Impacts of pesticides on the health of bees

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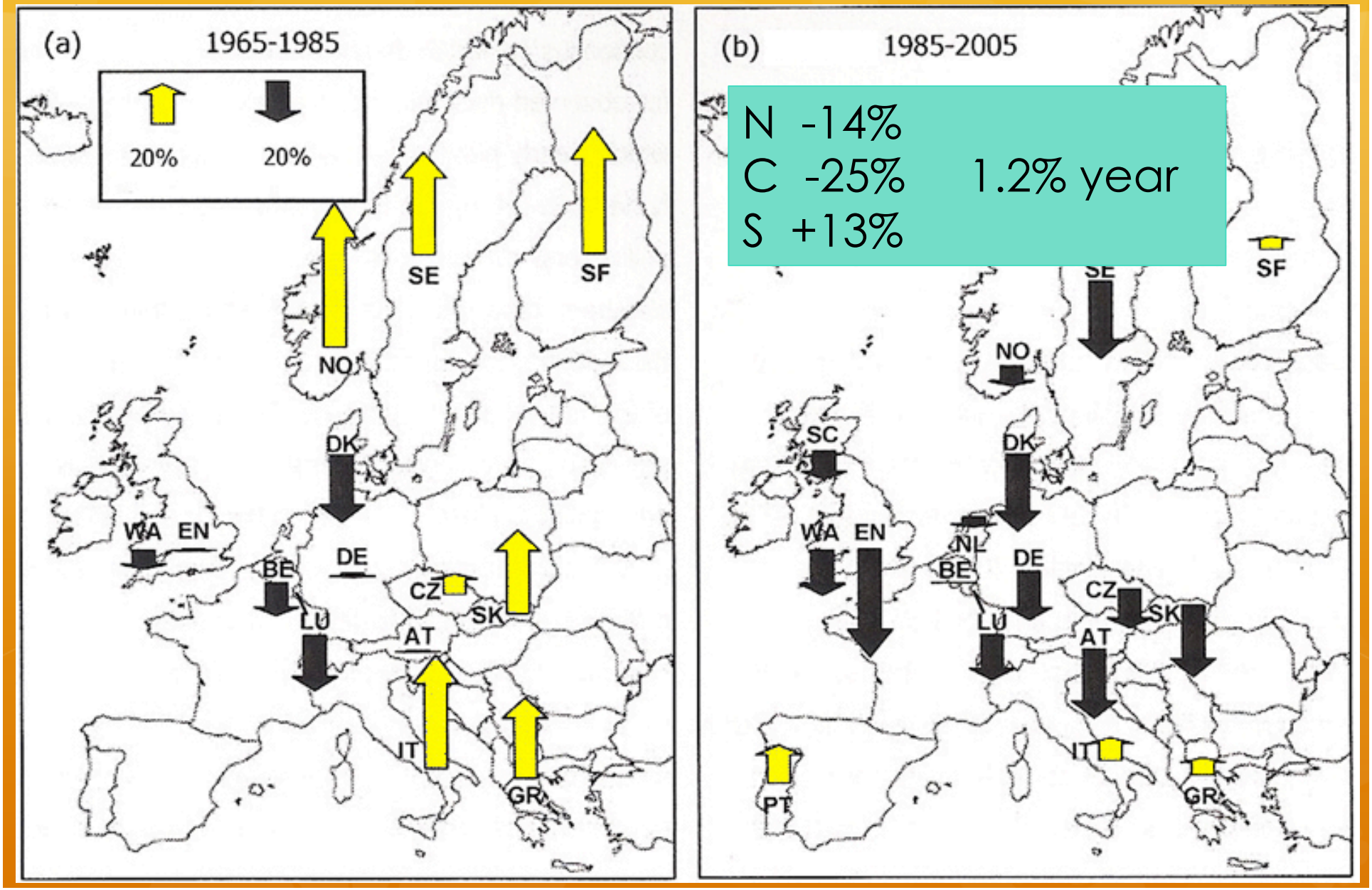
Colony collapses

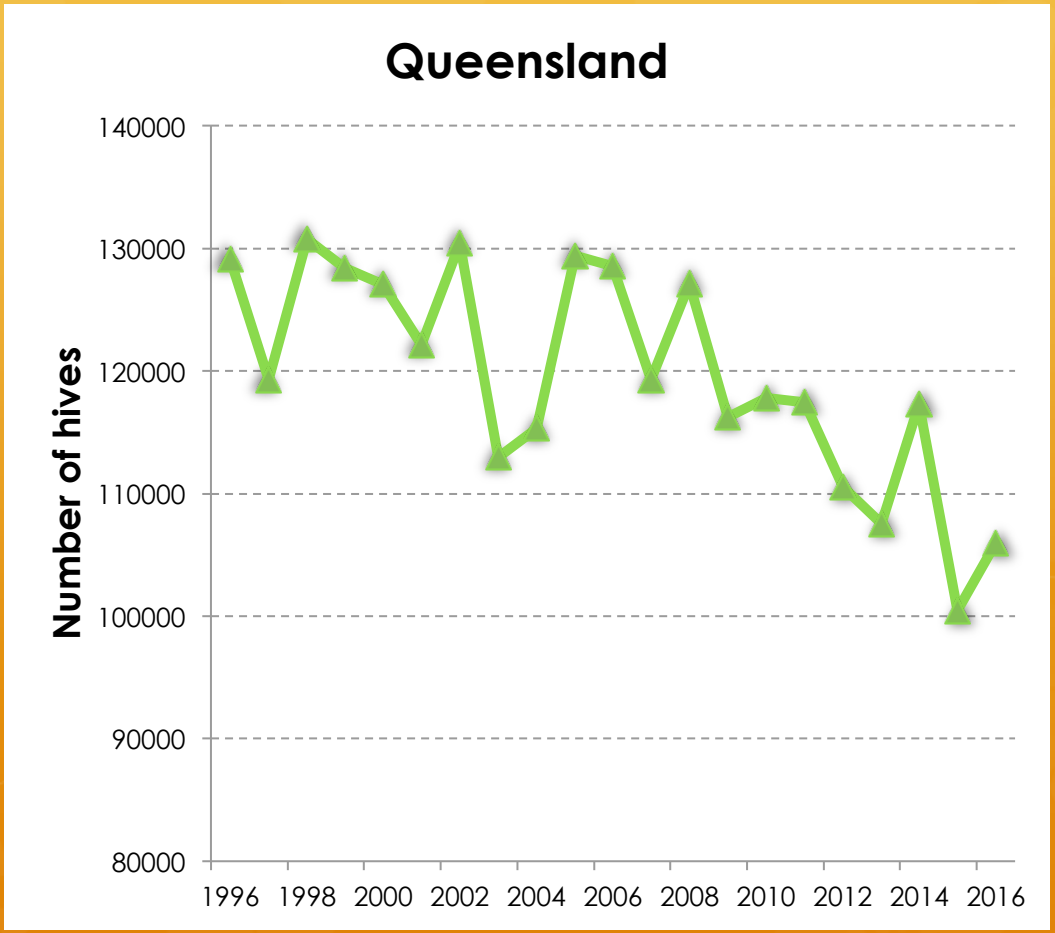
- Multifactorial syndrome
  - Pathogens – viruses, *Nosema*
  - Parasites – *Varroa destructor*
  - **Pesticides**
  - Poor nutrition → loss of weeds, biodiversity
  - Climate change

Hive declines in Europe

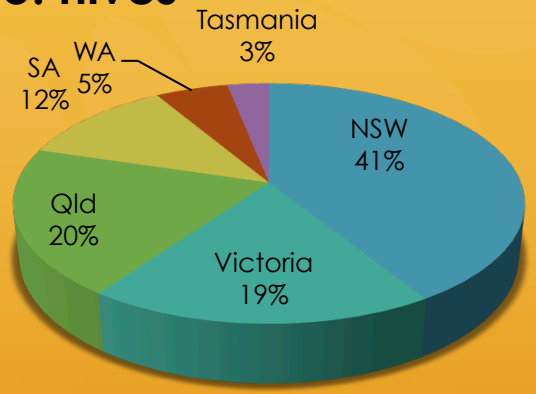
Source:
Potts et al. *J. Apicul. Res.* 49, 15 (2010)



Declines in Australia



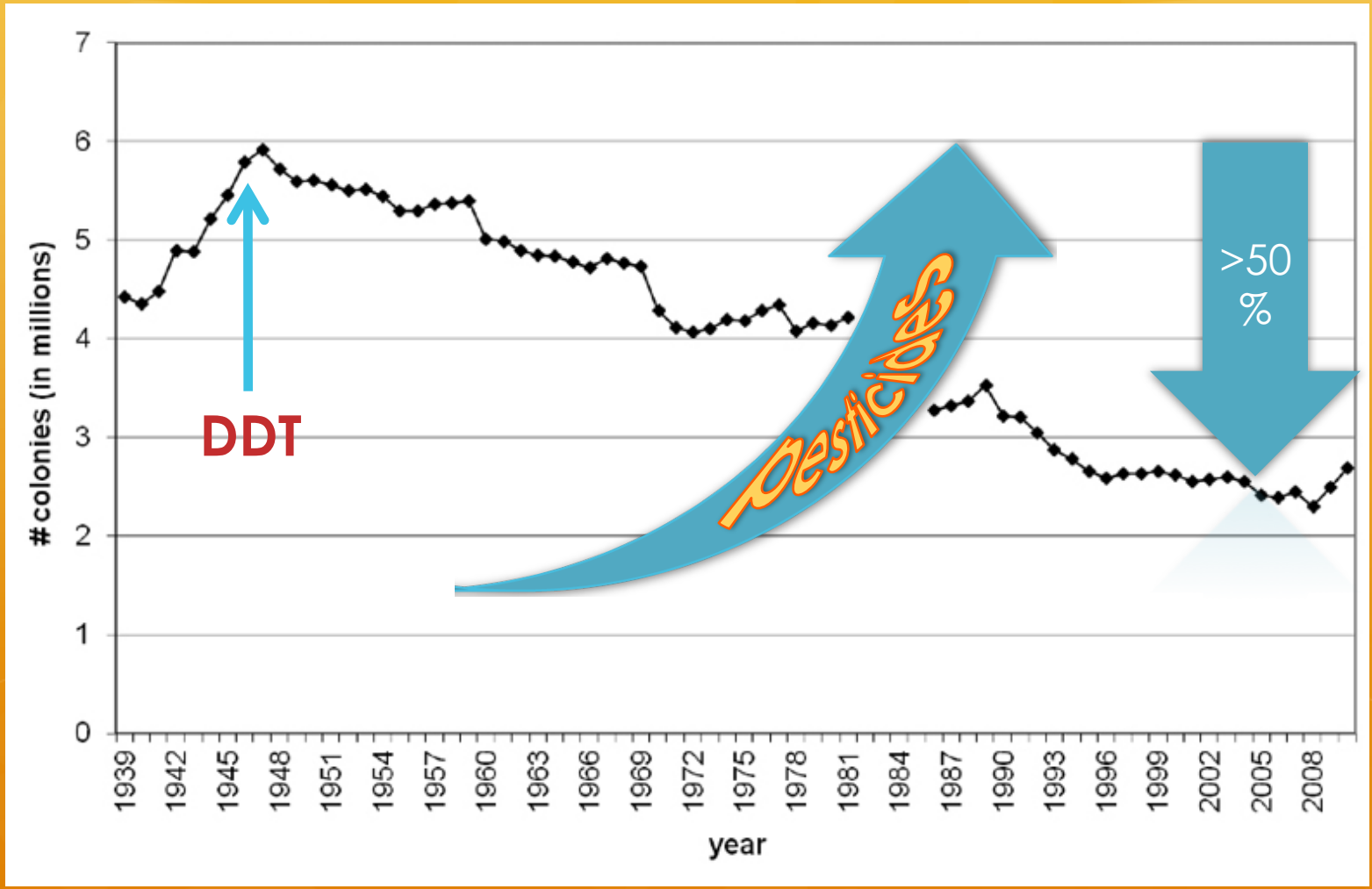
No. hives



Source:
Department of Primary Industries

Decline:
18% in 21 years
-0.9% annually

Declines in the USA



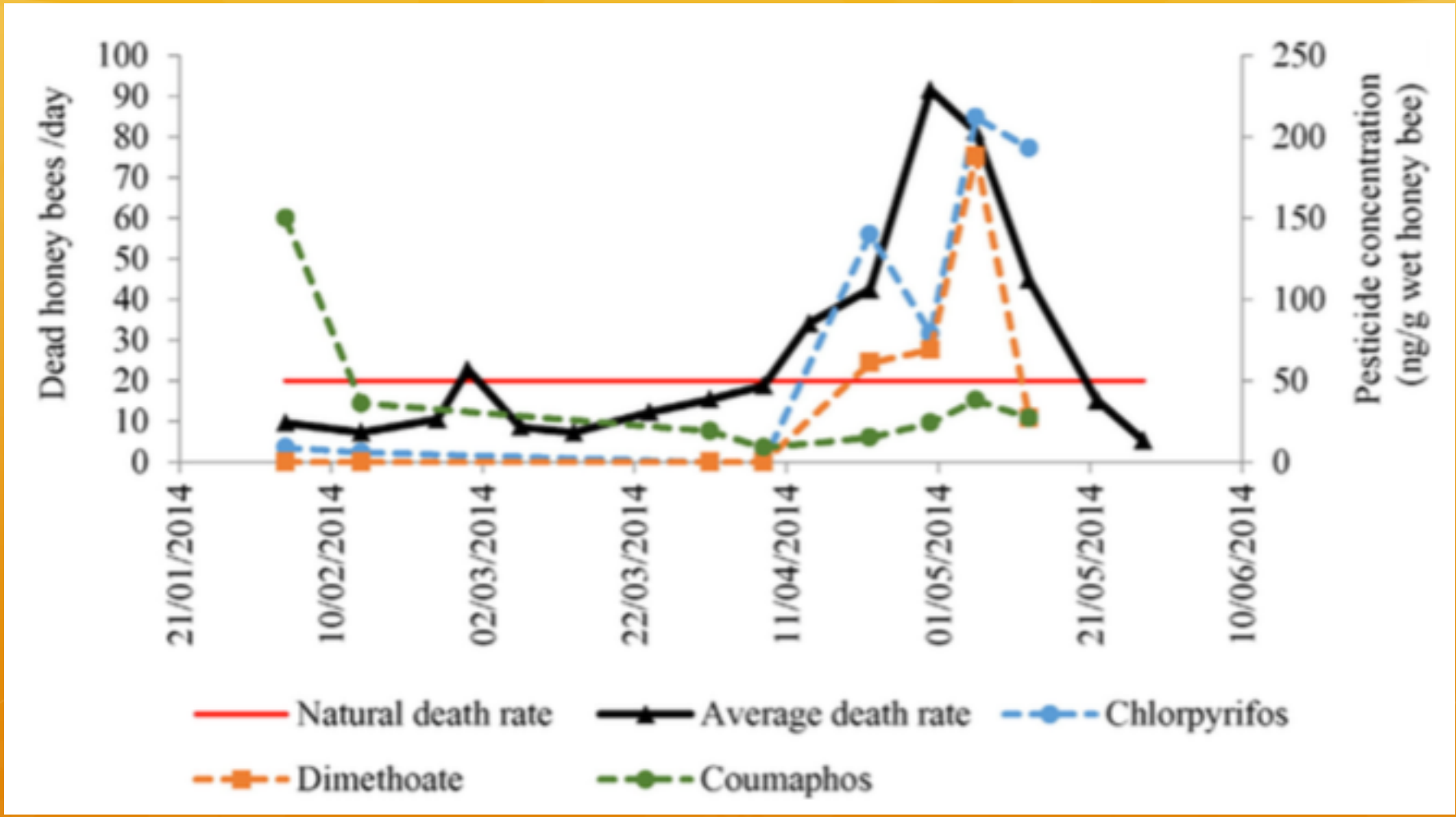
Source: Ellis, *Outlooks on Pest Management* 23, 35 (2012)

Why pesticides?

- Toxic chemicals designed to kill organisms
  - Insecticides & acaricides → insects, mites, arthropods
  - Fungicides → diseases
  - Herbicides ? Not toxic to bees

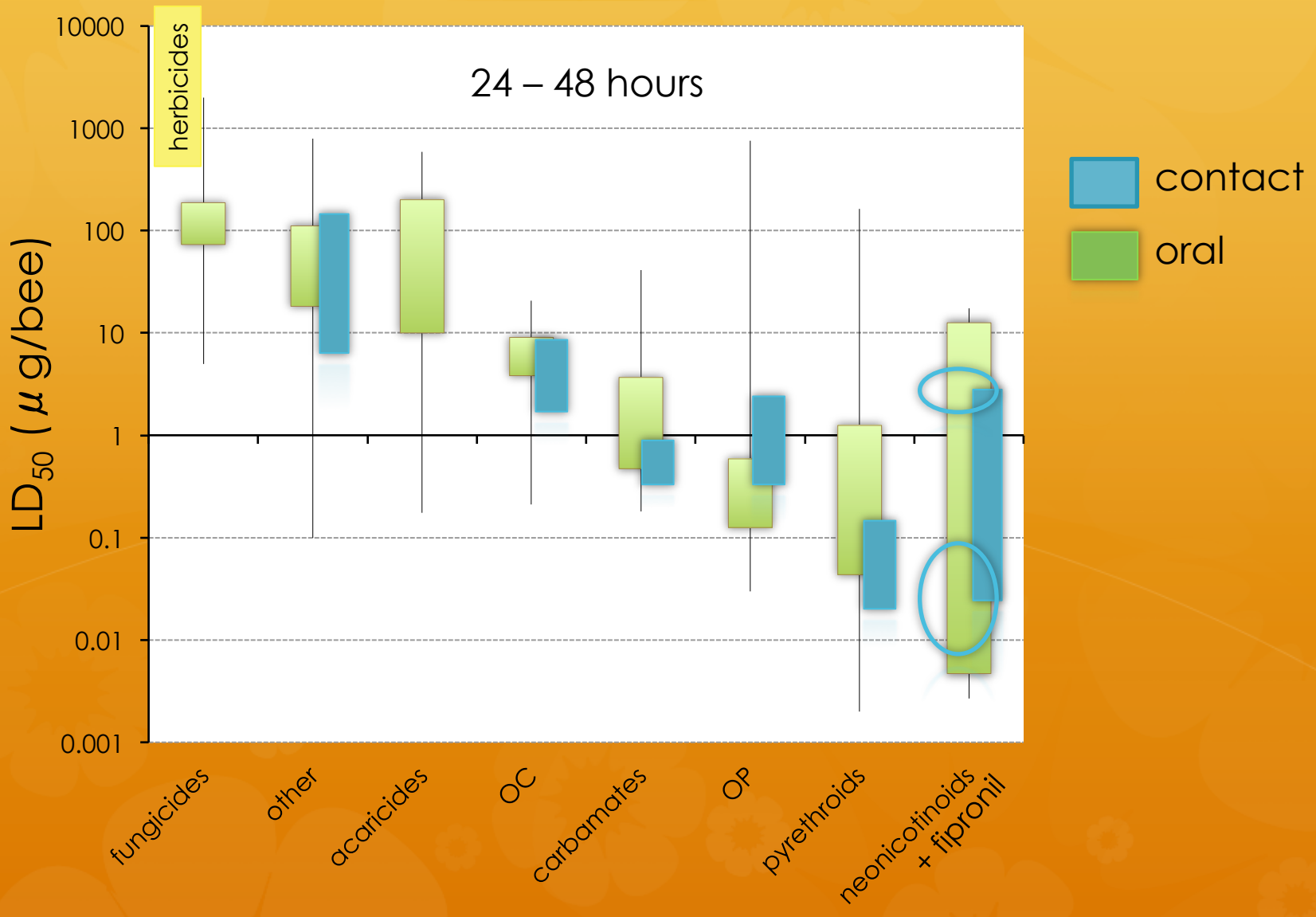
    LD50 > 100 μg/bee
- Agricultural fields = cocktail of pesticides
  - Bees → pollination of crops
  - Pesticides affect bees...

Direct mortality due to sprays

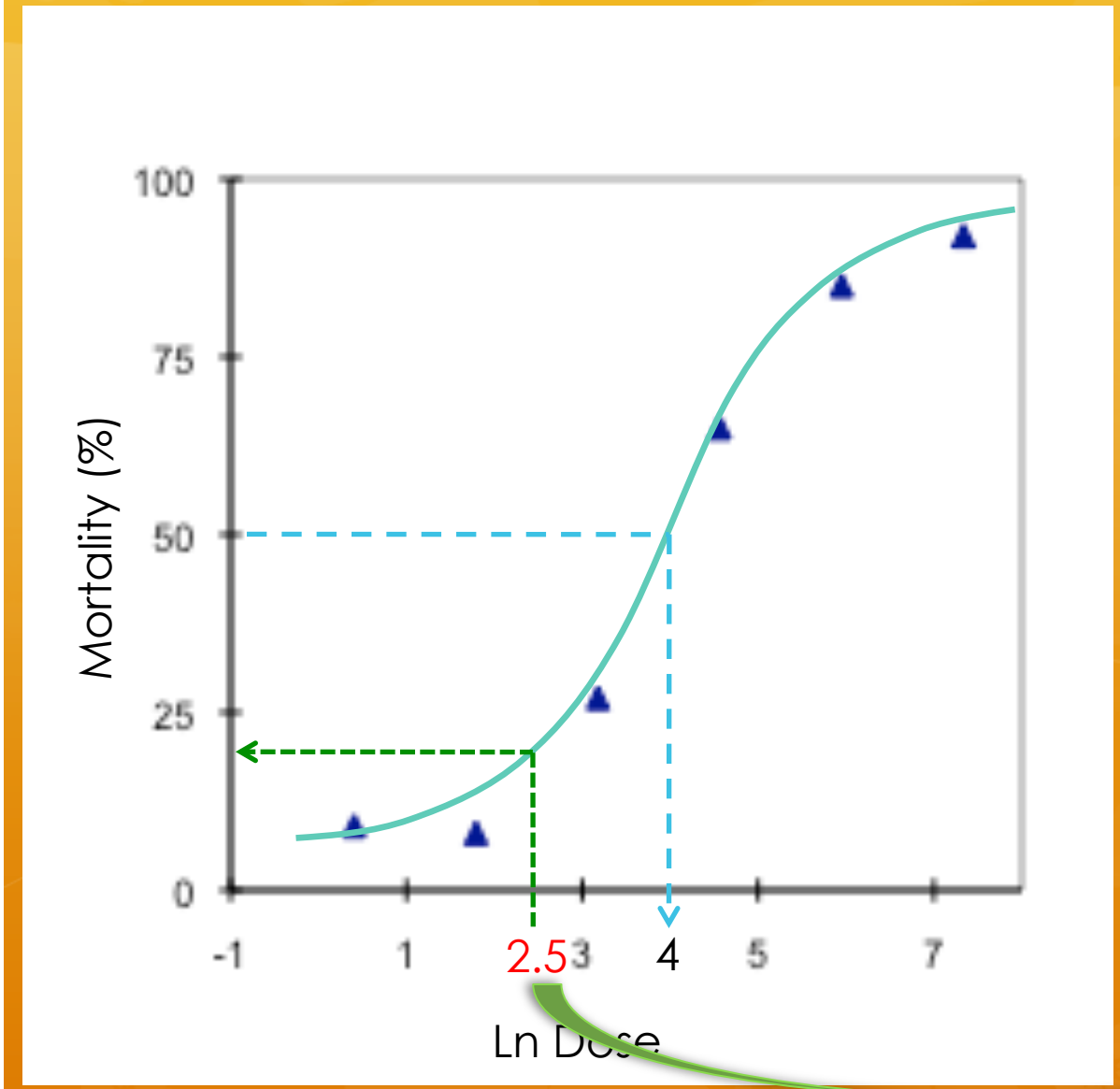


Source: Calatayud-Vernich et al. *Sci Total Environ* 541, 33 (2016)

Which pesticides are the most toxic to bees?

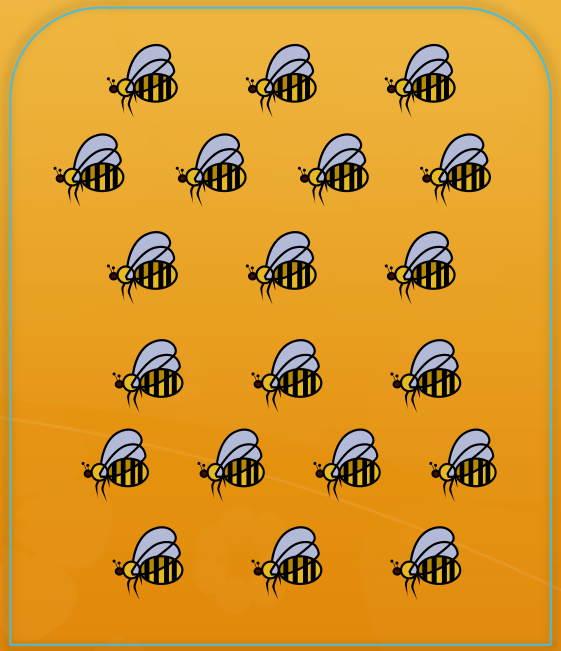


Acute toxicity: 24 – 48 hours



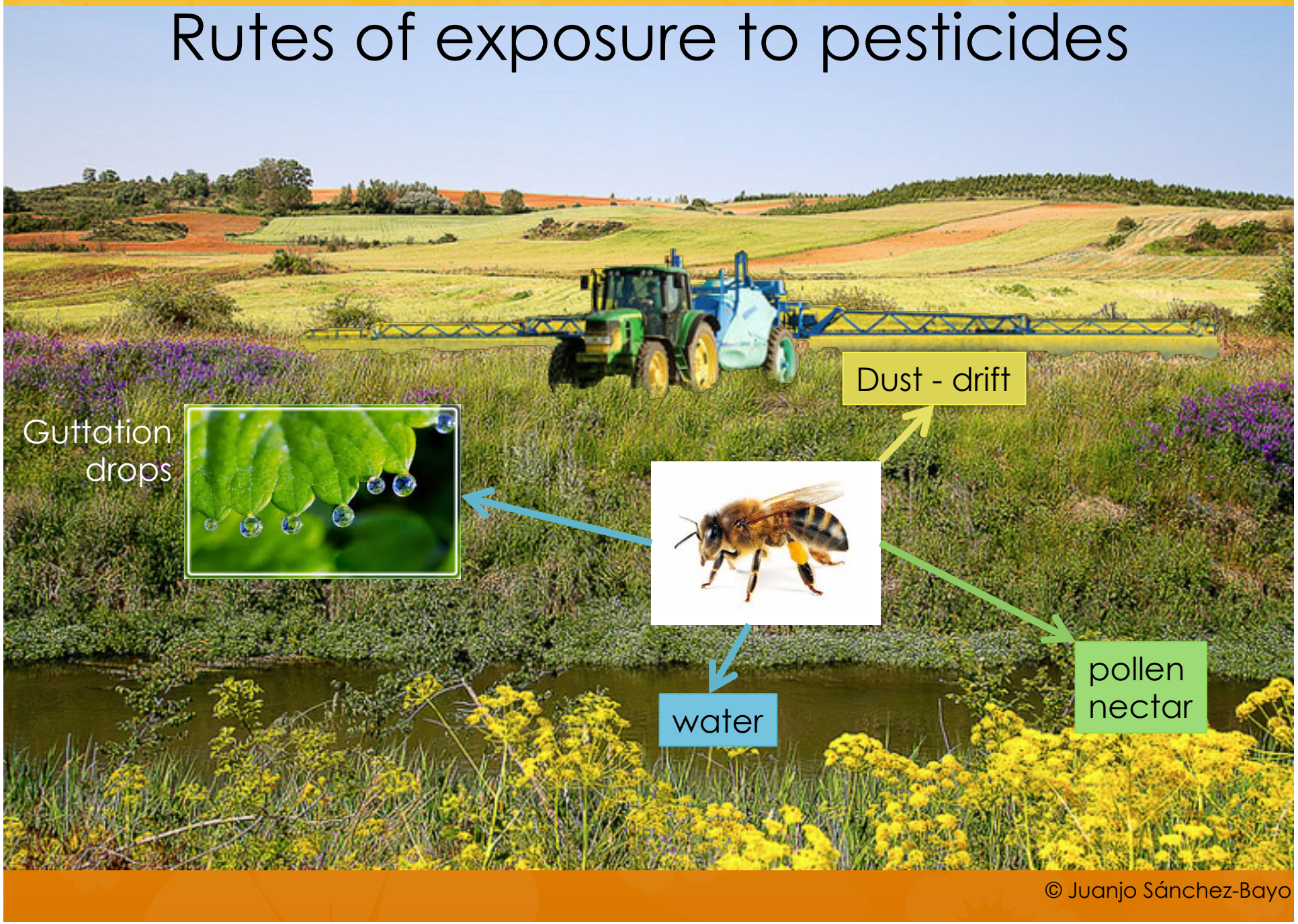
LD_{50} = lethal median (50% mortality)

Sublethal dose



20% mortality

Rutes of exposure to pesticides



Exposure in the hive

pollen

nectar

water

Forager workers

Nurse workers

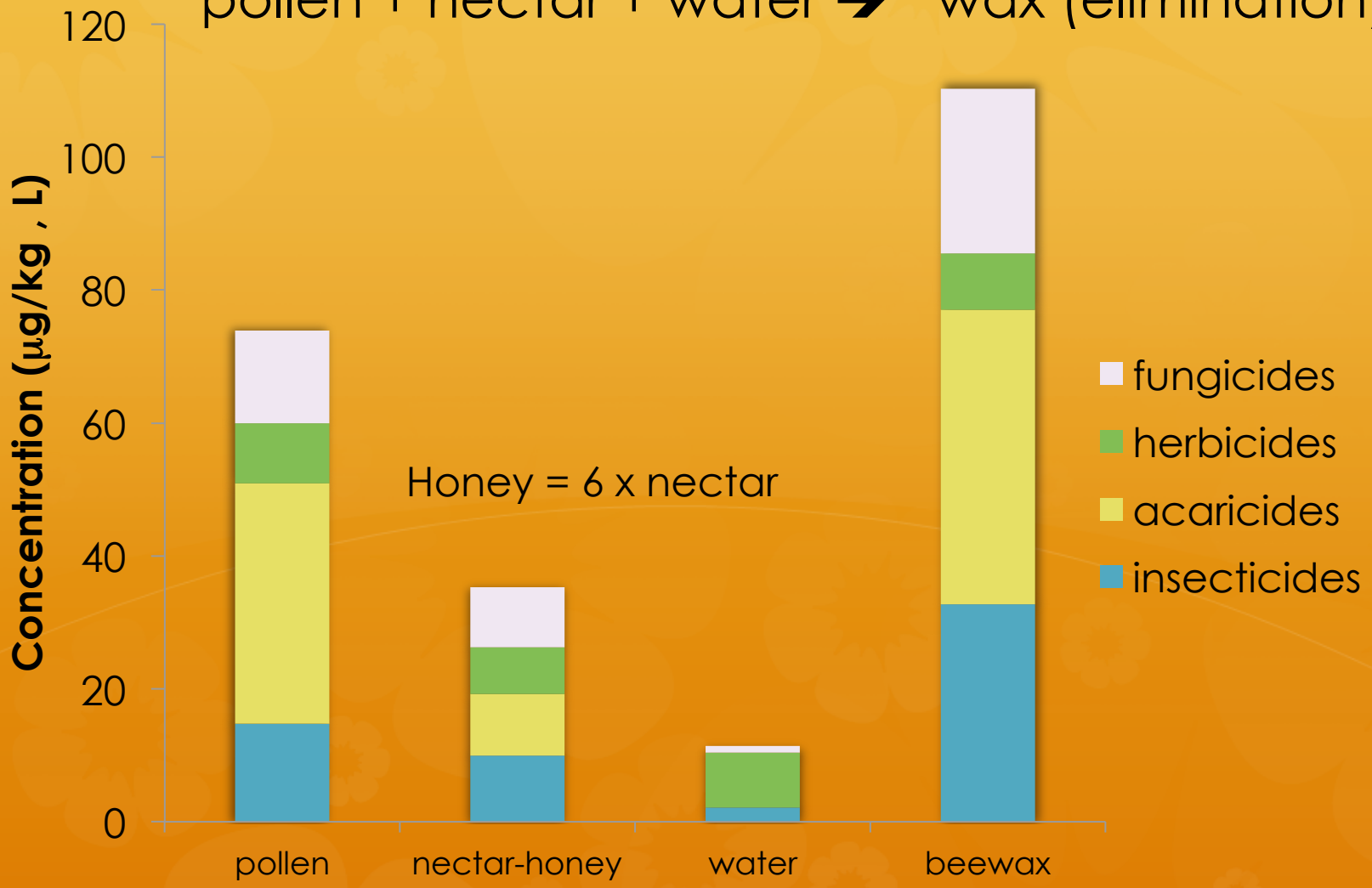
honey

beebread

Royal jelly

Food residues → chronic toxicity

pollen + nectar + water ➔ wax (elimination)



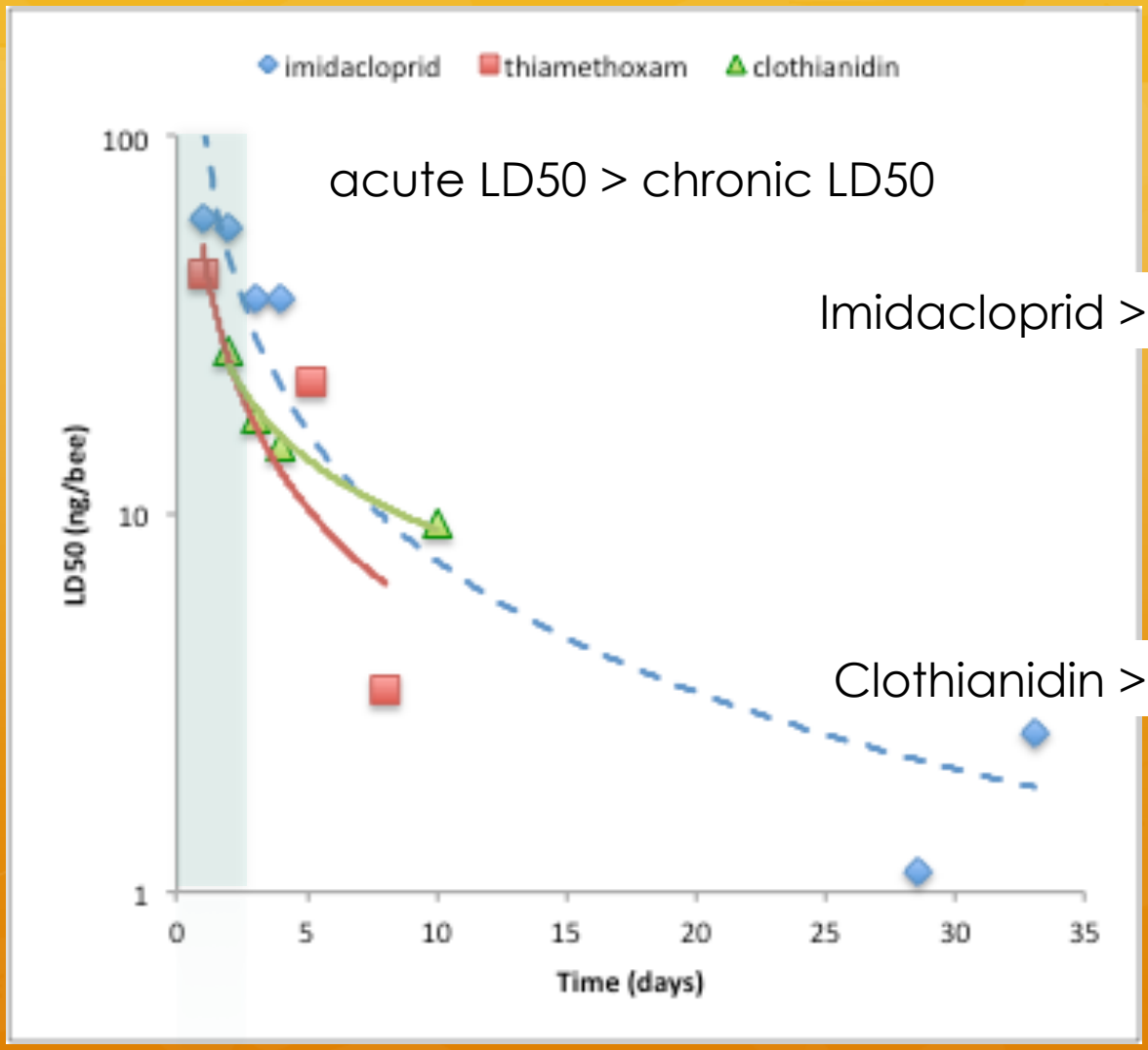
$$\text{Risk (\%)} = \frac{\text{frequency x concentration}}{LD_{50}}$$

$$T_{50} = \frac{LD_{50}}{\text{daily dose}}$$

NECTAR: average residues

Chemical	Freq. (%)	Conc. (μg/L)	LD50 (μg/bee)	Risk (%)	T50 (days)	Rank
thiamethoxam	65.0	6.4	0.005	200	10	high
imidacloprid	21.4	6.0	0.013	23.3	28	high
clothianidin	17.0	1.9	0.0035	22.0	23	high
cypermethrin	5.9	18.1	0.064	4.0	44	moderate
coumaphos	47.5	105.5	4.6	2.6	545	very low

Delayed mortality due to chronic exposure



	LD50 (ng/ bee)	Intake (ng/ day)	Time to LD50 (days)
Imidacloprid >	60	60	1
	57	28.5	2
	37	9.3	4
Clothianidin >	26.9	13.5	2
	15.1	3.8	4
	9.5	0.9	10

Sources: imidacloprid – Suchail et al. *ET&C* 20, 2482 (2001)
thiamethoxam – Oliveira et al. *Environ Toxicol* 29, 1122 (2013)
clothianidin – Alkassab & Kirchner, *Ecotoxicology* 25, 1000 (2016)

Other effects from chronic toxicity?

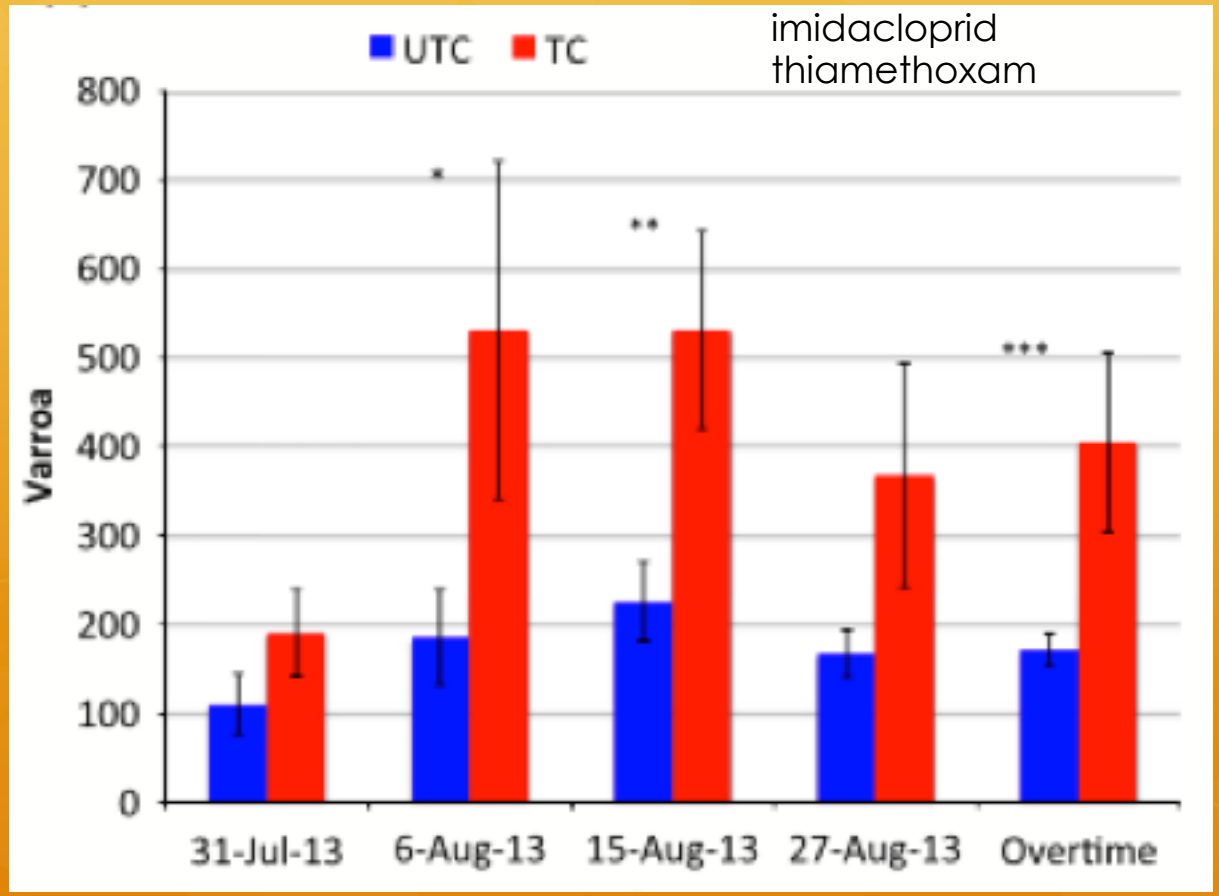
- Sublethal effects
  - Stress
  - Impaired mobility
  - Disorientation, memory loss
  - Feeding inhibition
  - Reduced fecundity
  - Queen supersedure
  - **Immune suppression**
    - Covert virus → deadly
    - Weak response to infections
    - Increase parasites

Neonicotinoids : suppress immune system foster parasite infections

Varroa destructor

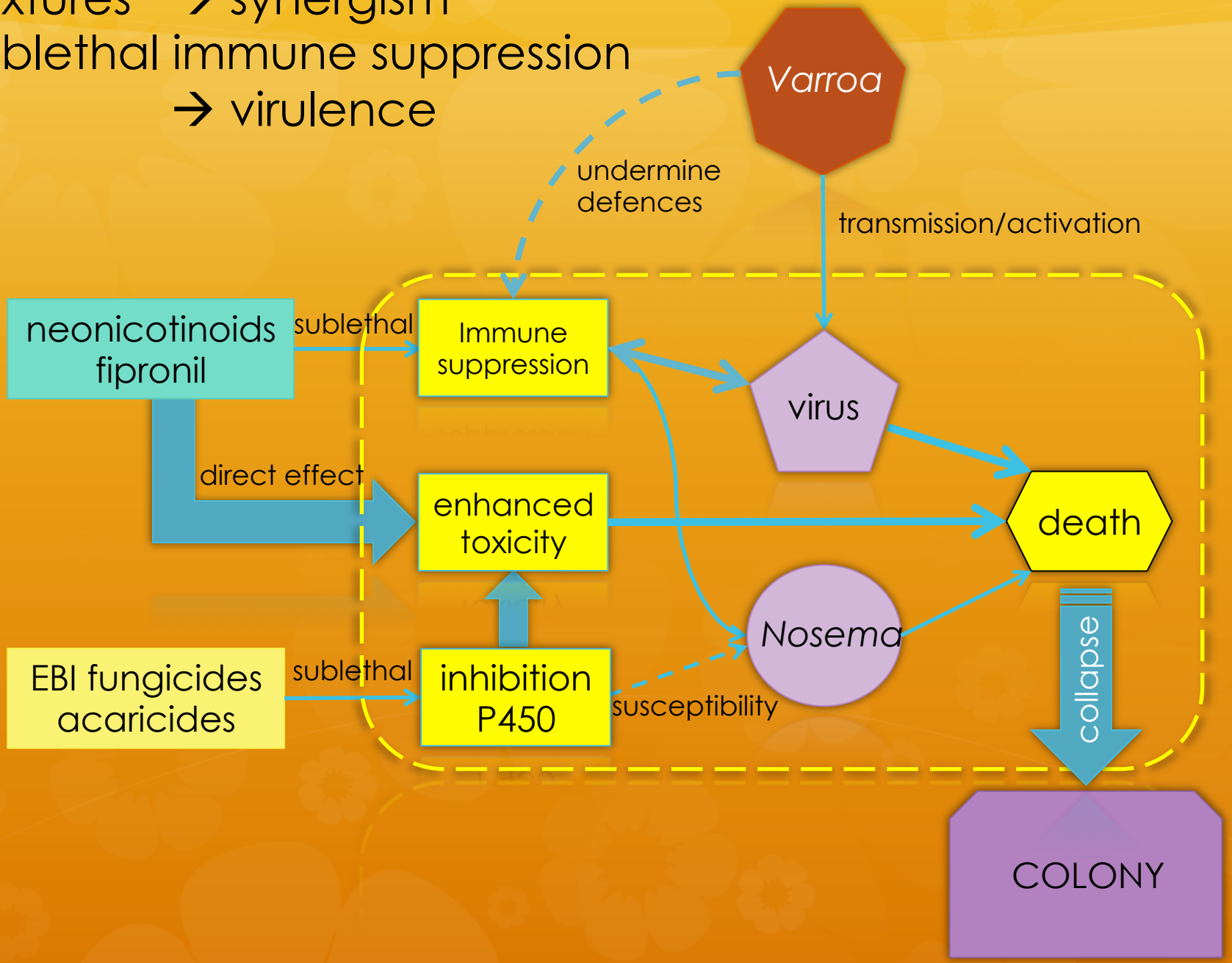
Viruses

Covert → **deadly**



Source: Alburaki et al. *J Appl Entomol* (online first, 2016)

Mixtures → synergism
Sublethal immune suppression
→ virulence



Causes of declines

Immediate

- Viruses (DWV, BQDV)
- *Nosema*

  → death
- *Varroa destructor*

  → viral infections

Underlying

- **Pesticide residues in pollen and nectar**
  - **Neonicotinoids**
  - **Fungicides**
- Amount of pollen collected
- % agricultural land
  - Habitat loss
  - Pesticide use