Risks to bees from neonicotinoid insecticides

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Chief Regulatory Scientist, Pesticides
The APVMA - an Australian government statutory authority established in 1993. Centralised the approval and registration of all agvet chemical products in Australia. Previously each State and Territory government had its own system of product registration.

Located approximately half-way between Canberra City and Queanbeyan, NSW.

Website: www.apvma.gov.au
Talk Outline

• Publication of APVMA’s overview report
  – Recommendations and research suggestions
• Is there a global honey bee crisis?
• What are neonicotinoid insecticides?
• Some pros and cons of the neonicotinoids
• Neonicotinoid exposure pathways for pollinators
• Why the focus on neonicotinoid insecticides?
• Their risks in relation to other pesticides
• The multitude of threats to bees
• What are the APVMA’s next steps?
Publication of APVMA’s overview report
19 FEBRUARY 2014
Overview report on neonicotinoids and honeybee health in Australia released
Overview report - contents

• INTRODUCTION
• BEE COLONY DECLINES OVERSEAS
• WHAT ARE NEONICOTINOIDs
• REGISTERED USES OF NEONICOTINOIDs IN AUSTRALIA
• AGRICULTURAL AND ECONOMIC IMPORTANCE OF NEONICOTINOIDs
• EXPOSURE OF POLLINATORS TO NEONICOTINOIDs
• EXPOSURE OF POLLINATORS TO NEONICOTINOIDs IN AUSTRALIA (by crop)
• LITERATURE RESEARCH - THE EFFECTS OF PESTICIDES ON POLLINATOR HEALTH
• REGULATION AND INVESTIGATIONS IN OTHER JURISDICTIONS
• TESTING REQUIREMENTS
• PRODUCT LABELS
• ADVERSE EXPERIENCE REPORTS (AERs) (Australia)
• SURVEILLANCE PROGRAMS (overseas)
• GUIDANCE DOCUMENTS FOR BEEKEEPERS, FARMERS AND HORTICULTURALISTS
• RECOMMENDATIONS, RESEARCH SUGGESTIONS & NEXT STEPS
Overview recommendations

1. Managing the release of NNi seed-treatment dusts at planting: *CropLife Australia could consider working together with relevant member companies to develop a best-management practice guide relevant to Australia and focusing on those industries where there is the potential for neonicotinoid dusts to be generated during the process of coating, transporting and planting of treated seeds.*
2. Surveillance - bee poisoning incidents: AHBIC and its member associations could consider the feasibility of trialling an annual survey of apiarists in the different states/territories and agricultural/horticultural regions on the health of their hives. This information would then be collated into a national report.
3. Residue monitoring for pesticide residues in bee media: *It is suggested that a research project be established and funded to analyse pesticide residues in various plant (nectar, pollen, guttation fluid) and bee (collected pollen, comb and foundation wax, bee bread, honey) media. It should be conducted in such a way to allow comparison with the quite extensive results collected in North America* - - - - -
Overview recommendations (4)

Residue monitoring in honey: A separate recommendation was to be that the National Residue Survey extend the range of residues measured in honey to include the NNI’s. However, the NRS advised that such monitoring had already commenced - the 2012-13 sampling program tested 23 random samples of Australian honey for:-

i. acetamiprid (+ N-demethyl metabolite)
ii. imidacloprid (+ 5-hydroxy & olefin metabolites)
iii. thiacloprid
iv. clothianidin (thiamethoxam not assayed as its primary active metabolite is clothianidin)
Overview recommendations (5)

4. National symposium: Relevant agencies (eg. RIRDC, Plant Health Australia, the Department of Agriculture, the Department of the Environment) should consider holding a one-day symposium for a wide range of stakeholders to hear about issues relating to bee health from Australian and international experts.
Research suggestions

a) Canola – varietal/cultivar differences?
b) Neonicotinoid persistence in the environment
c) Honey bee research in an environment free of Varroa
Is there a global honeybee crisis?
The Collapse of the Honey Bee and the Coming Agricultural Crisis

Bee Deaths Create Crisis for Crops

Bee numbers plummet as billions of colonies die across the world

Russia Warns Obama: Global War Over“Bee Apocalypse” Coming Soon  Posted by EU Times on May 10th, 2013

FAO = UN Food & Agriculture Organization
Global Stock of Honey Bees (cont.)

- **USA**: $y_{1961} = 5,514,000$ hives
- **ex-USSR**: $y_{1961} = 10,250,000$ hives
- **Germany**: $y_{1961} = 1,997,000$ hives
- **China**: $y_{1961} = 3,356,000$ hives
- **Argentina**: $y_{1961} = 650,000$ hives
- **Spain**: $y_{1981} = 728,100$ hives
Agricultural economists Randy Rucker and Wally Thurman examined the honeybee industry in the USA.

The beekeeping industry reacted to the CCD problem so swiftly that pollination continued and there was no impact on the food supply or its price.

Report (36 pages) downloadable at: www.perc.org/articles/colony-collapse-disorder-market-response-bee-disease
Figure 2. Honey Bee Colonies: Top Five States

1939-2010, in hundreds of thousands

What are the neonicotinoids?
List of Nni’s and related compounds

<table>
<thead>
<tr>
<th>GENERIC NAME</th>
<th>ORIGINATOR COMPANY</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neonicotinoids</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetamiprid</td>
<td>Aventis Crop Sciences</td>
<td></td>
</tr>
<tr>
<td>Clothianidin</td>
<td>Takeda Chemical Industries &amp; Bayer</td>
<td>Takeda’s agrochemical interests were transferred to Sumitomo Chemical Co. Ltd in 2007</td>
</tr>
<tr>
<td>Dinotefuran</td>
<td>Mitsui Chemicals</td>
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<tr>
<td>Imidacloprid</td>
<td>Bayer CropScience</td>
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<tr>
<td>Nitenpyram</td>
<td>Novartis Animal Health</td>
<td>Veterinary uses only</td>
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<tr>
<td>Nithiazine</td>
<td>Shell Development Co.</td>
<td>Prototype neonicotinoid – early 1970s</td>
</tr>
<tr>
<td>Thiacloprid</td>
<td>Bayer CropScience</td>
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<tr>
<td>Thiamethoxam</td>
<td>Syngenta</td>
<td>Active metabolite is clothianidin</td>
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<tr>
<td><strong>Other related insecticides acting at nicotinic AChRs</strong></td>
<td></td>
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</tr>
<tr>
<td>Sulfoxaflor</td>
<td>Dow AgroSciences</td>
<td></td>
</tr>
<tr>
<td>Flupyradifurone</td>
<td>Bayer CropScience</td>
<td></td>
</tr>
</tbody>
</table>
What are neonicotinoid insecticides?

Schematic diagram of a cholinergic nerve terminal (or synapse) in the CNS of an insect

ACh = acetylcholine
Some pros and cons of the neonicotinoid insecticides
Agricultural benefits of the neonicotinoids

Development of crop protection products for maize; grams (g) of active ingredient (a.i.) applied per hectare. IMI - imidacloprid; CLOTHI - clothianidin (from Jeschke & Nauen, 2010).
Neonicotinoids - some pros and cons

Pros
• Considerably less toxic to humans (and other mammals) than the OP and carbamate insecticides
• The properties of a subset of the neonicotinoids mean that they can be used as seed coatings:-
  – the coating protects the seeds and the growing plant
  – less need for regular application of chemical sprays

Cons
• Selection pressure on pests from ongoing exposure to systemic insecticides may → resistance development
• Effectiveness as a seed-treatment requires a reasonable level of soil and plant stability
  – The greater persistence of some neonicotinoids and their soil mobility raises more environmental concerns than other less persistent and/or less mobile insecticides
Exposure routes: How can pollinators be exposed to neonicotinoid insecticides?
Exposure routes

• Pollinators may be exposed to NNi’s by:-
  – contact with dusts arising during planting of coated seeds
  – intake of systemic residues in nectar, pollen and guttation fluid of the plant, arising from seed treatment or application of a spray or granule to the soil
  – contact with foliar sprays applied to the flowering plant (e.g. canola).
Neonicotinoids and application methods approved in Australia

<table>
<thead>
<tr>
<th>Neonicotinoids</th>
<th>Seed coating</th>
<th>Foliar spray</th>
<th>Soil drench etc</th>
<th>Granules, tablets</th>
<th>Stem inject’n</th>
<th>Animal treatment</th>
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<tr>
<td>acetamiprid</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
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<tr>
<td>clothianidin</td>
<td></td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td>imidaclorpid</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
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<tr>
<td>thiacloprid</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
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<td>✓</td>
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<tr>
<td>thiamethoxam</td>
<td>✓</td>
<td>✓</td>
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<td></td>
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<tr>
<td>Sulfoxaflor*</td>
<td></td>
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</tbody>
</table>

*NNi-related compound
Why the focus on neonicotinoid insecticides with respect to bee health?
Some background – coated seeds and vacuum planters
The ‘Rhine Valley Incident’ - April /May 2008– *ca.* 12,000 colonies poisoned

- delayed sowings of maize in the Upper Rhine valley because of adverse weather conditions - *ca.* 15 to 20,000 ha planted at the same time
- coincidental flowering of oil seed rape, fruit trees and weeds (eg. *Taraxacum*)
- Sowing accompanied by dry weather and constant winds which blew dusts into adjacent areas

Drift of free dusts (μg/kg of oilseed rape) emitted by pneumatic maize planters (vacuum systems) onto nearby oilseed rape crop at 1 up to 25 m from the maize field using different types of exhaust air pipes (directed up, down, and into the soil \(\text{via}\) the fertiliser tyne)
Germany immediately introduced regulatory measures:-

- Regulatory measures for seed dressing, labelling, sowing etc.
- Improving the abrasion resistance by the use of stickers
- Use of vacuum systems for insecticide-treated seeds only when the exhaust air pipes were modified with air deflectors
- Cautious handling of seed bags to avoid dust formation
- Strict avoidance of dust drift into adjacent areas (wind speed < 5 m/s or 18 kph)
- Ensure a high degree of seed incorporation in soil and minimisation of spillage
- Use of adequate seed drilling equipment (inspections)
- No use of treated seeds after crop rotation / without infestation
The neonicotinoids – their risks to bee health in relation to other pesticides
Many other pesticides are toxic to honey bees

- **Insecticides**
  - acetamiprid
  - cyhalothrin
  - deltamethrin
  - fipronil
  - parathion
  - neonicotinoids

- **Fungicides**
  - captan
  - chlorothalonil
  - myclobutanil
  - propiconazole
  - pyraclostrobin

- **Herbicides**
  - paraquat (?)

- **Interactions**
  - Insecticides (pyrethroids, neonicotinoids) and EBI fungicides
  - Insect Growth Regulators (IGRs) and fungicides
Data from the EU:-

- Anzahl der [Bienen]völker = number of bee colonies
- Anzahl Proben Deutschland = number of investigations in Germany
- Anzahl Bienenschäden Deutschland = number of bee poisonings in Germany
- The numbers of incidents steadily declined since the mid-1970s and, since 1992, has been constant
The multitude of threats to bees
Stress factors in honeybee populations

[Modified from OPERA Bee Health in Europe, 2013]
What are the APVMA’s next steps?
What’s the APVMA doing?


• Investigating:-
  – the adoption of more extensive tests before new pesticides are approved
  – Improved labelling including bee warning statements and more user guidance
Expanded bee testing and label statements

• In late 2012 the APVMA contracted Mr Chris Lee-Steere (Australian Environment Agency Pty Ltd) to review:-
  – the adequacy of the current battery of tests designed to investigate the effects of new insecticides on honey bees;
  – the value of new bee toxicity test protocols being developed internationally;
  – current bee protection statements on Australian pesticide products and advise if changes needed to be made to standard statements and existing labels.
Bee testing and label statements (cont.)

- The AEA report, *Consideration of Testing Requirements and Label Statements in Relation to the Impact of Pesticides on the Health of Honey Bees and other Insect Pollinators* (dated 13 November 2012), is available on the APVMA’s website.

- Its five (5) recommendations to the APVMA were considered by an APVMA workshop of regulatory stakeholders on 24 July 2013.

- The outcomes of the workshop are being considered by the APVMA and the Department of the Environment, together with the EFSA and USEPA guidance documents.
Reporting an Adverse Experience to the APVMA

- Reports relating to involvement (or suspected involvement) of an agvet chemical
- Access via APVMA’s home page (www.apvma.gov.au)
- Click on ‘Adverse Experiences and Using Chemicals Safely’ (LHS column)
End of presentation
Colony Collapse Disorder

- 2007 - the term ‘Colony Collapse Disorder’ or CCD applied to a drastic increase in losses of honeybee colonies in parts of the USA in late 2006.
- The term described a specific set of symptoms.
- USDA - “The defining characteristic of CCD is the disappearance of most, if not all, of the adult honey bees in a colony, leaving behind honey and brood but no dead bee bodies”.
- Definition recently revised to include low levels of Varroa mite and other pathogens, such as Nosema, as probable contributing factors (USDA-ARS, 2012).
Colony Collapse Disorder (cont.)

- Subsequent colony losses in Europe and in several Asian countries were reported in the media as being part of a worldwide CCD ‘epidemic’
- CCD as described in USA has not been observed in Europe
- Little evidence for the occurrence of CCD in Canada
CCD in the USA - Summary

• Estimates of US over-wintering losses attributed to CCD:
  – 2006 - 2007  45%
  – 2007 - 2008  60%
  – 2008 - 2009  36.4%
  – 2009 - 2010  42.1%
  – 2010 - 2011  26.3%
  – 2011 – 2012  23.6%
  – 2012 – 2013  51.3%*

Estimated total losses in managed colonies in the USA

www.beeinformed.org/2013/05/winter-loss-survey-2012-2013/
Data from the USA:-

Source: USDA National Agricultural Statistics Service (NASS) Honey Production Report

NNi's introduced (imidacloprid)
Data from the USA:

Source: USDA National Agricultural Statistics Service (NASS) Honey Production Report
Cholinergic Synapse

![Diagram of cholinergic synapse](image)
Neonicotinoids – key crops/ application methods

**Seed treatments:** maize, sweet corn, lentils & lupins, Faba beans, field peas, canola, sorghum, cereals, pulses, sunflower, cotton, forage & seed pasture, forage brassicas

**Soil treatments (drenches, sprays, or soil-incorporated granules):** sugarcane, apples, citrus, vegetables (capsicum, curcurbits, eggplant, potato, sweet potato, tomatoes), Elm trees, eucalyptus (seedlings, young trees), roses, azaleas, Lillypillies, potted palms, magnolias and other potted ornamentals, shrubs and small trees (home garden); seedlings of fruiting vegetables, brassicas, leafy vegetables, pome fruit, stone fruit, grapes

**Foliar sprays:** Cotton, pome fruit, stone fruit, citrus; grapes, vegetables (capsicum, melon & other curcurbits, eggplant, sweet potato, potato, cucumber, tomatoes, brassicas) flowers, ornamental plants (indoor and outdoor), including roses, shrubs, palms, bedding plants and trees; turf and lawn (home garden), shrubs

**Trunk injection:** Bananas, trees (termite nests)
NNi’s in Honey – Residue Testing

• 2012-13 NRS random honey program - 23 Australian honey samples tested for NNi’s:-
  – Acetamiprid & N-demethyl metabolite
  – Imidacloprid, 5-hydroxy & olefin metabolites
  – Thiacloprid
  – Clothianidin

• No detections in any samples

<table>
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<th>Permit Number</th>
<th>Permit Holder</th>
<th>Product</th>
<th>Purpose</th>
<th>Users</th>
<th>Validity</th>
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<td>PER11753</td>
<td>DAFF</td>
<td>Unleaded petrol</td>
<td>to kill European honeybees infected with Varroa mite, Tropilaelaps mite, Tracheal mite or other identified exotic diseases</td>
<td>Persons authorised by the Australian or State CVO</td>
<td>12/01/2010 – 30/09/2015</td>
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<td>PER11761</td>
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<td>Apistan Varroa Control for Bees (824 mg/ea tau-fluvalinate) Bayvarol Strips (3.6 mg/ea flumethrin)</td>
<td>“For the diagnosis and surveillance of varroa mite and tropilaeleps mites”</td>
<td>Persons authorised by the Secretary of DAFF or the Chief Plant Protection Officers (or equivalent) of the Commonwealth and States</td>
<td>1/10/2010 – 30/09/2015</td>
<td>“For use in hives within a 25 km radius of the location of an identified incursion of varroa or tropilaeleps or their exotic bee hosts”</td>
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<td>PER12920</td>
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<td>Apiguard gel (12.5 g thymol)</td>
<td>“Diagnosis and treatment of varroa mite”</td>
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<td>Apistan Varroa Control for Bees (824 mg/ea tau-fluvalinate)</td>
<td>For use in the queen bee import program ... following acceptance of the queen bee into the nucleus colony and until grafting commences</td>
<td>DAFF officers at the Eastern Creek Quarantine Station</td>
<td>11/07/2013 – 31/08/2015</td>
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<td>DAFF officers at the Eastern Creek Quarantine Station</td>
<td>11/06/2013 – 31/08/2015</td>
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