Deployment of a citizen science approach to study earthworm communities at the regional scale

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Introduction

The biodiversity of urban soils and the ecosystem services they provide remain largely understudied (Beninde et al. 2015), particularly for key organisms such as earthworms (Schmidt et al., 2024). Earthworms contribute significantly to soil health and ecosystem services (Blouin et al. 2013), including in urban areas (Steinberg et al., 1997), and are considered to be good bioindicators for soil sustainability (Paoletti, 1999).
Due to the difficulties inherent to sampling earthworms, mainly because of the time spent and the lack of funding, new monitoring methods are necessary to obtain large quantities of data, especially in understudied areas. Citizen science has been a rising and effective method for developing monitoring programs in soil and especially regarding earthworms (Burton, 2024; Mason et al. 2024).

This study evaluates the deployment of citizen science based monitoring program in the Ile de France region of France, which is characterised by a high percentage of urban landscapes.

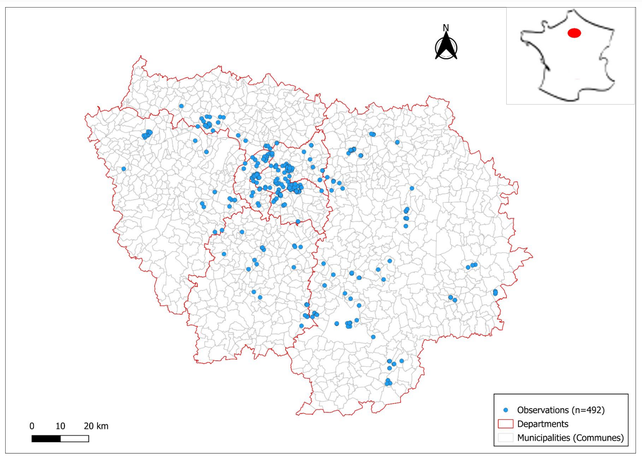
Who are the citizen scientists who participate in earthworm monitoring ?

What kind of earthworm communities can be observed in a highly urbanised region of France ?

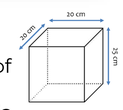
Materials & methods

Monitoring deployment method

1. **Preliminary diagnosis** : identifying existing networks that have a high territorial coverage in order to easily recruit participants and ensure their continuation
2. **Network mobilisation** : contacting regional and local stakeholders, informing group leaders about soil biodiversity and ecosystem services rendered, developing a sampling strategy, teaching the sampling protocol to operators and participants, co-organising sampling campaigns
3. **Logistical organization** : collecting needs from sampling groups,, preparing and shipping of ethanol vials for earthworm collection, sending necessary field documents
4. **Support for field sampling** : accompanying the most implicated networks for sampling sessions, accompanying all networks by mail / telephone during the sampling period
5. **Field data analysis** : collecting soil and management practices data, receiving vials containing sampled earthworms, taxonomic analysis at the lab, implementing the database, data analysis
6. **Feedback** : producing feedback sheets per plot / observation and per stakeholder group, organising feedback sessions in person or online



Sampling protocol



- Each earthworm sampling consisted of extracting **6 blocks** of soil (20 cm × 20 cm × 25 cm, length × width × depth)
- Earthworms were sent to the lab for **counting, taxonomic identification** (Bouché, 1972), and categorization of morphotypes

Available data

- **492 observations** were made in the Ile de France region between 2016 and 2023.
- **390 observations** were kept for all earthworm analysis, after a selection for homogeneous protocol conditions and coherent soil use.

Statistical analysis

- Kruskal-Wallis tests were performed to compare earthworm abundance, biomass and species richness per soil use ,
- Post-hoc Dunn tests were performed for pairwise comparisons.

Results

Citizen scientist dynamics

- Between 2016 and 2023, **80 unique organizations** participated in our monitoring program and sampled at least one site
- Of these organizations, **42% were collectivities** and **29% were gardening associations** (Fig.1.b)
- Similarly, **collectivities** were responsible for **45% of the observations**, while **gardening associations** were responsible for **32% of observations** (Fig.1.a)
- On average, **23 municipalities were sampled each year**, for a **total of 95 municipalities** (or inter-municipalities)

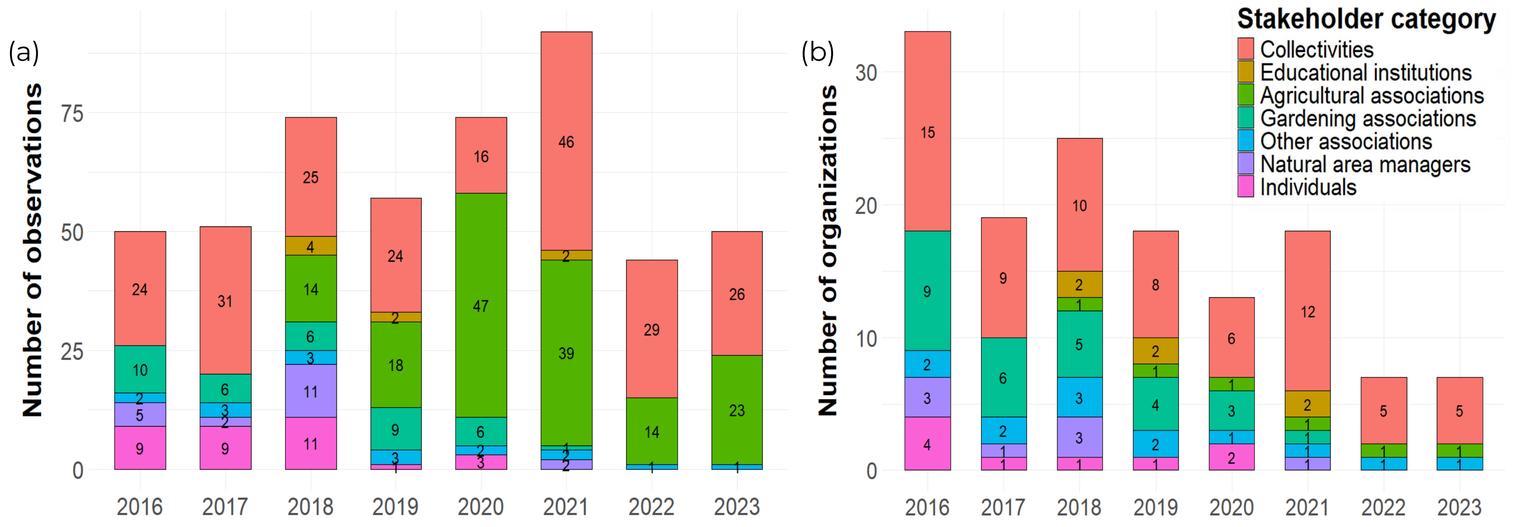


Fig. 1. Number of sites sampled each year, by stakeholder category (a) and Number of unique organizations that sampled at least one site, per year and per stakeholder category (b).

Earthworm abundance and species richness

- Between 2016 and 2023, out of **390 samplings**, 38% were urban lawns and grasslands, 16% field crops, 13% urban vegetable gardens, 10% urban ornamental beds, 8% agroforestry fields, 7% forests and woodlands, 3% market gardening plots, 3% were grass strips and 2% agricultural grasslands
- A total of **45 different earthworm species** were observed in the Ile de France region during this monitoring program
- There is a **significantly higher mean earthworm abundance (ind/m²) in urban ornamental beds, urban vegetable gardens and agroforestry fields than in forests and woodlands** (Fig.2.)
- There is a **significantly higher earthworm species richness in urban vegetable gardens than in field crops** (Fig.2.)
- There is a **significantly higher mean earthworm biomass (g/m²) in urban vegetable gardens than in field crops**

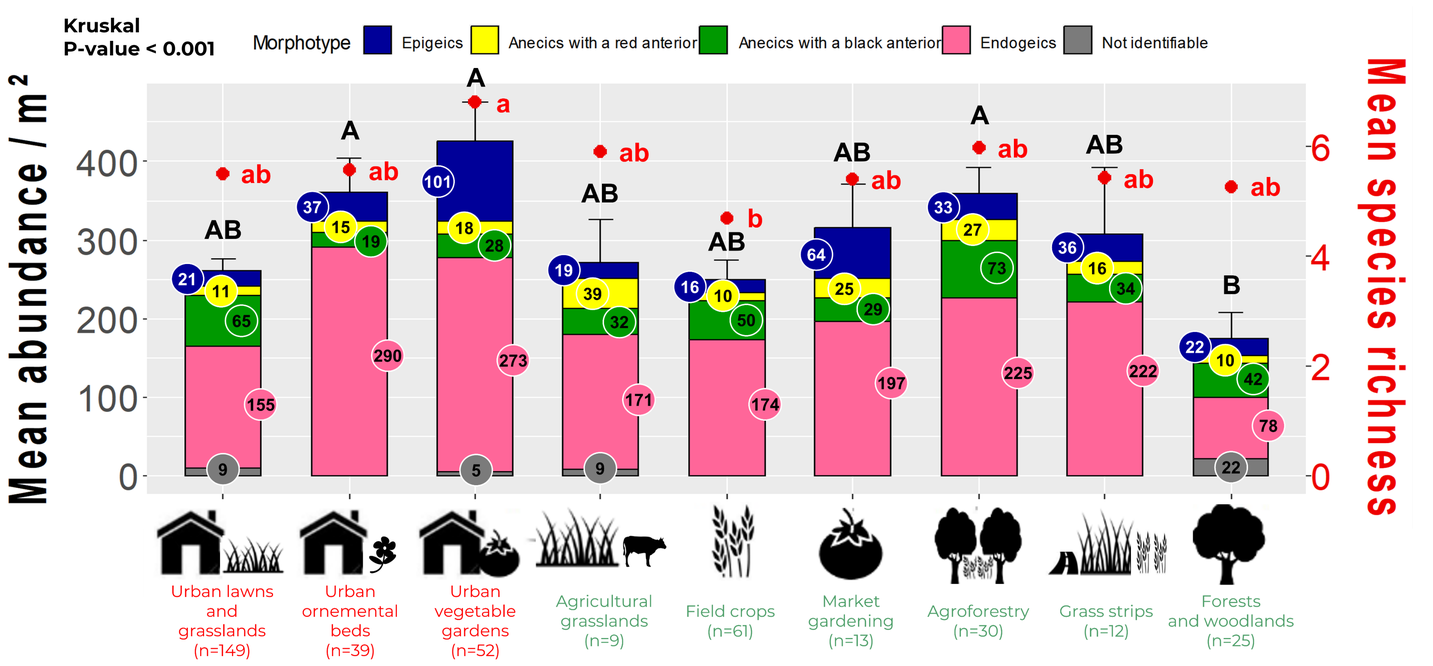


Fig. 2. Mean earthworm abundance (left y axis, bar plots) by morphotype, and species richness (right y axis, red dots) by soil use in the Ile de France region from 2016 to 2023 (n=390). Bars represent standard deviations of the means. Different letters (black uppercase for the total abundance and red lowercase for species richness) denote significant difference between the treatments based on post-hoc Dunn's test with a > b.

Highlights

- A regional earthworm monitoring program using a citizen science approach was successfully developed in the Ile de France region of France, with now 8 years of available data, with an average of more than 60 observations per year (and still ongoing).
- Collectivities and gardening associations were the biggest driving forces within citizen scientists, with collectivities being also the most stable participants throughout the years
- Urban soils, particularly ornamental beds and vegetable gardens, have similar or sometimes higher abundances and species richness compared to agricultural or even natural soils, suggesting that earthworms keep providing essential ecosystem services even in urban areas

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