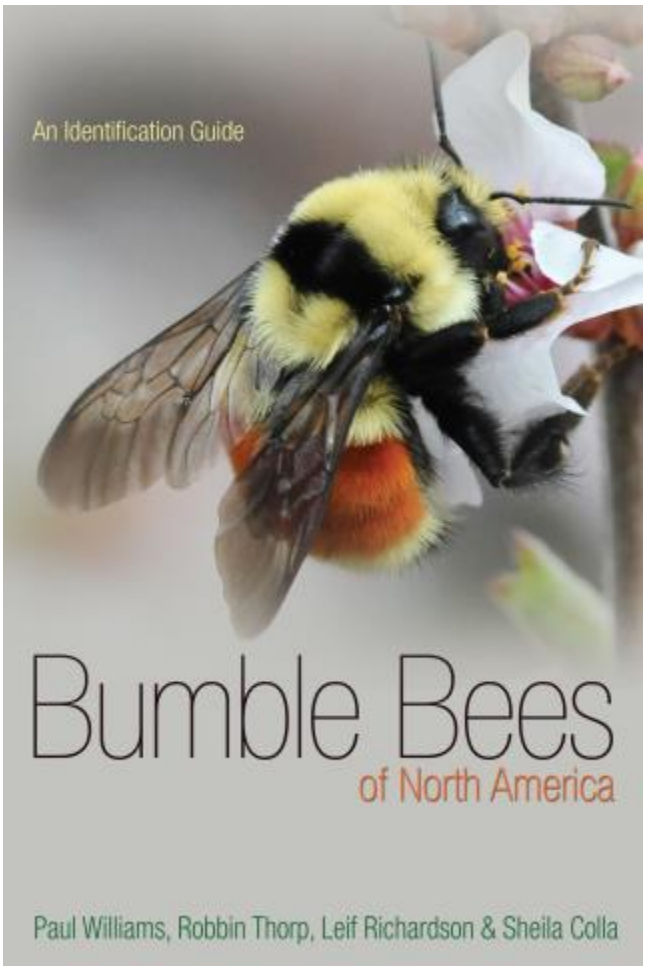
Buzz pollination

- https://www.youtube.com/watch?v=SZrTndD1H10

2. BASIC BUMBLE BEE BIOLOGY AND ECOLOGY

(a) Common and rare species

- 250 species worldwide
- Common in North America: *Bombus impatiens*
- Endangered*: Bombus affinis*



(b) Mimics

https://www.nytimes.com/interactive/2017/09/11/science/bees-pollinators-insects.html?smid=fb-nytimes&smtyp=cur

Test yourself!

Males can be thought of as mimics of females

- They benefit from their resemblance to stinging insects, but they don’t sting!

(c) Social behaviour in bumblebees

- Only the queen lays fertilized eggs, which become workers.
- Workers are sterile—they lay only unfertilized eggs, which become male.
- Workers help their mother rear more sisters (!!!!!).
- How can such self-sacrifice have evolved?

Haplo-diploid sex determination

- Fertilized eggs become workers (so females are “diploid”).
- Unfertilized eggs become ♂ (they are “haploid”: half the chromosomes).

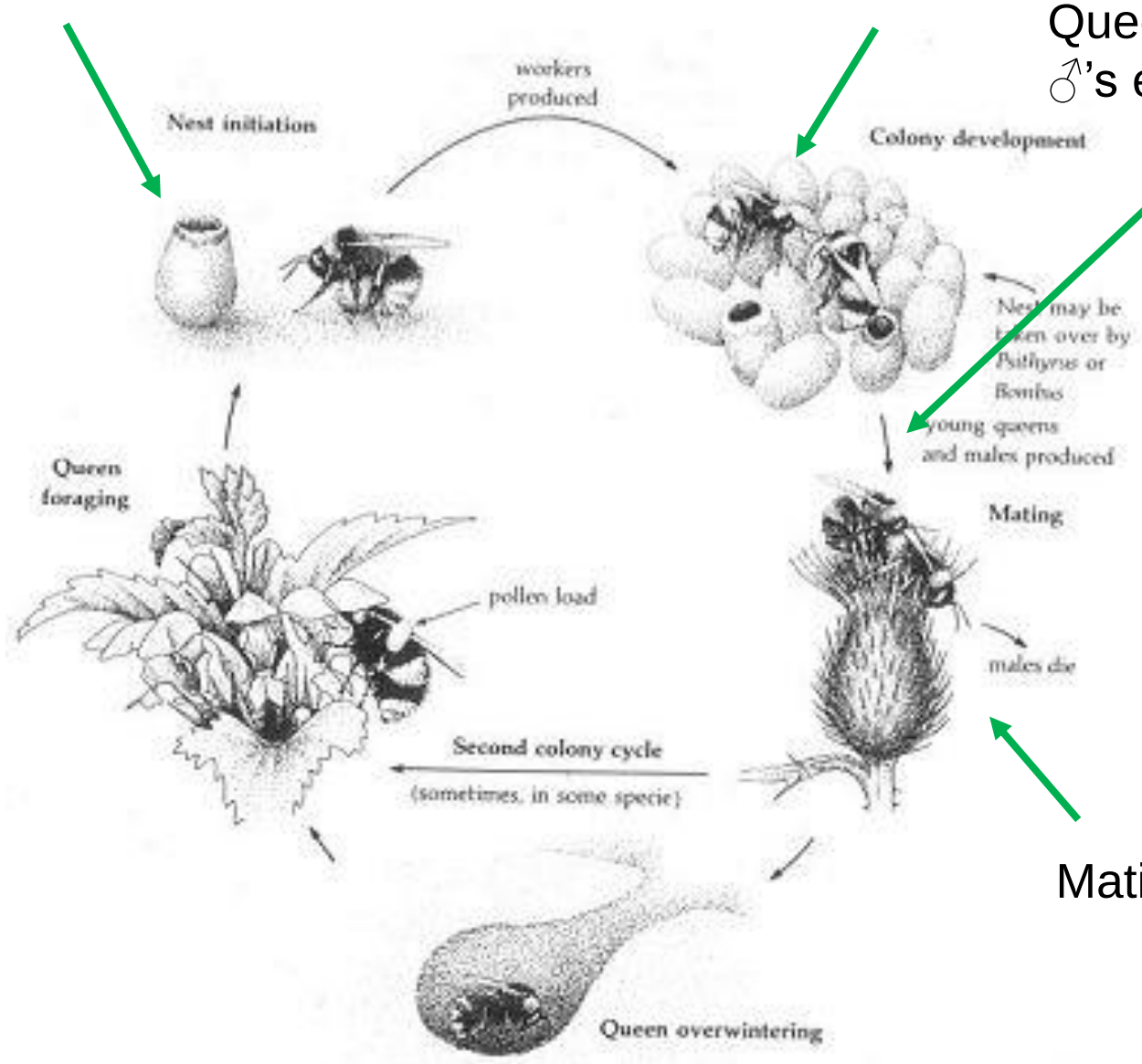
- Sisters are related to eachother by ¾.
- Sisters value eachother so much that it is in their own interest NOT to reproduce sexually.

(d) The colony cycle

In the spring,
Queen starts a new colony

New workers are produced

Later, new Queens & ♂'s emerge



Mating

Young fertilized queen hibernates

Prŷs-Jones & Corbet, 1987

(e) Foraging behaviour

Workers do most of the work.
Males just forage for themselves.

- Pollen collection:
  - Buzzing or scrabbling
  - Needed for protein to feed larvae

- Nectar collection
  - Probing with proboscis
  - Species vary in “tongue” length
  - Another way: “nectar robbing”

(f) Anaphylactic reactions

- Rare but serious
- Allergist can test for allergies to honeybees or wasps
- Some people become allergic with exposure to stings.
- If in doubt ask physician about Epipens

(g) Bee perception

- Colour vision only at short distances.
- Sensitivity in the UV range but not the infrared range
- Bee-flowers are mostly blue, yellow and white
- Flowers as seen with UV photography (Horth et al., 2014)

2. STUDYING BEE BEHAVIOUR IN THE LAB

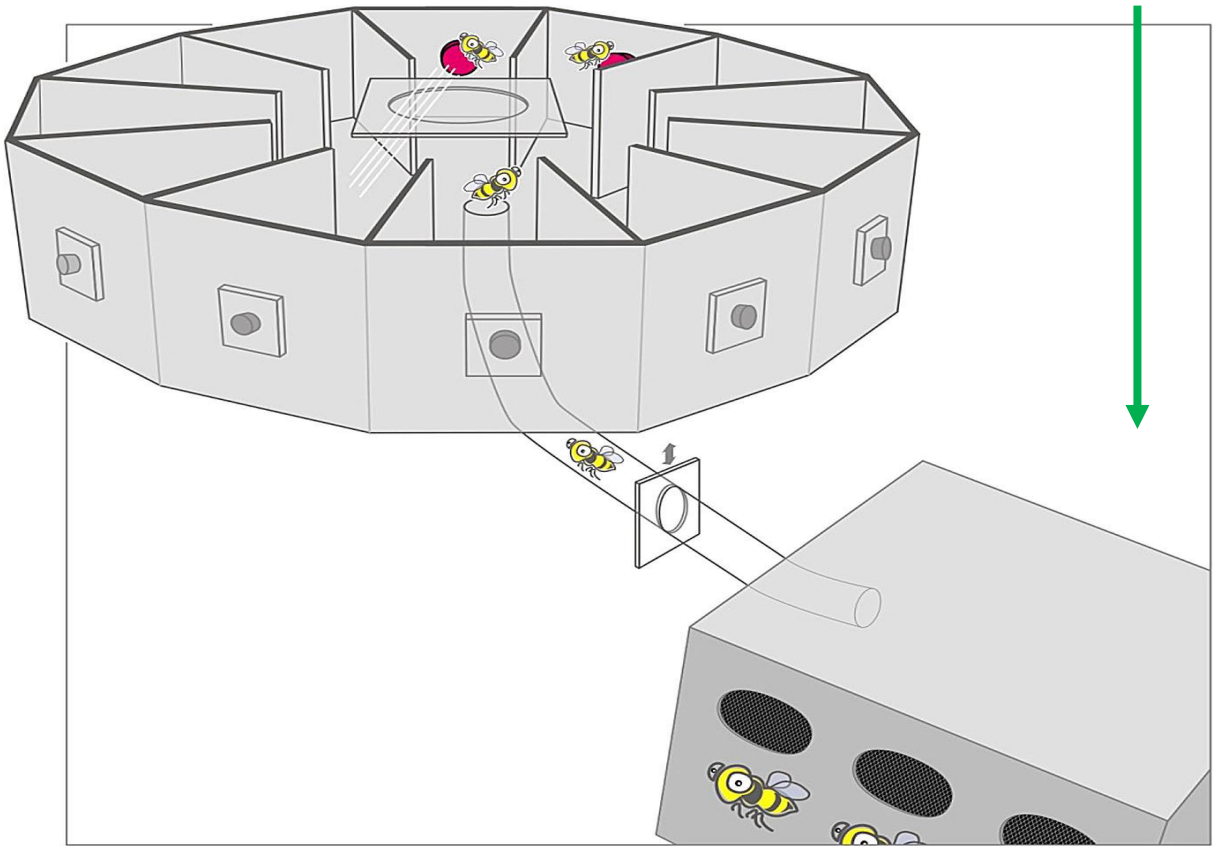
- Identifying individual bees and recording their choices.

Individual coloured numbered tags

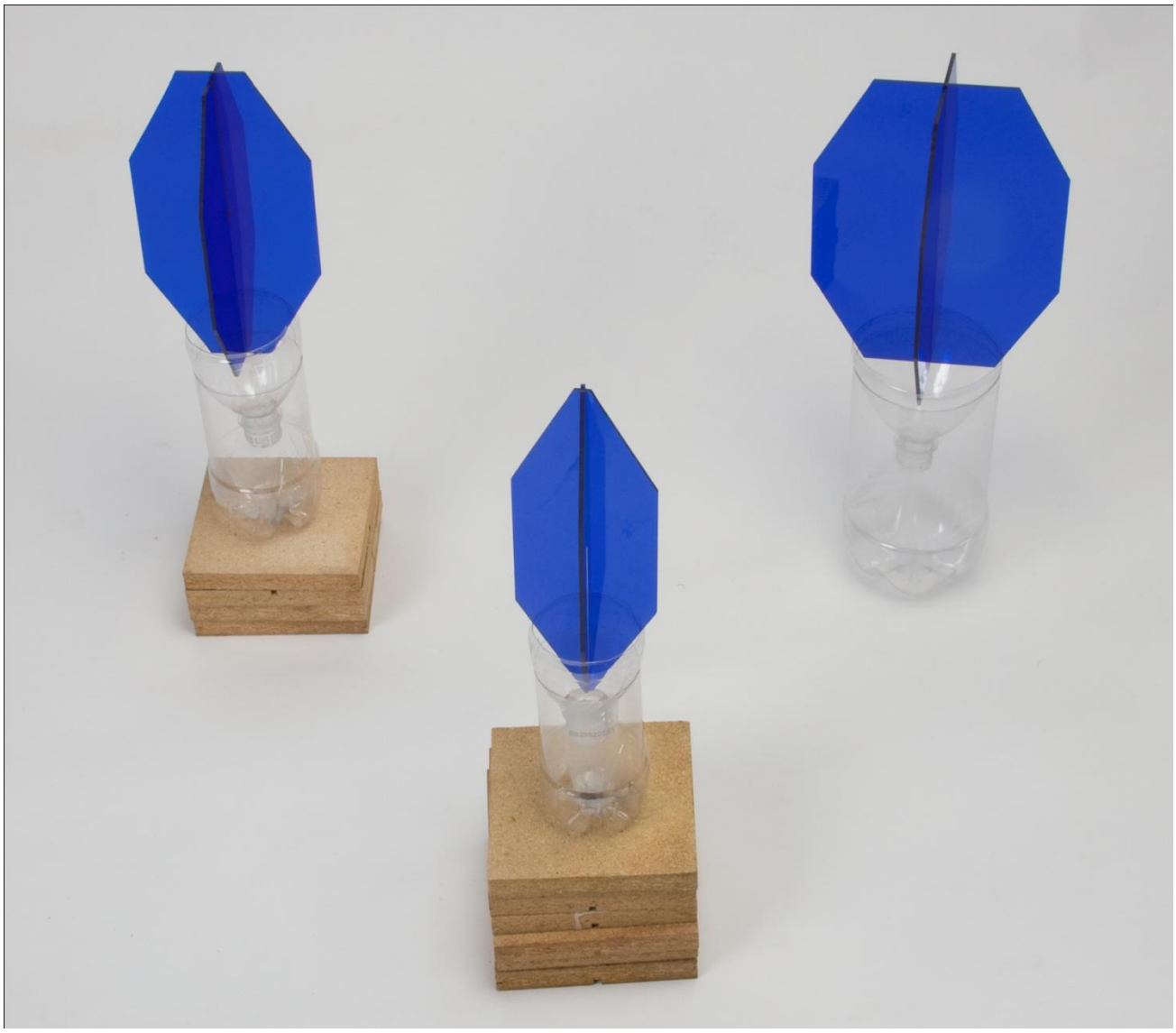
Radio-frequency identification (RFID).

Technology used to monitor activity levels in the field

Radial maze with patterns at the end of each corridor



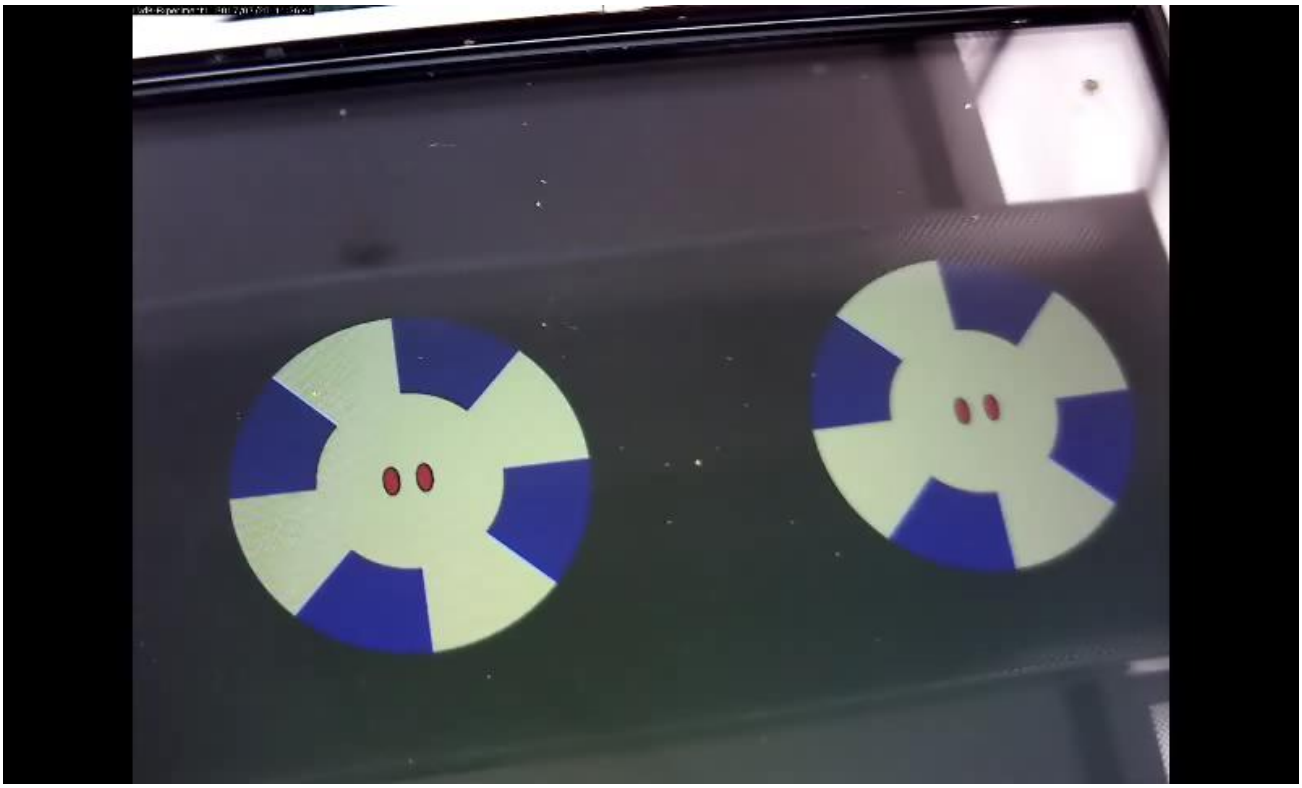
Artificial flowers that trap the foragers: does size matter?



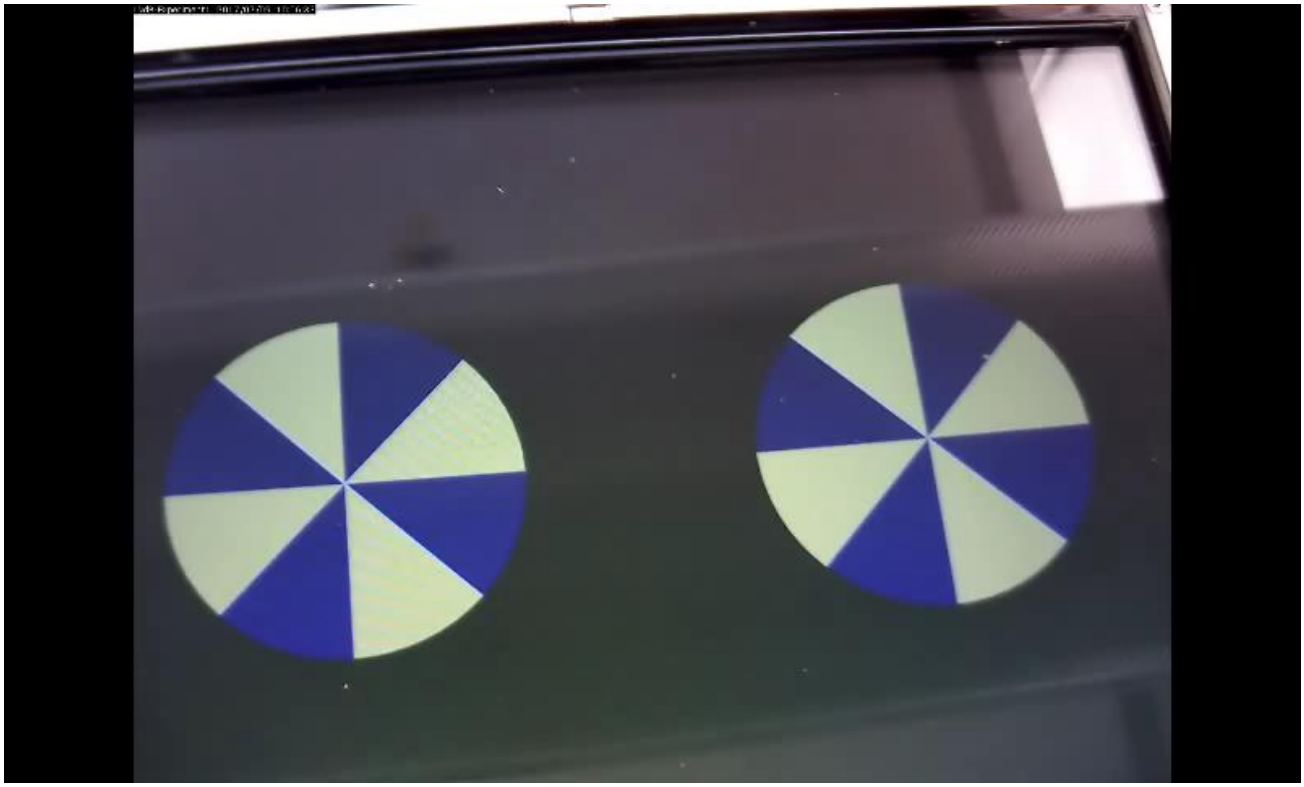
Hudon & Plowright (2010)

Similar traps also used to census populations

Work in progress: Touch screens



Does presence of “anthers” affect where they land?



Do the linear patterns help the bees to find the center of the flower?

When? Before or after landing?

3. THE MECHANISMS OF FORAGING BEHAVIOUR

- Social cues: a help or hindrance in finding flowers?

Zoologists interested in invertebrates have not been much interested in learning and psychologists have not been much interested in invertebrates

(Bitterman, 1996)

Bee #54 landing on an occupied flower:

Photo: Ashley Brian

Colony differences in a *preference* for occupied flowers:

	Occupied stimulus		Unoccupied stimulus	
	Landings	**Approaches**	**Landings**	**Approaches**
Colony 1				
Days 1-8	4	7	8	7
Days 9-19	51	24	13	5
Colony 2	7	7	17	1
Colony 3	8	3	5	1

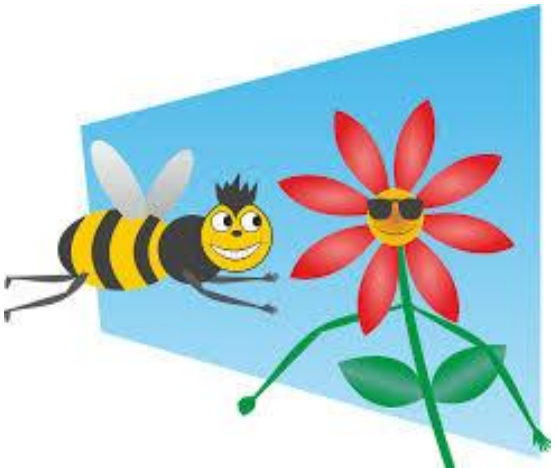
But does the occupier *help the bee to find the flower*?

No.

	Occupied stimulus		
	Landed on flower only	**Landed on flower and occupiers**	**Landed on occupiers only**
Colony 1			
Days 1-8	0	3	1
Days 9-19	2	21	28
Colony 2	0	2	5
Colony 3	3	4	1

Conclusion

- There is more than one way to react to another bee occupying a flower—we have seen *both* approach and avoidance. Aggression too!
- Behaviour may be affected by colony state (nutritional status, stress etc.)
- We do not know how the occupier is perceived—it might "bee" perceived as part of the flower, in which case "social learning" is not really social at all!



4. BUMBLEBEES IN GARDENS (URBAN AND OTHERWISE)

Bee gardens

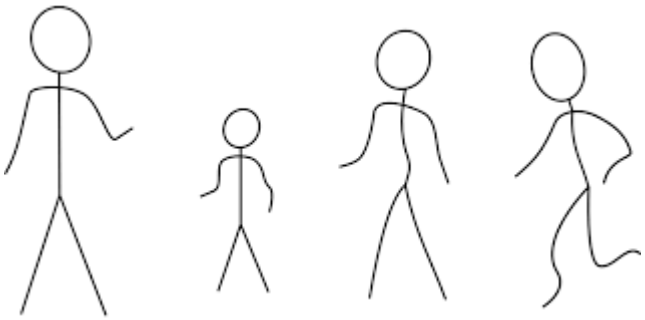
- Comfrey, caragana, lilacs, amur maple, bee balm, sunflower, begonias, thistles, clover, turtleheads

- Try for continuous supply of food from spring to fall.
- https://davidsuzuki.org/queen-of-green/create-pollinator-friendly-garden-birds-bees-butterflies/
- Some showy flowers are sterile, or too hard to handle—no interest to bees

Provide nesting sites

- Minimize use of woodchips, pebbles, and mulch.
- Leave raspberry canes and bamboo stakes for other bee species

People are the problem. People can be part of the solution

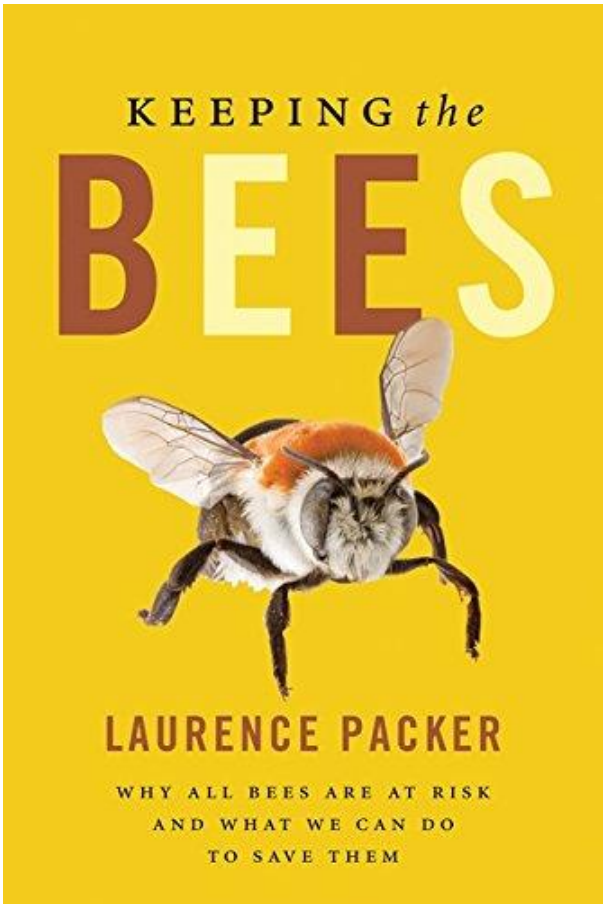


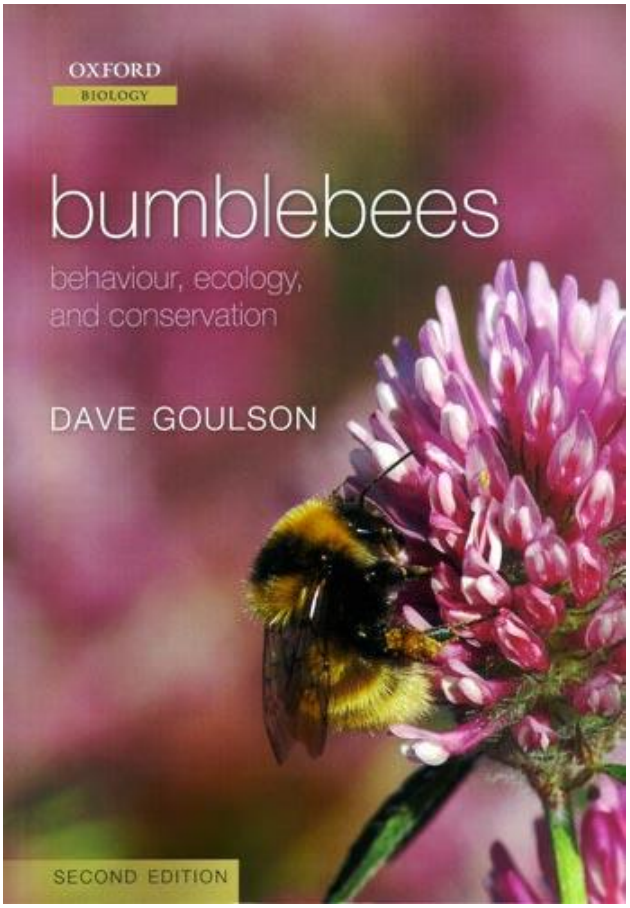
- Oppose development
- Oppose pesticides
- Buy organic
- Share your knowledge and enthusiasm
- Sightings:

https://www.bumblebeewatch.org/

Resources

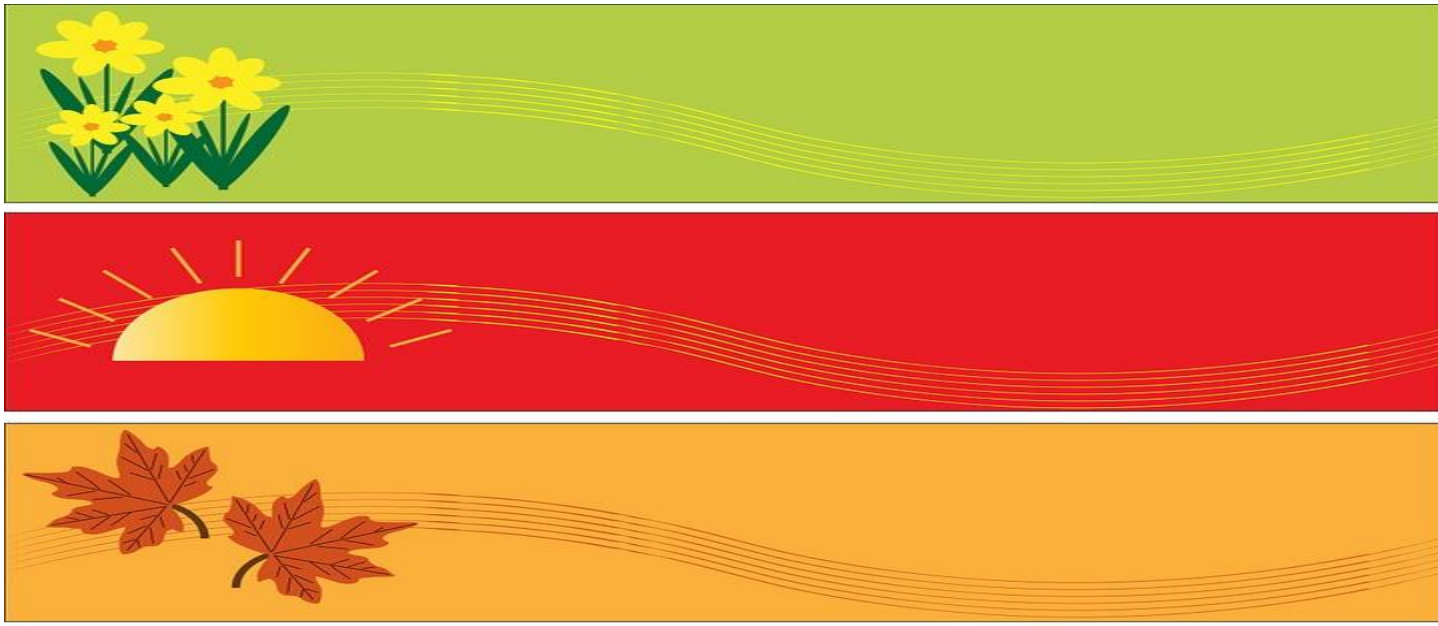
https://www.toronto.ca/wp-content/uploads/2017/08/8eb7-Biodiversity-BeesBook-Division-Planning-And-Development.pdf





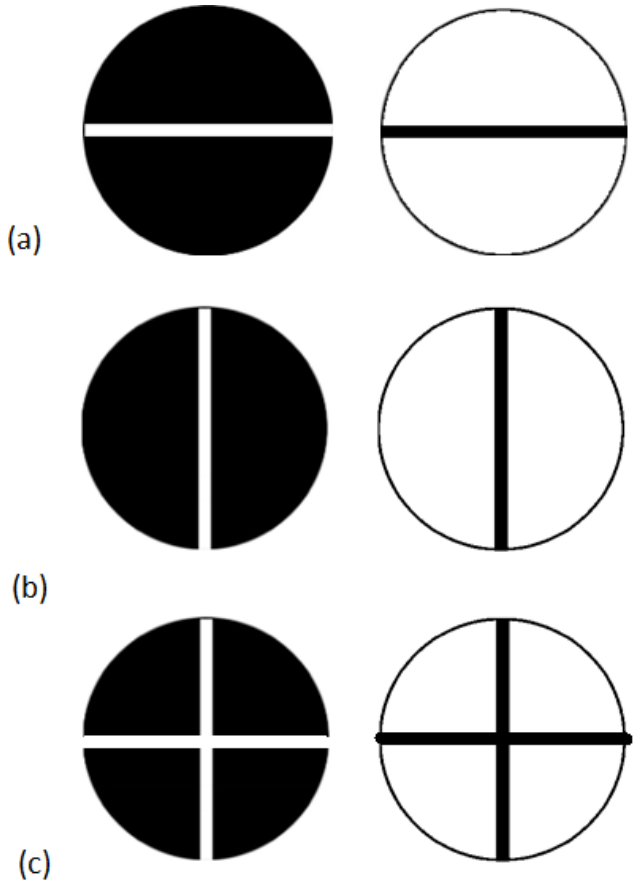
Questions?
Comments?
Gardening tips?

An ecological approach to learning

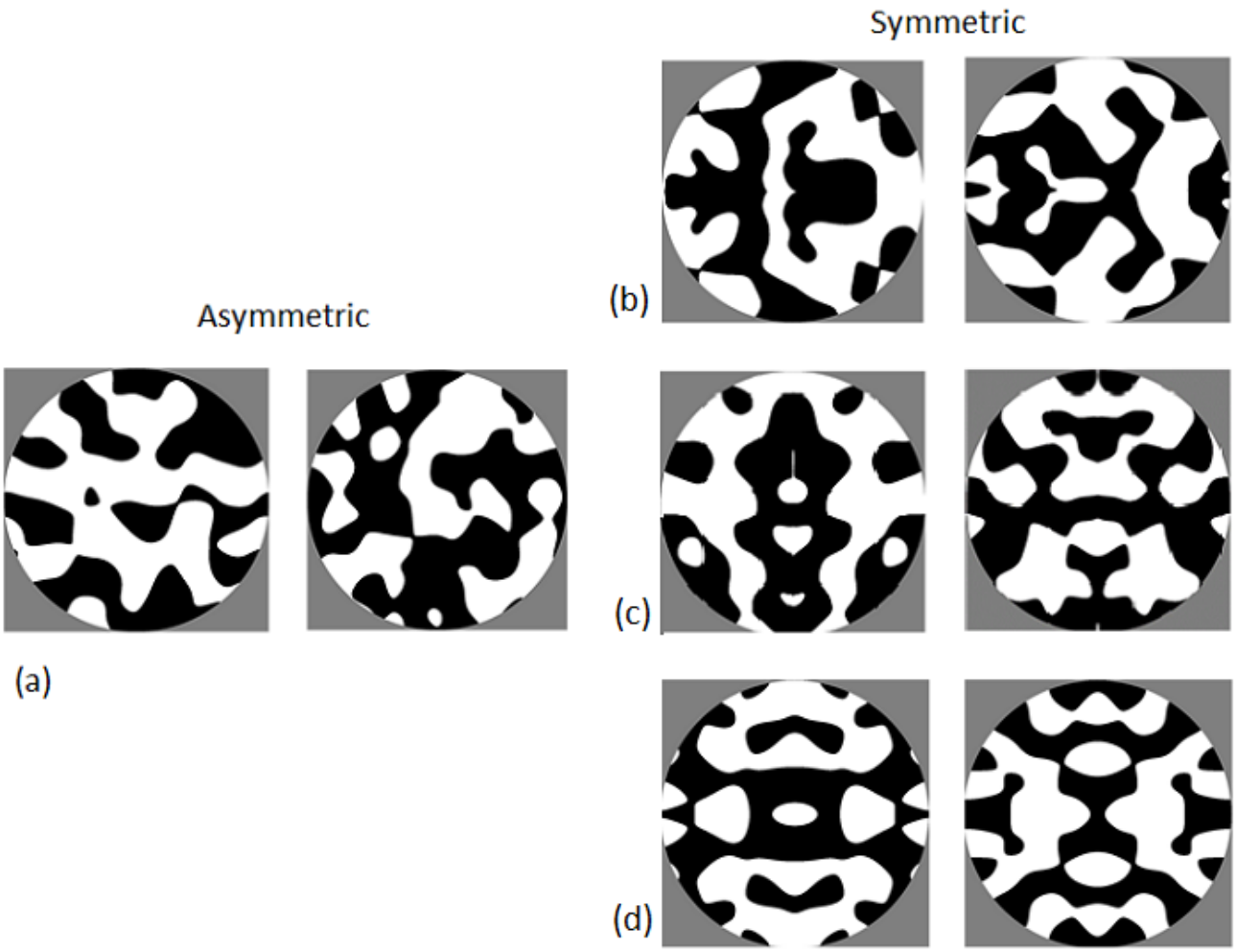


- Symmetry is an indicator of floral health.
- Bees choose symmetric flowers in nature
- How do they do it?
- To detect symmetry, *need to find an axis of symmetry.*

(a) Training on two *rewarding* patterns that bias a particular axis of symmetry

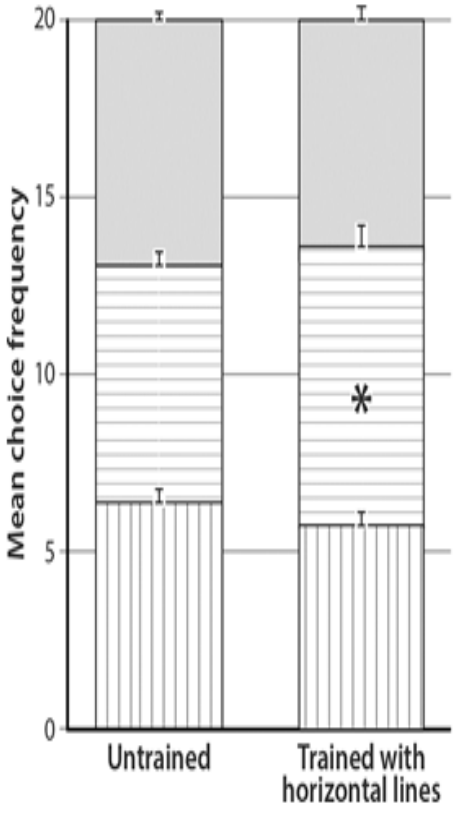


Testing on unrewarding patterns:



Plowright et al., 2017

e.g. Training with horizontal lines leads to a preference for horizontal symmetry.



(a)

So?

- Our results point to an ancillary function of floral guides: that they make plain the axes of symmetry to their visitors so as to facilitate symmetry detection in later floral encounters.

Learning something difficult requires preparation. The flowers guide the learning: easy-to-hard.