Tokyo 11 June 2013

Neonicotinoids, bee disorders and the sustainability of pollinator services

Dr. Jeroen P. van der Sluijs

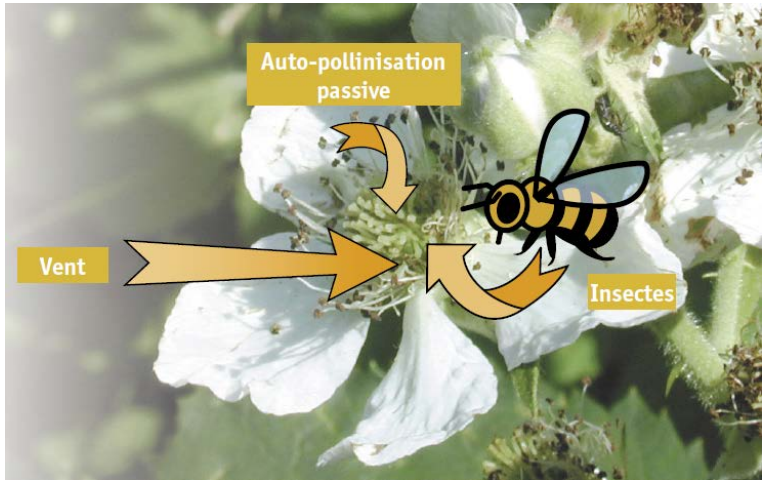
IUCN CEM SSC Species Survival Commission

actbeyondtrust
empowering actions for just and sustainable society
www.actbeyondtrust.org

Triodos Foundation

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

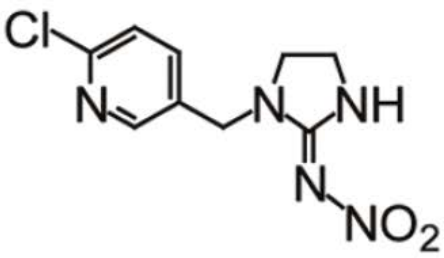


Some crops pollinated by bees[3]

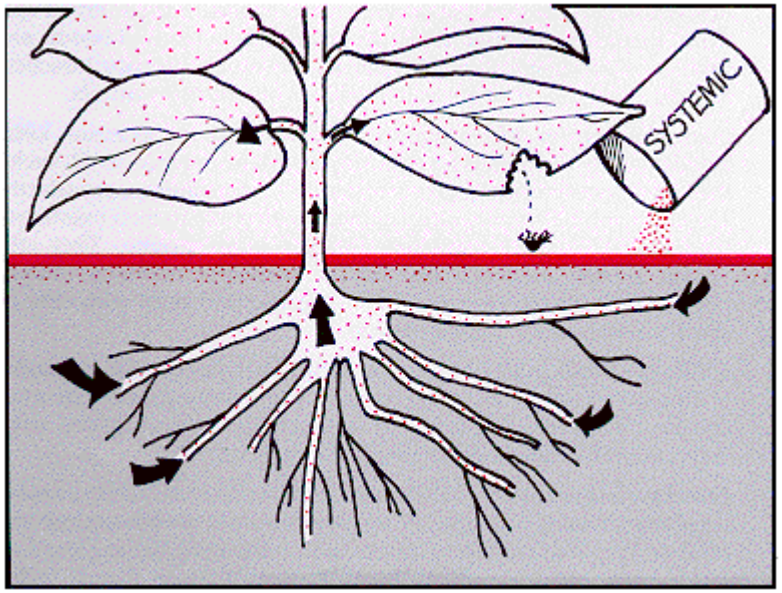
Alfalfa
Apple
Almond
Artichoke
Asparagus
Blackberry
Blueberry
Broccoli
Brussels sprouts
Cabbage
Cacao
Cantaloupe
Carrot
Cashew
Cauliflower
Celery
Cherry
Citrus
Dill
Eggplant/ Aubergine
Fennel
Garlic
Kale
Kola nut
Leek
Lychee
Macadamia
Mango
Mustard
Nutmeg
Onion
Passion fruit
Peach
Pear
Plum
Pumpkin
Raspberry
Sapote
Squash
Sunflower
Tangerine
Tea
Watermelon

Systemic insecticides: revolution in plant protection

Shinzo Kagabu



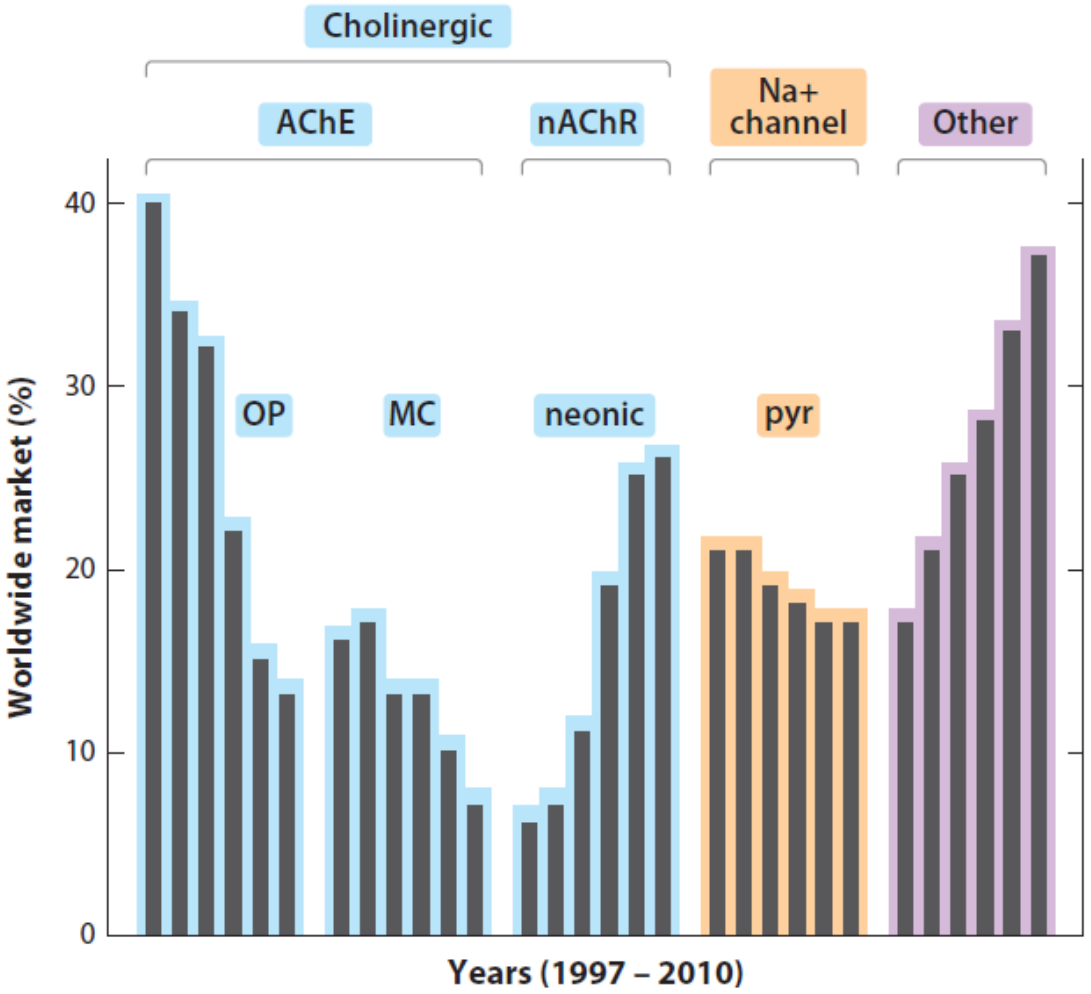
imidacloprid (1991)



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)



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

Imidacloprid 2010 World production: 20,000 tonnes

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

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).

Toxicity of neonicotinoids

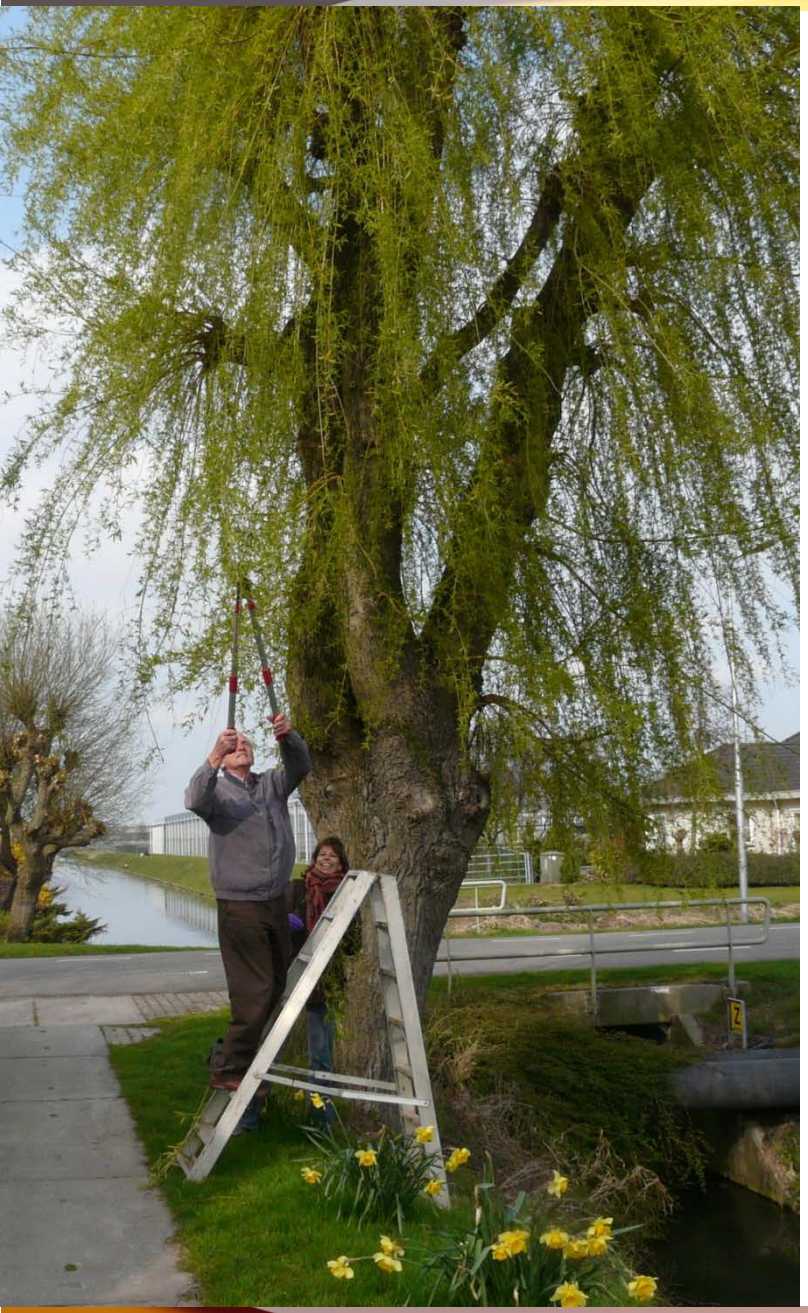
Pesticide	®	Use	LD50 (ng/honeybee)	Toxicity index relative to DDT
DDT	Dinocide	insecticide	27000	1
Amitraz	Apivar	insecticide / acaricide	12000	2
Coumaphos	Perizin	insecticide / acaricide	3000	9
Tau-fluvalinate	Apistan	insecticide / acaricide	2000	13.5
Methiocarb	Mesurol	insecticide	230	117
Carbofuran	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

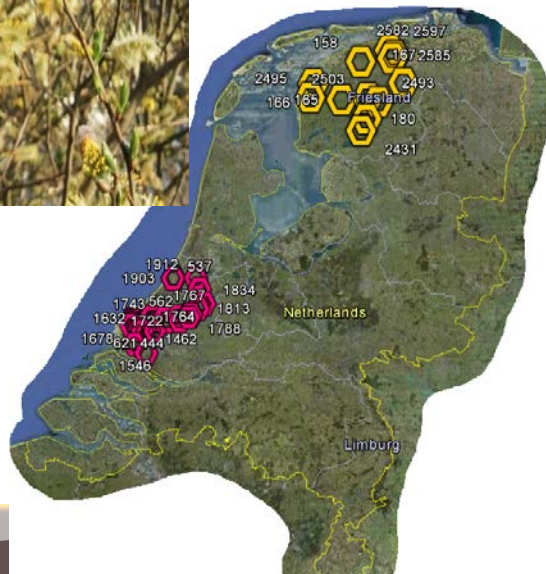
Exposure pathways:

- direct contact with spray drift and dust drift during application;
- intake of nectar, pollen, water, guttation, honeydew etc. that contain residues;
- residue in nesting material (resin, wax, etc.);
- contact with contaminated plants, soil, water;
- residue in cooling water used in the hive;
- inhalation of contaminated air



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

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



Effects on honeybees

- Acute lethal effects
- Chronic lethal effects
- Acute sublethal effects.
- Chronic sublethal effects
- Synergy effects

Pomurje, Slovenia April 2011, sowing period clothianidin corn

Damage 2500 colonies lost

> 100 million bees

Yamada 2012

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

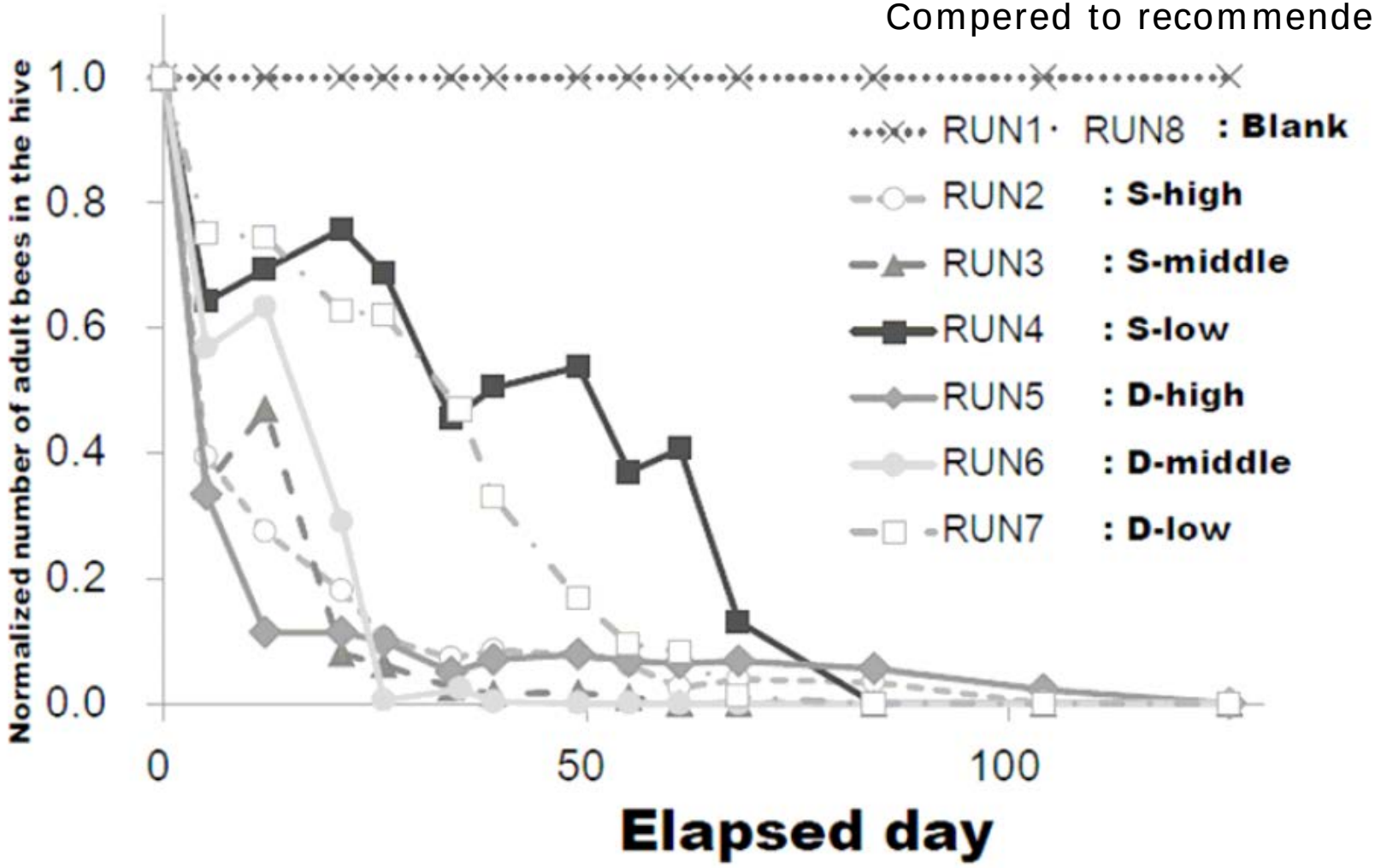


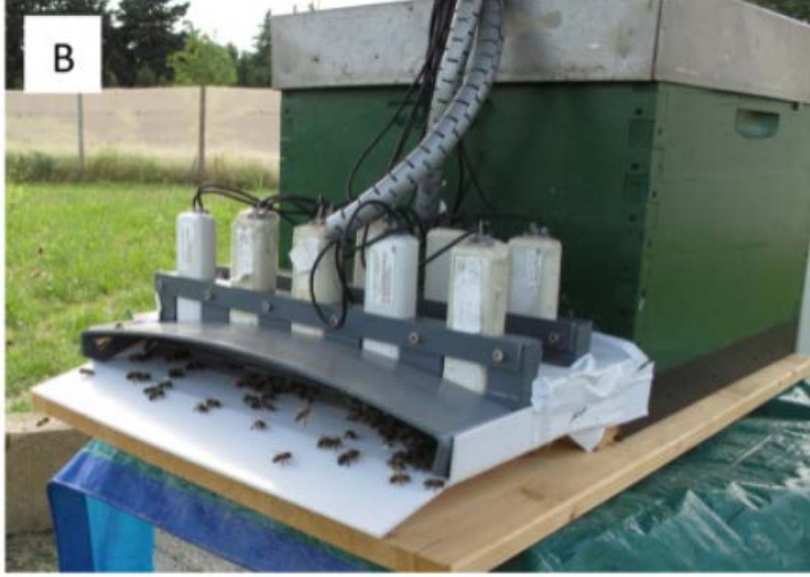
Figure 1 Normalized number of adult bees in the hive with the elapsed days

Sublethal effects

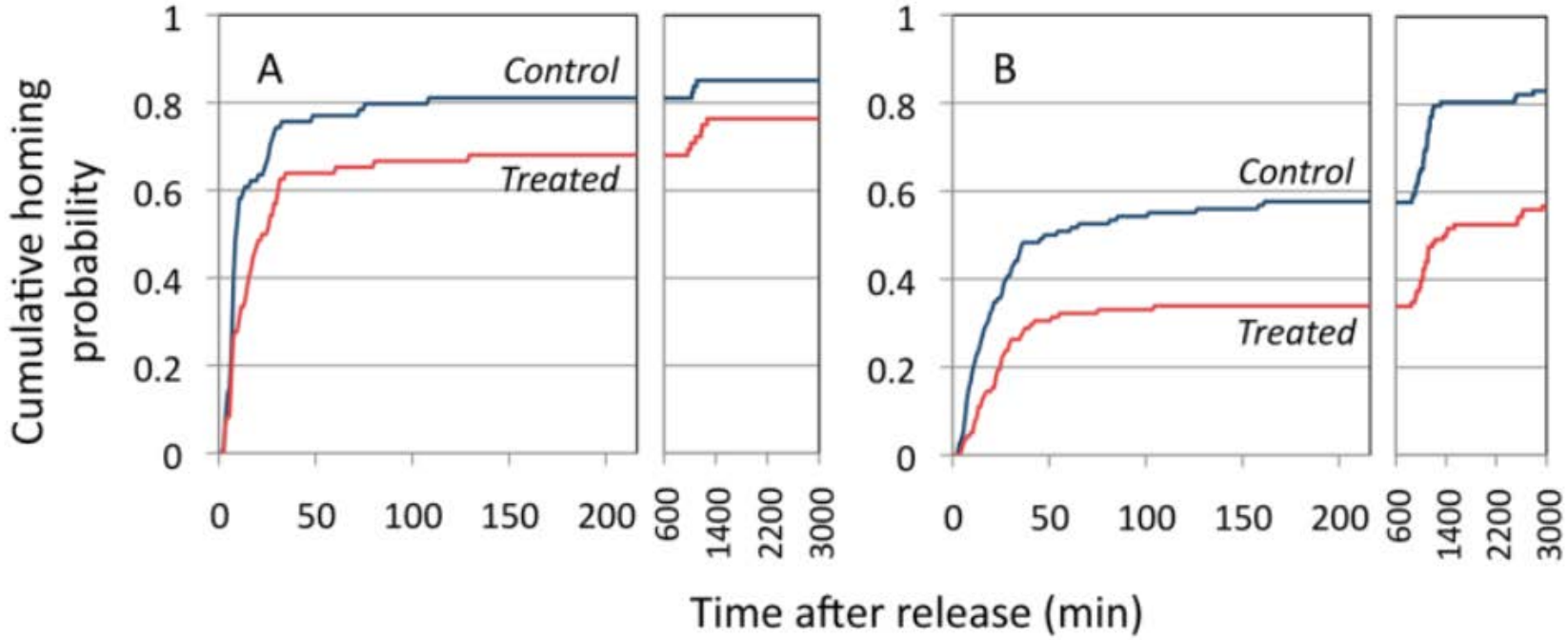
- Navigation and orientation
- Feeding behaviour
- Memory and learning
- Neurophysiology
- Larval development
- Task differentiation in the colony
- Moulting
- Adult longevity
- Immunology
- Fecundity
- Sex ratio
- Mobility
- Oviposition behaviour
- Groomig and alloogrooming

Henry ea. 2012 *Science* studie

Radio ID chips



Dosis per bij: 1.34 ng thiamethoxam in 20-µl sucrose oplossing



A: vertrouwde plek; B random plek

http://dx.doi.org/10.1126/science.1215039

Neonicotinoid Pesticide Reduces Bumble Bee Colony Growth and Queen Production

Penelope R. Whitehorn,[1] Stephanie O'Connor,[1] Felix L. Wackers,[2] Dave Goulson[1*]

[1]School Natural Sciences, University of Stirling, Stirling FK9 4LA, UK. [2]Lancaster University, LEC, Lancaster LA1 4YQ, UK.

*To whom correspondence should be addressed. E-mail: dave.goulson@stir.ac.uk

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.

***Science*, 29 Mar 2012 http://dx.doi.org/10.1126/science.1215025**

Conclusions on pollinators

- At field realistic concentrations, neonicotinoids produce wide range of adverse sublethal effects in bees, affecting colony performance through impairment of foraging success, brood, larval development, memory and learning, susceptibility to diseases, hive hygiene, etc.
- Neonicotinoids synergistically reinforce infectious agents such as *Nosema ceranae*.
- 85% reduction in bumblebee queen production could be a key factor explaining global trends of bumblebee decline.
- Few studies assessed toxicity to other wild pollinators. Available data suggest that they are likely to exhibit similar toxicity to all wild insect pollinators.
- Pollination is of vital importance both natural ecosystems and farming.
- Insect pollinators require a high level of protection.
- Transition to pollinator-friendly alternatives to neonicotinoids is urgently needed

Tokyo - 11 June 2013

Macro-invertebrate decline in Dutch surface waters polluted with imidacloprid

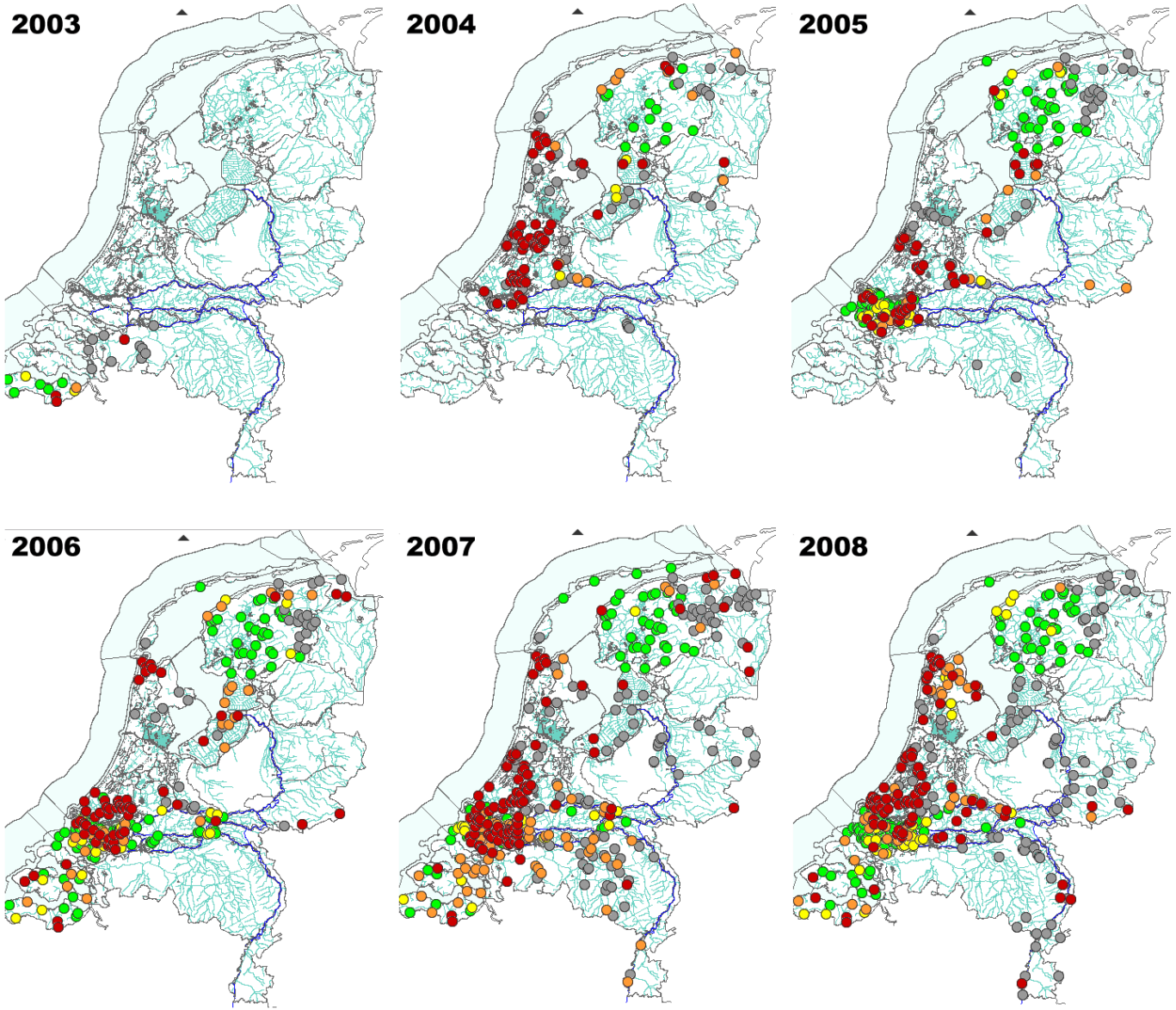
Tessa van Dijk, Marja van Staalduinen and Jeroen P. van der Sluijs

j.p.vandersluijs@uu.nl www.jvds.nl

Copernicus Institute, Utrecht University

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



www.bestrijdingsmiddelenatlas.nl

PLOS ONE study

Macro-Invertebrate Decline in Surface Water Polluted with Imidacloprid

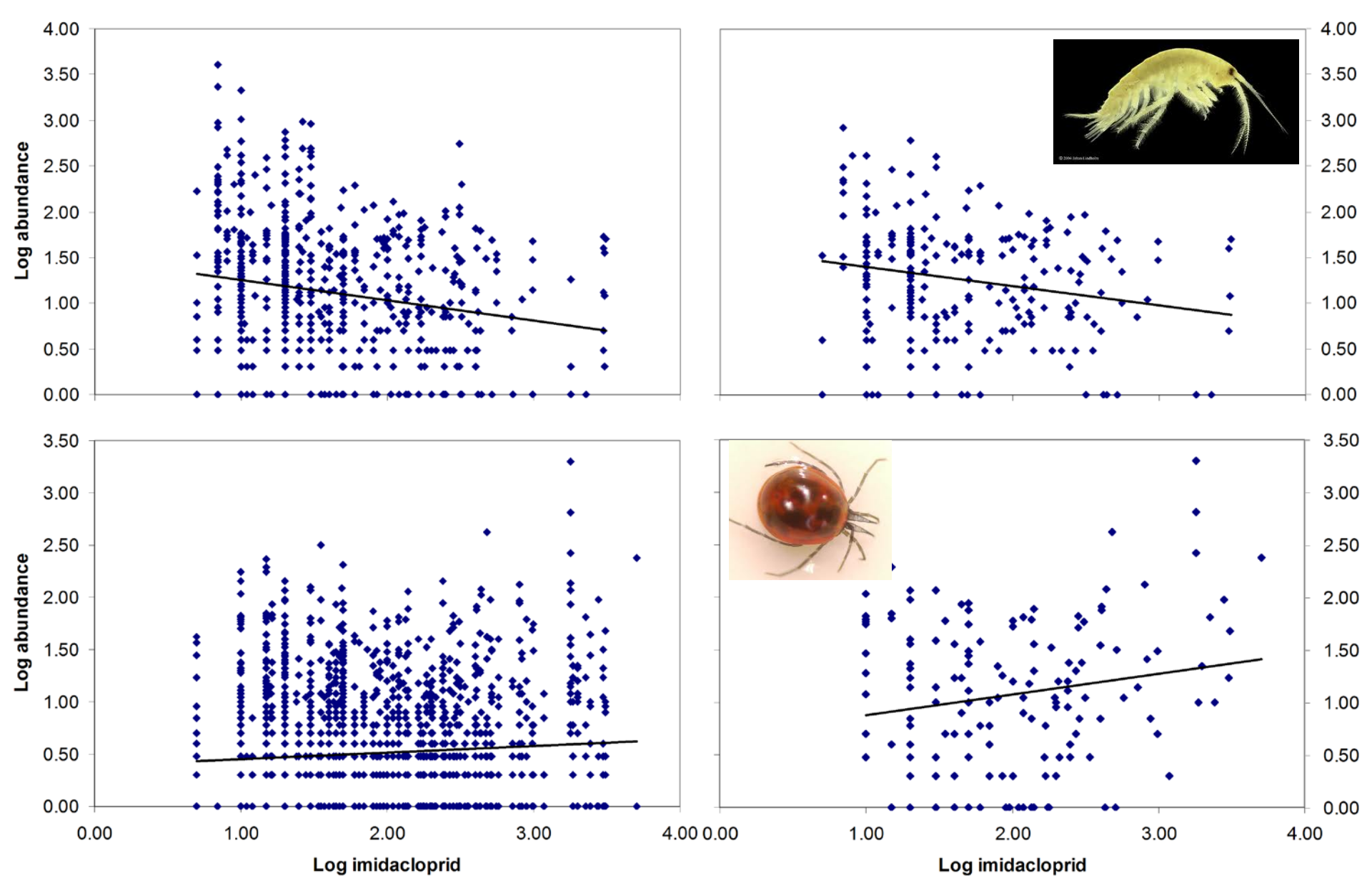
- Dataset constructed from raw data obtained from 23 of 26 NL water boards.
- >600000 data points (x, y, t, species, abundance) of macro invertebrates
- 18898 points with IMI data within 1 km radius & < 160 days time difference
- Much more species included (4009 species from 92 orders) compared to Van Dijk 2010 MSc Thesis

http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0062374

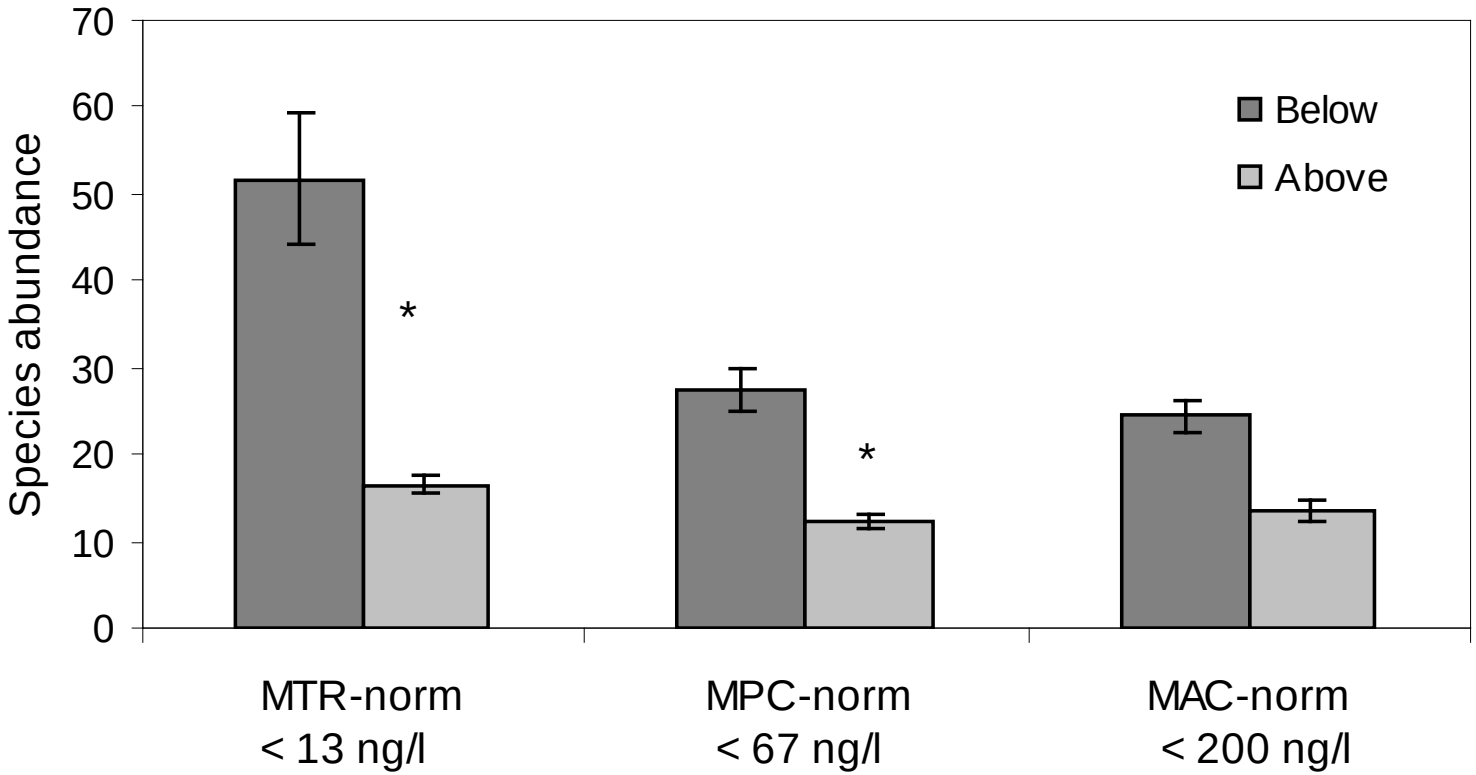
Significant negative relationship between species abundance and imidacloprid concentration found for:

- 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

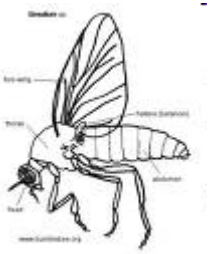


log10 imidacloprid concentration (ng/l) versus log10 macro-invertebrate species abundance in surface water for a) Amphipoda, b) its most abundant species *Gammarus tigrinus*, c) Actinedida and d) its most abundant species *Limnesia undulata*.

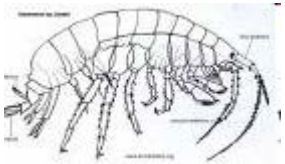


Mean and standard error of aquatic macro-invertebrate species abundance at median imidacloprid concentration in surface water below and above the level of different water quality norms. Dependent variables were tested with the Mann Whithney test separately. * Indicates significant differences at $p<0.05$.

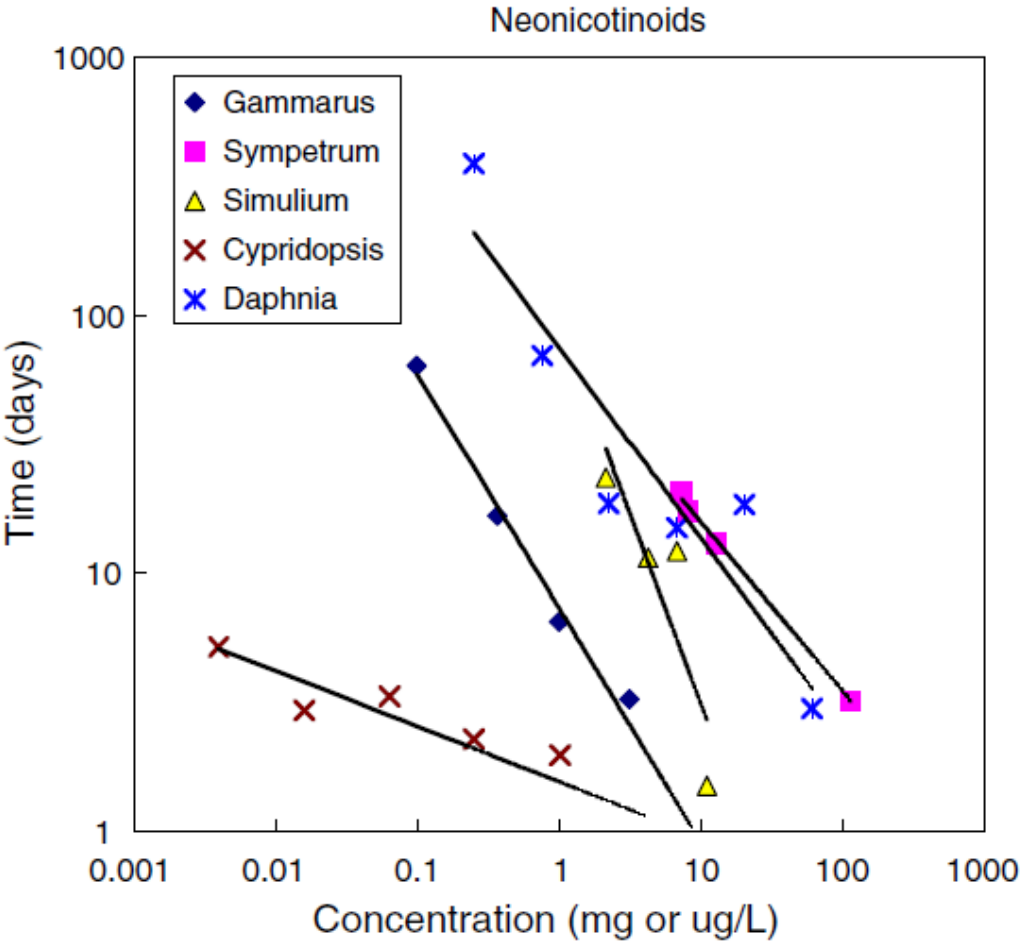
Sympetrum

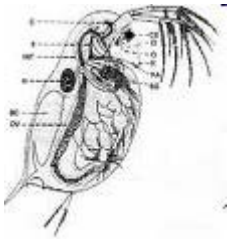


Simulium

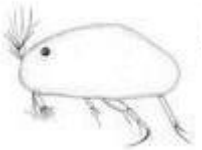


Gammarus





Daphnia



Cypridopsis

Time to 50% mortality for several arthropod species imidacloprid (Cypridopsis vidua and Daphnia magna) and thiacloprid (other species). Concentrations for Sympetrum and Simulium species are in μg/l; for all other species in mg/l.

Findings on aquatic ecosystems

- 45% of all samples (*n*=9037) on all (*n*=801) Dutch measurement locations had imidacloprid concentrations that exceed the MTR (>13 ng/liter)
- 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%.