Numbers for Policy, Castelldefels, 31 Aug 2018

Neonicotinoids and pollinators

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European Research project ALARM:

The trend of world wide pollinator loss is a major threat to biodiversity

*Causes include: **new pesticides**, land use change and climate change*

PLOS | ONE

RESEARCH ARTICLE

More than 75 percent decline over 27 years in total flying insect biomass in protected areas

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OPEN ACCESS

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Abstract

Global declines in insects have sparked wide interest among scientists, politicians, and the general public. Loss of insect diversity and abundance is expected to provoke cascading effects on food webs and to jeopardize ecosystem services. Our understanding of the extent and underlying causes of this decline is based on the abundance of single species or taxonomic groups only, rather than changes in insect biomass which is more relevant for ecological functioning. Here, we used a standardized protocol to measure total insect biomass using Malaise traps, deployed over 27 years in 63 nature protection areas in Germany (96 unique location-year combinations) to infer on the status and trend of local entomofauna. Our analysis estimates a seasonal decline of 76%, and mid-summer decline of 82% in flying insect biomass over the 27 years of study. We show that this decline is apparent regardless of habitat type, while changes in weather, land use, and habitat characteristics cannot explain this overall decline. This yet unrecognized loss of insect biomass must be taken into account in evaluating declines in abundance of species depending on insects as a food source, and ecosystem functioning in the European landscape.

http://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0185809&type=printable

Insects Opinion

Insectageddon: farming is more catastrophic than climate breakdown

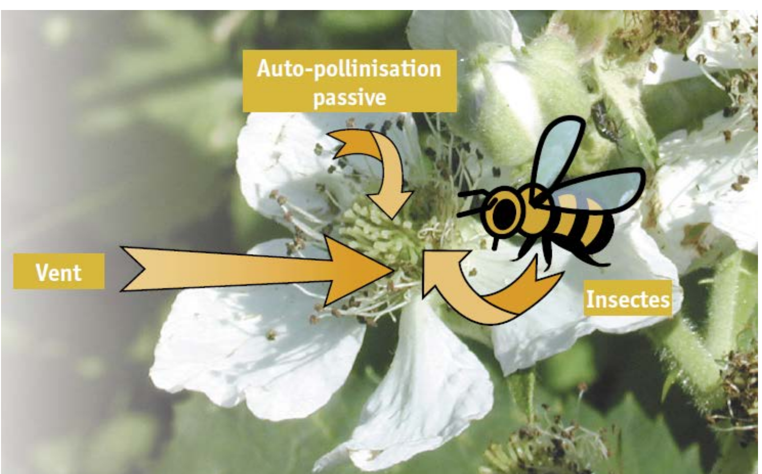
George Monbiot

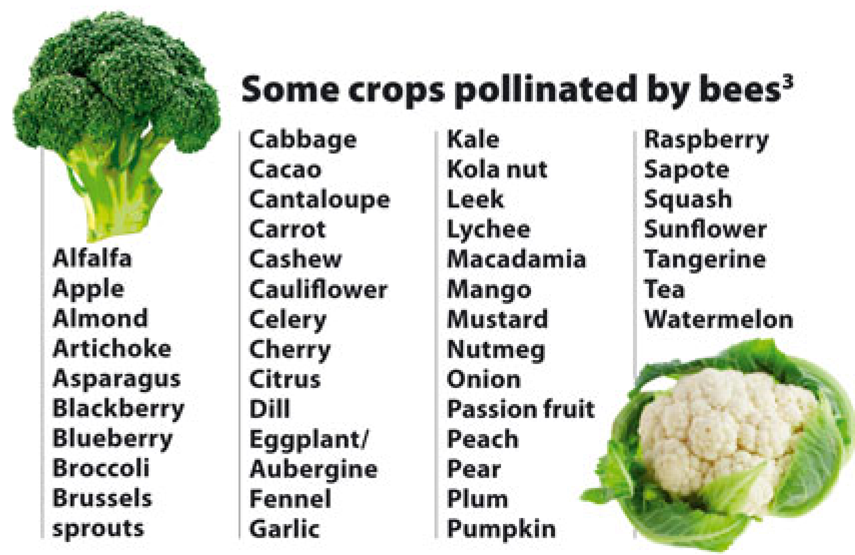
The shocking collapse of insect populations hints at a global ecological meltdown

“The impact on wildlife of changes in farming practice (and the expansion of the farmed area) is so rapid and severe that it is hard to get your head round the scale of what is happening. A study published this week in the journal Plos One reveals that flying insects surveyed on nature reserves in Germany have declined by 76% in 27 years. The most likely cause of this Insectageddon is that the land surrounding those reserves has become hostile to them: the volume of pesticides and the destruction of habitat have turned farmland into a wildlife desert.”

The importance of pollinators

- 90 major crops (35% world food production volume) depend on pollinators
- Key nutrients: 90-100% from pollinator mediated crops (vit C, antioxidants, lycopene, β-tocopherol, vit A and folic acid)
- Value in Europe: 14.2 billion Euro / yr
- 87% of all flowering plants on earth depends on 25000 bee species for reproduction and evolution





World wide: 25000 bee species
In NL about 350 bee species, 181 of them are on the Red List / at risk of extinction

2013

Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands

2006

J. C. Biesmeijer,[1*] S. P. M. Roberts,[2] M. Reemer,[3] R. Ohlemüller,[4] M. Edwards,[5] T. Peeters,[3,6] A. P. Schaffers,[7] S. G. Potts,[2] R. Kleukers,[3] C. D. Thomas,[4] J. Settele,[8] W. E. Kunin[1]

Despite widespread concern about declines in pollination services, little is known about the patterns of change in most pollinator assemblages. By studying bee and hoverfly assemblages in Britain and the Netherlands, we found evidence of declines (pre- versus post-1980) in local bee diversity in both countries; however, divergent trends were observed in hoverflies. Depending on the assemblage and location, pollinator declines were most frequent in habitat and flower specialists, in univoltine species, and/or in nonmigrants. In conjunction with this evidence, outcrossing plant species that are reliant on the declining pollinators have themselves declined relative to other plant species. Taken together, these findings strongly suggest a causal connection between local extinctions of functionally linked plant and pollinator species.

2011

PNAS

Patterns of widespread decline in North American bumble bees

Sydney A. Cameron[a,1], Jeffrey D. Lozier[a], James P. Strange[b], Jonathan B. Koch[b,c], Nils Cordes[a,2], Leellen F. Solter[d], and Terry L. Griswold[b]

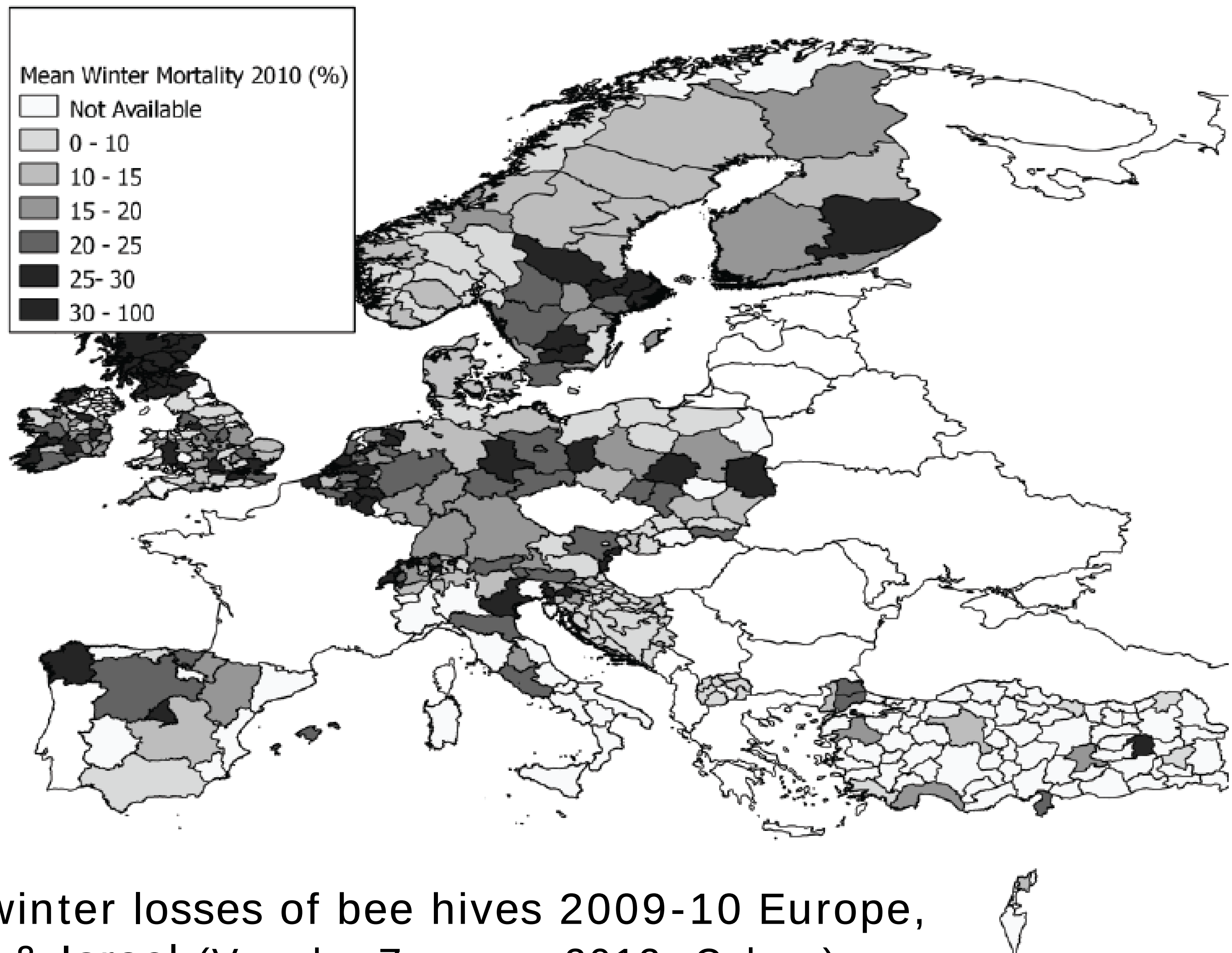
[a]Department of Entomology and Institute for Genomic Biology, University of Illinois, Urbana, IL 61801; [b]United States Department of Agriculture-Agricultural Research Service Pollinating Insects Research Unit, Utah State University, Logan, UT 84322; [c]Department of Biology, Utah State University, Logan, UT 84321; and [d]Illinois Natural History Survey, Institute of Natural Resource Sustainability, University of Illinois, Champaign, IL 61820

Edited* by Gene E. Robinson, University of Illinois, Urbana, IL, and approved November 24, 2010 (received for review October 3, 2010)

Bumble bees (*Bombus*) are vitally important pollinators of wild study in the United States identified lower genetic diversity and

2011

intensive nationwide surveys of >16,000 specimens. We show that the relative abundances of four species have declined by up to 96% and that their surveyed geographic ranges have contracted by 23–87%, some within the last 20 y. We also show that declining populations have significantly higher infection levels of the microsporidian pathogen *Nosema bombi* and lower genetic diversity compared



Mean winter losses of bee hives 2009-10 Europe, Turkey & Israel (Van der Zee e.a., 2012; Coloss)
http://dx.doi.org/10.3896/IBRA.1.51.1.12

The work of the honeybee

- Colony 10,000 to 80,000 bees
- Empty honeybee 80 to 100 mg
- Maximum “freight”: 70 mg/honeybee.
- Water “freight” up to 40 microliter per bee
- One colony visits 21 million flowers / day
- 700 flowers visited per honeybee per day
- 1 liter nectar requires 20,000 to 100,000 flights
- Worker honeybee lives ca. 20 - 42 days, winterbees 170 days and more.

Modified from: http://www.unaf-apiculture.info/presse/DOSSIER_DE_PRESSE_2009_L_ABEILLE_SENTINELLE_DE_L_ENVIRONNEMENT.pdf

New pollinator emerging in China

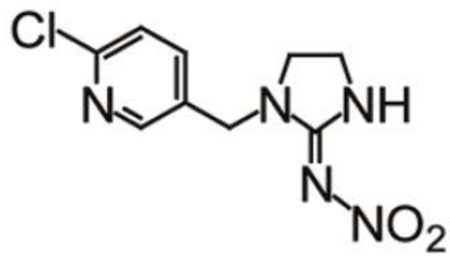
Pollinator decline: interaction of mutually reinforcing causes

PPPP

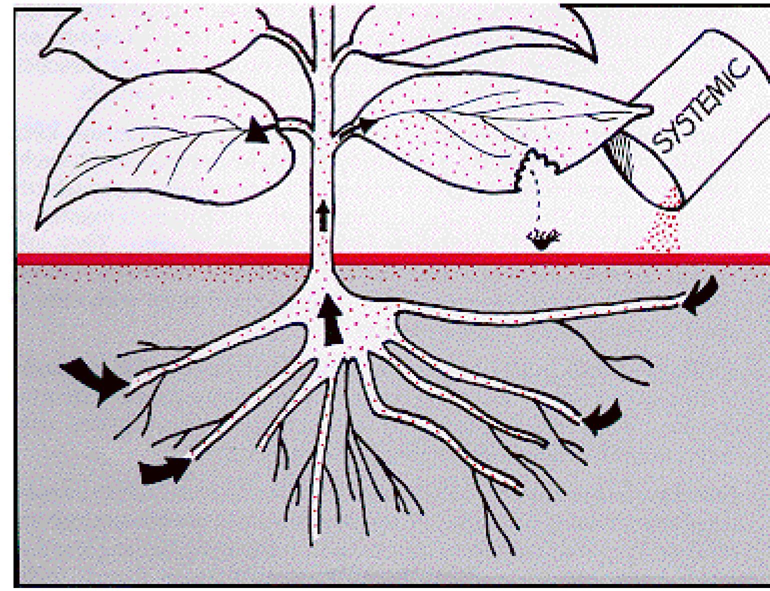
- **P**ollen
- **P**athogens
- **P**esticides
- **P**laces (for nesting)

Systemic insecticides: revolution in plant protection

Shinzo Kagabu



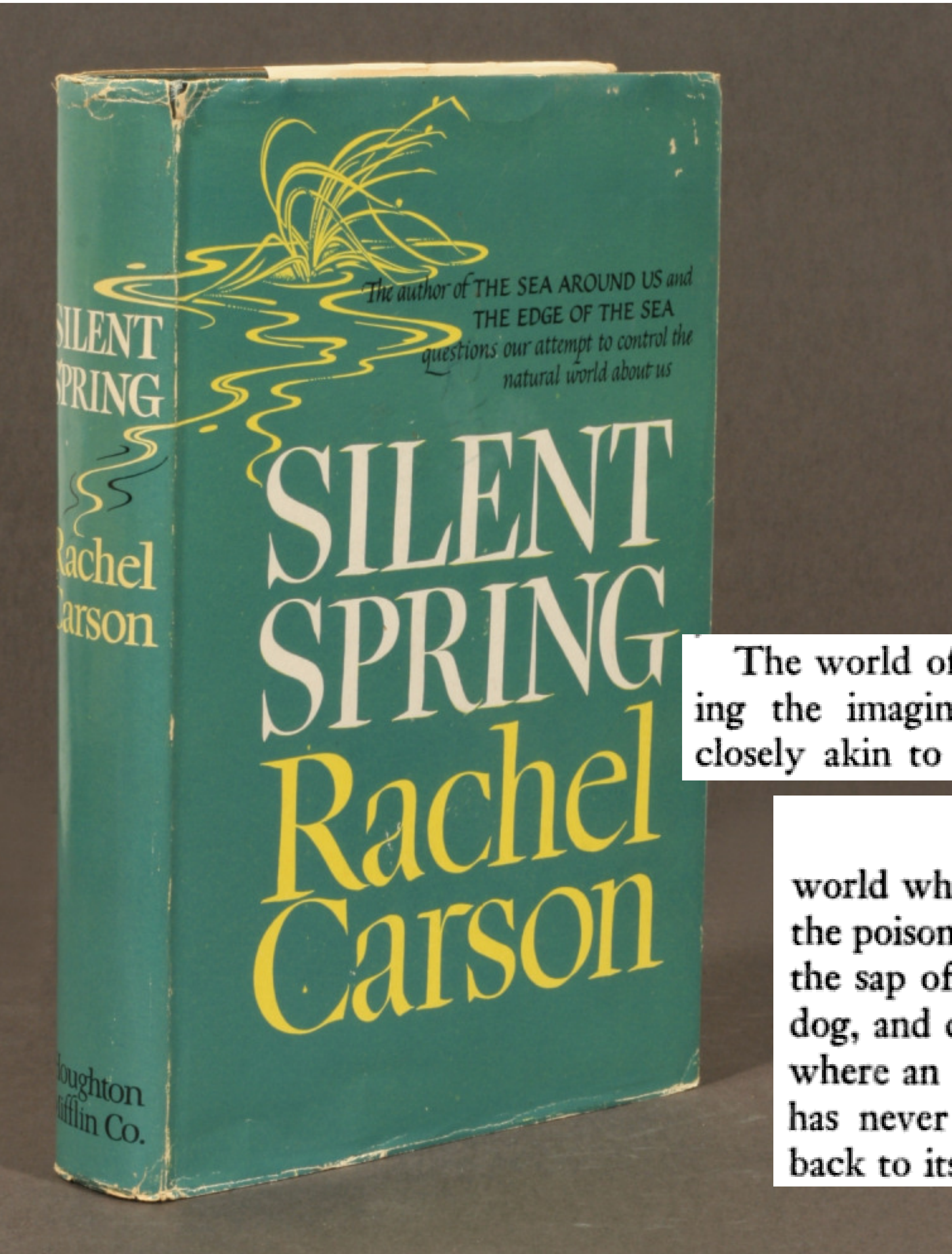
imidacloprid (1991)



Systemic = crop takes it up into its plantsap: chemical makes plant toxic from inside

Professor Shinzo Kagabu received the **2010 American Chemical Society International Award for Research in Agrochemicals** in recognition of his discovery of imidacloprid (IMI) and thiacloprid, which opened the **neonicotinoid era of *systemic* pest management**.

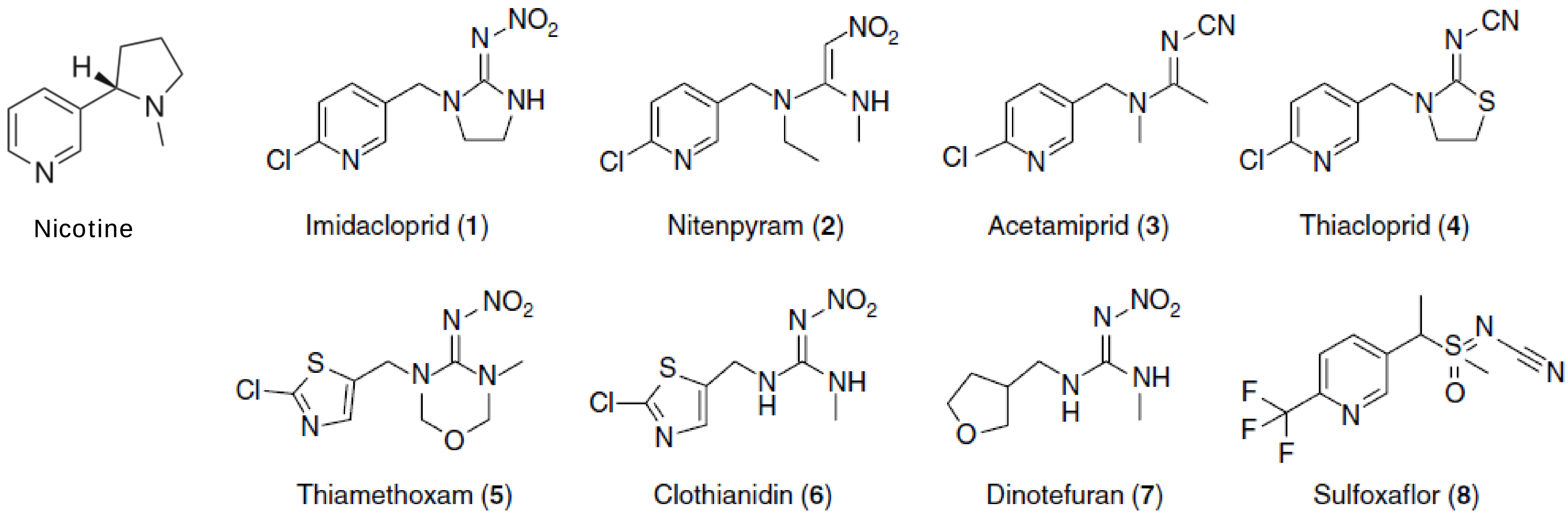
(Tomizawa & Casida, 2010, DOI:10.1021/jf103856c)



1962

The world of systemic insecticides is a weird world, surpassing the imaginings of the brothers Grimm — perhaps most closely akin to the cartoon world of Charles Addams. It is a

world where the enchanted forest of the fairy tales has become the poisonous forest in which an insect that chews a leaf or sucks the sap of a plant is doomed. It is a world where a flea bites a dog, and dies because the dog's blood has been made poisonous, where an insect may die from vapors emanating from a plant it has never touched, where a bee may carry poisonous nectar back to its hive and presently produce poisonous honey.

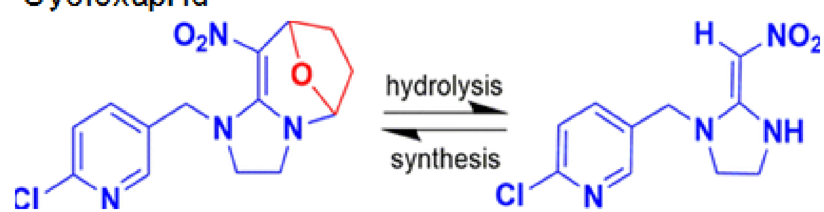


Imidacloprid + Thiamethoxam + Clothianidin in EU:

>200 products

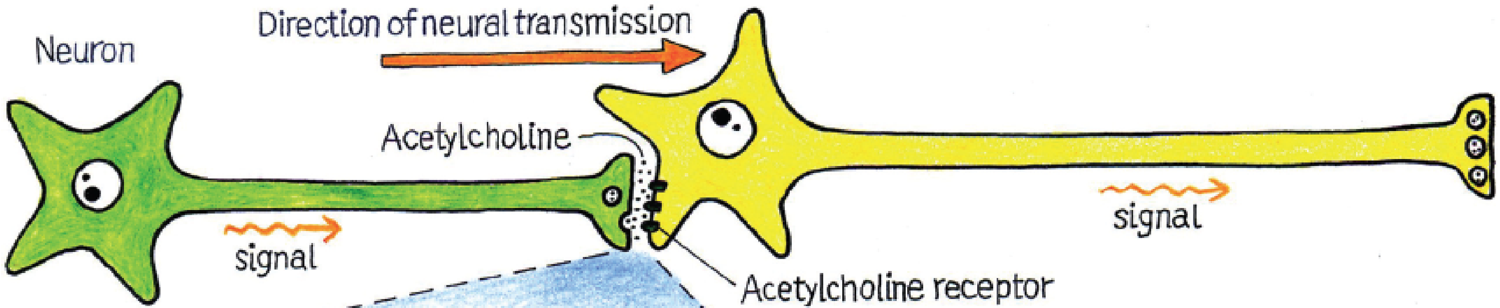
>1000 allowed applications

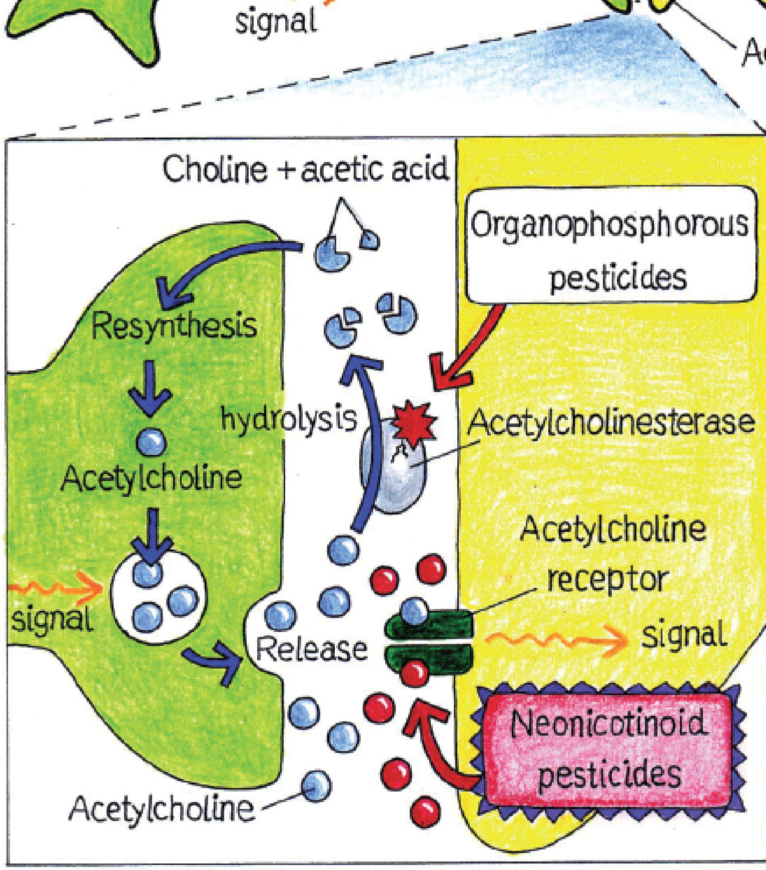
Cycloxaprid



Neonicotinoid / Organophosphorous pesticides disrupt the neural transmission

Neural transmission mechanism through acetylcholine





Humans and insects cannot live unless the neural transmission functions normally. Neurotransmitters such as acetylcholine and glutamic acid are important substances that carries out this neural transmission.

Organophosphorous pesticides block acetylcholinesterase(hydrolytic enzyme of acetylcholine) and make the neural transmission stay on. It has the same effect as dangerous toxic nerve gas such as the Sarin.

Neonicotinoids bind with acetylcholine receptors, and become "false-neurotransmitters", where neural transmission switch will turn on even if there is no acetylcholine present.

Illustration: Saori Yasutomi

http://www.bijensterfte.nl/sites/default/files/Neonicotinoid_e.pdf

Toxicity of neonicotinoids

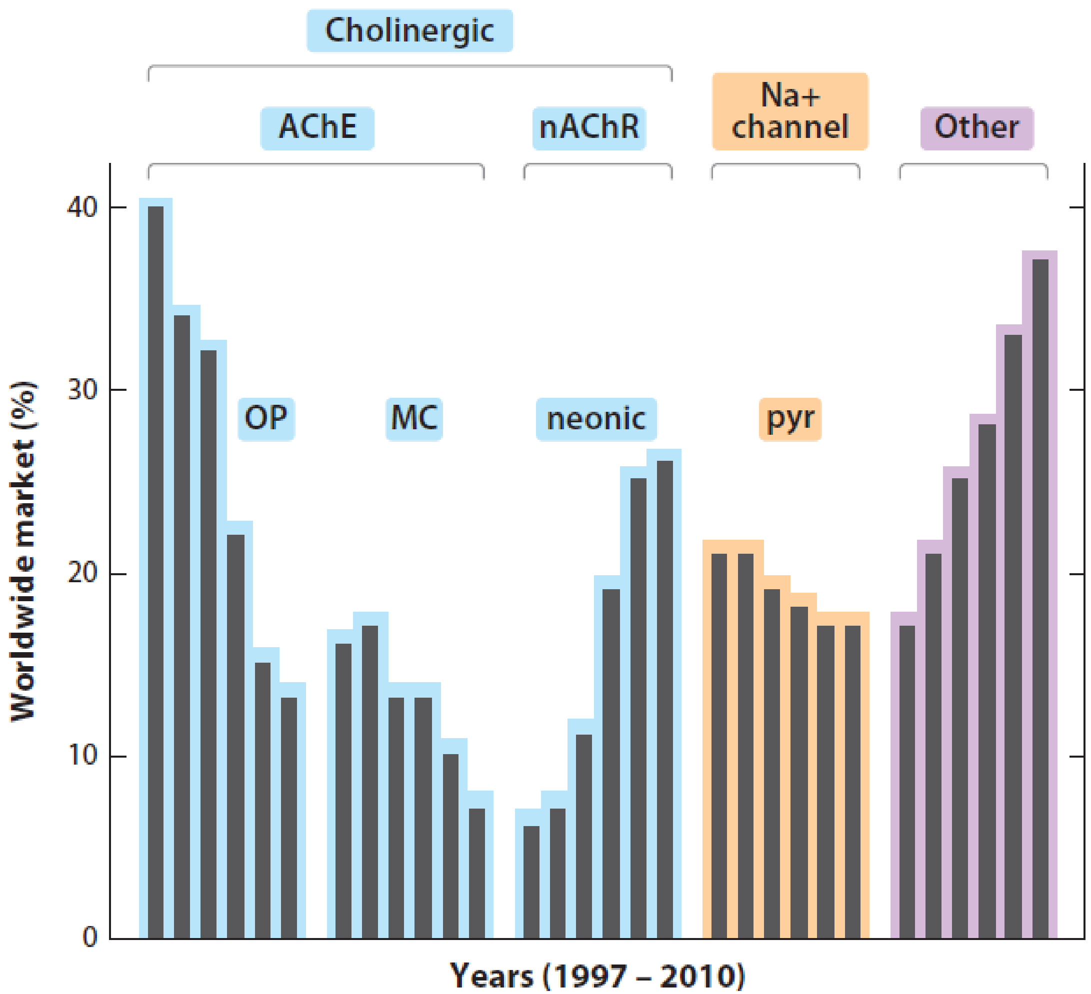
Pesticide	®	Use	LD50 (ng/honeybee)	Toxicity index relative to DDT
DDT	Dinocide	insecticide	27000	1
Amitraz	Apivar	insecticide / acaricide	12000	2
Coumaphos	Perizin	insecticide / acaricide	3000	9
Tau-fluvalinate	Apistan	insecticide / acaricide	2000	13.5
Methiocarb	Mesurol	insecticide	230	117
Carbofuran	Curater	insecticide	160	169
λ-cyhalothrin	Karate	insecticide	38	711
Deltamethrine	Decis	insecticide	10	2700
Thiamethoxam	Cruise	insecticide	5	5400
Fipronil	Regent	Insecticide	4.2	6475
Clothianidine	Poncho	Insecticide	4.0	6750
Imidacloprid	Gaucho	Insecticide	3.7	7297

Toxicity of insecticides to honeybees compared to DDT. The final column expresses the toxicity relative to DDT. (Source: Bonmatin, 2009)

http://www.bijensterfte.nl/images/Bonmatin-conclusions-sentinelle-gb-2009.pdf

Systemic insecticides

- Systemic: Contamination of nectar and pollen
- Very high toxicity for honeybees
- A long persistence in soils ($t_{1/2}$ = 9 months) and water (160 days)
- Main metabolites as toxic as imidacloprid for bees
- Acute effects (overdosing, sowing...)
- Subletal effects and chronic exposure
- Risks in fields : PEC/PNEC >> 1
- Synergies with other pesticides
- Synergies with other pathogens (Nosema, Wing Deform Virus)
- **Major weakening factor of bee colonies**



Imidacloprid 2010 World production: 20,000 tonnes

(DDT peak-use 80,000 tonnes in 1959)

Source: Casida and Durkin, 2013 doi: 10.1146/annurev-ento-120811-153645

Figure 4

Changes in use of insecticide classes between 1997 and 2010 showing decreases for organophosphates (OPs), methylcarbamates (MCs), and pyrethroids (pyr) and increases for neonicotinoids (neonic) and other compounds. Abbreviations: AChE, acetylcholinesterase; nAChR, nicotinic acetylcholine receptor. Data shown for the years 1997, 2000, 2002, 2005, 2008, and 2010 from T.C. Sparks (personal communication) are similar to those from his coauthored paper (95).

Uses:
spray, seed treatment, other

Spray uses in Europe (70%)

thiamethoxam	potato, nut trees, pome fruit, stone fruit, cucurbits, brassicas, citrus fruits, cotton, vines, salad, herbs, ornamentals, peppers, tobacco, tomato, floriculture crops, tree nursery, flower bulbs, cereals, carrot, sunflower, onions, oilseed rape, cotton,
clothianidin	potato, stone fruit, pome fruit
imidacloprid	ornamentals, potato, pome fruit, hops, vines, stone fruit, tobacco, pepper, flower bulbs, floriculture crops, tree nursery, stone fruit, tomato, almonds, cucurbits, artichoke, beans, brassicas, celery, citrus fruits, hazel, olives, salad, palm trees, peppers, forestry, alfalfa, cereals, strawberry.
acetamiprid	pome fruit, ornamentals, oilseed rape, turnip rape, salad, herbs, stone fruit, maize, potato, tobacco, brassicas, forestry, cucurbits, soft fruits, tomato, peppers, floriculture crops, tree nursery, flower bulbs, citrus fruits, fig, artichoke, clover, lucerne, cotton, strawberry, citrus fruits
thiacloprid	stone fruit, pome fruit, strawberry, oilseed rape, potatoes, cereals, mustard, ornamentals, soft fruits, salad, herbs, nut trees, fennel, asparagus, carrot, brassicas, celeriac, celery, onions, cucurbits, leeks, garlic, shallot, flower bulbs, beans, ornamentals, floriculture crops, tree nursery, sugar beet, fodder beet, hemp, strawberries, sunflower, maize, cotton, alfalfa, olive trees, fig trees,

Seed treatment uses in Europe (20%)

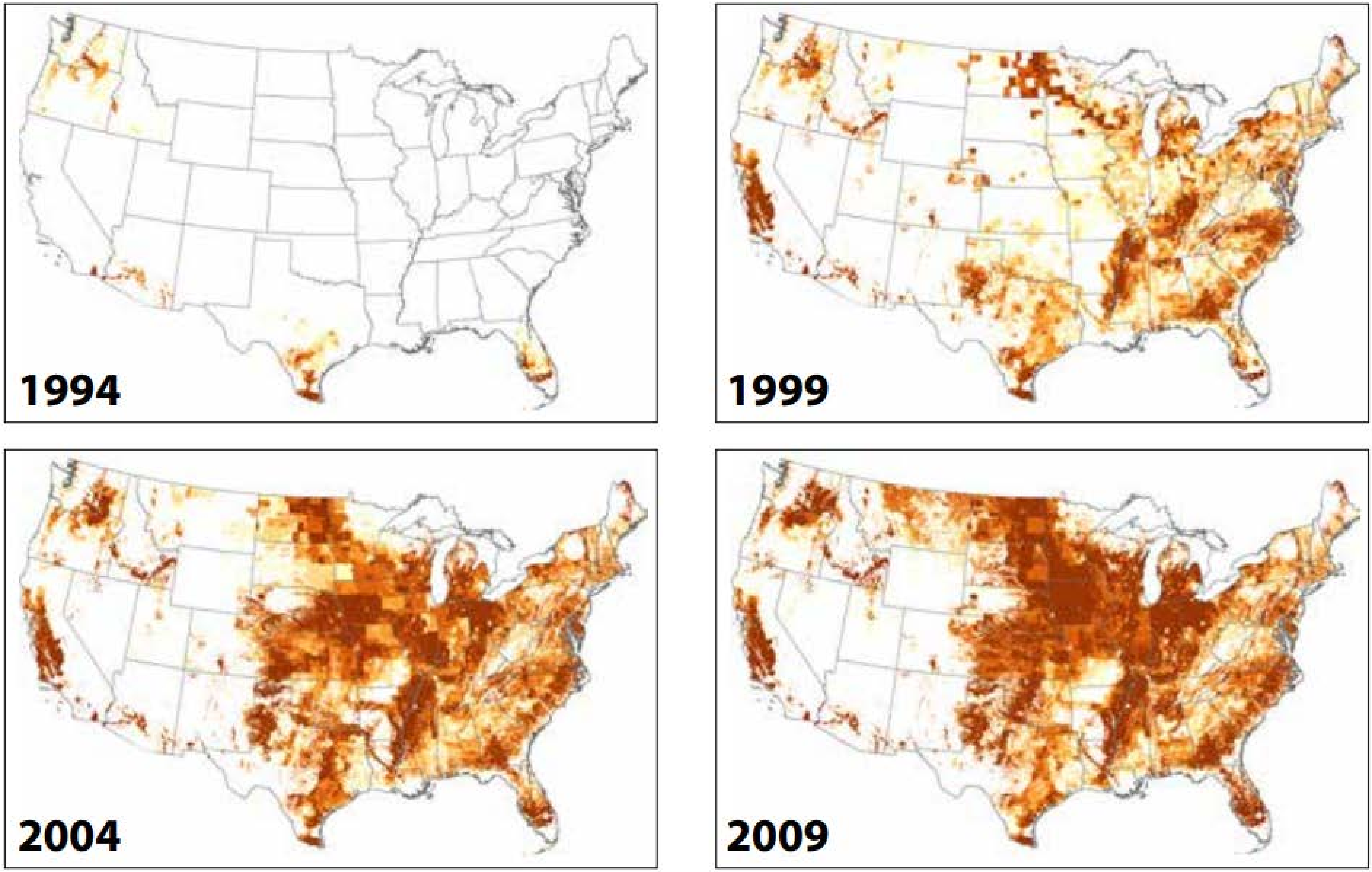
thiamethoxam	beet seeds, cabbage, cauliflower, cotton, kale, lettuce, maize, mustard, peas, potato, oilseed rape, sorghum, sunflower, wheat, barley, rye, oat, triticale
clothianidin	beet seeds, cereals (wheat, barley, oat, rye, triticale), maize, oilseed rape, potato, sunflower
imidacloprid	beet seeds, oat, asparagus, broccoli, cauliflower, barley, bulb crops, corn, lettuce, cabbage, brassicas, hop, leek, linseed, maize, onion, peas, potato, pumpkin seeds, oilseed rape, sunflower, wheat
thiacloprid	maize

Bayer CropScience
Horti
Admire

Other uses in Europe

thiamethoxam	cucurbits, beans, brassicas, citrus fruit, salad, herbs, ornamentals, palm trees, peppers, tomato, flower bulbs, potato, house plants, pome fruit, forestry, citrus fruits, peppers,
clothianidin	maize, potato, sorghum, sorghum, poppy
imidacloprid	grassland, hops, salad, herbs, potato, brassicas, chicory–roots, beans, citrus fruits, cucurbits (eggplant, melons, cucumber), palm tree, peppers, tomato, rice, forestry, pome fruit, stone fruit, artichokes, vines, alfalfa, tobacco, olive trees, ornamentals, strawberries, hops,
acetamiprid	non fruiting trees and bushes
thiacloprid	ornamentals, tree nursery

Imidacloprid use on farms. Darker color indicates greater quantity used per square mile.

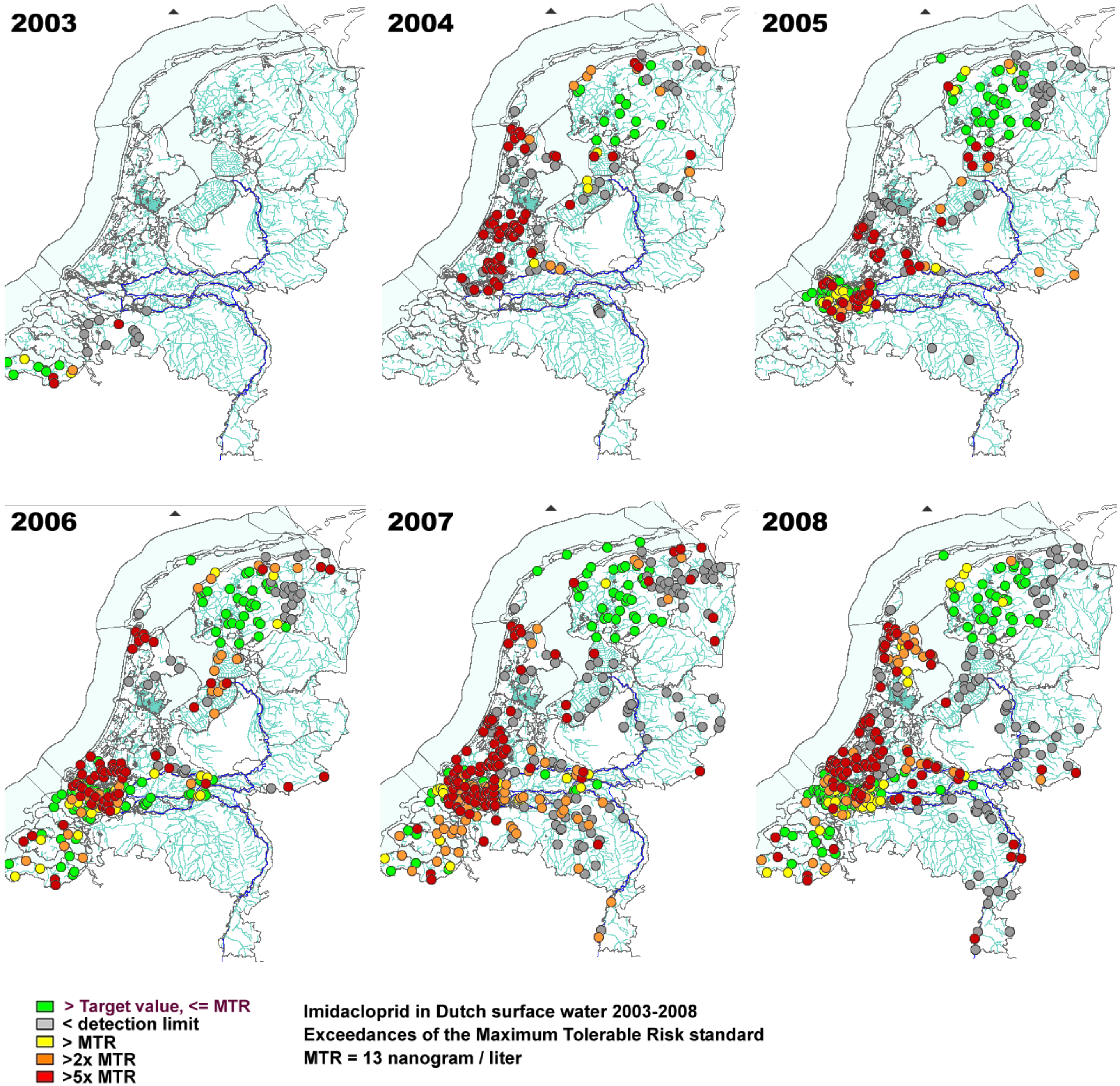


Source: USGS National Water-Quality Assessment Program Pesticide National Synthesis Project, http://water.usgs.gov/nawqa/pnsp/usage/maps/compound_listing.php (accessed 9/16/13).

Only 1.6 to 20% of applied neonicotinoid is absorbed by the growing crop (Sur & Stork 2003)

80 to 98.4% leaches to soil & water!

Since 2004, Netherlands surface water is heavily polluted with Imidacloprid



Imidacloprid in Dutch surface water 2003-2008
Exceedances of the Maximum Tolerable Risk standard
MTR = 13 nanogram / liter

www.bestrijdingsmiddelenatlas.nl

Effects on honeybees

- Acute intoxication
- Chronic intoxication
- Sublethal effects
- Synergy effects

Corn coated with Gaucho® (imidacloprid)

75	gram imidacloprid / ha corn
100000	seeds / ha
0.00075	gram imidacloprid / seed
3.7	nanogram = LD50 Honeybees
202702	LD50 / corn seed

Pomurje, Slovenia April 2011, sowing period clothianidin corn

**Damage
2500
colonies
lost**

**> 100
million
bees**

Field test in Padua

Deadly dust cloud
< 30 seconds 10m away:
300 to 4000 ng imidacloprid per bee

http://www.bijensterfte.nl/en/node/507

What are exposure pathways?

- Treated crops
  - Contact
  - Pollen (delayed consumption!, Bee bread etc.)
  - Nectar (delayed consumption!, honey)
  - Extrafloral nectar
  - Honey-dew (from aphids)
  - Guttation (plant sap excreted by the plant)
  - Dew/rain (waterdrops from the atmosphere)
  - Sweet remains of e.g. sugarbeets, etc.
- Systemic uptake by untreated wild plants and trees on same soil
- Systemic uptake of contaminated water by wild plants and trees
- Spray drift / dust drift to flowering fields
- Direct contact with dust (flying through the dust cloud)
- Foraging on polluted surface water (for drinking and COOLING!)
- Residues in sugar used for sugar syrup supplementary feeding
- Residues in water used by beekeepers to make sugar syrup (violation of drinkingwater norm in NL > 100 ng/liter)
- Can it travel trough the air? On PM2.5? On diessel soot/black carbon? On airosol-water?
- Brabant, NL scandal 2011: Waste-sand from treated Lilly bulbs used for trails in protected nature area
- Etc……..

Krupke e.a. 2012 study

Table 6. Pesticide concentrations found in unplanted fields near apiary during planting period in 2011, all concentrations shown are expressed as parts per billion.[1]

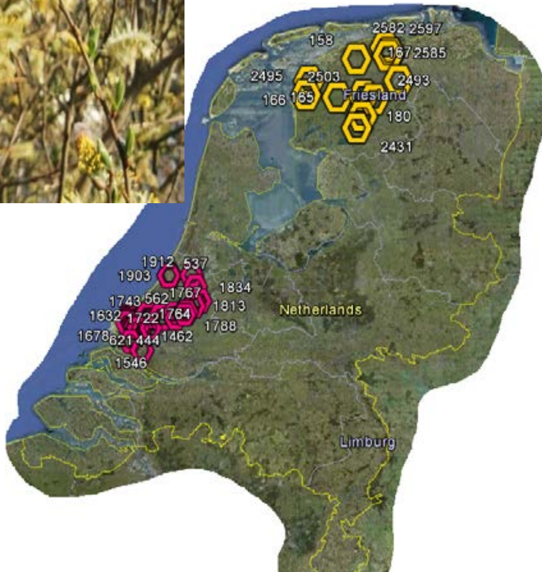
SAMPLE TYPE	Sample wt. (g)	THIAMETHOXAM LOD = 1.0	CLOTHIANIDIN LOD = 1.0	METOLACHLOR LOD = 0.5	ATRAZINE LOD = 0.2	AZOXYSTROBIN LOD = 0.2	COUMAPHOS LOD = 1.0
Soil, unplanted field 1, Soybeans 2010 (2 samples)	5.15, 5.01	ND	6.0±0.3	1014±14	771±170	0.2±0.1	ND
Soil, unplanted field 2, Soybeans 2010 (2 samples)	5.28, 5.43	ND	8.9±0.1	8.3±0.7	160±15	26±17	ND
Dandelions near maize field	2.96	ND	1.4	49	677	ND	ND
Dandelions near maize field	3.81	1.6	5.9	64	1133	ND	ND
Dandelions near maize field	4.51	1.3	3.1	28	522	ND	ND
Dandelions near maize field	4.05	2.9	1.1	60	269	ND	ND
Dandelions near maize field	3.10	1.1	1.6	5.7	125	ND	ND
Dandelions near maize field	3.44	ND	9.4	295	1004	ND	ND
Dandelion, CAES (non-agricultural area)	3.93	ND	ND	ND	0.3	ND	ND

When two aliquots of the same sample were analyzed the results are expressed as ± the standard deviation of the two analyses.
[1]ND = Not detected.
doi:10.1371/journal.pone.0029268.t006

Krupke e.a. 2012. Multiple Routes of Pesticide Exposure for Honey Bees Living Near Agricultural Fields. http://dx.doi.org/10.1371/journal.pone.0029268

Do trees translocate imidacloprid from surface water into pollen & nectar?

In NL we took samples from willow trees (Salix) in polluted areas



Exposure via guttation?

Via water for drinking and cooling?

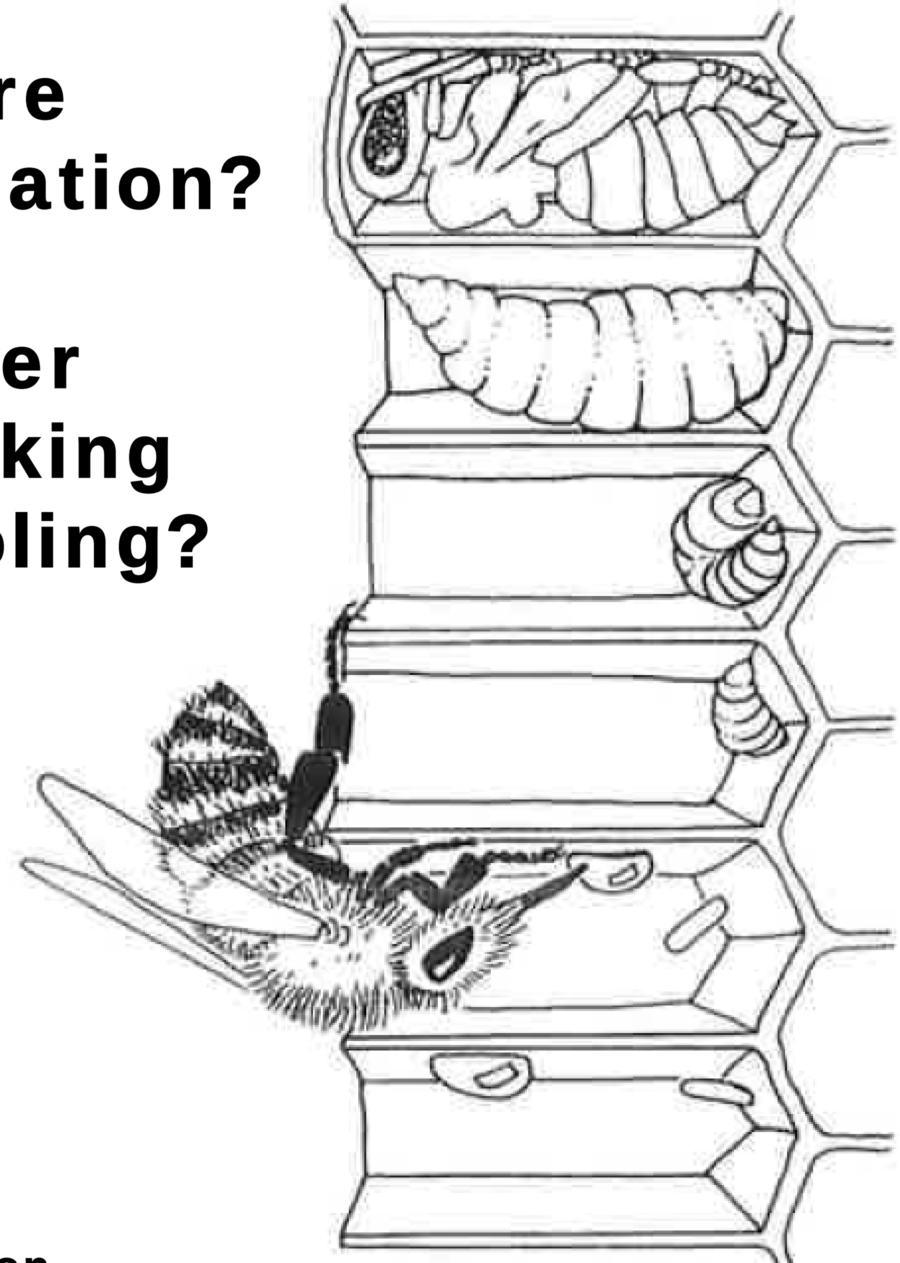


Figure 9.1 The spreading of water droplets by nurse bees when a colony's broodnest is threatened by overheating. Spreading water, combined with fanning the wings to expel hot air from the hive, causes evaporative cooling of the brood combs. After Park 1925.

T. Seeley, The wisdom of the hive
Chapter 9 regulation of water collection

Chronic toxicity imidacloprid for bumblebees

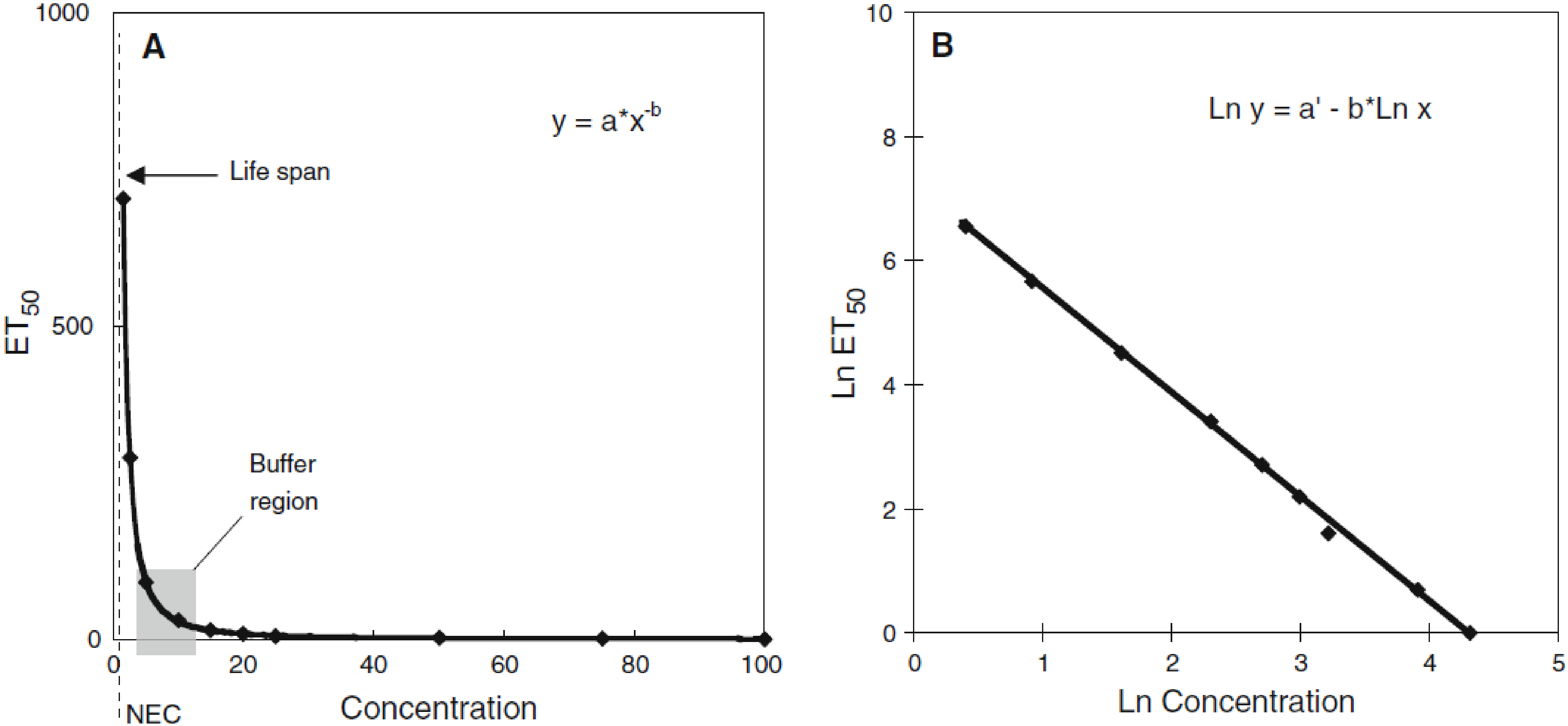
Micro colonies fed with imidacloprid at

- 200 ppm 100% mortality few hours
- 20 ppm 100% mortality 14 days
- 2 ppm 100% mortality 28 days
- 0.2 ppm 100% mortality 49 days,
- 20 ppb 15% mortality (77 days)
- 10 ppb 0% mortality (77 days)

NOEC reproduction <2.5 ppb

http://dx.doi.org/10.1007/s10646-009-0406-2 Mommaerts e.a. 2010

Mismatch with EU regulatory 10 day test!!



Relationship between neonicotinoid concentration and time to 50% effect (ET50) in the organisms exposed follows a hyperbolic curve asymptotic on the y axis; in reality, this asymptote is determined by the no-effect concentration (NEC), while the upper limit of the curve is determined by the life span of the organism. (Sanchez-Bayo, 2009)

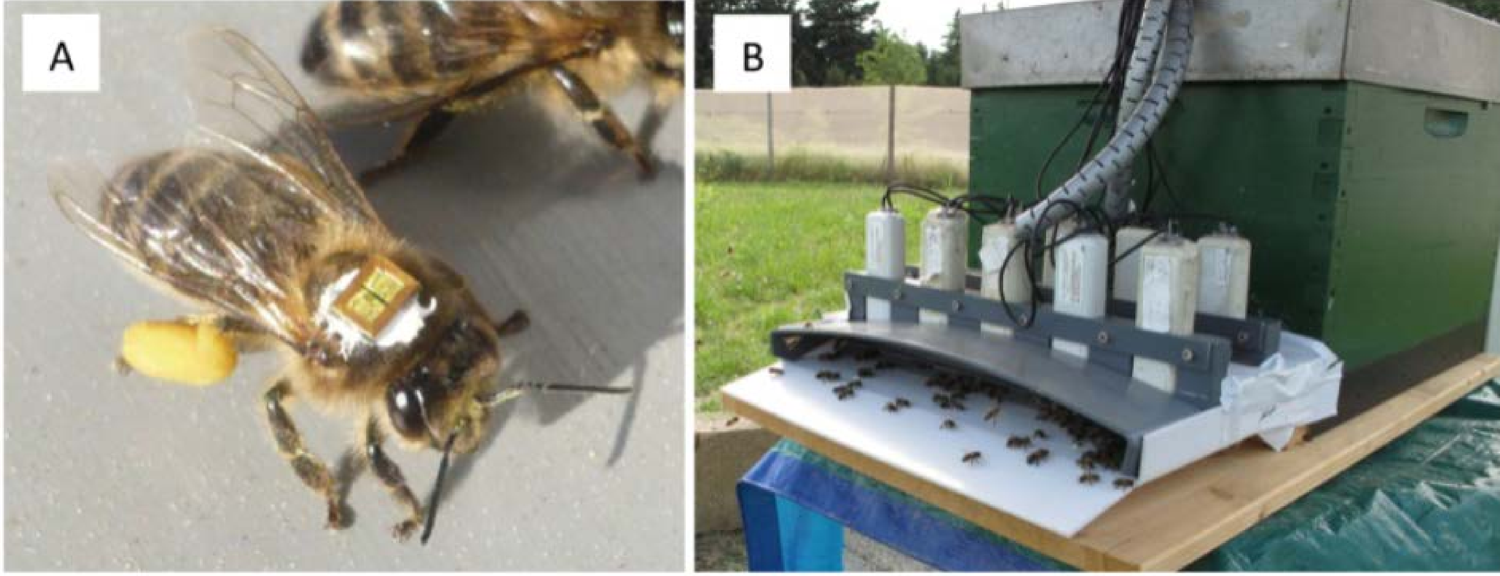
http://dx.doi.org/10.1080/03601230701229239

Sublethal effects

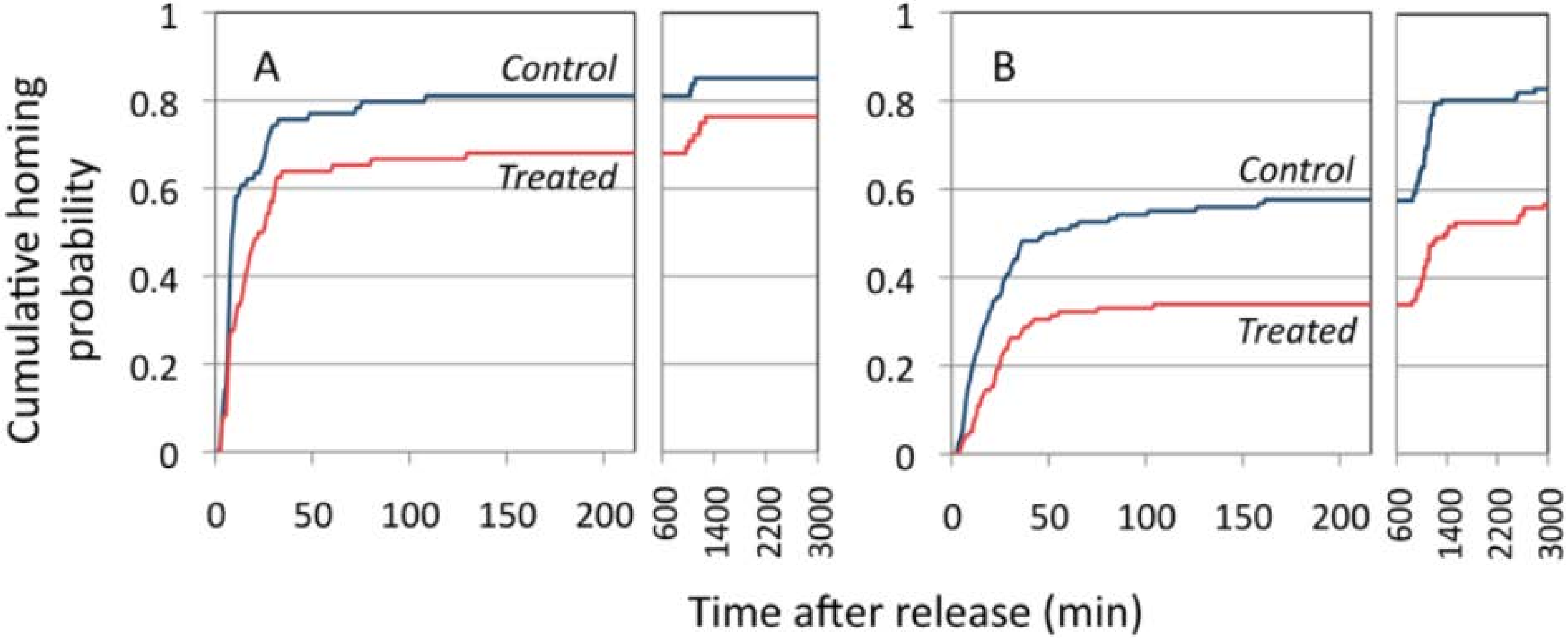
- Foraging behaviour / navigation
- Task differentiation in the hive
- Grooming
- Immune system
- Brood
- Larval development
- etc/.

Henry ea. 2012 *Science* studie

Radio ID chips

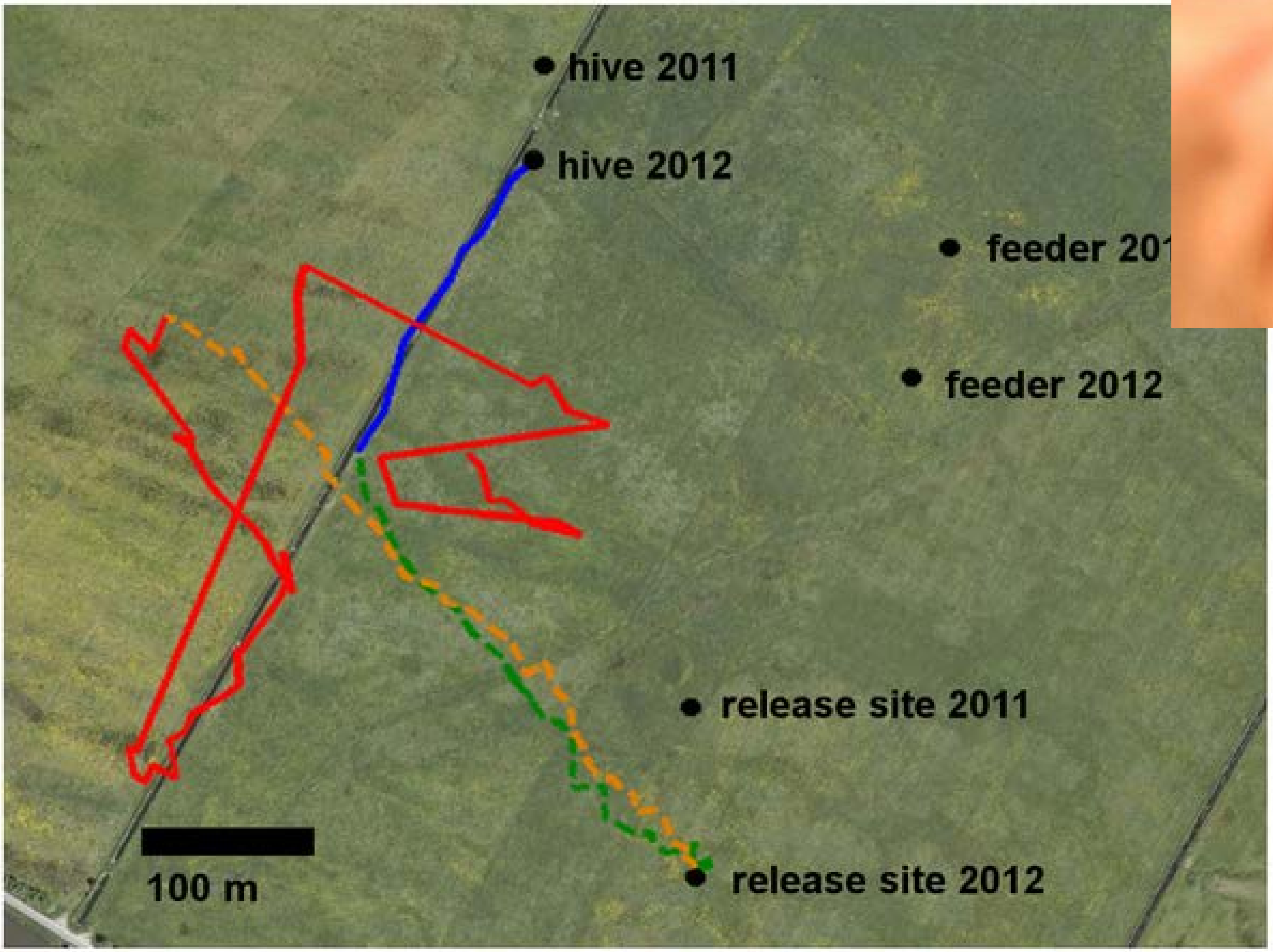


Dose per bee: 1.34 ng thiamethoxam in 20-µl sucrose solution



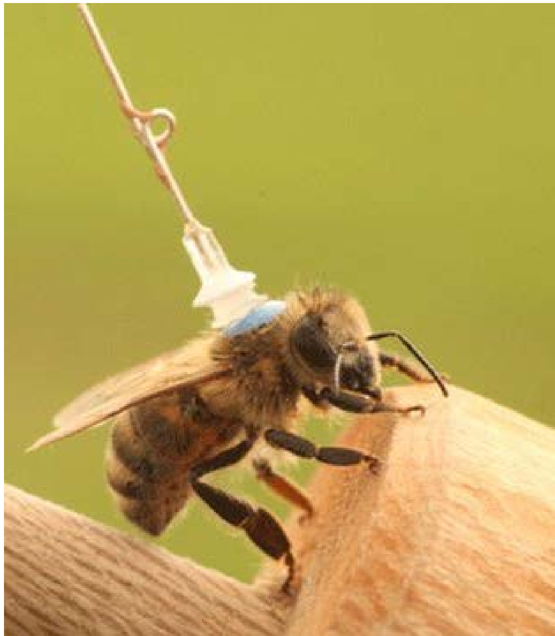
A: familiar location; B random location http://dx.doi.org/10.1126/science.1215039

Radar-tracking experiment Randolf Menzel:
Bees exposed to neonicotinoids loose orientation



Yellow-Red Thiacloprid-bees

Green-Blue Control bees



Fischer J, Müller T, Spatz A-K, Greggers U, et al. (2014) Neonicotinoids Interfere with Specific Components of Navigation in Honeybees. PLoS ONE 9(3): e91364. doi:10.1371/journal.pone.0091364

http://www.plosone.org/article/info:doi/10.1371/journal.pone.0091364

PLOS | ONE

Using video-tracking to assess sublethal effects of pesticides on honey bees

- Bees exposed to 0.05, 0.5, 5.0, 50, and 500 ppb imidacloprid in a sugar agar cube
- significant reduction in distance moved at 50 and 500 ppb imidacloprid ($p<0.001$).
- Obvious biological gradient

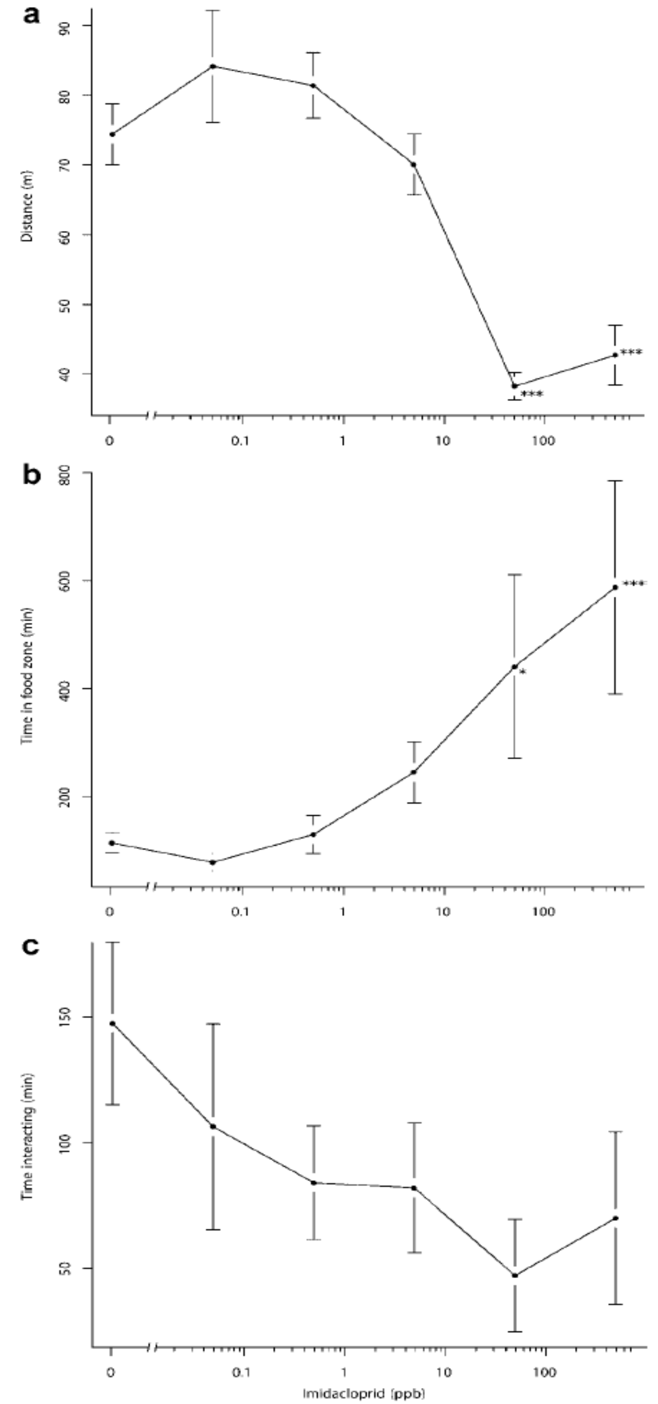


Figure: a=distance, b=time in foodzone, c=time interacting
http://dx.doi.org/10.1002/etc.1830

Neonicotinoid Pesticide Reduces Bumble Bee Colony Growth and Queen Production

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Growing evidence for declines in bee populations has caused great concern due to the valuable ecosystem services they provide. Neonicotinoid insecticides have been implicated in these declines as they occur at trace levels in the nectar and pollen of crop plants. We exposed colonies of the bumble bee *Bombus terrestris* in the lab to field-realistic levels of the neonicotinoid imidacloprid, then allowed them to develop naturally under field conditions. Treated colonies had a significantly reduced growth rate and suffered an 85% reduction in production of new queens compared to control colonies. Given the scale of use of neonicotinoids, we suggest that they may be having a considerable negative impact on wild bumble bee populations across the developed world.

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The neonicotinoids thiacloprid, imidacloprid, and clothianidin affect the immunocompetence of honey bees (*Apis mellifera* L.)

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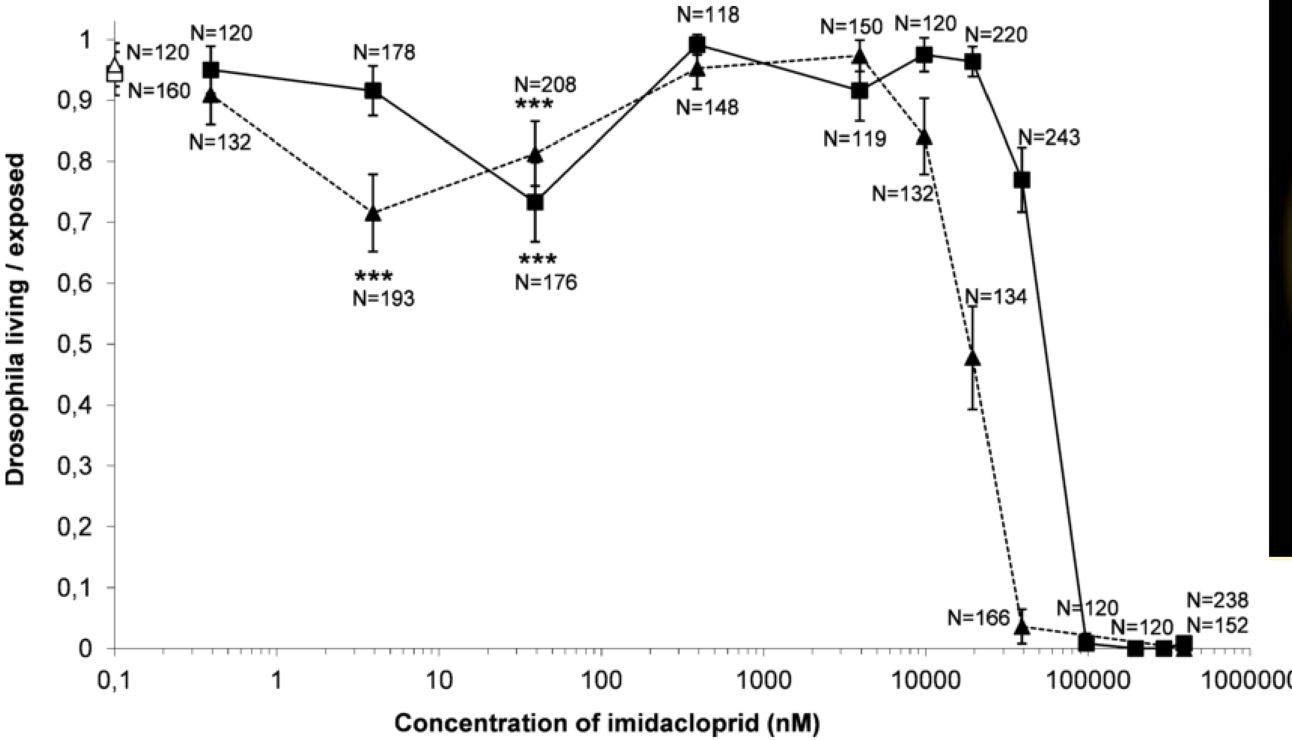
ABSTRACT

A strong immune defense is vital for honey bee health and colony survival. This defense can be weakened by environmental factors that may render honey bees more vulnerable to parasites and pathogens. Honey bees are frequently exposed to neonicotinoid pesticides, which are being discussed as one of the stress factors that may lead to colony failure. We investigated the sublethal effects of the neonicotinoids thiacloprid, imidacloprid, and clothianidin on individual immunity, by studying three major aspects of immunocompetence in worker bees: total hemocyte number, encapsulation response, and antimicrobial activity of the hemolymph. In laboratory experiments, we found a strong impact of all three neonicotinoids. Thiacloprid (24 h oral exposure, 200 μg/l or 2000 μg/l) and imidacloprid (1 μg/l or 10 μg/l) reduced hemocyte density, encapsulation response, and antimicrobial activity even at field realistic concentrations. Clothianidin had an effect on these immune parameters only at higher than field realistic concentrations (50–200 μg/l). These results suggest that neonicotinoids affect the individual immunocompetence of honey bees, possibly leading to an impaired disease resistance capacity.



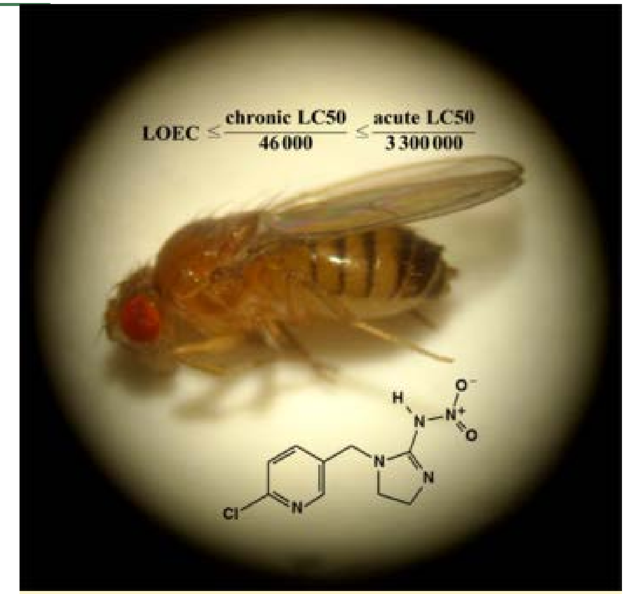


Figure 1. Average ratios of surviving drosophila after chronic exposure. Data are reported for adult flies: males (■) and females (▲). Concentrations of imidacloprid ranged from 0.391 nM to 0.391 mM. Ratios are given from the number of flies still alive, after chronic exposure to imidacloprid (8 days), over the number of flies exposed (see the Experimental Section). N: number of flies. Bars corresponding to 95% confidence intervals (CI95) are reported for each data point. Ratios for controls are indicated on the vertical axis: males (□) and females (△). Significant differences are indicated in the low concentration range only (*** when $p < 0.001$).

Charpentier ea, 2014

http://dx.doi.org/10.1021/es405331c

Lu e.a. 2012 Harvard University- 5 Apr 2012

In situ replication of honey bee colony collapse disorder

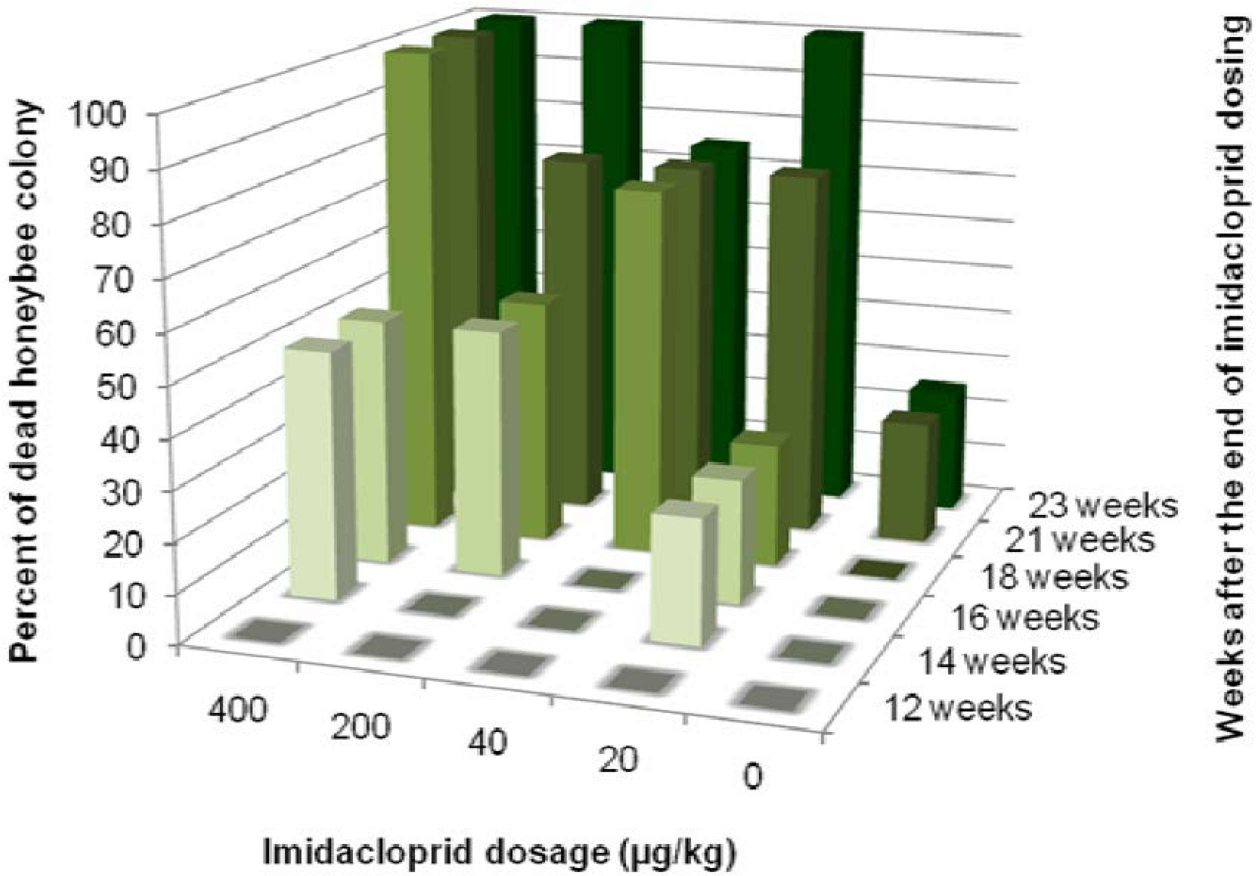


Figure 3. Dead hive (ID# 4-4) treated with 20 µg/kg of imidacloprid which shows the abundance of stored honey and some pollen, but no sealed brood or honey bees. Photo was taken on February 24th, 2011.

http://goo.gl/1a0Aa

Yamada 2012

D= clothianidin 10, 50, 100x diluted
S= dinotefuran 10, 50, 100x diluted
Compered to recommended field rate

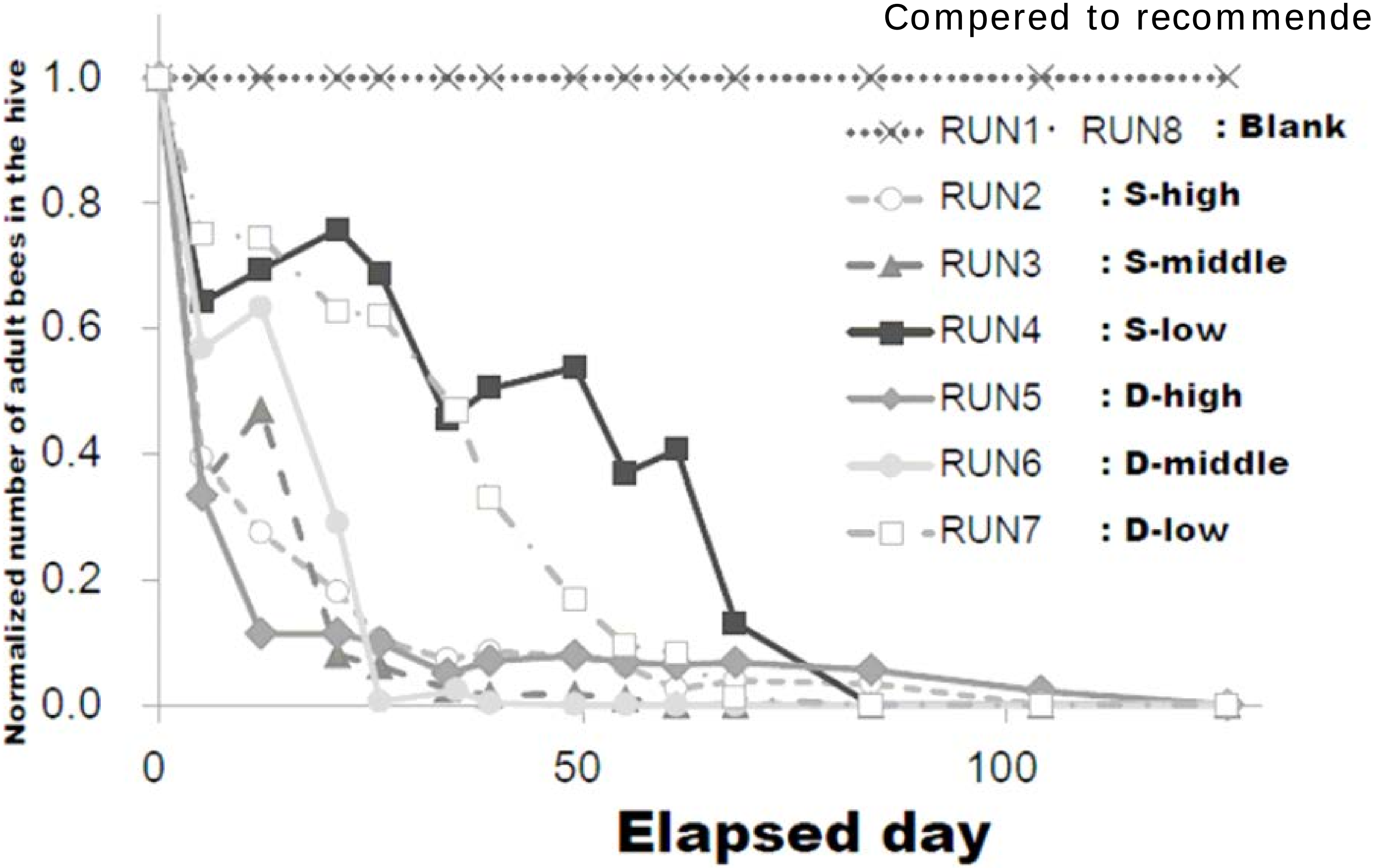
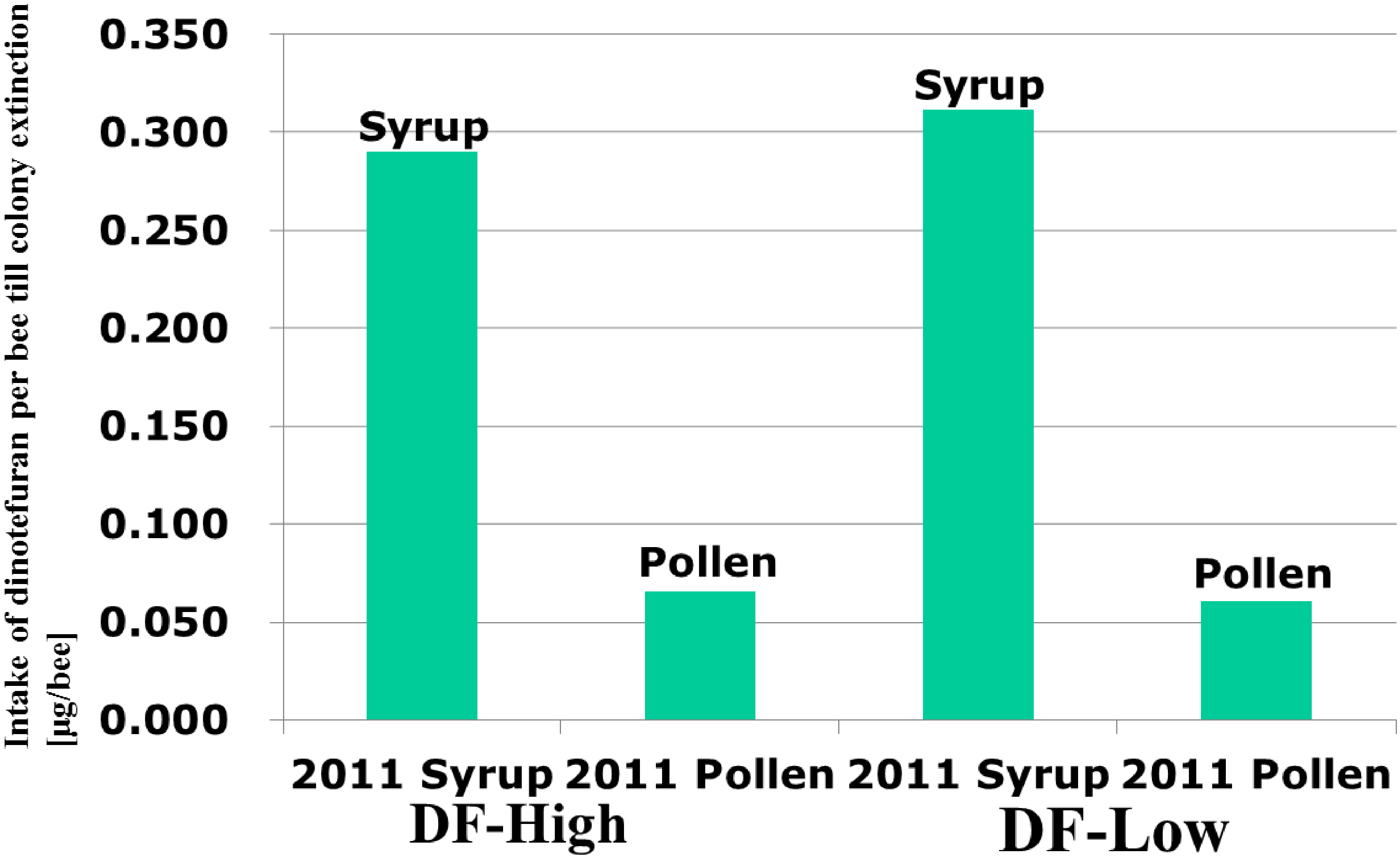


Figure 1 Normalized number of adult bees in the hive with the elapsed days

Required dose of neonicotinoid per bee till colony extinction



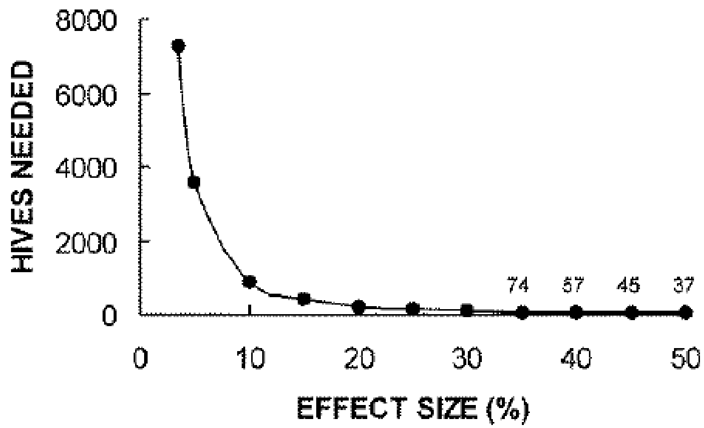
(Yamada, 2013)

Problems with field studies

- Some field studies have $n=1$ (Schmuck 2001)
- Statistical power:
  - 75 hives needed to detect 35% drop in colony performance
  - >2000 hives to detect 5% drop in colony performance
- Many flaws in experimental set-up of field studies used for authorization. Transport of nectar & pollen ≠ exposure!
- Many field studies turned out to have a hidden sponsor: Bayer Cropscience – Flawed-by-design!
- Example: Cutler and Dupree 2007 study
- In authorization protocols field studies (even flawed ones and $n=1$ ones) get more weight than lab studies, but from a scientific point of view lab studies are more reliable!

Toxicity tests available for risk assessment

Field test problems



The number of honey bee hives needed to detect specified increases in mortality rate (percentage effect size) using dead bee traps.
A field-scale experiment using conventional dead bee traps would require 74 hives to detect an effect of 35% with a significance level of 0.05.

(bron: Robert Luttik, 2013)

Plurality and uncertainty in risk assessment: lessons learned

- **Diversity of the knowledge base**:
  - It must be based on the full spectrum of available scientific knowledge;
- **Robustness of the knowledge claims**
  - Include uncertainty, dissent and criticism in the analysis, synthesis and assessments;
- Make thorough **Knowledge Quality Assessment the key task in the science policy interface** and develop a joint language to communicate limitations to our knowledge and understanding clearly and transparently
- Make use of **information of non-scientific sources** (local knowledge)
  - But scrutinize this information and be clear on its status;
- **Clarify values, stakes and vested interests** that play a role in research and in the political and socioeconomic context within which the research is embedded.

(Maxim and van der Sluijs, 2007, 2012)

If time allows...

A few more concerns ...

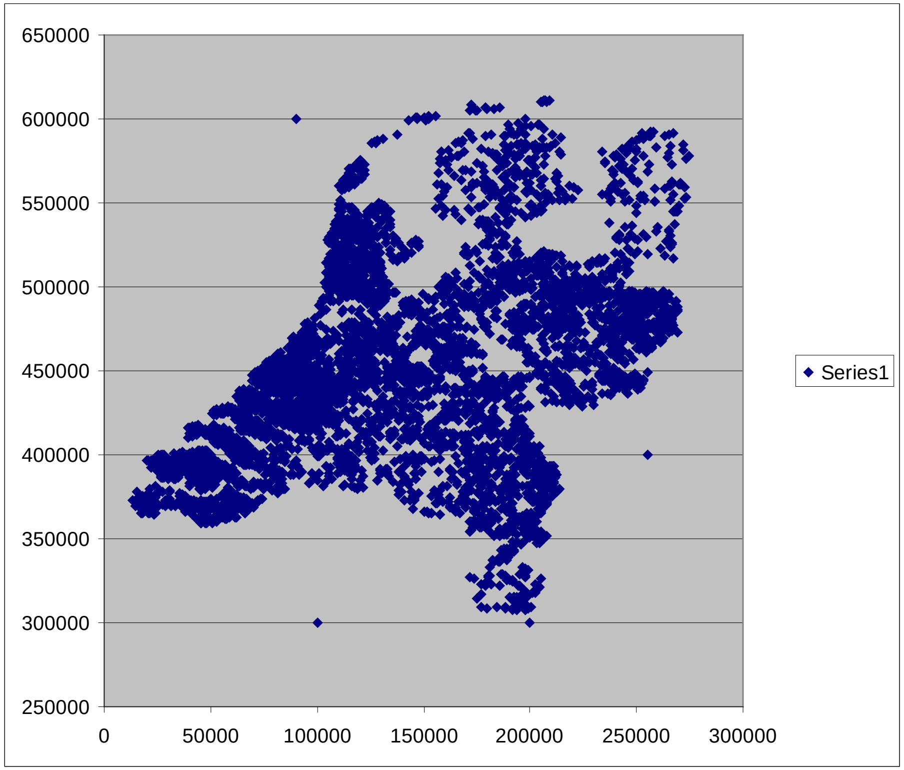
ECOSYSTEM FUNCTIONING

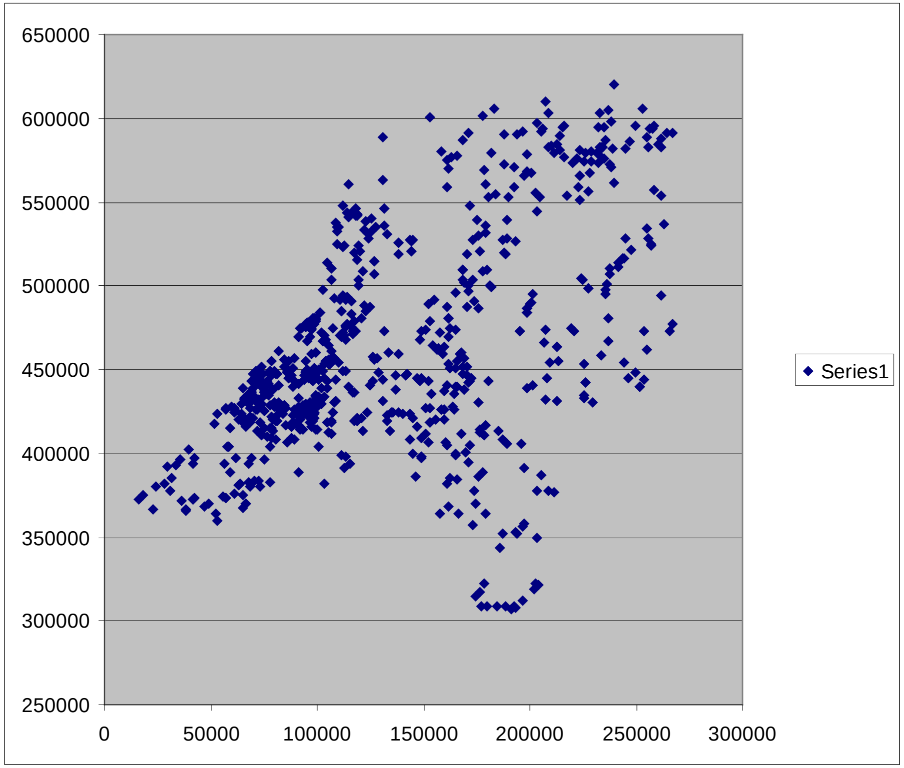
Impacts cascade through the ecosystem weakening its stability

- **Persistence & solubility led to large scale contamination of:**
  - **soils and sediments**
  - **ground and surface water**
  - **treated and non-treated vegetation**
- **Multiple routes chronic & acute exposure non-target species**
- **Toxicity increased by the duration of exposure**
- **Effects lethal & sublethal: behaviour, immune suppression, reproduction**
- **Levels resulting from authorized uses frequently exceed 'lowest observed adverse effect concentrations' for wide range of non-target species.**

Macro-invertebrate decline in Dutch surface waters polluted with imidacloprid

- Species abundance data: 7381 locations (left)
- Imidacloprid database: 801 locations (right)
- Years 1998, 2003-2009 pooled
- 18898 points with IMI data within 1 km radius & < 160 days
- 4009 species from 92 orders included

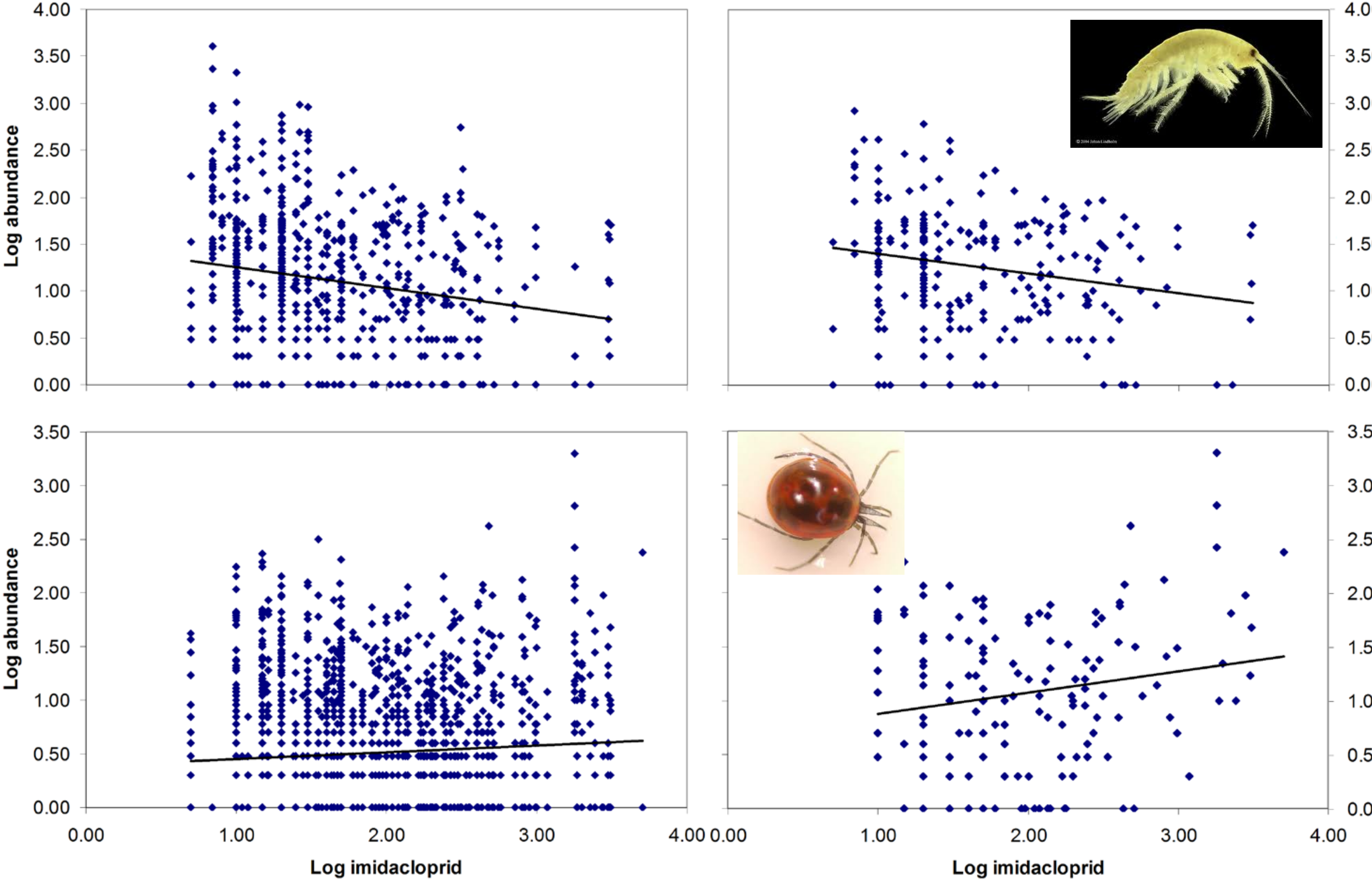




Significant negative relationship between species abundance and imidacloprid concentration found for:

- All orders pooled
- Amphipoda (crustaceans)
- Diptera (true flies)
- Ephemeroptera (mayflies)
- Isopoda (crustaceans)
- Odonata (dragonflies & damselflies)
- Basommatophora (snails)
- All marcro invertebrates pooled

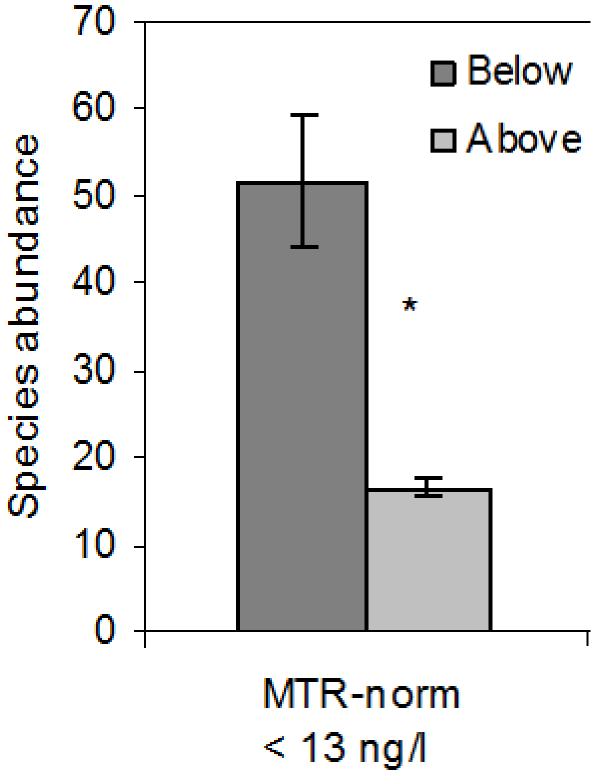
For one order we found significant positive relation: Actinedida

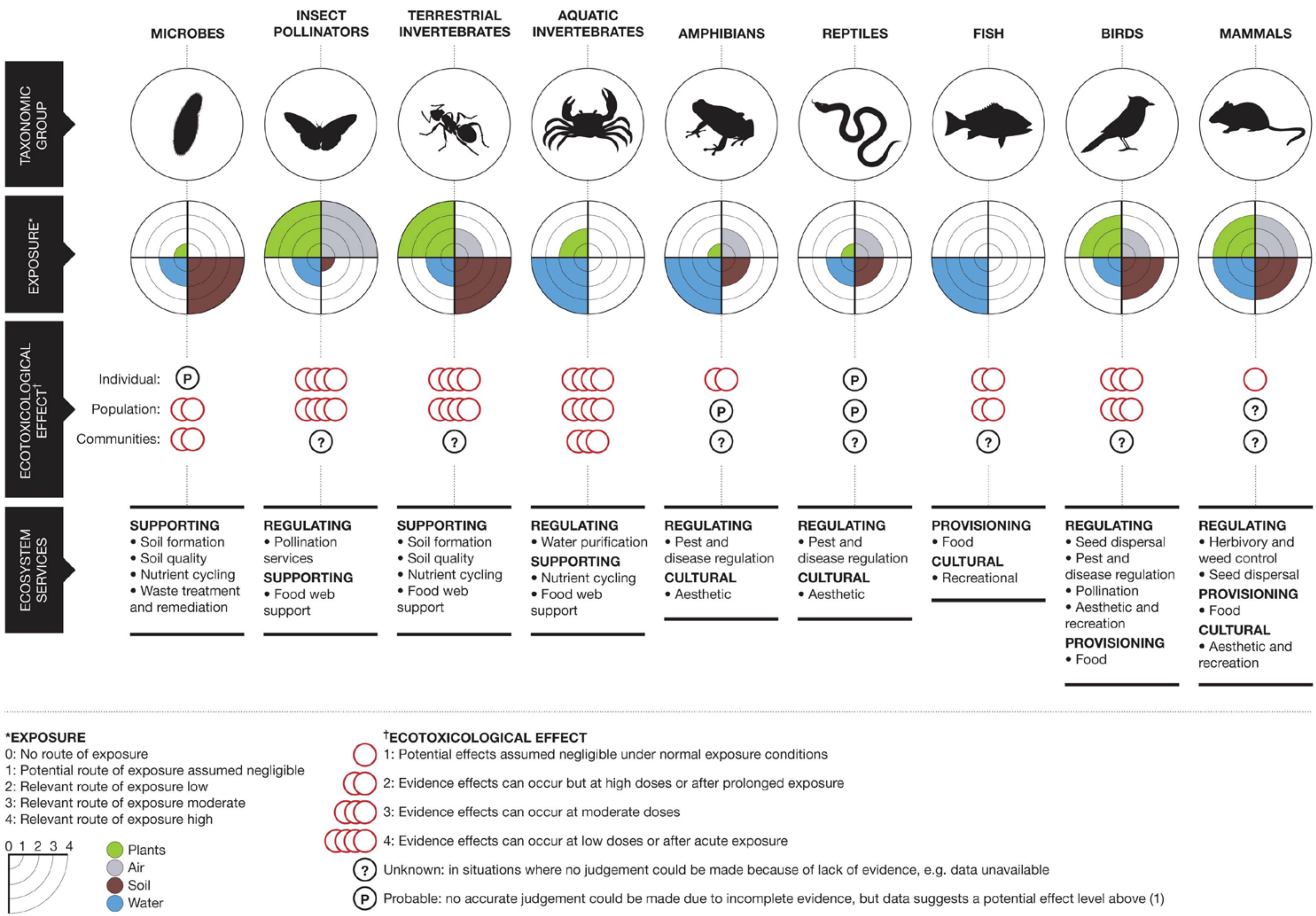


log10 imidacloprid concentration (ng/l) versus log10 macro-invertebrate species abundance in surface water for a) Amphipoda, b) its most abundant species *Gammarus tigrinus*, c) Actinedida and d) its most abundant species *Limnesia undulata*.

Findings on aquatic ecosystems

- 45% of all samples (*n*=9037) on 801 locations: imidacloprid exceeds MTR (>13 ng/l)
- 70% reduction in macrofauna abundance in polluted water
- Permanent leaching of Imidacloprid year round from fields to surface water
- Meeting MTR requires reduction of use by at least 90%




MICROBES
INSECT POLLINATORS
TERRESTRIAL INVERTEBRATES
AQUATIC INVERTEBRATES
AMPHIBIANS
REPTILES
FISH
BIRDS
MAMMALS
TAXONOMIC GROUP
EXPOSURE*
ECOTOXICOLOGICAL EFFECT†
Individual:
Population:
Communities:
P
?
ECOSYSTEM SERVICES
SUPPORTING
• Soil formation
• Soil quality
• Nutrient cycling
• Waste treatment and remediation
REGULATING
• Pollination services
SUPPORTING
• Food web support
SUPPORTING
• Soil formation
• Soil quality
• Nutrient cycling
• Food web support
REGULATING
• Water purification
SUPPORTING
• Nutrient cycling
• Food web support
REGULATING
• Pest and disease regulation
CULTURAL
• Aesthetic
REGULATING
• Pest and disease regulation
CULTURAL
• Aesthetic
PROVISIONING
• Food
CULTURAL
• Recreational
REGULATING
• Seed dispersal
• Pest and disease regulation
• Pollination
• Aesthetic and recreation
PROVISIONING
• Food
REGULATING
• Herbivory and weed control
• Seed dispersal
PROVISIONING
• Food
CULTURAL
• Aesthetic and recreation
*EXPOSURE
0: No route of exposure
1: Potential route of exposure assumed negligible
2: Relevant route of exposure low
3: Relevant route of exposure moderate
4: Relevant route of exposure high
0 1 2 3 4
Plants
Air
Soil
Water
†ECOTOXICOLOGICAL EFFECT
1: Potential effects assumed negligible under normal exposure conditions
2: Evidence effects can occur but at high doses or after prolonged exposure
3: Evidence effects can occur at moderate doses
4: Evidence effects can occur at low doses or after acute exposure
Unknown: in situations where no judgement could be made because of lack of evidence, e.g. data unavailable
Probable: no accurate judgement could be made due to incomplete evidence, but data suggests a potential effect level above (1)

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LETTER

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Declines in insectivorous birds are associated with high neonicotinoid concentrations

Caspar A. Hallmann[1,2], Ruud P. B. Foppen[2,3], Chris A. M. van Turnhout[2], Hans de Kroon[1] & Eelke Jongejans[1]

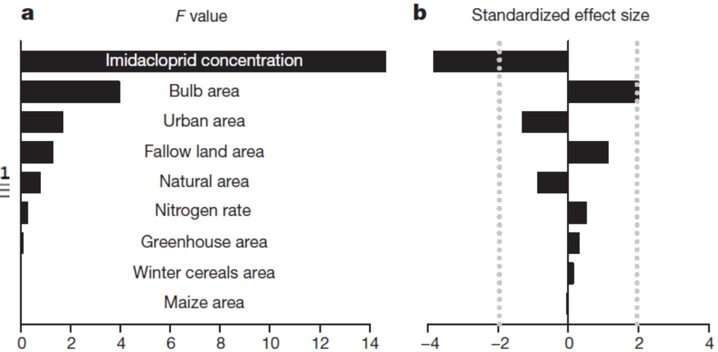
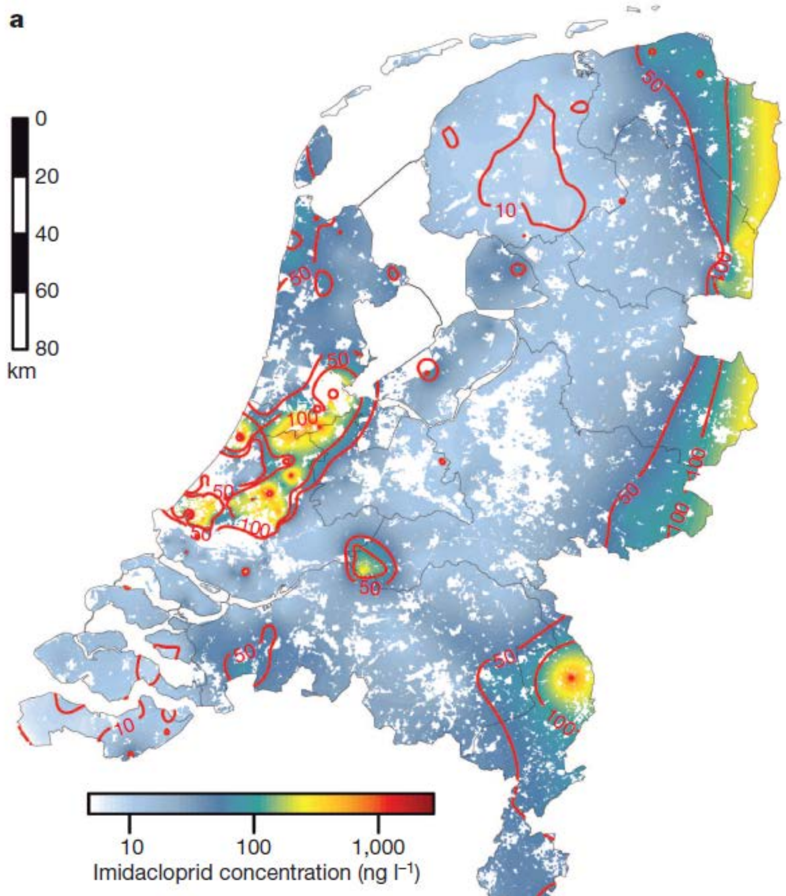
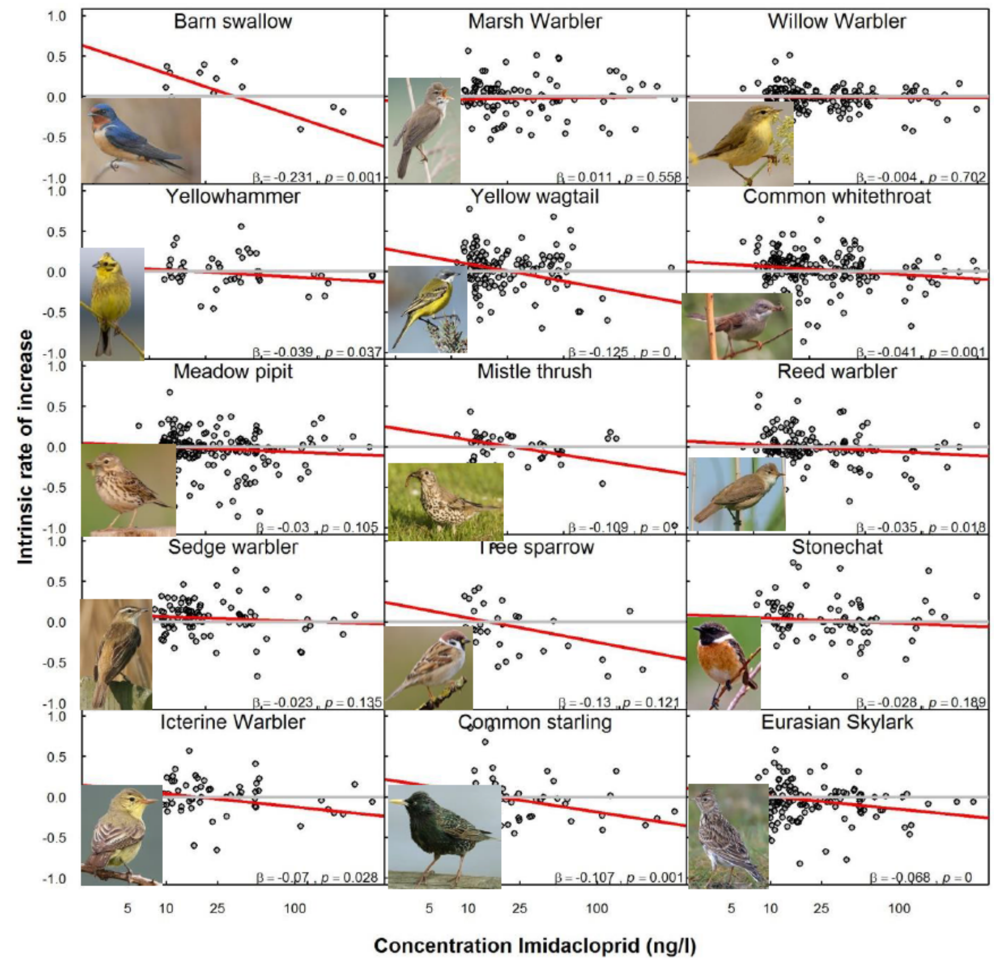


Figure 2 | Comparison of the effect of agricultural land-use changes and the effect of imidacloprid on bird population trends. **a**, The marginal variance





Risks for humans?

- Neonicotinoids are not less toxic than organophosphates
- Subacute poisoning of humans in Japan
- ADI norms outdated (IMI 0.06 mg/kg = knowledge of 2005)
- Japanese research Kimura-Kuroda 2012:
  damage to developing brain in rats at 1173x lower dose imidacloprid than the thyroid effect on which present ADI is based.
- Autism, Schizofrenia, ADHD??
- invivo versus invitro
- Parkinson (?)

http://www.actbeyondtrust.org/wp-content/uploads/2012/10/kuroda.pdf

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PLoS one

Nicotine-Like Effects of the Neonicotinoid Insecticides Acetamiprid and Imidacloprid on Cerebellar Neurons from Neonatal Rats

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Abstract

Background: Acetamiprid (ACE) and imidacloprid (IMI) belong to a new, widely used class of pesticide, the neonicotinoids. With similar chemical structures to nicotine, neonicotinoids also share agonist activity at nicotinic acetylcholine receptors (nAChRs). Although their toxicities against insects are well established, their precise effects on mammalian nAChRs remain to be elucidated. Because of the importance of nAChRs for mammalian brain function, especially brain development, detailed investigation of the neonicotinoids is needed to protect the health of human children. We aimed to determine the effects of neonicotinoids on the nAChRs of developing mammalian neurons and compare their effects with nicotine, a neurotoxin of brain development.

Methodology/Principal Findings: Primary cultures of cerebellar neurons from neonatal rats allow for examinations of the developmental neurotoxicity of chemicals because the various stages of neurodevelopment—including proliferation, migration, differentiation, and morphological and functional maturation—can be observed *in vitro*. Using these cultures, an excitatory Ca^{2+}-influx assay was employed as an indicator of neural physiological activity. Significant excitatory Ca^{2+} influxes were evoked by ACE, IMI, and nicotine at concentrations greater than 1 μM in small neurons in cerebellar cultures that expressed the mRNA of the α3, α4, and α7 nAChR subunits. The firing patterns, proportion of excited neurons, and peak excitatory Ca^{2+} influxes induced by ACE and IMI showed differences from those induced by nicotine. However, ACE and IMI had greater effects on mammalian neurons than those previously reported in binding assay studies. Furthermore, the effects of the neonicotinoids were significantly inhibited by the nAChR antagonists mecamylamine, α-bungarotoxin, and dihydro-β-erythroidine.

Conclusions/Significance: This study is the first to show that ACE, IMI, and nicotine exert similar excitatory effects on mammalian nAChRs at concentrations greater than 1 μM. Therefore, the neonicotinoids may adversely affect human health, especially the developing brain.

Research by dr. Kumiko Taira

Subacute neonicotinoid poisoning humans

MRL Imidacloprid
5 mg/kg (berries)
= **5000 ppb** !!!
1 mg/kg (citrus)

1111 patients 2006/2007; 549 high fruit & tea diet

- Most sensitive group: non-smoking females
- Trembling fingers
- Abnormal ECG (Heartrate abnormality tachycardia >100, bradycardia <60)
- Loss of memory
- Headache, shoulder pain, chest pain, muscle crump
- **6-chloronicotinic acid (6CNA) in urine**

http://www.actbeyondtrust.org/wp-content/uploads/2012/10/taira.pdf