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

- Assess the impacts
- Describe the systems
- Follow their evolution
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- Representativity
- Functional role
- Sensitivity (« agri »)
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C. Fritsch

Soil profile

Epigeics
Endogeics
Anecics
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Bioindicators

C. Fritsch

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Bioindicators

Representativity
Functional role
Sensitivity (« agri »)

Physiological, morphological, phenological or behavioral changes/responses

C. Fritsch

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Soil profile

Epigeics

Anecics
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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→ **Tests for the registration of pesticides**

→ **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

\[ < \]

2 times less sensitive

(Eisenia fetida)

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

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\[ Aporrectodea\ caliginosa \]

\[ \begin{array}{c}
\text{2 times less sensitive} \\
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\end{array} \]

\[ \begin{array}{c}
\text{More than 3 times less sensitive}
\end{array} \]

\[ Eisenia\ fetida \]

*Meta-analysis*  
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Earthworm sensitivity to pesticides

Aporrectodea caliginosa

More than 3 times less sensitive

Eisenia fetida

<

2 times less sensitive

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

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

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

**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)
At the population level

Organic and conventional cropping systems

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

[Graph showing the impact of herbicide on earthworm and cocoon density]
At the ecosystem level

Confidor®, imidacloprid, insecticide, *Aporrectodea nocturna*

Predictive Environmental Concentration

Burrowing behavior => soil structure

Control

0.1 ppm

0.5 ppm
At the ecosystem level

Confidor®, imidacloprid, insecticide, *Aporrectodea nocturna*

Predictive Environmental Concentration

**Burrowing behavior => soil structure**

- 40% gas diffusion

Capowiez et al. 2006
Conclusion

All the pesticides
Conclusion

All the pesticides

No effects
Some pesticides commonly used in Europe at realistic concentrations => negative effects on earthworms
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Lines of thought for risk assessment

• Pre-registration procedures

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