Effects of Neonicotinoids on Pollinators

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MIROCHA

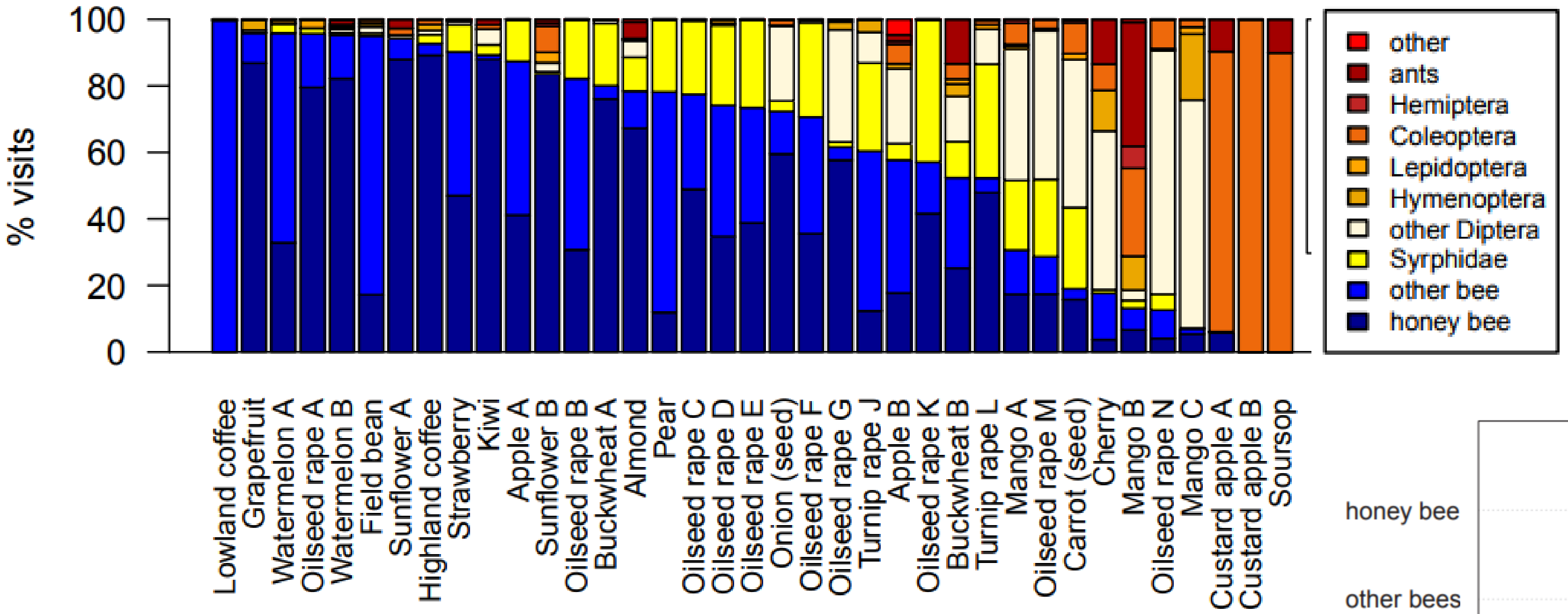
Pollination

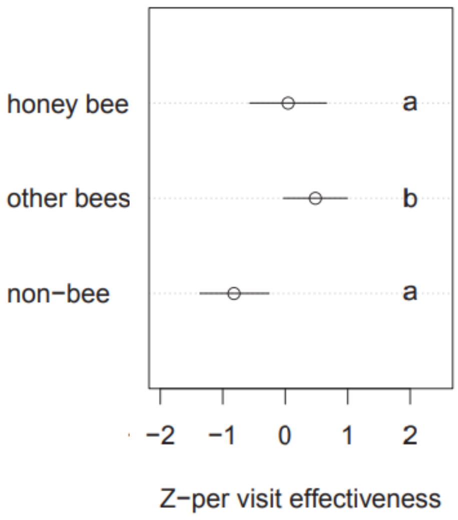
- 90% of all flowering wild plants depend on insect pollination
- At least ⅓ of the global crop production is from crops that to some extent depend on insect pollination




Ollerton et al. (2011) Oikos; Klein et al (2007) Proc R Soc B

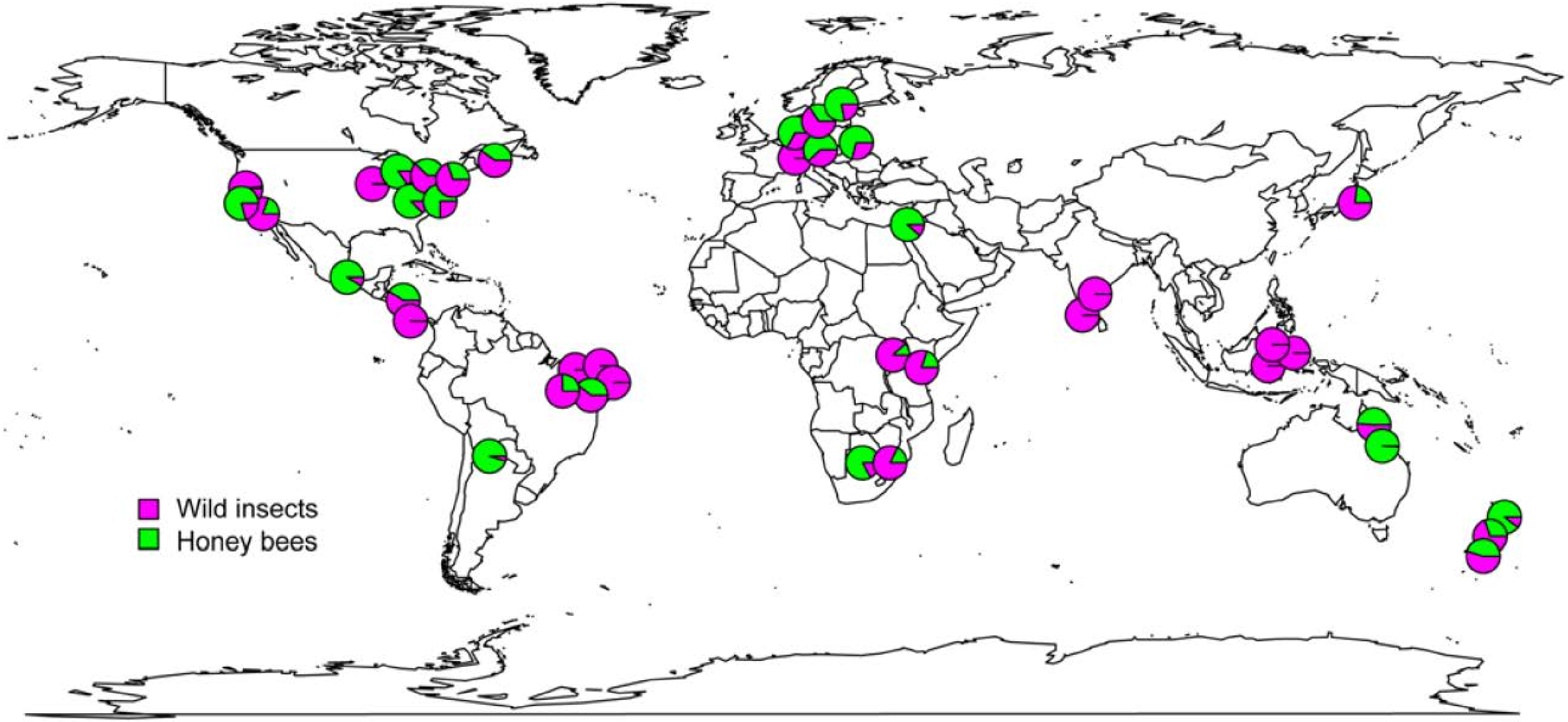
Both **bee** and **non-bee** pollinators





Rader et al. (2016) PNAS

Both honey bees and wild bees



Both wild insect and honey bees contribute to crop pollination and rather complement than replace each other.

Garibaldi et al. (2013) Science

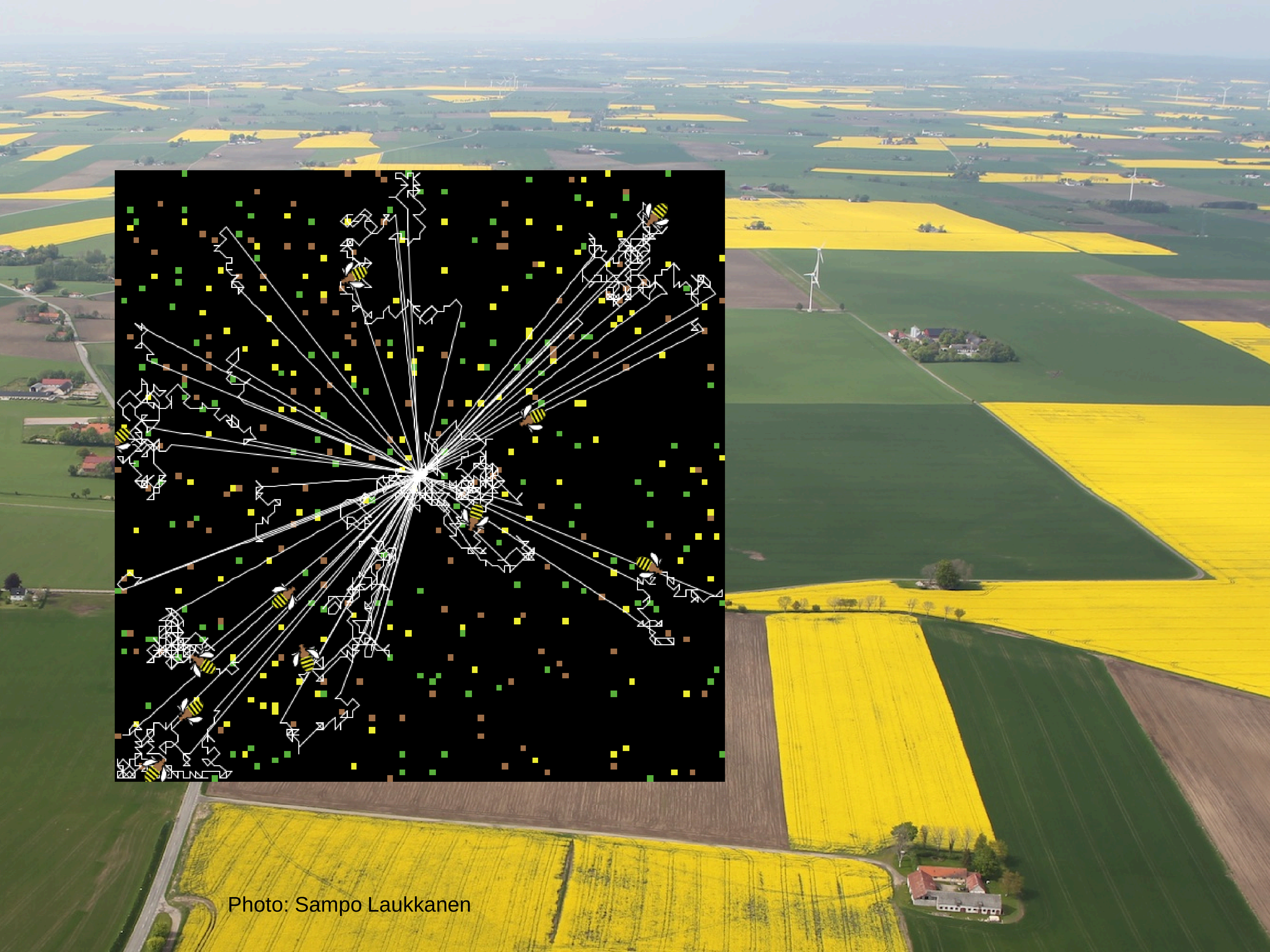
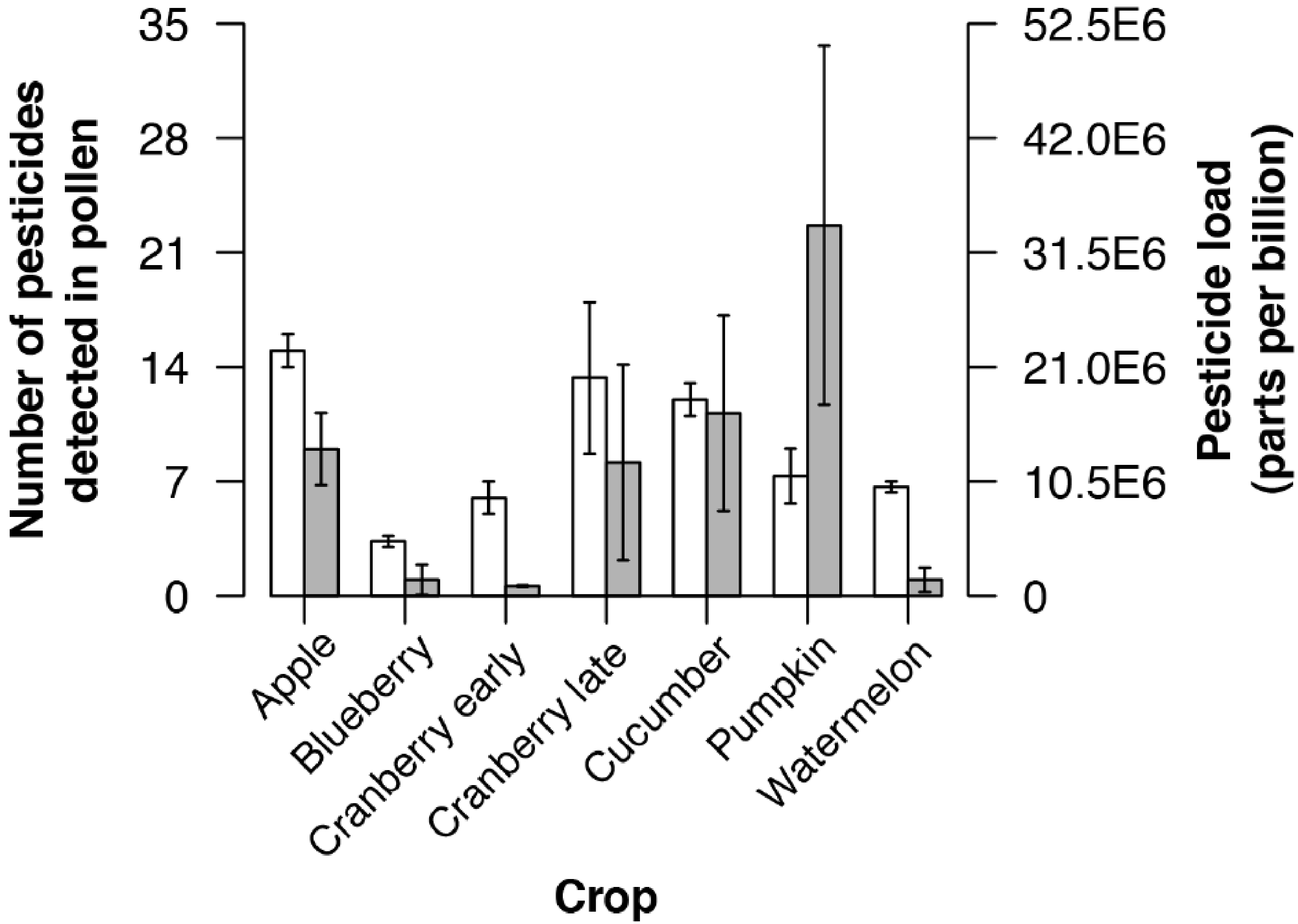


Photo: Sampo Laukkanen



Pettis et al. (2013) PLoS ONE 8: e70182.

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Pest Management Science

Pest Manag Sci **64**:1084–1098 (2008)

Review

Neonicotinoids – from zero to hero in insecticide chemistry

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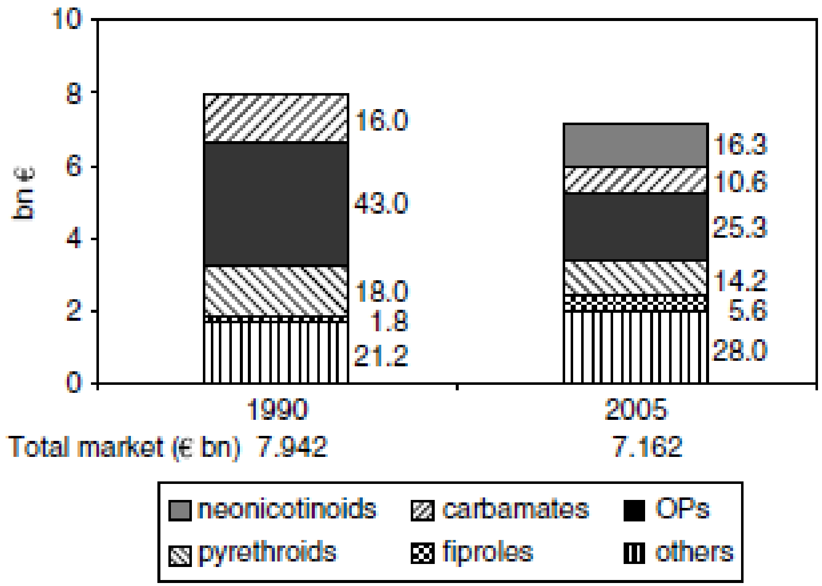

Figure 1. Development of insecticidal classes in crop protection, 1990–2005, expressed as percentage of total.

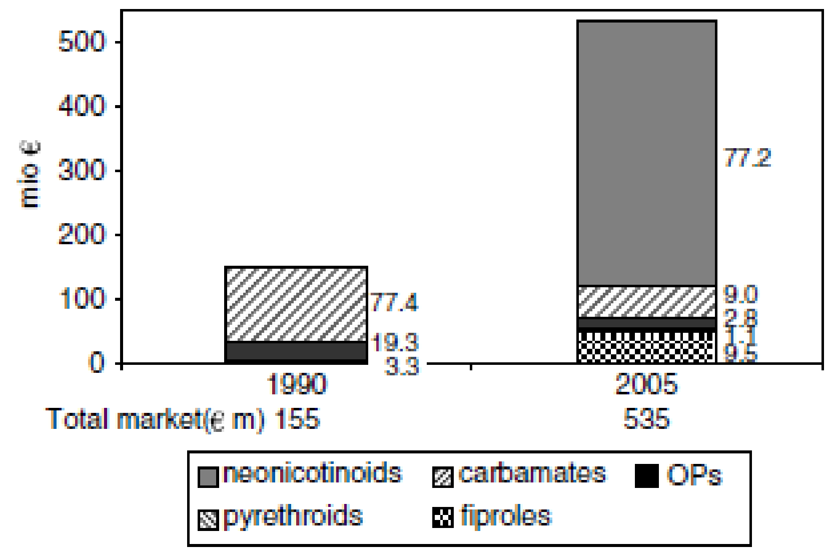

Figure 2. Development of insecticidal classes in seed treatment, 1990–2005, expressed as percentage of total.

Elbert et al. 2008 J. Agri. Food Chem., Jeschke & Nauen 2008 Pest Man. Sci.,

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Neonicotinoids

- Imidacloprid (Bayer Crop Science) was the first (1991)
- Acetamiprid, nitenpyram, thiamethoxam, thiacloprid, clothianidin, dinotefuran (1995-2002)

- Effective against many insect pests
- **Systemic**
- Water soluble
- **Slow degradation (long half-life)**
- **High selectivity against insects over mammals**

Elbert et al. 2008 J. Agri. Food Chem., Jeschke & Nauen 2008 Pest Man. Sci., Jeschke et al. 2011 J. Agri. Food Chem.

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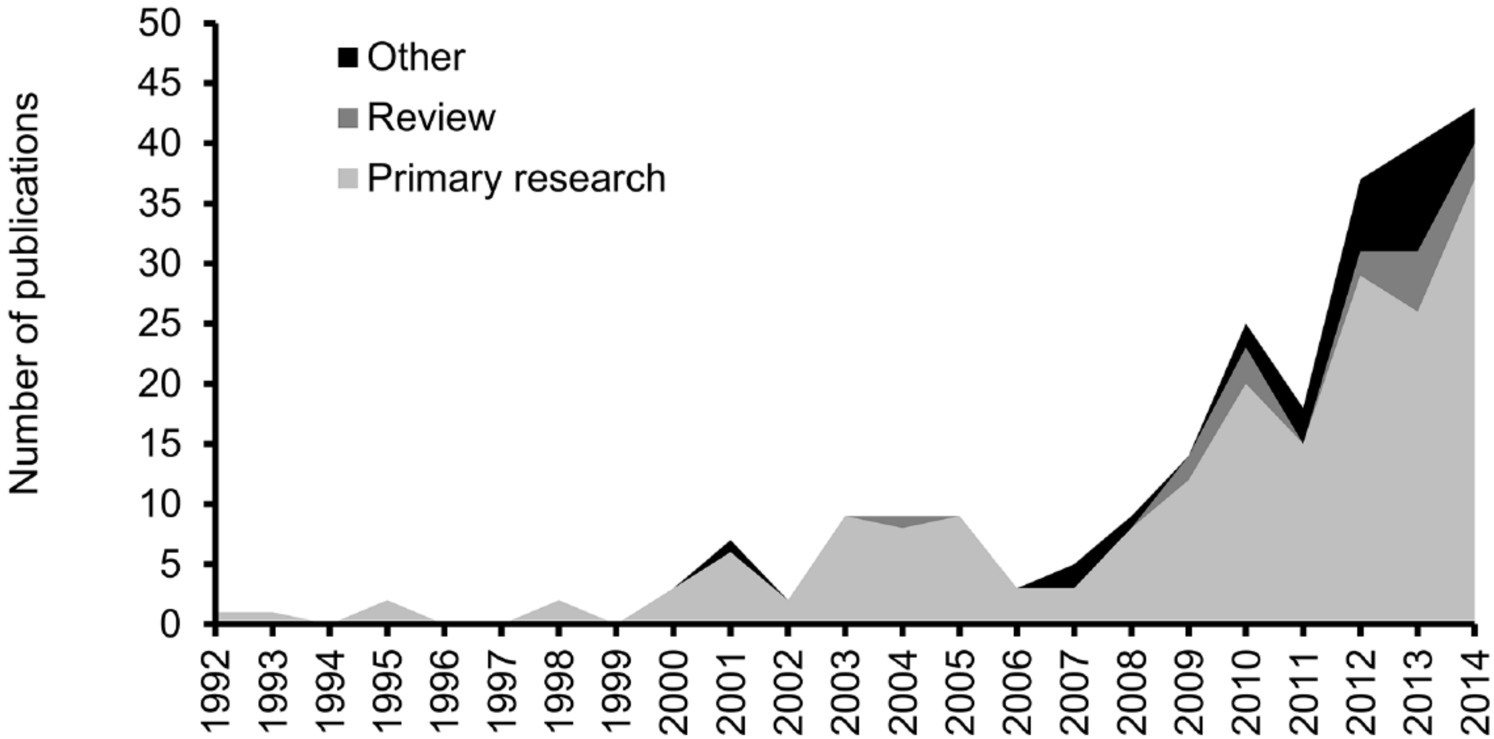
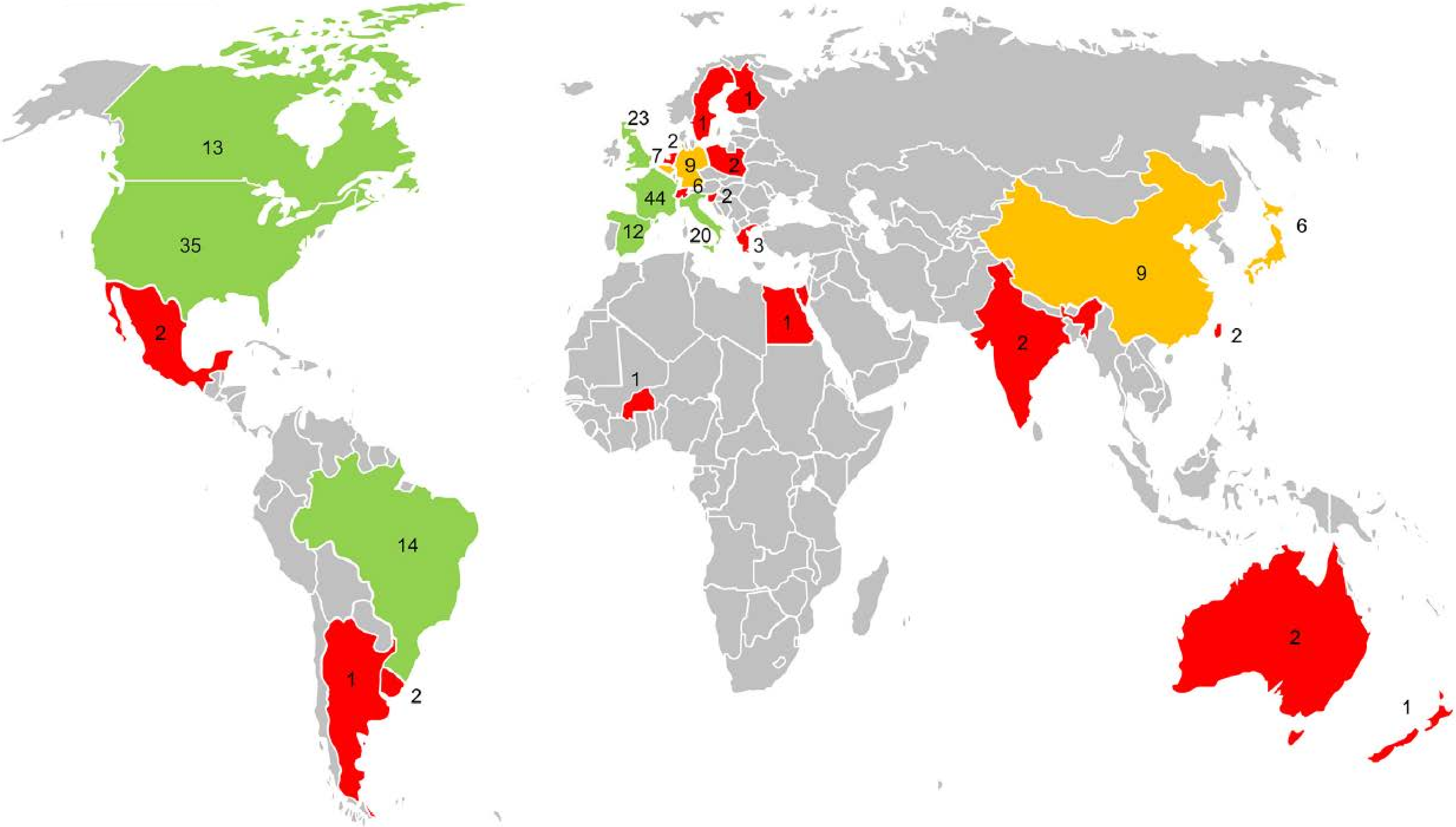
Increasing knowledge on neonics and bees



Lundin et al. (2015) PLoS ONE



Lundin et al. (2015) PLoS ONE

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Most known about seed treatment in corn

Table 1. Total number of studies on neonicotinoids and bees in different crops, study examples for each crop, and number of studies for each method of application in each crop ('Seed' = seed treatment application, 'Foliar' = foliar spray application, 'Soil' = furrow, drench or drip irrigation application, Granulate = granulate application).

Crop Linnean name	Common name	# studies	Study example	Application method			
				Seed	Foliar	Soil	Granulate
Zea mays	Maize	28	[28]	28			
Brassica napus	Oilseed rape	7	[29]	6	3		
Helianthus annuus	Sunflower	7	[30]	7			
-	Turfgrass	4	[31]		4		1
Cucumis melo	Cantaloupe	3	[32]		1	2	
Gossypium spp.	Cotton	3	[33]	1	2		
Solanum lycopersicum	Tomato	3	[34]		2	2	
Citrus spp.	Citrus fruits	2	[35]		1	1	
Cucurbita pepo	Pumpkin, squash	2	[36]	1	1	2	
Malus domestica	Apple	2	[37]		2		
Brassica juncea	Mustard	2	[38]	1	1		
Actinidia spp.	Kiwifruit	1	[39]				
Brassica rapa	Turnip rape	1	[40]		1		
Glycine max	Soybean	1	[33]	1			
Medicago sativa	Alfalfa	1	[10]		1		
Triticum spp.	Wheat	1	[41]	1			

Lundin et al. (2015) PLoS ONE

Most knowledge about honey bees

Species	N studies
Apis mellifera, Apis cerana	168
Bombus terrestris, Bombus impatiens, *Bombus* spp.	42
Megachile rotundata, *Apoidea* spp., *Melipona quadrifasciata, Osmia bicornis*, *Osmia lignaria, Nannotrigona perilampoides, Nomia melanderi*; *Osmia cornifrons*, *Scaptotrigona postica*	17

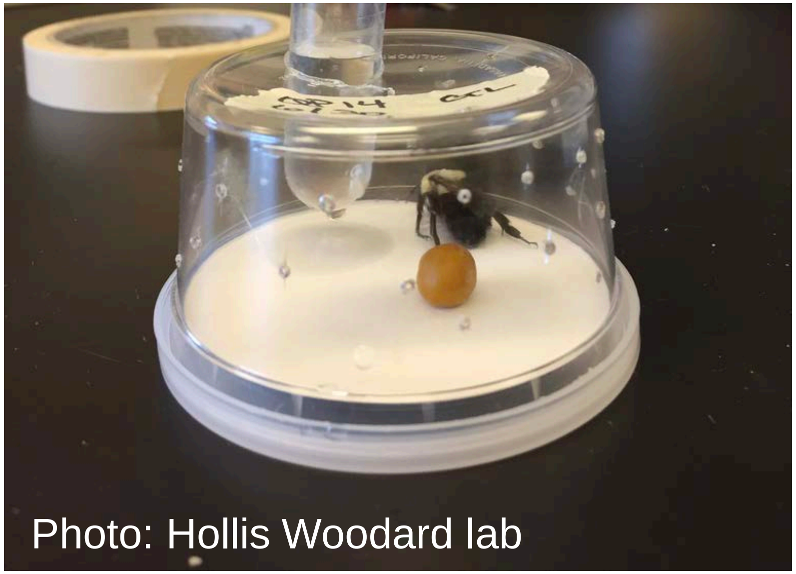
7 species

250 species

>20 000 species

Lundin et al. (2015) PLoS ONE

Most knowledge from lab studies



…and field studies estimating exposure in honey bee collected pollen or nectar/honey (but very few on effects)

Lundin et al. (2015) PLoS ONE

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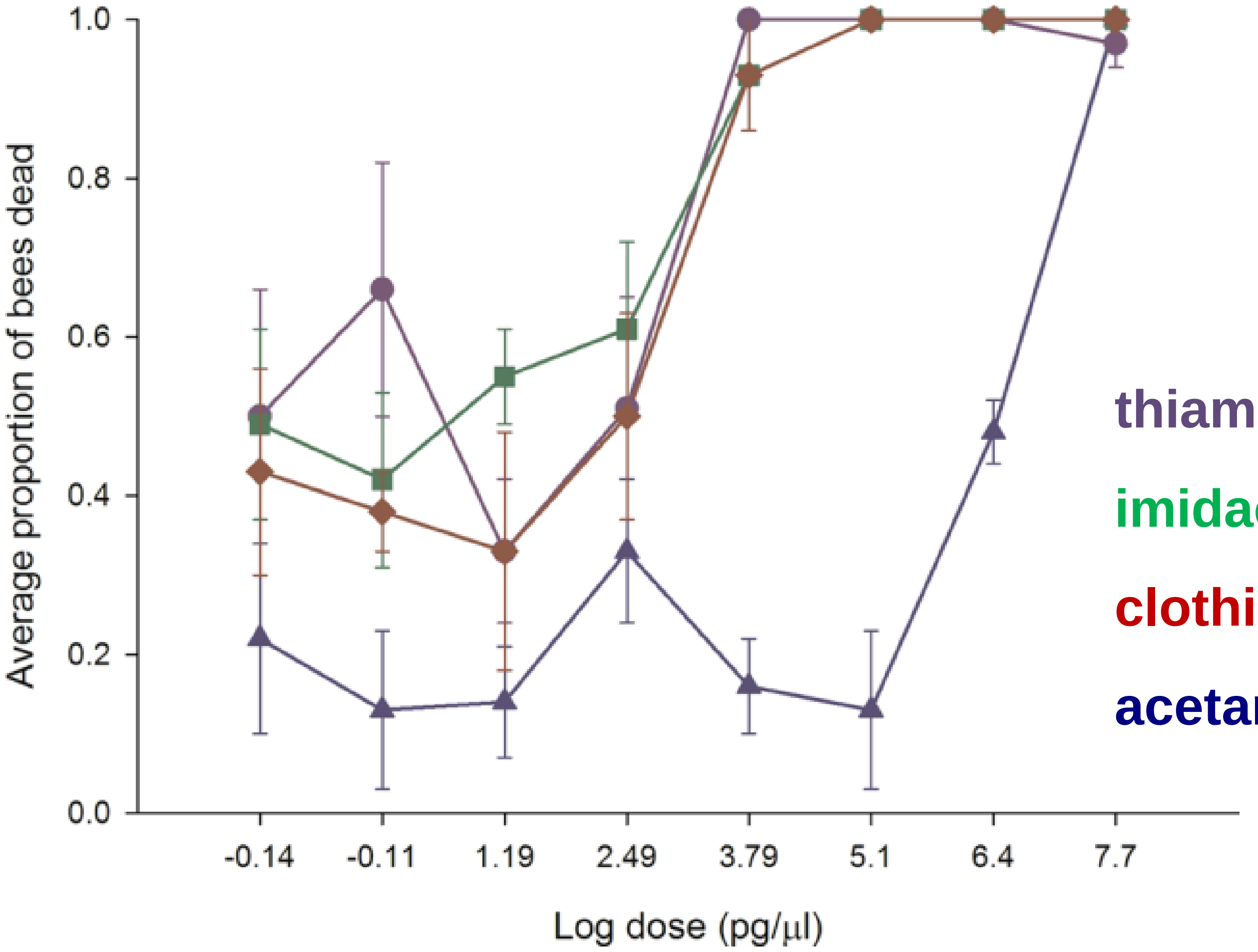
24 h exposure of bumble bees in cage trial



	NOAEL
thiamethoxam	0.93 ng/bee
imidacloprid	0.93 ng/bee
clothianidin	1.9 ng/bee
acetamiprid	37.5 ng/bee

Baines et al. (2017) Scientific Reports

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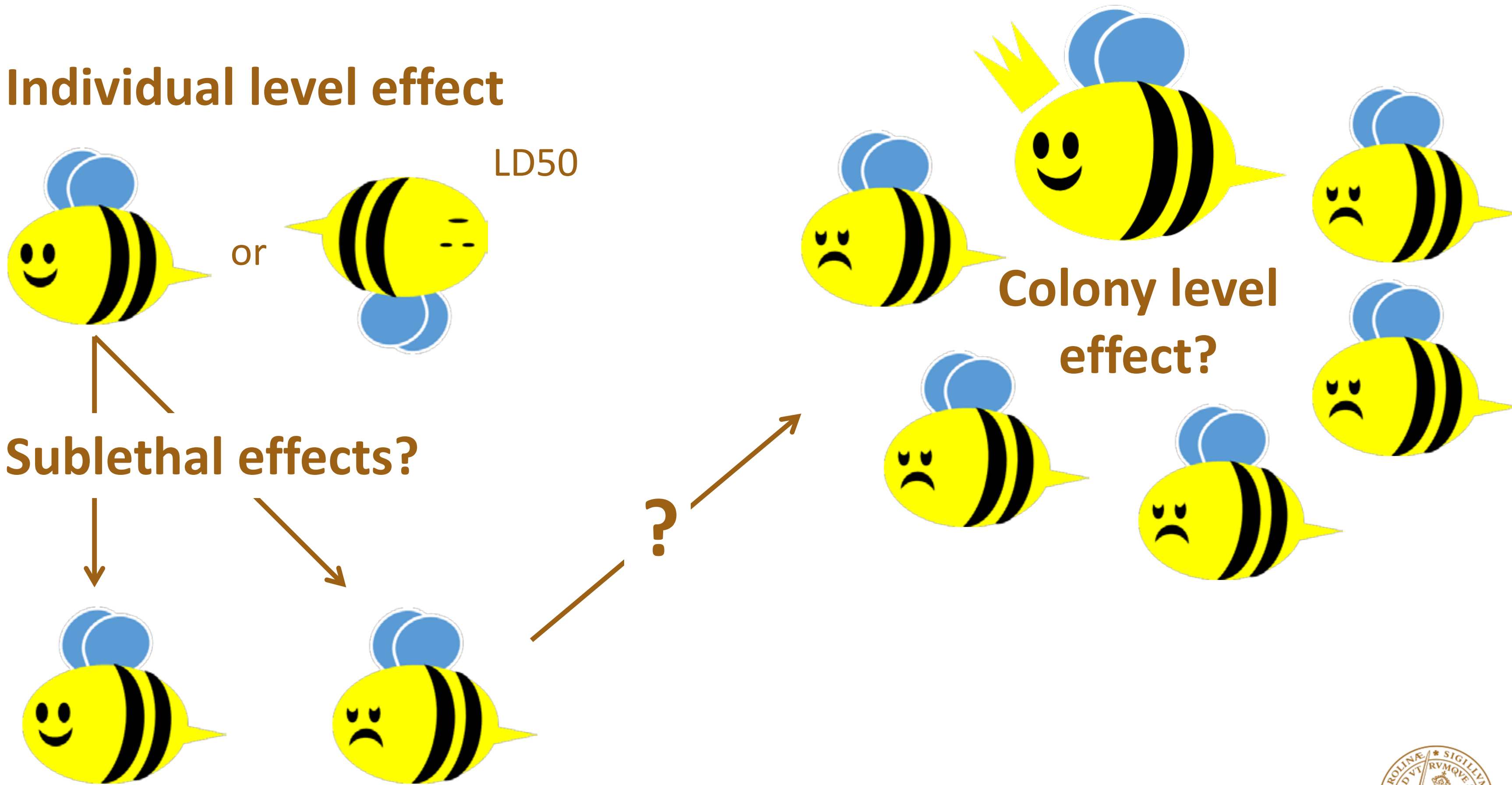
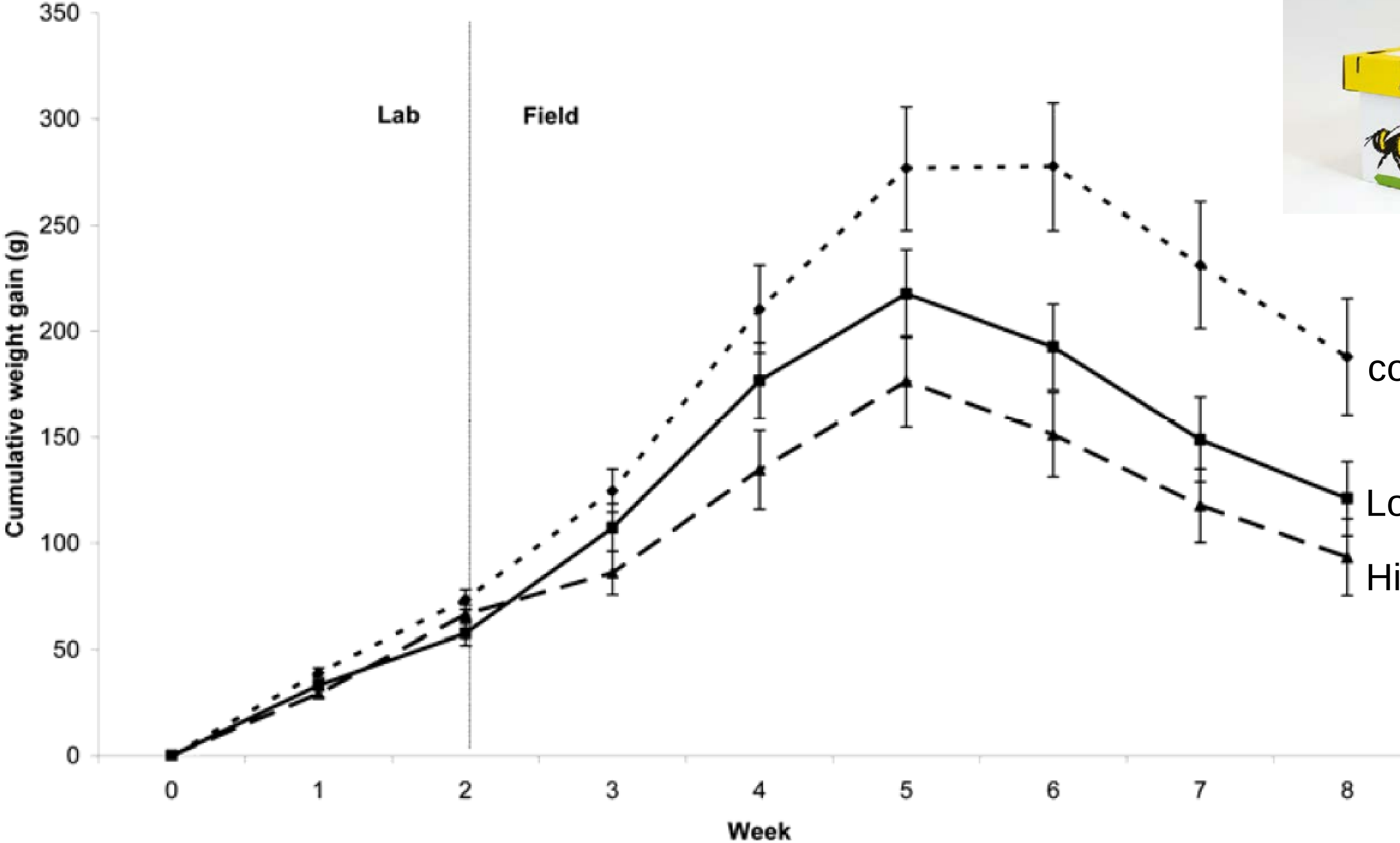
Lethal and sublethal effects



Three alarming studies in 2012

Semi-field study on bumble bee colonies



Whitehorn et al. (2012) Science

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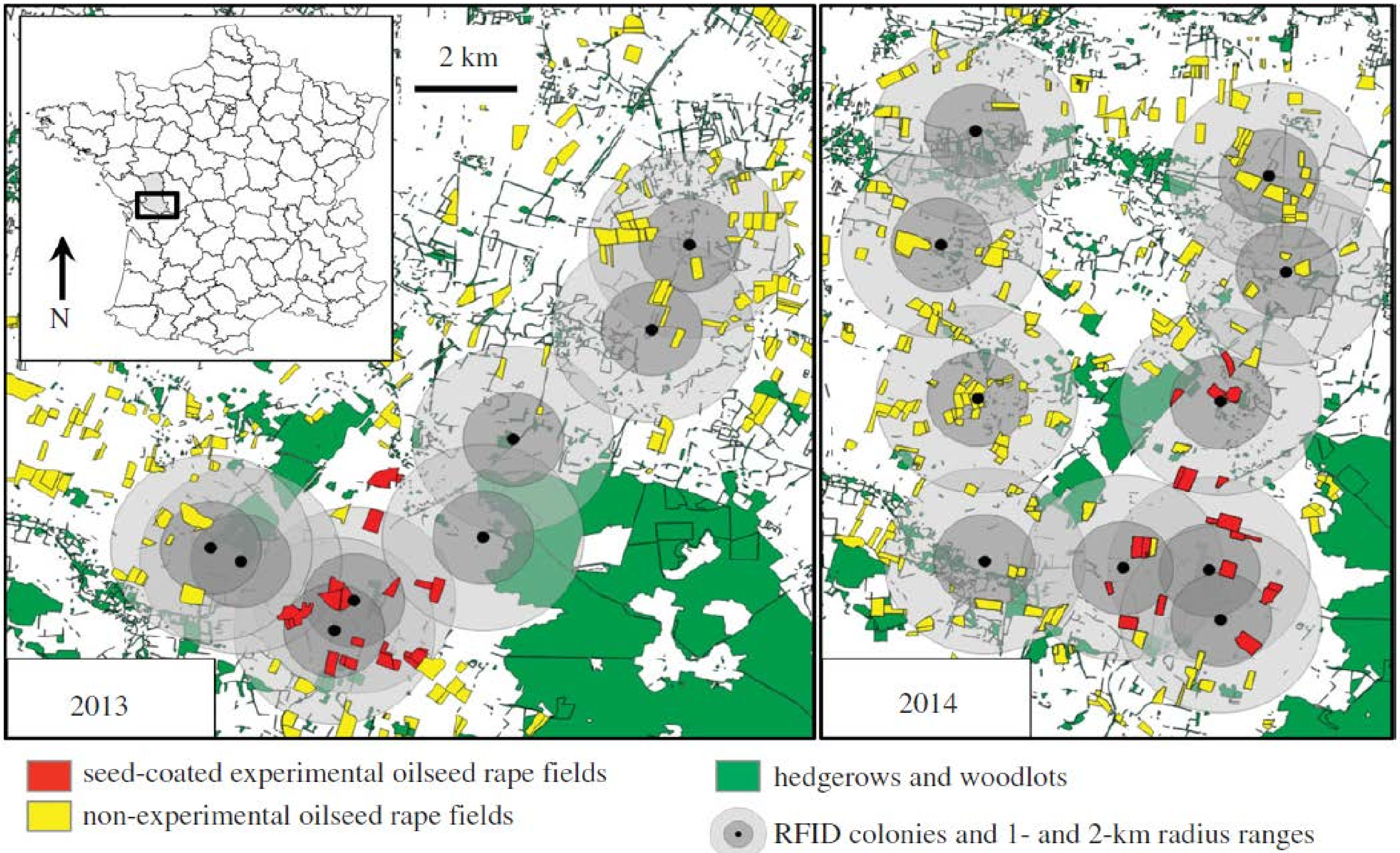
Semi-field study on honey bee foraging



Henry et al. (2012) Science, Henry et al. (2015) Proceedings B

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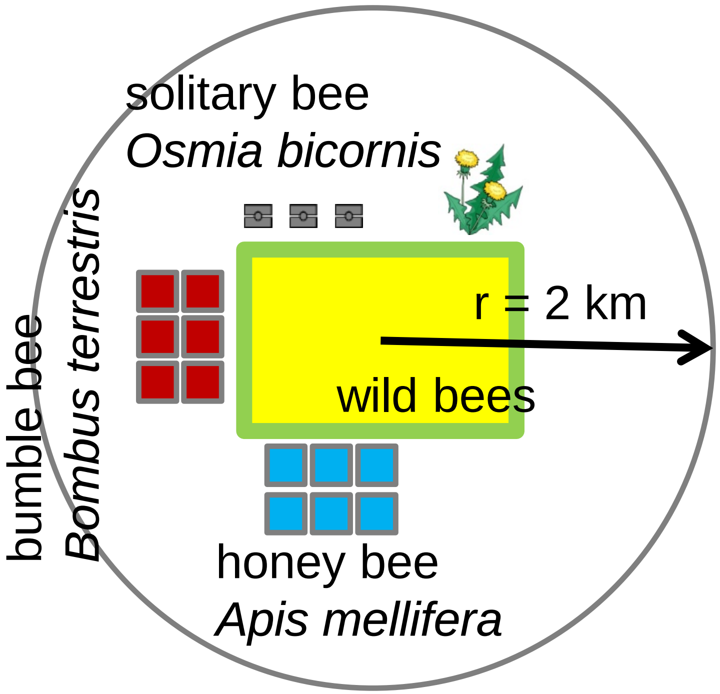
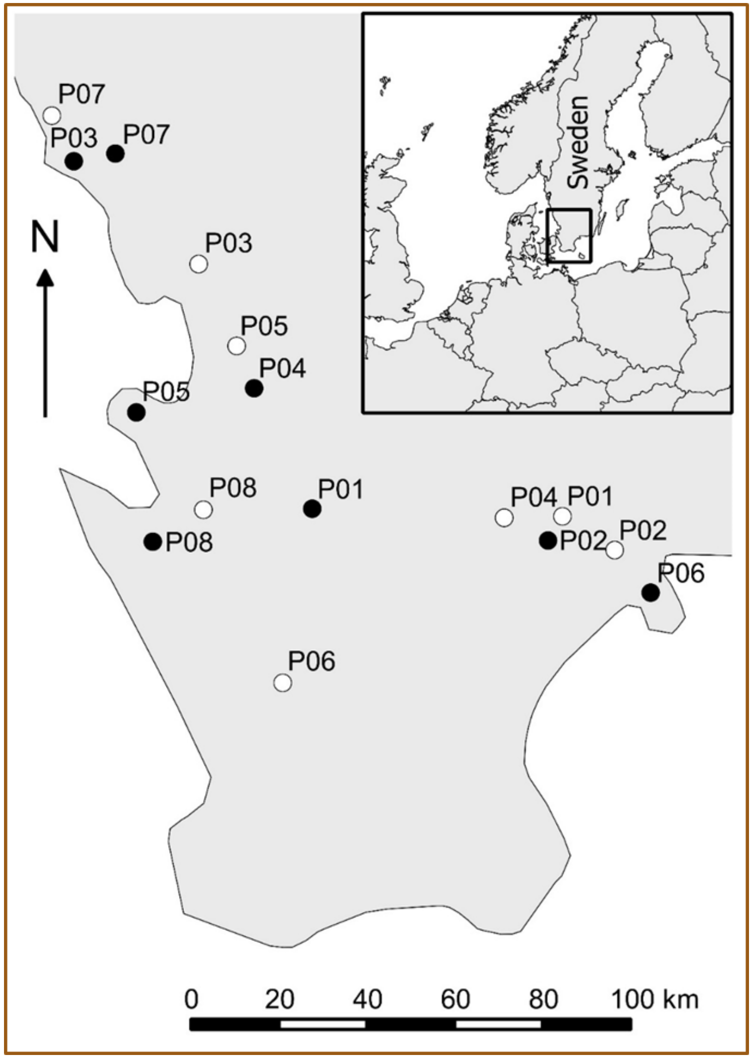
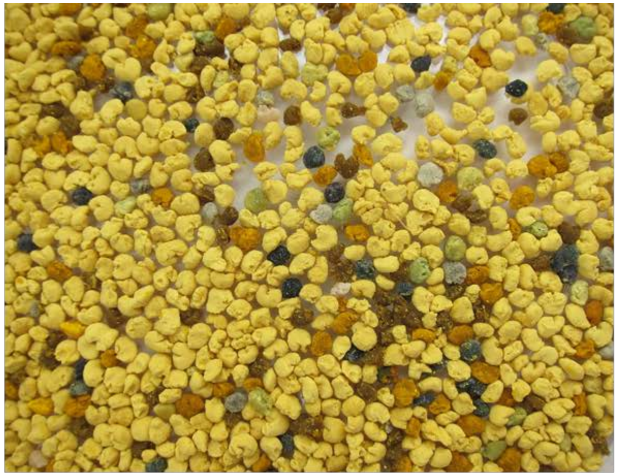
Landscape-scale experiment in 2013

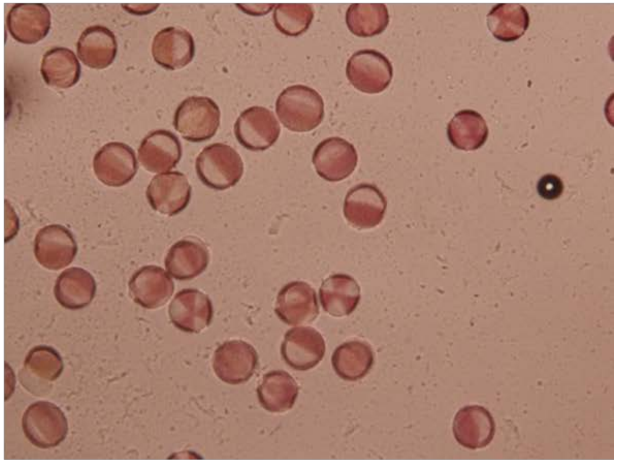


- 8 pairs of spring-sown canola fields and surrounding landscapes
- random assignment to treatment (clothianidin seed dressing) and control
- treatment blinded during field work



Verifying exposure – oilseed rape pollen use and clothianidin residues





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35 ± 17%

80 ± 5%

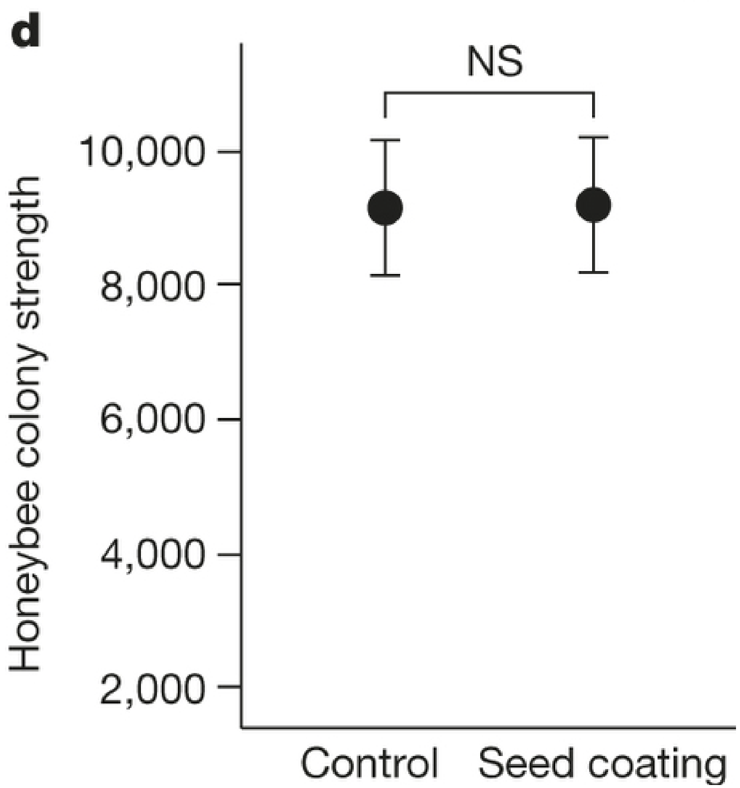
58 ± 5%

Table 1 | Clothianidin concentrations in bee-collected pollen (ng g^{-1}) and nectar (ng ml^{-1}), and field border differences between treatments (control or insecticide-coated seeds)

	Control		Insecticide seed coating	
	Range	Mean ± s.e.m.	Range	Mean ± s.e.m.
Honeybee pollen	0	0	6.6–23	13.9 ± 1.8
Honeybee nectar	0–0.61	0.1 ± 0.1	6.7–16	10.3 ± 1.3
Bumblebee nectar	0	0	1.4–14	5.4 ± 1.4
Field border plants (≤2 days after sowing)	0	0	0–5.9	1.2 ± 0.8
Field border plants (2 weeks after sowing)	No material collected		0–6.5	1.0 ± 0.8

Rundlöf et al. (2015) Nature 521: 77-80.

The neonic treatment had no significant influence on *Apis mellifera* colony strength



Rundlöf et al. (2015) Nature 521: 77-80

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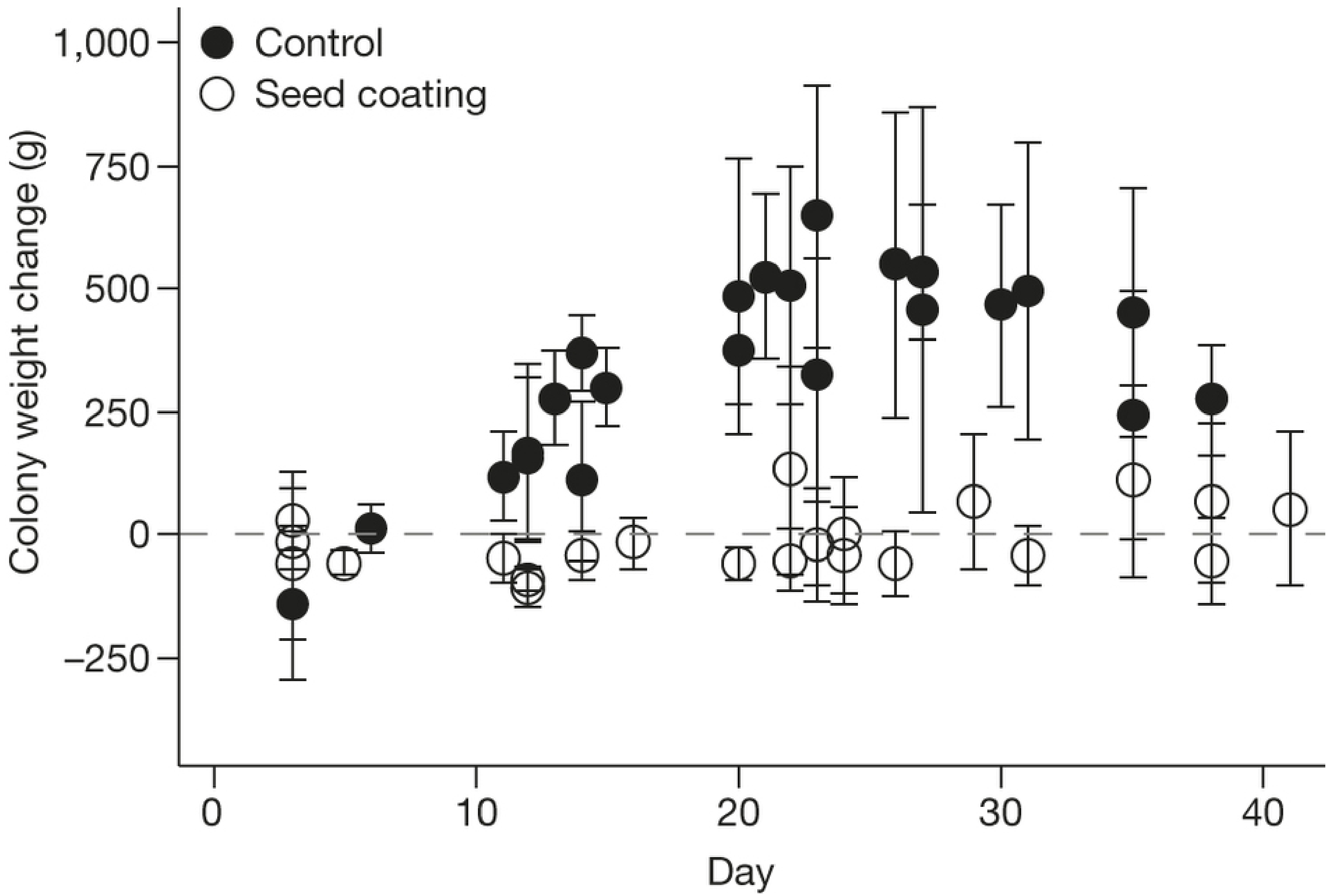
The neonic treatment was negatively related to *Bombus terrestris* colony growth



Rundlöf et al. (2015) Nature 521: 77-80.

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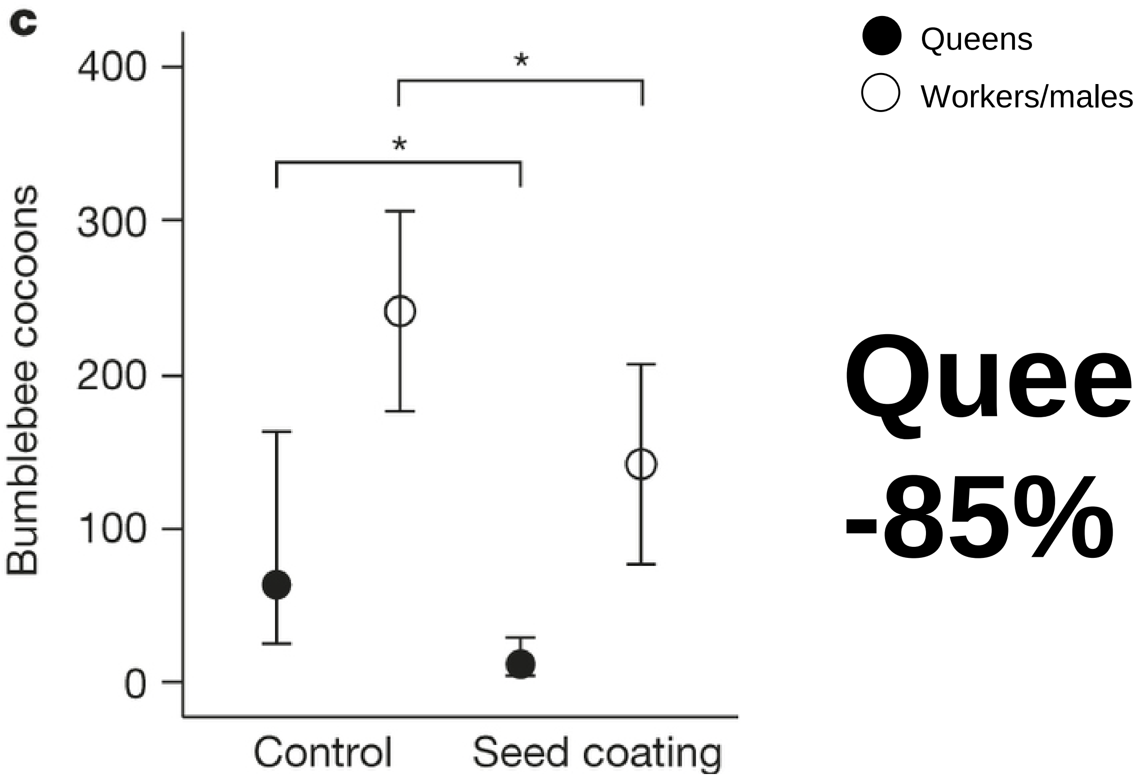
…and *Bombus terrestris* reproduction



Queens: -85%

Rundlöf et al. (2015) Nature 521: 77-80.

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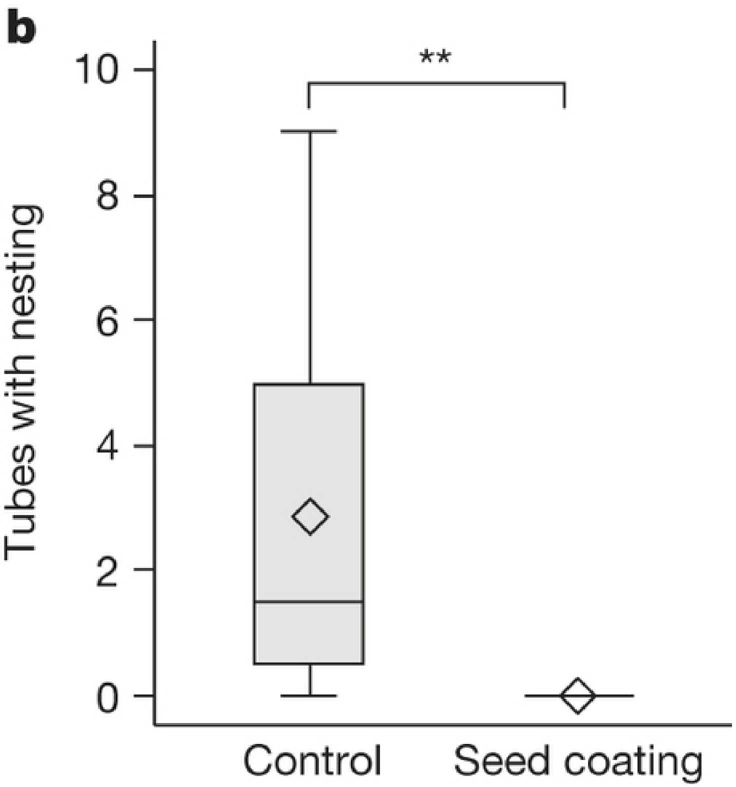
Relation between the neonic treatment and reduced nesting of *Osmia bicornis*



Rundlöf et al. (2015) Nature 521: 77-80.

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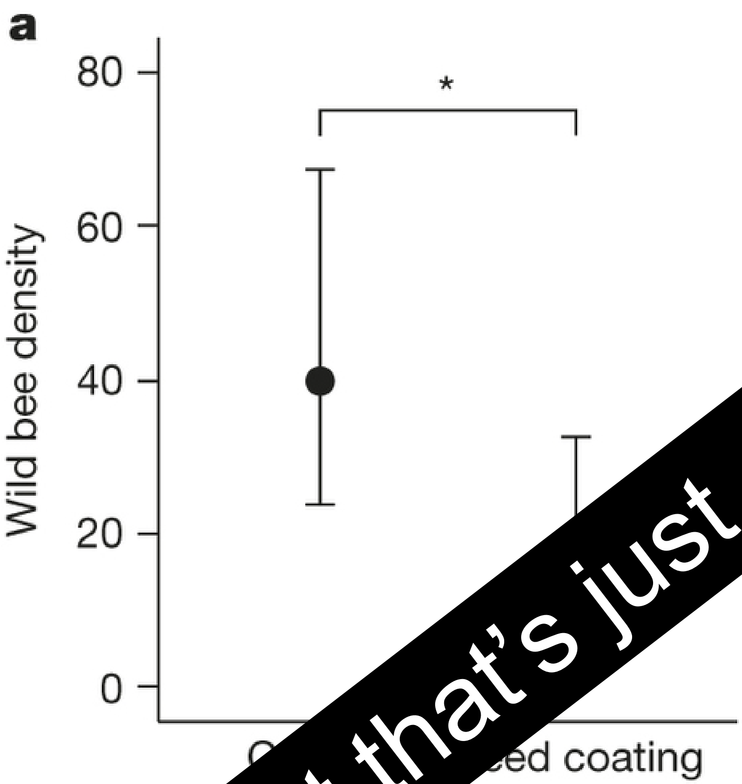
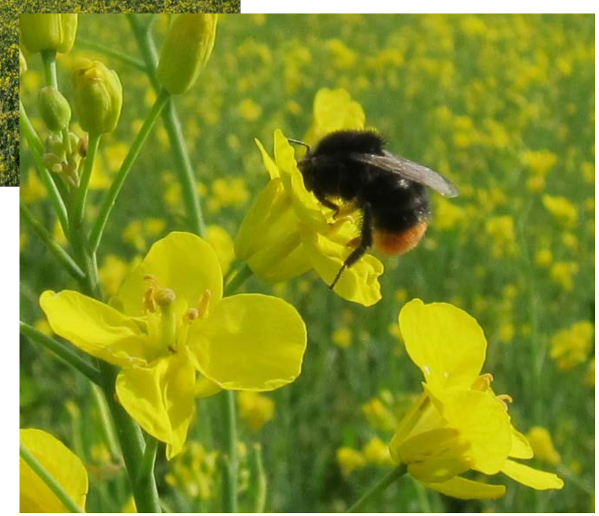
Reduced wild bee density in oilseed rape fields treated with the neonic



But that's just one crop/year/region…

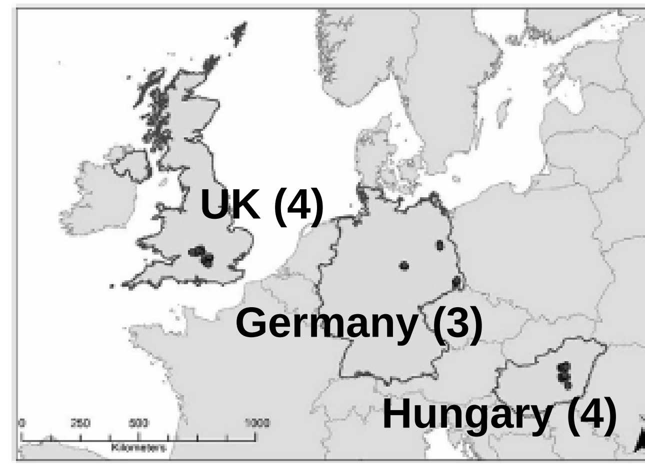


Wild bees are in Sweden bumble bees and solitary bees

Rundlöf et al. (2015) Nature 521: 77-80.

Autumn sown canola in three countries

- Clothianidin treated canola expressed higher clothianidin residues than the control crop, but residues very low (LOD-2.21 ppb)
- No systematic differences in neonicotinoid (clothianidin + thiamethoxam + imidacloprid) residues between treated and control sites
- No systematic differences in (most) bee measures between treated and control sites



Woodcock et al. (2017) Science

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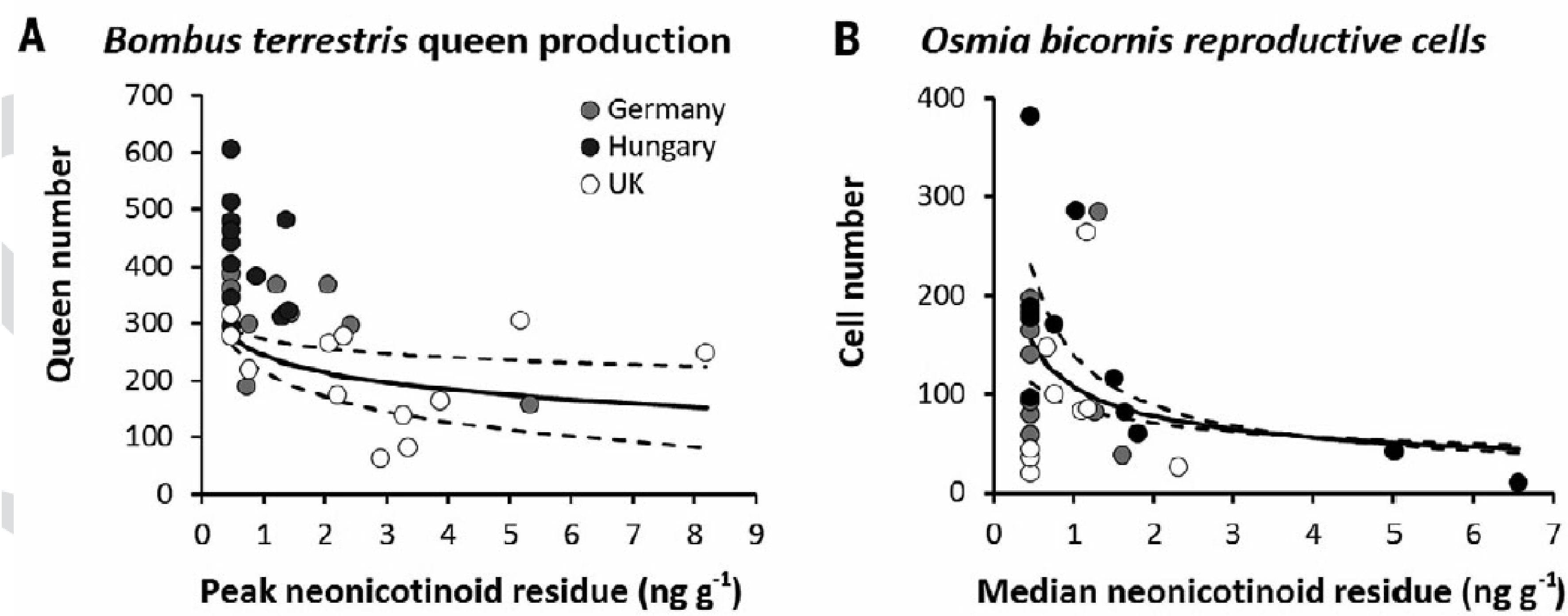
Autumn sown canola in three countries



Woodcock et al. (2017) Science

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Correlative study links bee decline to neonics

Neonicotinoids:
-- canola foraging bees
- other bees

Canola cover:
+ canola foraging bees
other bees

Foliar applied insecticides:
canola foraging bees
other bees

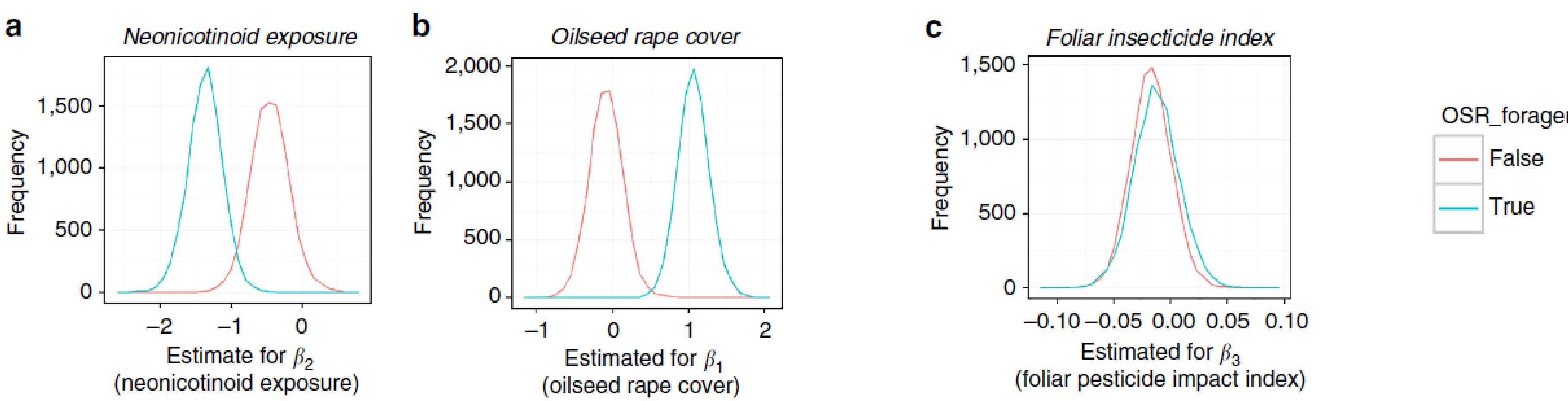

Figure 2 | Posterior distributions for the effect sizes describing wild bee population persistence in England.

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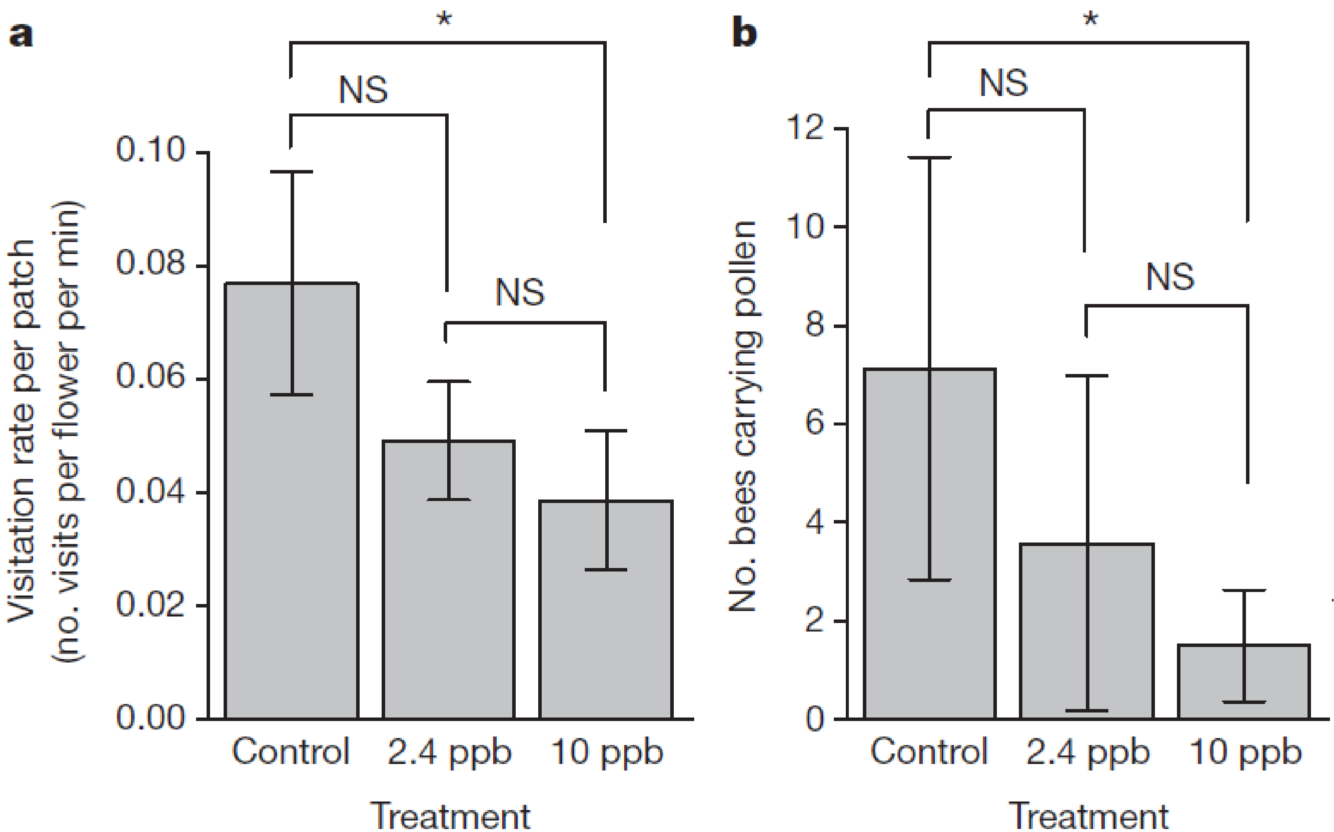
Woodcock et al. (2016) Nature Communications

Effects on pollination



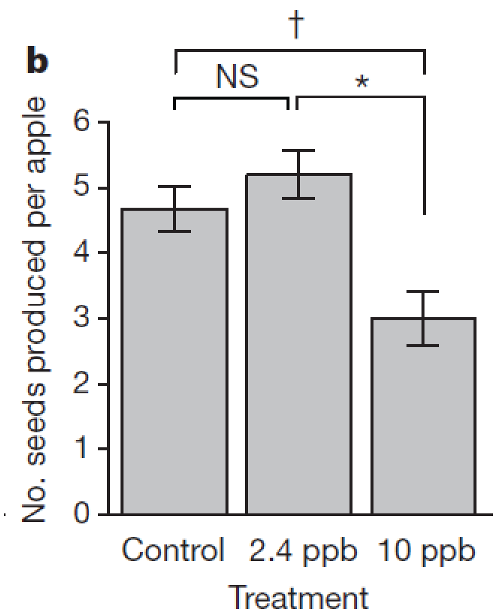


Figure 1 | Effects of pesticide treatment on colony-level behaviour.

Stanley et al. (2015) Nature

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Routes of exposure

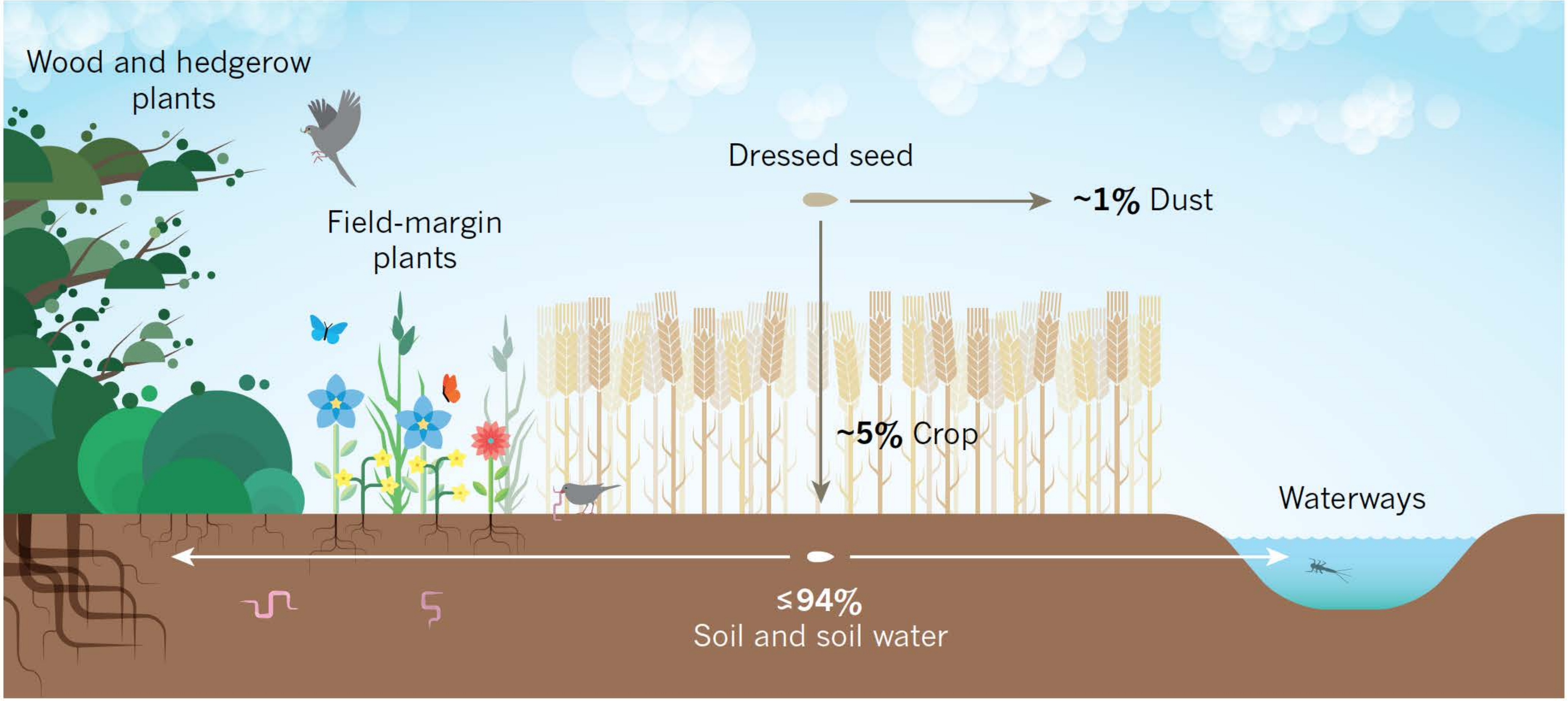
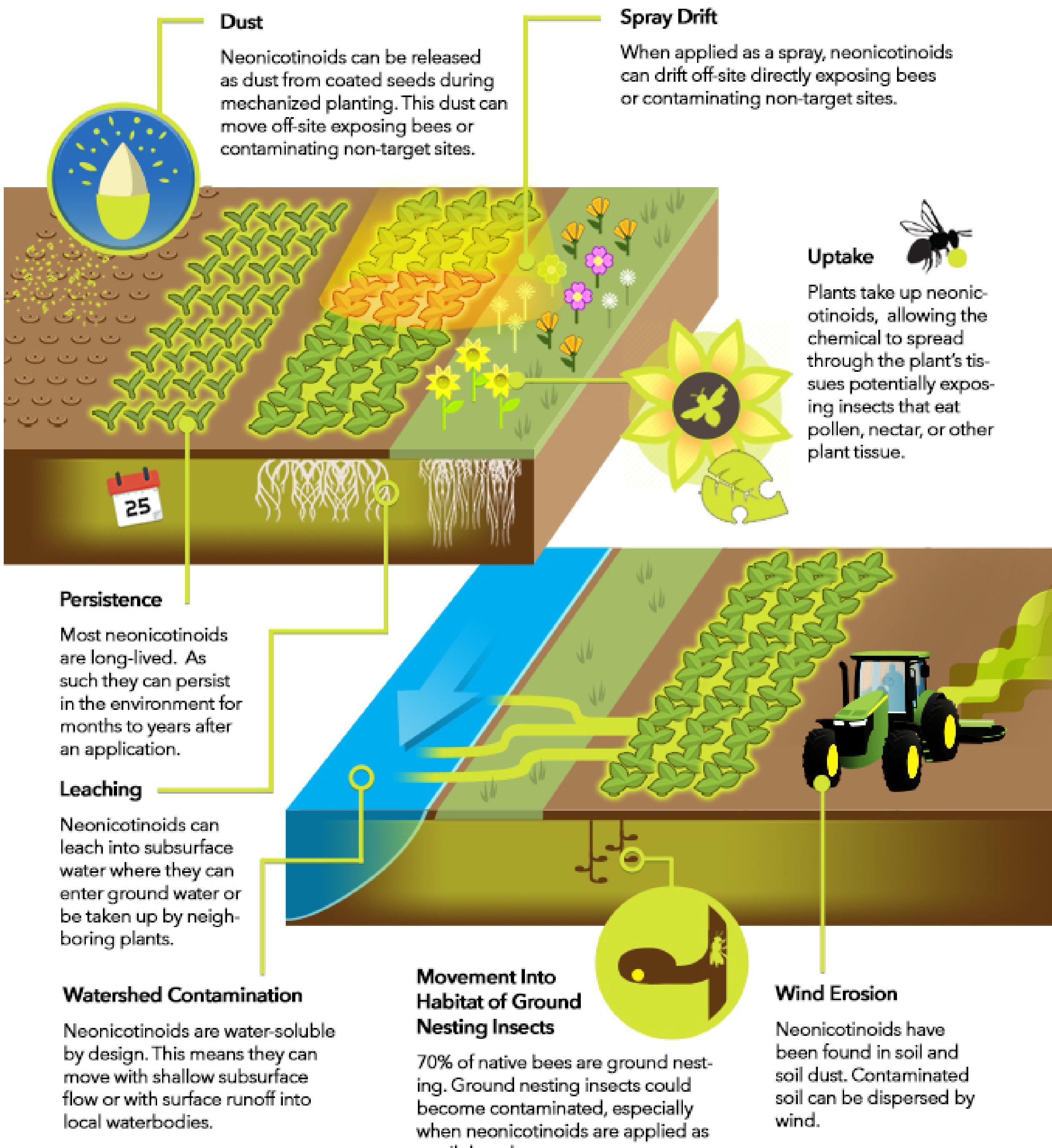


Figure 1 | The environmental fate of neonicotinoids. When neonicotinoids are applied as a seed

Goulson (2014) Nature



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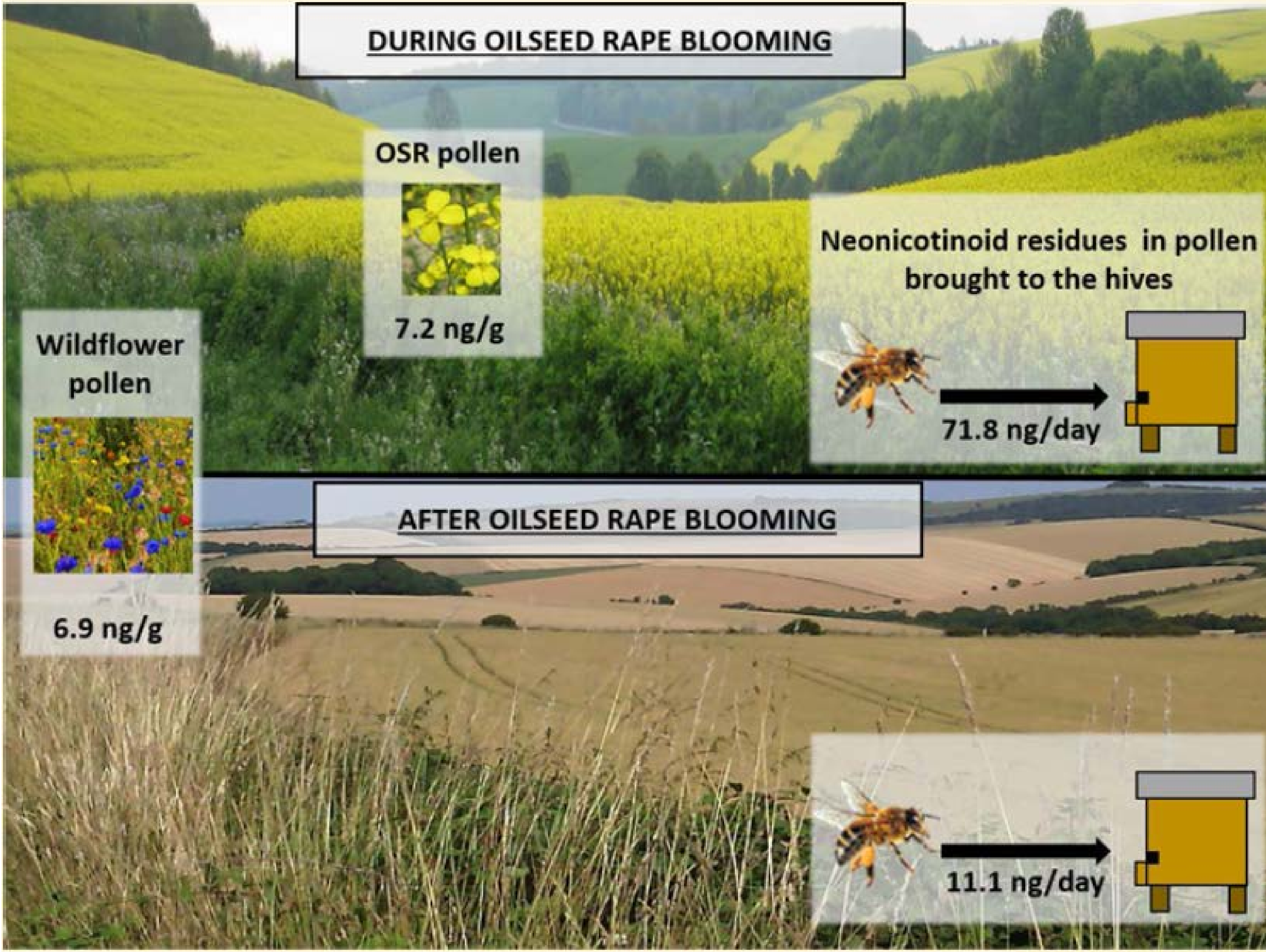
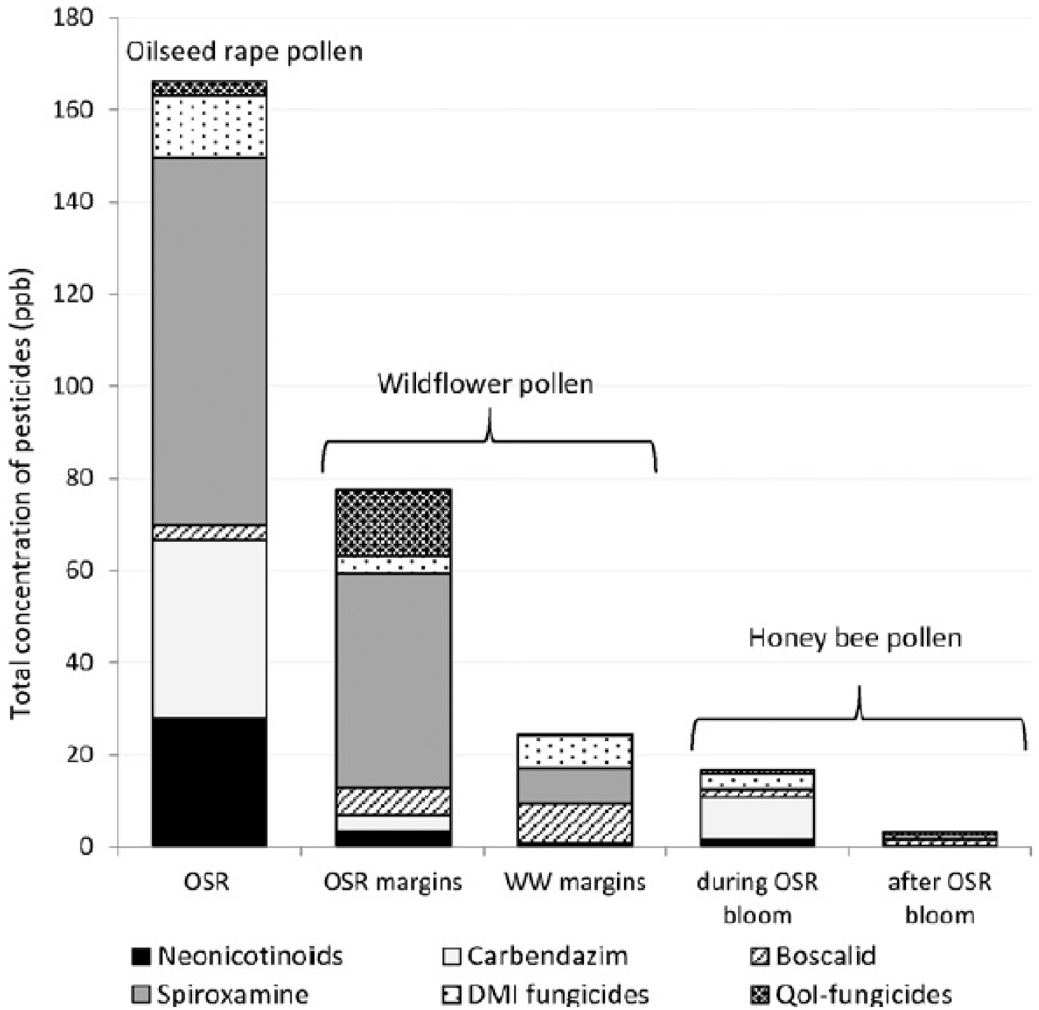


Botías et al. (2015) Environmental Science & Technology 49: 12731-12740.

Non-crop habitats emerge as exposure routes



David et al. (2016) Environment International 88: 169-178.

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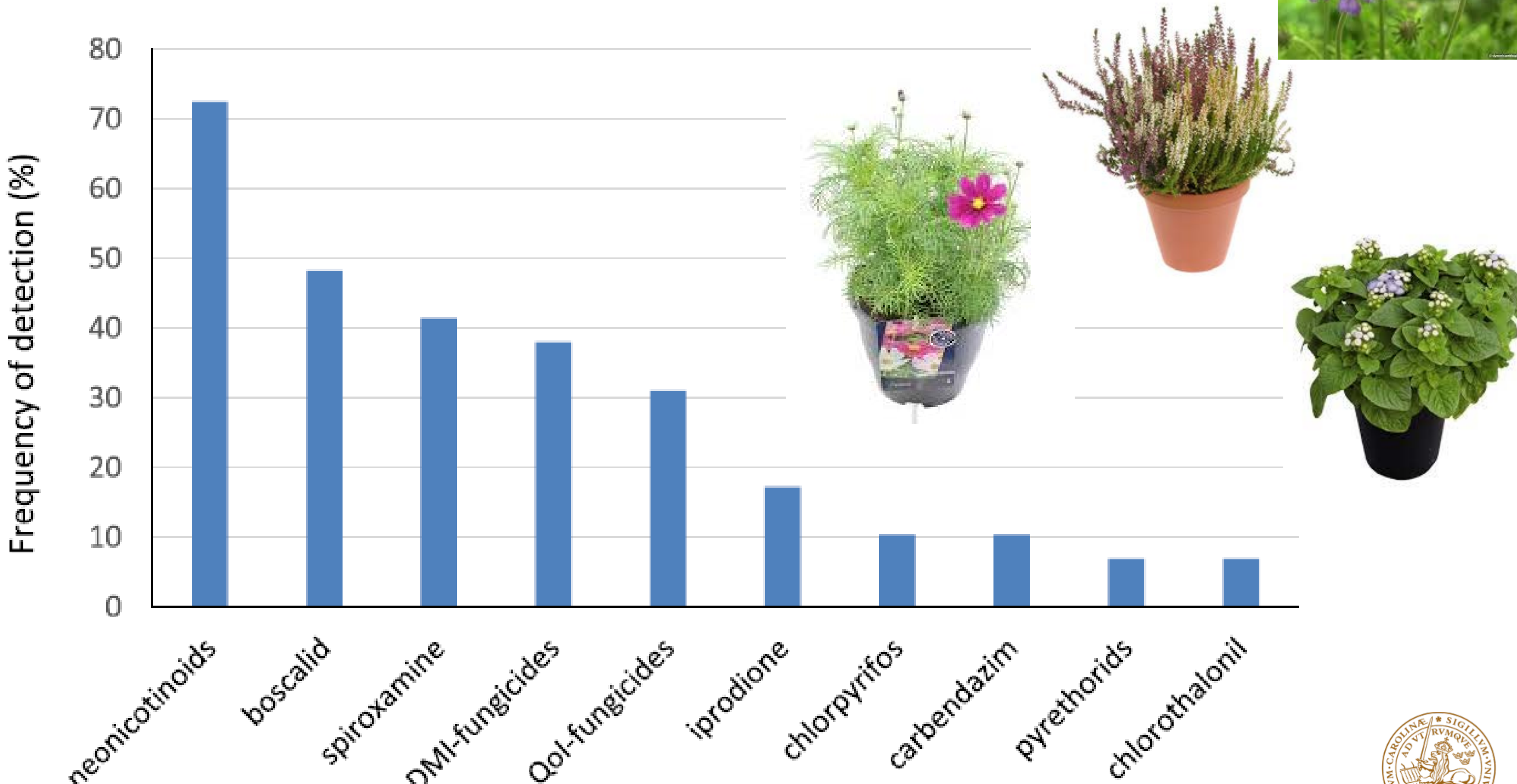
Neonicotinoids in “bee-friendly” ornamental plants



Lentola et al. (2017) Environmental Pollution

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All but one of these garden insecticides contain neonicotinoids, and none of the labels indicate that they are poisonous to bees and adult butterflies. Photograph by Matthew Shepherd.

Hopwood & Shepherd (2012) Neonicotinoids in Your Garden. Xerces Society

Visit for more information: http://xerces.org/neonicotinoids-and-bees/

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Drivers of bee decline

Habitat loss & degradation

Pathogens

Pesticides

Nutrition

Invasive species

Climate change

Interacting multiple factors!

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Questions?

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Myndigheten för samhällsskydd och beredskap

Carl Tryggers Foundation for Scientific Research

Kungl. Fysiografiska Sällskapet i Lund

CAnMove
Centre for Animal Movement Research
Lund University, Sweden

Vetenskapsrådet

Lund University

SLU

Jordbruksverket
Swedish Board of Agriculture