How pesticides are affecting earthworms?

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Anthropic activities and threats to ecosystems

Biomonitoring procedures

Ellenberg et al. 1991
Anthropic activities and threats to ecosystems

Biomonitoring procedures

Ellenberg et al. 1991
Bioindicators
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- Assess the impacts
- Describe the systems
- Follow their evolution
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- Representativity
- Functional role
- Sensitivity (« agri »)
- - - - - Bioindicators

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C. Fritsch

*Representativity*

*Functional role*

*Sensitivity (« agri »)*
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Representativity

Functional role

Sensitivity (« agri »)
- Assess the impacts
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- Functional role
- Sensitivity (« agri »)

- Physiological, morphological, phenological or behavioral changes/responses
Earthworm sensitivity to pesticides

*Eisenia fetida*
Earthworm sensitivity to pesticides

Since the 80’s
Short generation time
Easy to breed

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ISO 11268. Soil quality - effects of pollutants on earthworms (*Eisenia fetida*)
1. Determination of *acute toxicity* using artificial soil substrate (1993)
2. Determination of effects on *reproduction* (1998)

ISO 17512-1, 2008. Soil quality - avoidance test for determining the quality of soils and effects of chemicals on *behaviour* – Test with earthworms (*Eisenia fetida* and *Eisenia andrei*).
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Tests for the registration of pesticides
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Ecotoxicological studies

Pelosi et al. 2014
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Earthworm sensitivity to pesticides

Eisenia fetida

(LC50: lethal concentration for 50% of exposed individuals)

Meta-analysis
Pelosi et al. 2013, Chemosphere
Earthworm sensitivity to pesticides

Eisenia fetida

<

2 times less sensitive

(LC50: lethal concentration for 50% of exposed individuals)

Meta-analysis
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Earthworm sensitivity to pesticides

\textbf{Aporrectodea caliginosa} < 2 times less sensitive

\textit{Eisenia fetida}

More than 3 times less sensitive

(LC50: lethal concentration for 50% of exposed individuals)

\textit{Meta-analysis}

\textit{Pelosi et al. 2013, Chemosphere}
Earthworm sensitivity to pesticides

Species found in natural conditions
- *Eisenia fetida* (natural conditions)
- *Aporrectodea caliginosa* (natural conditions)

Realistic concentrations (Recommended Dose)
- Natural soils
- Commercial formulations: Representative of practices for cereal crops
- Potential effects (toxic reference values – recommended dose)

(LC50: lethal concentration for 50% of exposed individuals)

Meta-analysis
*Pelosi et al. 2013, Chemosphere*
Effects at different levels of biological organization

- Gene
- Cell
- Individual
- Population
- Community
- Ecosystem
Effects at different levels of biological organization

⇒ Overview of the potential effects at the different levels of organization
At the gene level

DNA damage

ATANOR 48®, chlorpyrifos, insecticide, *E. fetida andrei*

97% damage (compared to the control)

Casabé et al. 2007
At the cell level

Opus®, epoxiconazole, fungicide, *Allolobophora icterica*

Transitory effects on an **enzymatic activity** (cell defense towards oxidative stress)

+ decrease in **energy reserves**

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**GST activity**  
(glutathione-S-transferase)

Pelosi et al. 2016
At the individual level

Swing Gold®, fungicide, epoxiconazole & dimoxystrobin, *Aporrectodea caliginosa*

**Reproduction:** RD: - 35% cocoons, - 20% hatchlings
3 RD: - 50% cocoons, - 33% hatchlings, + 5 days to hatch

**Growth:** + 9 days to become adult

Bart et al., in prep.
At the population level

Organic and conventional cropping systems

Loamy soils, neutral pH, ploughed, winter wheat, organic inputs (type and proportions)
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Loamy soils, neutral pH, ploughed, winter wheat, organic inputs (type and proportions)

The more an earthworm species lives near the soil surface, the more it is affected by pesticide applications

Pelosi et al. 2013
At the population level

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Pelosi et al. 2013
At the community level

García-Pérez et al. 2014

Shaded coffee plots
With and without glyphosate application

García-Pérez et al. 2014
At the ecosystem level

Confidor®, imidacloprid, insecticide, *Aporrectodea nocturna*

Predictive Environmental Concentration

Burrowing behavior => soil structure

Capowiez et al. 2006
At the ecosystem level

Confidor®, imidacloprid, insecticide, *Aporrectodea nocturna*

Predictive Environmental Concentration

Burrowing behavior => soil structure

- 40% gas diffusion

Capowiez et al. 2006
All the pesticides

No effects

Ecosystem

Community

Population

Individual

Cell

Gene

Time

Space

Conclusion
Conclusion

Some pesticides commonly used in Europe at realistic concentrations => negative effects on earthworms
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Some pesticides commonly used in Europe at realistic concentrations => negative effects on earthworms
Lines of though for risk assessment

- Pre-registration procedures
  - Representative and sensitive species => ISO norms (annex)
  - Other relevant endpoints e.g., growth, behavior => life cycle (population dynamics)
Lines of thought for risk assessment

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• Pre-registration procedures
  - Representative and sensitive species => ISO norms (annex)
  - Other relevant endpoints e.g., growth, behavior => life cycle (population dynamics)

• Post-registration
  - Field studies (confounding factors e.g., agricultural practices)
  - Exposure of non-target organisms at the landscape scale, effects at higher trophic levels
Thanks for your attention

“Without the work of this humble creature, who knows nothing of the benefits he confers upon mankind, agriculture, as we know it, would be very difficult, if not wholly impossible”

CHARLES DARWIN, 1881
40 references (1995 - 2018): glyphosate or AMPA

→ Mortality: do not affect the survival of earthworms (4 studies)
→ Biomass: decrease in biomass (2 studies)
→ Avoidance (2 studies)
→ Viability of cocoons: neutral (1 study) or negative effects (2 studies)
→ Nutrition activity: neutral (1 study) or negative effects (2 studies)

Very few studies under field conditions

Trans-generational effects