WHICH SPECIES SHOULD WE MODEL?
EXAMPLES OF HOW TO DEFINE FOCAL SPECIES FOR THE RISK ASSESSMENT OF PLANT PROTECTION PRODUCTS

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All photos: wikipedia.org
OUTLINE

- What do we want to protect?
  - Vulnerability concept
- Focus on population models
- Four approaches to select the species to be modelled
  - Standard species
  - Protected species
  - Species identified in higher tier tests
  - Species selected based on trait analysis
- Summary

Acute Effect Assessment    Chronic Effect Assessment

**Specific Protection Goal**

RAC\textsubscript{sw,ac} – derivation (linked to PEC\textsubscript{sw,max})

Tier-4: Field studies and landscape level models

RAC\textsubscript{sw,ch} – derivation (linked to PEC\textsubscript{sw,max} or PEC\textsubscript{sw,twa})

Tier-3: Population and community level experiments and models

Tier-2: Acute lab tests with additional species and/or refined exposure

Tier-1: Core acute toxicity data

Tier-2: Chronic lab tests with additional species and/or refined exposure

Tier-1: Core chronic toxicity data

Ecological realism

Complexity (data)

Aquatic Guidance Doc, EFSA PPR panel (2013)
The species to be modelled depends on the protection goal of the assessment

- General protection goals: ‘no unacceptable effects on the environment…impact on biodiversity and ecosystem’ (Reg 1107/2009)
- Currently the EU is working on defining specific protection goals based on the ecosystem services approach (see EFSA GD 2016)
- This includes the identification of services which might be affected and the ‘service providing units’ or ‘key drivers’ which are most relevant for the services
- The approach has been used already e.g. in the aquatic guidance document (EFSA PPR panel 2013)
- However, this definition stops at a relatively high level since only groups are listed as aquatic key drivers, i.e. algae, plants, invertebrates, vertebrates and microbes
- Thus, if models should be used for risk assessment it is often still to be decided which species should be considered
Species to be modelled should be vulnerable to the stressor

- The **vulnerability** concept was introduced by van Straalen (1994)

![Venn diagram showing Exposure, Sensitivity, and Resilience/recovery](image)
There are four approaches (in my view) to select the species for modelling in pesticide risk assessment

- Reed et al. (2018):
  ‘When choosing the species to model, a conflict is seen between species with good laboratory toxicity data, species with good field data, and ecologically relevant species.’

- For the following approaches examples will be given
  1. Using the standard test species
  2. Considering status of protection of species
  3. Evidence from higher tier tests
  4. Trait based approaches
At the lower tiers, there is no need to define a focal species

- The Tier 1 species are defined by the legal data requirements
- They are most often surrogate test species to measure intrinsic sensitivity
- Intrinsic sensitivity is not related to geographical distribution and also not necessarily to the recovery potential
- Thus, practicability of culturing and testing in the lab is an important criterion for selection
- The protection of vulnerable species is assumed to be achieved by the use of assessment factors

- This is also the case for the lowest level of effect models, toxicokinetic-toxicodynamic models (TKTD models) used to address time variable exposure
- The modelling is usually done for the most sensitive tier 1 species and thus, the Tier 1 assessment factor is still be used
Also population models can be developed for the standard species, but…

### Standard species

- Population modelling standard test species is attractive since information on the performance of control organisms and toxicity data available
- On the other hand, field data on population dynamics might not be available for the test species
- Test species are often not vulnerable with respect to reproduction → predictions of recovery under field situation can be misleading
- Thus, such models can be useful to extrapolate from individual level to population level effects but the uncertainty in the extrapolation to the species to be protected in the field has to be considered with care
- Reed *et al.* (2018): Population modeling should address ecologically relevant species.

### Focal species?

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*E. fetida*  
*A. calliginosa*  
*L. terrestris*

All photos: wikipedia.org
The status of protection can be a criterion, e.g. in the US, the Endangered Species Act can trigger population modelling in pesticide risk assessment.

Schmolke et al. (2018): Mead’s Milkweed

Schmolke et al. (2019): Topeka shiner
Higher tier data can suggest species to be modelled

- Aquatic mesocosm studies, soil or arthropod field tests or monitoring studies can identify vulnerable species
- Population modelling can be used to extrapolate from these tests, e.g.
  - to other exposure patterns
  - to other environmental conditions (e.g. other weather conditions)
  - to longer-term dynamics and recovery
- Examples: Models for *Daphnia*, *Chaoborus*, *Asellus*, *Gammarus*, …
Focal species for pesticide risk assessment are already defined for birds and mammals

Effect assessment

Exposure assessment

Focal species

depending on crop, zone and type of ppp

- Relevant traits

  Distribution & habitat - presence in crop?

  Diet and foraging - feeding on contaminated food?

  Feeding rate / body weight?

- e.g. Japanese quail

- e.g. sky lark as focal omnivorous species in cereals

EFSA (2009) B&M guidance doc

photos: wikipedia.org
The focal B&M species can be considered to be relevant vulnerable species for risk assessment and thus, some models have already been developed

- **Almass (Animal, Landscape and Man Simulation System)** includes population spatial explicit population models for several birds & mammal (but also other) species in EU agricultural landscapes, e.g.
  - Eurasian Skylark (*Alauda avensis*)
  - Field Vole (*Microtus agrestis*)
  - Grey Partridge (*Perdix perdix*)
  - European Brown Hare (*Lepus europaeus*)

- But also other models are available, e.g. for
  - Common vole (Wang M. 2013)
  - Wood mouse (Liu et al. 2013)
  - an others…
Species traits driving exposure and recovery can be used to rank species based on ecological vulnerability

- **Multi-criteria approach**, using weight factors assigned through expert judgment, to weigh the relative contribution of each ecological characteristic to overall vulnerability.

- Results for NTA example (De Lange et al., 2012)
  - For insecticides, herbicides and fungicides, the average vulnerability of typical off-crop species was higher than that of typical in-crop species.
  - The difference between off-crop and in-crop species can be explained by differences in exposure and especially recovery.
  - The standard test non-target arthropods were found to be less vulnerable.

<table>
<thead>
<tr>
<th>Trait class</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure habitat on soil (endogeic)</td>
<td>0</td>
</tr>
<tr>
<td>Exposure habitat on soil (epigeic)</td>
<td>0.5</td>
</tr>
<tr>
<td>Exposure on canopy or flying food</td>
<td>1</td>
</tr>
<tr>
<td>Food prey</td>
<td>0</td>
</tr>
<tr>
<td>Food nectar/pollen</td>
<td>0.5</td>
</tr>
<tr>
<td>Food vegetation</td>
<td>1</td>
</tr>
<tr>
<td>Breeding period autumn</td>
<td>0</td>
</tr>
<tr>
<td>Breeding period spring</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trait</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery dispersion</td>
<td></td>
</tr>
<tr>
<td>Recovery flying</td>
<td>0</td>
</tr>
<tr>
<td>Recovery ballooning</td>
<td>0.333</td>
</tr>
<tr>
<td>Recovery walking and flying</td>
<td>0.667</td>
</tr>
</tbody>
</table>

For trait based approaches in more detail, see the presentation by Andrea R. Rico:

What to model? Selecting vulnerable species and landscape parameters for the development of ecological scenarios.
Simple population models can support the identification of focal species

- Fish tests are usually conducted with species not native to Europe (e.g. rainbow trout, zebra fish)
- What could be focal fish species for pesticide risk assessment in the EU?

1. Exposure potential
   - Review information on geographical distribution and habitat preferences of freshwater fish in Europe
     - Native to Europe?
     - Inhabit streams, ditches or ponds?
     - Widespread in at least 1 of the 3 EU mutual recognition zones?
     - Living in streams, ditches or ponds?

→ List of 27 widespread and potentially exposed fish species in the EU

579 freshwater fish species in Europe

27 species highly susceptible to pesticide exposure

Ibrahim et al. (2013) ESPR 20(4): 2679-2687
Simple population models can support the identification of focal species

Fish tests are usually conducted with species not native to Europe (e.g. rainbow trout, zebra fish)

What could be focal fish species for pesticide risk assessment in the EU?

2. Population resilience/recovery

- Using matrix models to assess the sensitivity of population growth rate to changes of
  - juvenile survival
  - adult survival
  - and fecundity

- If the focus is on effects on fecundity, the European minnow was found most vulnerable

Ibrahim et al. (2013) ESPR 20(4): 2679-2687
Simple population models can support the identification of focal species

- Fish tests are usually conducted with species not native to Europe (e.g. rainbow trout, zebra fish)
- What could be focal fish species for pesticide risk assessment in the EU?
- E.g. IBM of the minnow (Ibrahim 2015)

### 3. Sensitivity

- Usually no toxicity data available for focal species
  - Use the one of the most sensitive species
  - Use the one of the taxonomically closest species
  - Use models to extrapolate species sensitivity
Summary: Which species should we model?

- **TKTD models**: need to stick to the test species and keep the standard assessment factors to deal with all the uncertainties not addressed by the model.

- **Population models**: Often it is not the best idea to use the standard test species if it is not vulnerable.

- There is not only the ‘Myth of the most sensitive species’ (Cairns 1986) – there is also no most vulnerable species within a taxonomic group:
  - The likelihood of exposure depends also on where and when the pesticide is used.
  - Modes of action and species traits determine the species sensitivity.
  - However, population resilience to different effects can be assessed in a generic way.

- The selection of focal species for population modelling can be driven by:
  - Status of protection, e.g. species listed in the Endangered Species Act in the US.
  - Higher tier data, e.g. SSD or field tests identify an (ecologically) vulnerable species also as sensitive.
  - Trait based analysis of vulnerability.
Where we are - a very first draft

<table>
<thead>
<tr>
<th>Group</th>
<th>Typical tier 1 test species</th>
<th>Native in EU?</th>
<th>Ecol. vulnerable</th>
<th>Focal species defined?</th>
<th>Available pop models for ERA (examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bird &amp; Mammals</td>
<td>Japanese or Bobwhite quail, Rat</td>
<td>No</td>
<td>Yes, EFSA (2009) for exposure assessment, very detailed,</td>
<td>several, e.g. skylark, common / field vole, hare</td>
<td></td>
</tr>
<tr>
<td>Amphibian &amp; Reptiles</td>
<td>none</td>
<td>No</td>
<td></td>
<td>Proposed 6 species in EFSA PPR panel (2018)</td>
<td>In prep. (great crested newt)</td>
</tr>
<tr>
<td>Fish / amphibia</td>
<td>Rainbow trout, Zebrafish, Medaka, Fathead Minnow</td>
<td>No</td>
<td></td>
<td>Not officially</td>
<td>E.g. Zebrafish, Fathead, Stickleback, European minnow</td>
</tr>
<tr>
<td>Aquatic invertebrates</td>
<td>Daphnia, Chironomus, Americamysis, Lumbriculus</td>
<td>Yes, except A. bahia</td>
<td>No</td>
<td>No (but SSD and Mesocosms)</td>
<td>Daphnia, Chaoborus, Asellus, Gammarus</td>
</tr>
<tr>
<td>Macrophytes</td>
<td>Lemna sp., Myriophyllum sp., Glyceria maxima</td>
<td>yes Partly</td>
<td>No (but SSD and Mesocosms)</td>
<td>Lemna sp., M. spicatum</td>
<td></td>
</tr>
<tr>
<td>Algae</td>
<td>Green algae (P. subcapitata, 2nd species)</td>
<td>yes ?</td>
<td>No (but SSD and Mesocosms)</td>
<td>P. subcapitata, D. subspicatus</td>
<td></td>
</tr>
<tr>
<td>Soil</td>
<td>Earthworm (Eisenia fetida)</td>
<td>yes ?</td>
<td>No (but field tests might help) EFSA SO (2017) with SPGs for other groups</td>
<td>E. fetida, L. terrestris, L. rubellus, F. Candida</td>
<td></td>
</tr>
<tr>
<td>Terrestrial plants</td>
<td>At least 6 species (usually crop species)</td>
<td>-</td>
<td>?</td>
<td>No. Focus in EFSA SO (2014) is more on test species</td>
<td>Community models</td>
</tr>
<tr>
<td>Non Target Arthropods incl.</td>
<td>Honeybee, bumble bee</td>
<td>yes ?</td>
<td>Honey bee, but no official list of other focal species, groups of key drivers in EFSA SO (2015)</td>
<td>Honeybee Carabid beetle Linyphiid spider</td>
<td></td>
</tr>
<tr>
<td>bees</td>
<td>Aphid parasitoid (A. rhopalosiphi)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Predatory mite (T. pyri)</td>
<td></td>
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</tbody>
</table>
I am happy to answer any further questions

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