EFSA guidance for exposure assessment of honey bees

Jos Boesten
Outline

- Introduction
- Contact exposure assessment
- Exposure assessment for water consumption in hive
- Exposure assessment for nectar and pollen consumption in hive
  - Overview
  - Higher-tier field exposure experiments
- Concluding remarks
Introduction

- Presentation limited to honey bees
  - No bumble bees and solitary bees

![Bumble bee](image1.png)

![Solitary bee](image2.png)

![Honey bee](image3.png)
Introduction

EFS A guidance: risks to honey bees to be assessed resulting from:
- contact exposure (during or shortly after application)
- consumption of water
  - guttation water, surface water, puddles
- consumption of nectar and pollen in hive

Possibly important but no guidance yet available:
- consumption of nectar and pollen outside hive (homing)
- consumption of honey dew
Introduction

Exposure assessment goal

- 90th percentile worst-case exposure considering colonies at edges of treated fields in area of use of substance
  - e.g. a certain crop in a certain Member State

- so statistical population of colonies includes not all colonies in landscape, but only those at edges of treated fields (more strict of course)

- exposure assessment goal is territory of SCFCAH

- 90th percentile has some tradition in SCFCAH since 1999
  - FOCUS groundwater & surface water, EFSA soil organisms
Introduction

Linking of effect and exposure assessment goals

- overall level of protection is combination of effect and exposure assessment goals
  - linked like Siamese twins

- link: effect assessment goal applies to 90th percentile exposure case

- effect assessment goal for honey bees: negligible effects on colonies
Introduction

Linking of effect and exposure assessment goals

- for substances without safety margin it may e.g. be like:
  - 90% of colonies: negligible effects
  - 7% of colonies: small effects
  - 2% of colonies: medium effects
  - 1% of colonies: large effects

- for substances with a large safety margin it is probably like:
  - 100% of colonies: negligible effects
Introduction

Linking of effects and exposure:

effect assessment uses results of exposure assessment
Contact exposure assessment

- Spray applications: contact with spray liquid

- Koch & Weisser: sodium fluorescein mass on bees returning to hive after downward spray applications in Phacelia
  - 5 field experiments in 4 years
Contact exposure assessment

- do bees fly through spray clouds?

- one-sided surface area of bee = 1 cm² approximately

- mass expressed as % of mass applied per 1 cm²
  - 100% = “full shower”
Contact exposure assessment

- bees collect considerably less than corresponds to their surface area
- $90^{th}$ percentile = highest of five experiments (10-30-50-70-90)
- thick dashed line used for downward spraying: only data from one source with one type of spraying equipment and one type of plant
- for upward spraying estimated exposure two times lower based on 9 experiments in apple orchards by Koch & Weisser
Contact exposure assessment

- seed treatments and granule applications: contact with dust

- no measurements

- exposure from spray is a matter of hours but dust is longer available

- dust may stick to hairs of foragers

- so dust exposure assumed to be 3 times higher than spray exposure
Exposure assessment for water consumption in hive

bees in hive need water; possible sources:
- surface water
- water from puddles
- guttation water

<table>
<thead>
<tr>
<th></th>
<th>surface water</th>
<th>puddle water</th>
<th>guttation water</th>
</tr>
</thead>
<tbody>
<tr>
<td>typical concentration</td>
<td>0.01 (without</td>
<td>0.1</td>
<td>100 seed</td>
</tr>
<tr>
<td>(mg/L)</td>
<td>mitigation)</td>
<td></td>
<td>treatments</td>
</tr>
<tr>
<td>preference of bees</td>
<td>++</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>likelihood of</td>
<td>known in</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>occurrence</td>
<td>landscape</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Exposure assessment for water consumption in hive

**surface water:**
- exposure assessment available
- effects on bees usually covered by aquatic effect assessment
  - not if substance more toxic to bees than to aquatic insects and crustaceans

**water from puddles:**
- likelihood of occurrence to be assessed considering location – calendar year combinations
  - 90th percentile remains yardstick
  - runoff risk mitigation not applicable
  - first tier based on FOCUS runoff scenarios

**guttation water:**
- likelihood of occurrence to be assessed considering location – calendar year combinations plus likelihood of use by bees
  - 90th percentile remains yardstick
- alternative water source is solution but no consensus on acceptability
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Exposure assessment for nectar and pollen consumption in hive

Exposure: function of application method and type of plant

Main sources of contamination of nectar and pollen:

<table>
<thead>
<tr>
<th>application</th>
<th>treated crop</th>
<th>adjacent crops</th>
<th>succeeding crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>sprays</td>
<td>uptake from overspray</td>
<td>spray drift</td>
<td>root uptake</td>
</tr>
<tr>
<td>seed treatments</td>
<td>uptake from seed coating</td>
<td>dust drift</td>
<td>root uptake</td>
</tr>
<tr>
<td>granules</td>
<td>uptake from dust deposition</td>
<td>dust drift</td>
<td>root uptake</td>
</tr>
</tbody>
</table>

Different sources have different drivers, so different flow charts needed for different application-plant combinations.
Exposure assessment for nectar and pollen consumption in hive

overall structure of exposure assessment for nectar/pollen entering the hive

registration based on certain application method so starting point for exposure assessment

schemes containing all relevant types of plants

flow charts for each type of plant

some flow charts are identical: e.g. sprays, seed treatments and granules use same flow chart for succeeding annual crops
Exposure assessment for nectar and pollen consumption in hive

- target is peak in time of average concentration entering the hive for acute toxicity and 5/10-d TWA for chronic toxicity

- bees collect nectar/pollen from different plants so concentrations from different types of exposed attractive plants needed
  - treated crop
  - weeds in treated field
  - plants in field margins
  - adjacent crops
  - succeeding crops

concentration in nectar (spray appl.)

Schatz & Wallner (2009)

Abbildung 50: Verlauf der Konzentration von Metconazo im Nektar von Volk 1 am Ihinger Hof

- time (days)
Exposure assessment for nectar and pollen consumption in hive

- Problem: no reliable models/measurements for linking concentrations in nectar/pollen in treated fields to average concentrations entering the hive
  - In September-2012 draft EFSA asked for such data: 1000 comments but no data
  - Landscape-level exposure assessment needed but yet impossible

- So conservative approach in lower tiers: for assessment of concentration entering the hive assume that foragers forage exclusively on one type of plant:
  - Treated crop
  - Weeds in treated field
  - Plants in field margins
  - Adjacent crops
  - Succeeding crops
Exposure assessment for nectar and pollen consumption in hive

same scheme for spray and granule applications

seed treatments: no weeds in treated fields:
  # not present at application
  # almost no root uptake

assess PEC in treated crop
1

assess PEC in weeds in treated field
2

assess PEC in field margins
3

assess PEC in adjacent crops
4

assess PEC in permanent crops next year and in succeeding annual crops
5

post-authorisation monitoring of concentrations entering the hive
Exposure assessment for nectar and pollen consumption in hive

Higher-tier field exposure experiments

- option in a number of flow charts for spray applications
  - treated crop or crop in treated field next year

- aim 90th percentile of peak concentration in nectar/pollen entering hive
  - five experiments and take highest number (10-30-50-70-90)

- problem: 1-ha treated field may lead to underestimation of concentration entering hive
  - because of dilution caused by “clean” bee-attractive plants
  - because later in agricultural practice more fields in foraging area will be treated with this plant protection product
Exposure assessment for nectar and pollen consumption in hive

Higher-tier field exposure experiments

- so no bee-attractive crops within radius of 2 km of hive and minimal other alternative forage
  - may lead to overestimation of concentration entering the hive if much alternative forage under normal agricultural practice
  - may still lead to underestimation of concentration entering the hive if too much alternative forage in experiment

- so need to measure at same time concentrations in nectar/pollen in treated field and in honey and pollen sacks of bees that enter hive

- nectar in treated field can be sampled either from plants or from honey sacks of bees foraging in treated field
Exposure assessment for nectar and pollen consumption in hive

Example: nectar concentrations after spraying 1 kg/ha at five locations in area of use

<table>
<thead>
<tr>
<th>Location nr</th>
<th>Conc. in treated field (mg/kg)</th>
<th>Conc. entering hive (mg/kg)</th>
<th>Foraging dilution factor (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>2</td>
<td>2.0</td>
<td>1.4</td>
<td>0.7</td>
</tr>
<tr>
<td>3</td>
<td>4.0</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>4</td>
<td>5.0</td>
<td>2.0</td>
<td>0.4</td>
</tr>
<tr>
<td>5</td>
<td>7.0</td>
<td>1.4</td>
<td>0.2</td>
</tr>
</tbody>
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no experience yet, so expert judgement needed for interpretation
e.g. large dilution in all cases may be due to repellency (to be substantiated by additional data or argumentation)
Exposure assessment for nectar and pollen consumption in hive

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Interpretation for this example case

- 90\textsuperscript{th} percentile is highest of five (10-30-50-70-90)
- 90\textsuperscript{th} percentile entering hive < 7 mg/kg (highest of treated fields)
- 90\textsuperscript{th} percentile entering hive probably close to 2 mg/kg if dilution factor of 0.4 is close to 90\textsuperscript{th} percentile dilution case
- whether this is the case may depend on e.g. market share
Exposure assessment for nectar and pollen consumption in hive

Higher-tier field exposure experiments

- nectar concentrations used in effect assessment for calculation of daily intake of the plant protection product by the bees
- daily intake based on sugar demand
  - 500 mg nectar with 10% sugar = 250 mg nectar with 20% sugar
- so concentrations in nectar should be in mass of substance per mass of sugar, not per mass of nectar
- therefore sugar content of all samples should be measured
Exposure assessment for nectar and pollen consumption in hive

Higher-tier field exposure experiments

linking to the effect field studies

- protection goal: negligible effect for 90% of colonies at edge of treated fields

- so in effect field studies concentrations entering the hive should be at least as high as the 90th percentile from the field exposure experiments
  - so no bee-attractive crops within radius of 2 km of hive and minimal other alternative forage

- for adequate interpretation also in effect field studies nectar/pollen concentrations should be measured both in treated field and in honey and pollen sacks of bees that enter hive
  - nectar concentrations again on sugar basis

- if large dilution due to repellency, then additional data or argumentation needed

- no experience so far, so expert judgement needed on case-by-case basis
Concluding remarks

- **exposure assessment of honey bees is quite complex:**
  - contact
  - consumption of water
  - consumption of nectar and pollen
    - many flow charts to be followed in parallel
  - in addition different diets for foragers, nurses and larvae

- **no experience so far with application of higher tiers of guidance to dossiers so case-by-case expert judgement needed**
Thank you for your attention!