



Focus on collembolans: their role in ecosystem and their use as bioindicators of soil quality – Case studies from Europe and Campania region

*Biodiversity and bioindicators in monitoring and management of contaminated soils
Portici, 4-7 June 2019*

Lucia Santorufo, Giulia Maisto



Summary

01

Characteristics of collembolans

Origin
Taxonomy
Anatomy
Diet
Reproduction

02

Ecology of collembolans

Distribution
Soil distribution
Role in ecosystem

03

Collembolans as bioindicators

Land uses
Agricultural practices
Contaminants
Functional approach

04

Conclusions

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Characteristics of collembolans



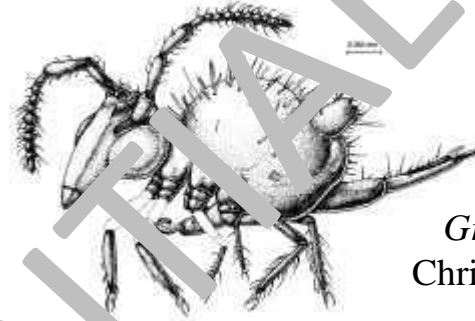
Characteristics of collembolans: Origin

Ecology of collembolans

Bioindication

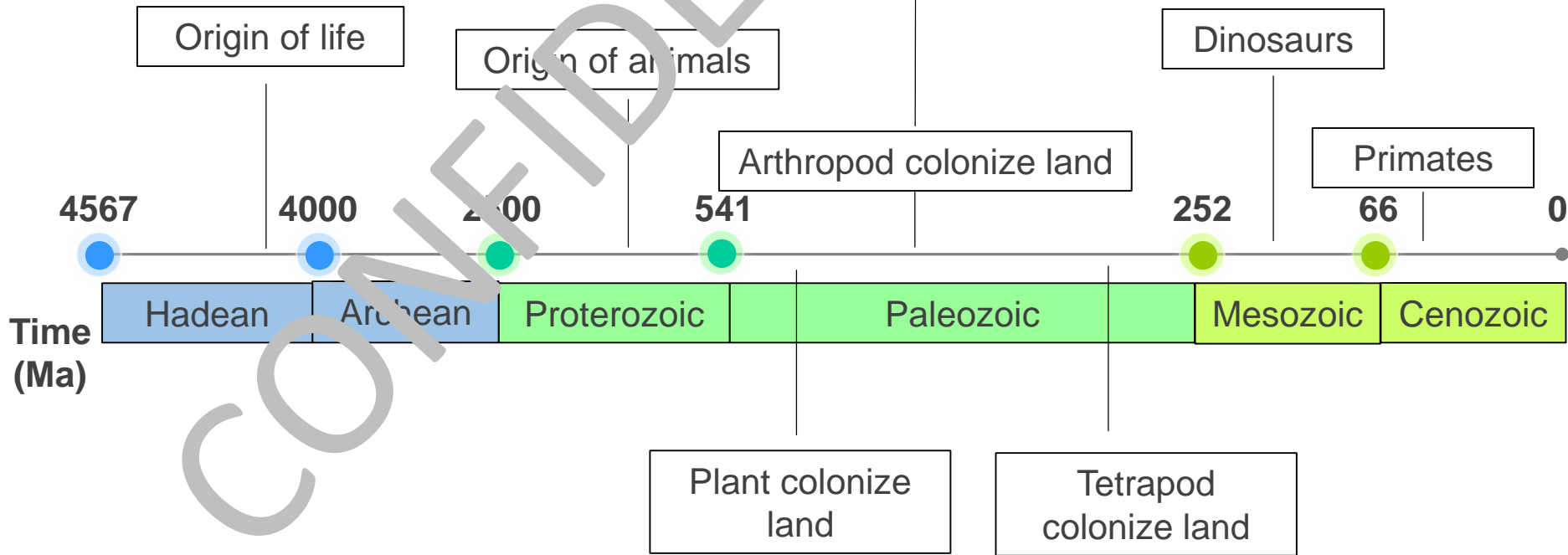
Conclusions

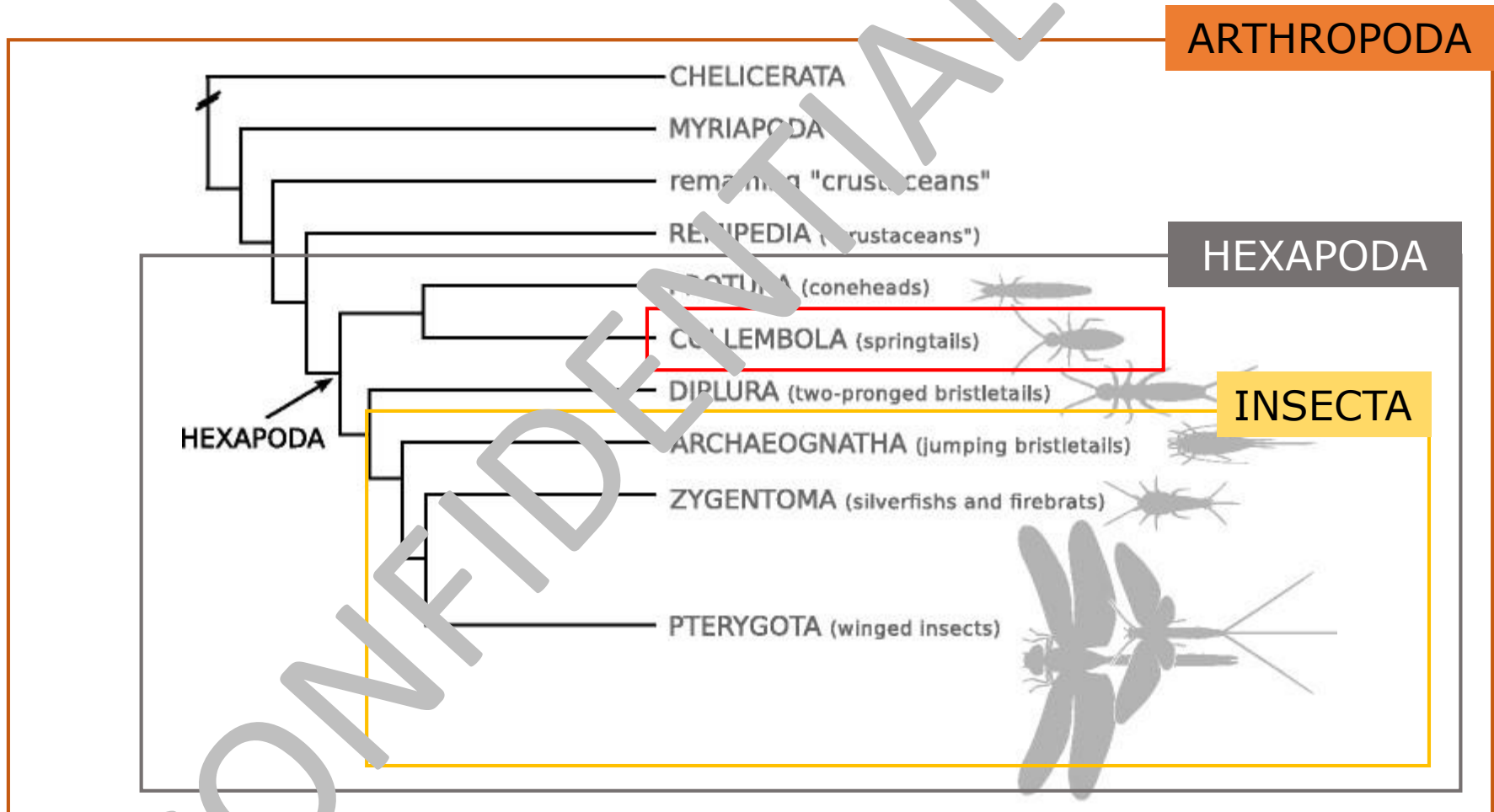
Among the oldest known records of terrestrial animals



Grinnellia ventis reconstruction
Christiansen and Nascimbene, 2006

First recorded collembolans





- ~9000 known species of collembolans
- supposed to be between 50,000 to 65,000
- 100 new species are described in the latter 10 years

Characteristics of collembolans: Anatomy

Ecology of collembolans

Bioindication

Conclusions

Small 1-5 mm (min. 0.12; max.17 mm)

Wingless hexapods with antennae always present



**Characteristics of collembolans:
Anatomy**

Ecology of collembolans

Bioindication

Conclusions

Small 1-5 mm (min. 0.12; max.17 mm)

Wingless hexapods with antennae always present



Ventral tube

Collembola (*Lubbock 1870*):
colla (Latin): glue
embolon (Greek): projection

Furcula

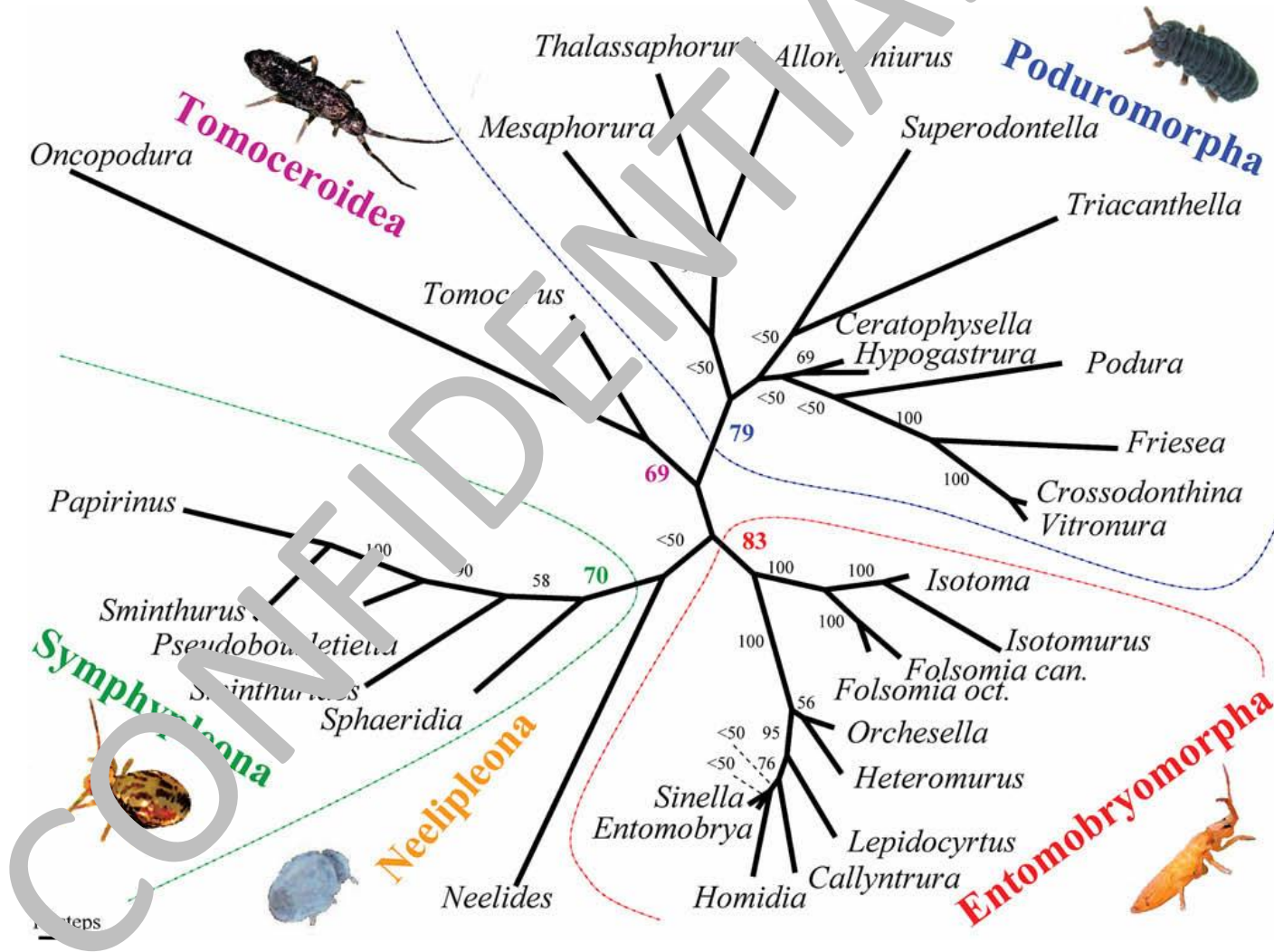
Springtail: when furcula is released it springs the organisms into the air

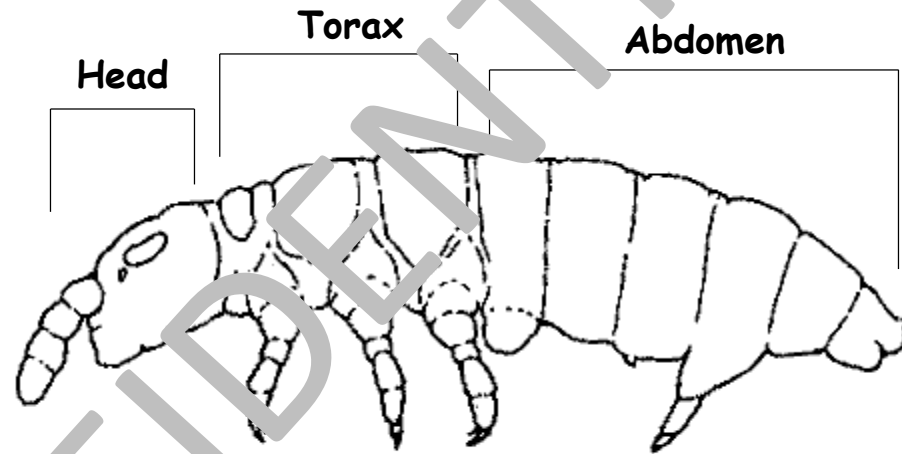
Characteristics of collembolans: Diversity

Ecology of collembolans

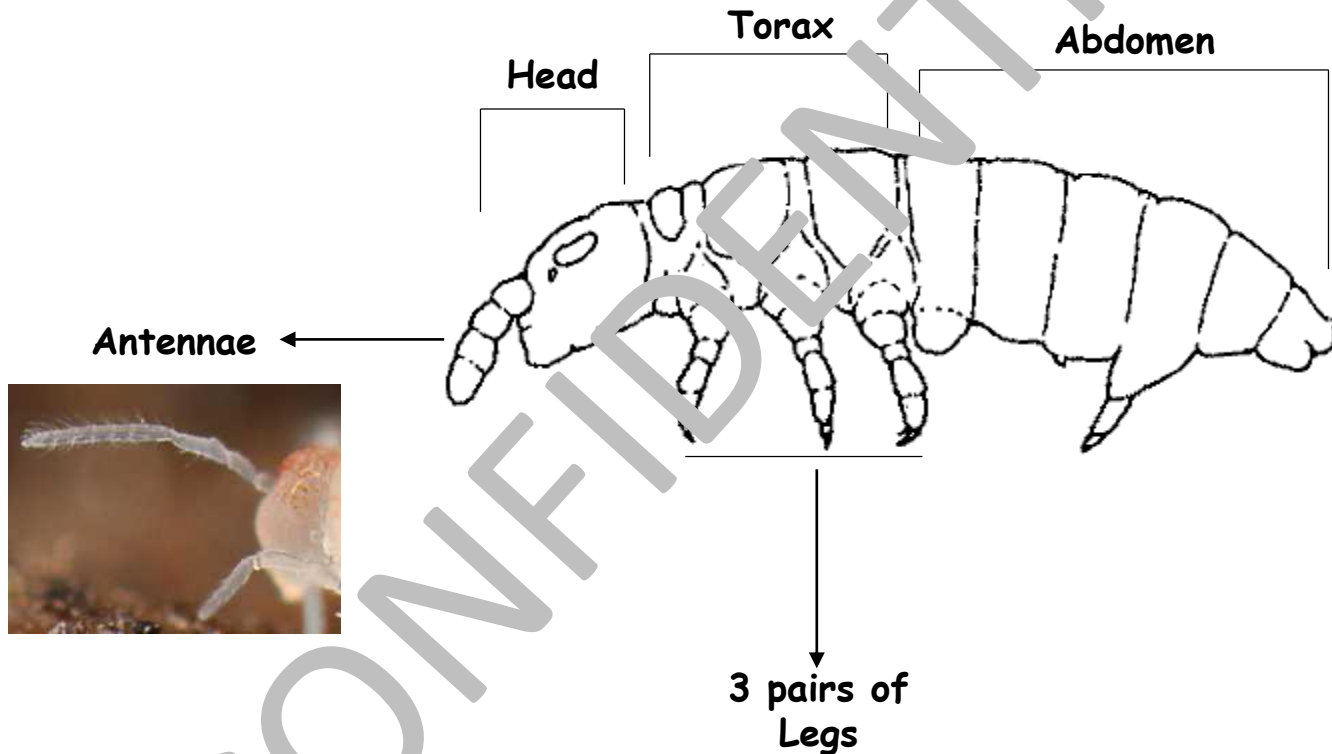
Bioindication

Conclusions





Always present

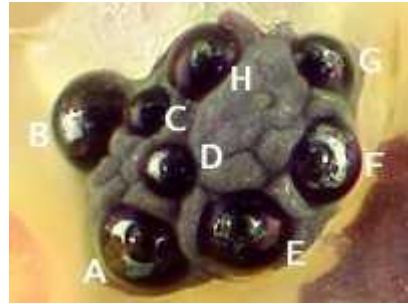


Characteristics of collembolans: Identification

Ecology of collembolans

Bioindication

Conclusions



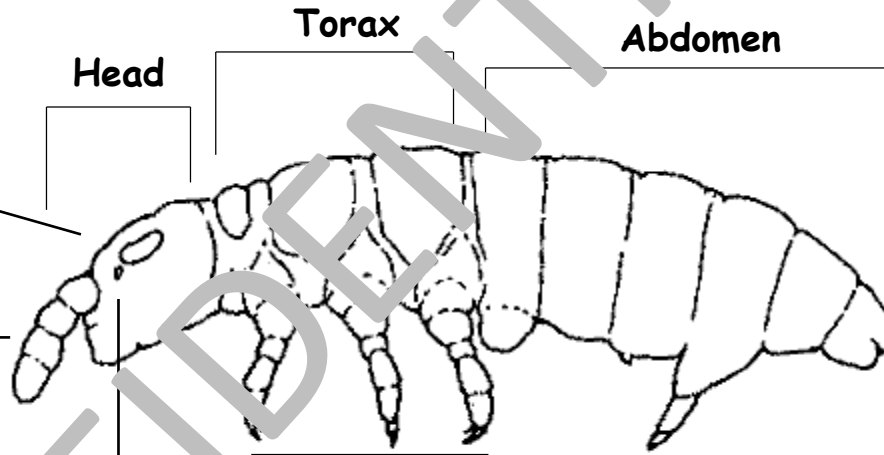
Eyes

Antennae



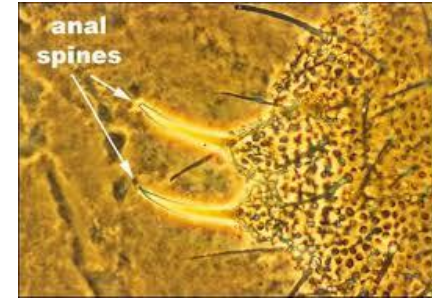
Post-antennal organ (PAO)

May have



3 pairs of Legs

Furca



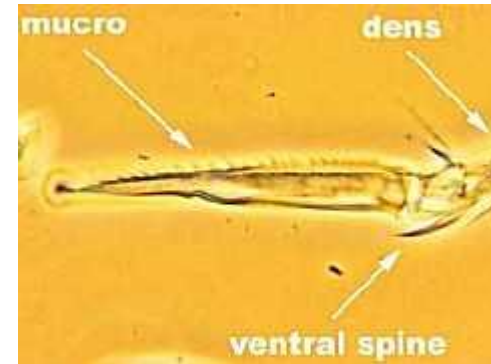
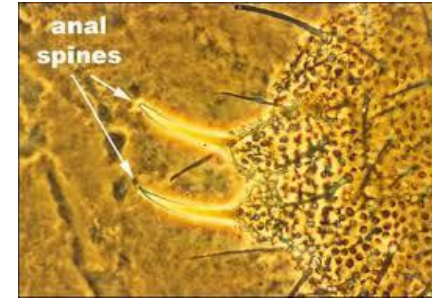
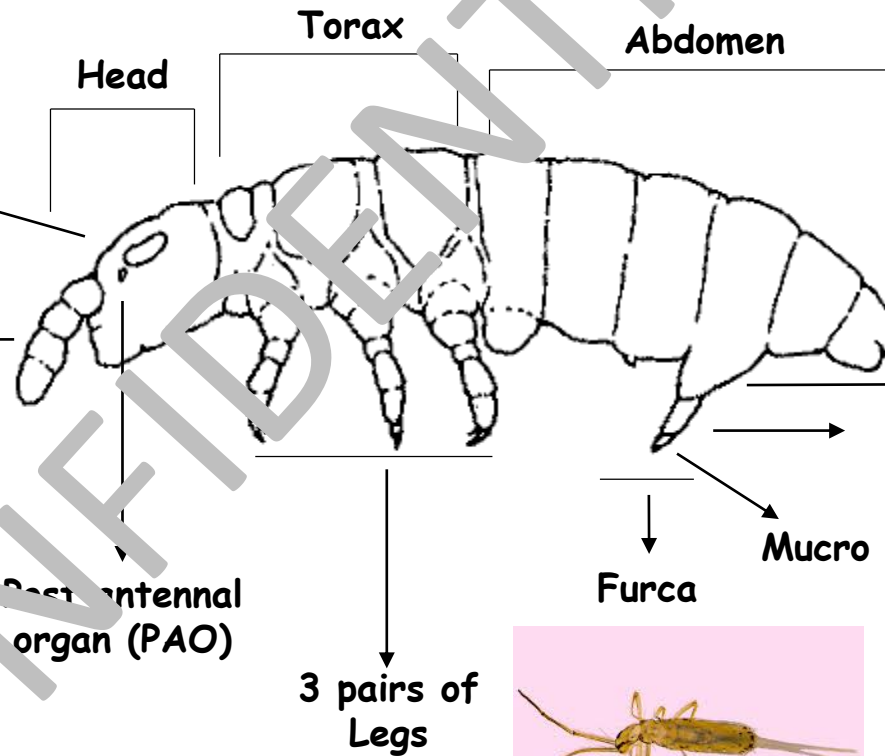
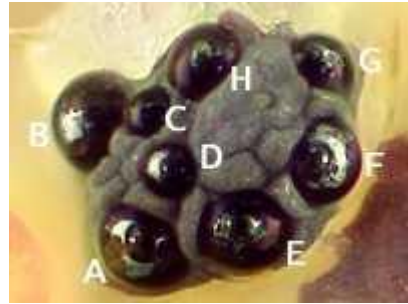
Anal spines

Characteristics of collembolans: Identification

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Collembola

DIET

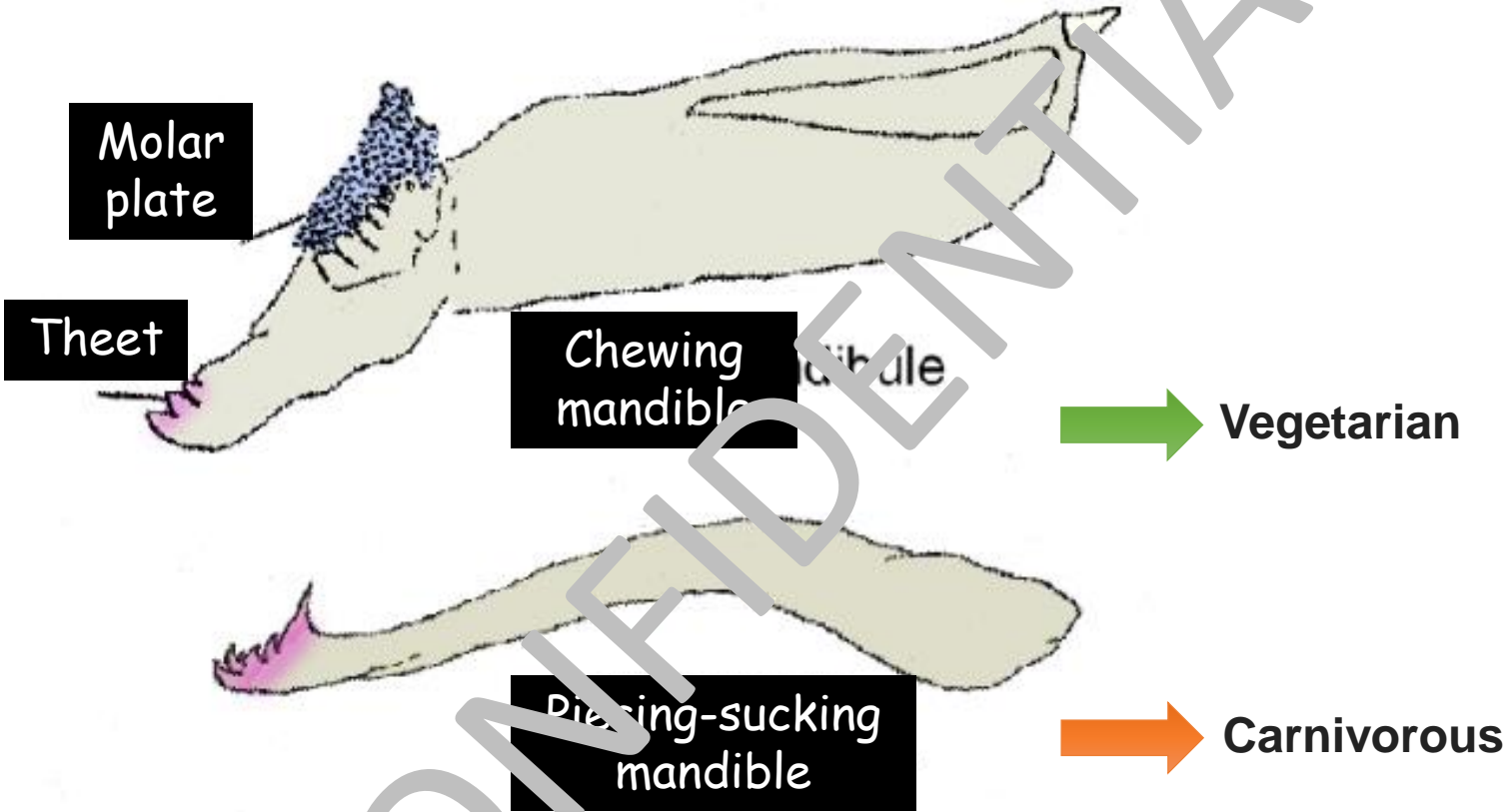
Commonly they consume fungal hyphae and spores

BUT

they can switch their diet if other resources become available



According to mouth-parts





According to gut content analyses

Soil Biology & Biochemistry

Soil Biology & Biochemistry 37 (2005) 1718–1725

www.elsevier.com/locate/soilbio

Feeding guilds in Collembola based on nitrogen stable isotope ratios

Masoumeh Chahartaghi^{a,*}, Reinhard Jöngel^b, Stefan Scheu^a, Liliane Russ^a

^aInstitut für Zoologie, TU Darmstadt, Schloßgartenstr. 3, 64287 Darmstadt, Germany

^bGeorg-August Universität Göttingen, Kompetenzzentrum Stabile Isotope, Forschungszentrum Waldökosysteme, Büsgenweg 2, 37077 Göttingen, Germany

Received 6 October 2004; received in revised form 8 February 2005; accepted 11 February 2005

Phycophages/
herbivorous



Algae, lichens



Primary
decomposers



Litter material



Secondary
decomposers



Fungi, mycorrhiza





- Controlled by Wolbachia bacteria

Sexual

Parthenogenesis

- Sexual dimorphism or not
- Indirect sperm transfer
- Deposition of spermatophore



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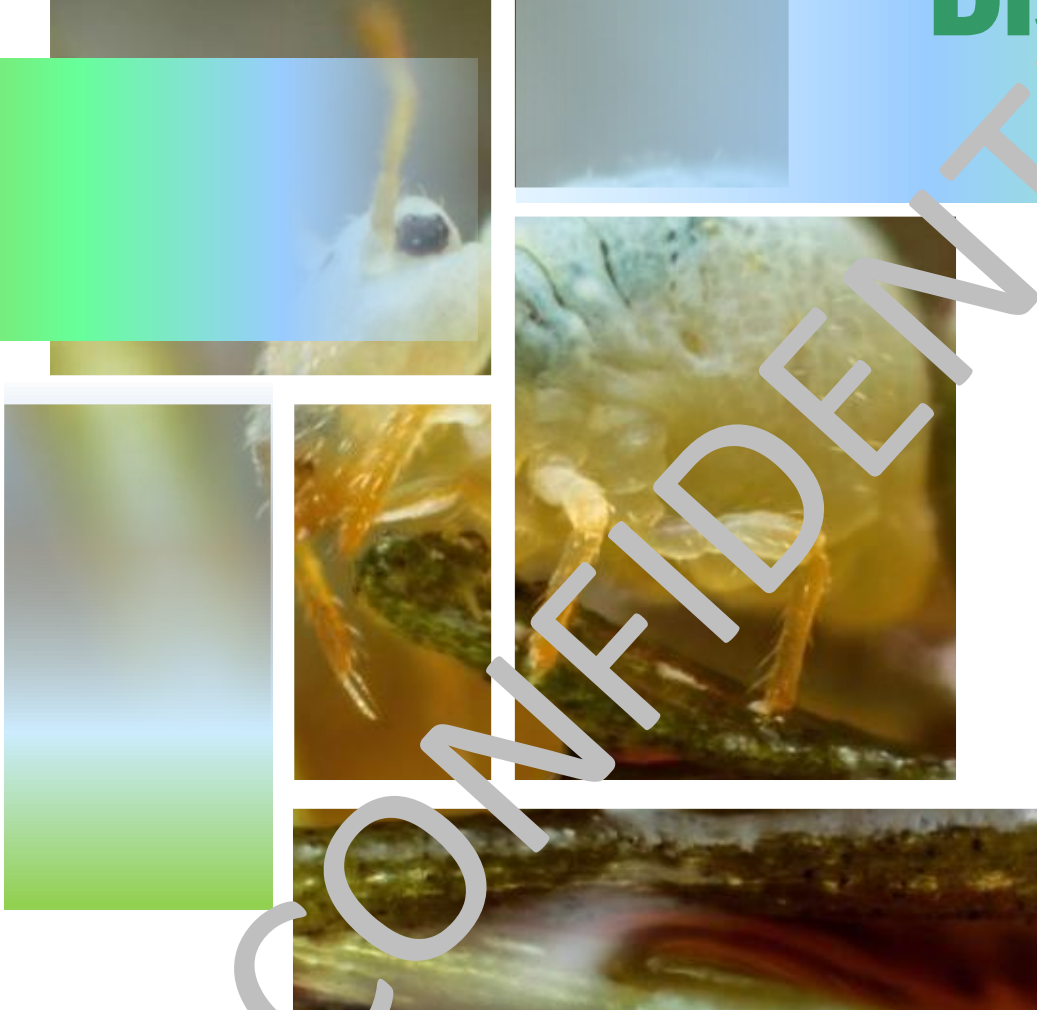
Ecology of collembolans



Distribution

- ❑ Soil dwelling, wet or damp surroundings
- ❑ Worldwide distributed
- ❑ 10^4 - 10^5 ind. m^{-2}
- ❑ 60 to 80 species in forests
- ❑ 15 to 30 species in agricultural areas

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Characteristics of collembolans

Ecology of collembolans: Soil distribution

Bioindication

Conclusions



Epi-edaphic



Hemi-edaphic



Eu-edaphic

Characteristics of collembolans

Ecology of collembolans: Soil distribution

Bioindication

Conclusions



Epi-edaphic

Sexual reproduction

Herbivores

High mobility



Hemi-edaphic

Sexual reproduction

Litter eating

High mobility



Eu-edaphic

Asexual reproduction

Fungivores

Low mobility

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Characteristics of collembolans

Ecology of collembolans:
habitat preferences

Bioindication

Conclusions



**Factors
influencing
Distribution**



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pH (3-8)

*Journal of
Applied Ecology*
1997, **34**,
217-232

**The development of a bioindicator system for soil acidity
based on arthropod pH preferences**

NICO M. VAN STRAALEN and HERMAN A. VERHOEF

*Department of Ecology and Microecology, Vrije Universiteit, De Boelelaan 1087, 1081 HV Amsterdam, The
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**Temperature
(7-25° C)**

**Locomotor Response of *Folsomia candida*
(Collembola: Isotomidae) to Cooling Temperatures**



G. Bouteau ✉, P. Mackinley

Environmental Entomology, Volume 41, Issue 4, 1 August 2012, Pages 916-924,

<http://doi.org/10.1603/EN12008>

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Umidity (variable according the species)

Distribution and population dynamics of Collembola in relation to soil moisture

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**Texture (soils with
high porosity)**

**Soil Tillage in
Agroecosystems**

Edited by
Adel El Titi

Form soil microstructure in weakly developed soils



Some species make microtunnels



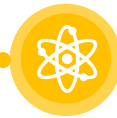
Disseminators of soil microbial propagules in the soil



Degradation of organic matter and litter



Release nutrients



Collembola are food sources for many predators



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Collembolans as bioindicators



Characteristics of
collembolans

Ecology of
collembolans

Bioindication

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Collembola optimum habitat

Characteristics of collembolans

Ecology of collembolans

Bioindication

Conclusions



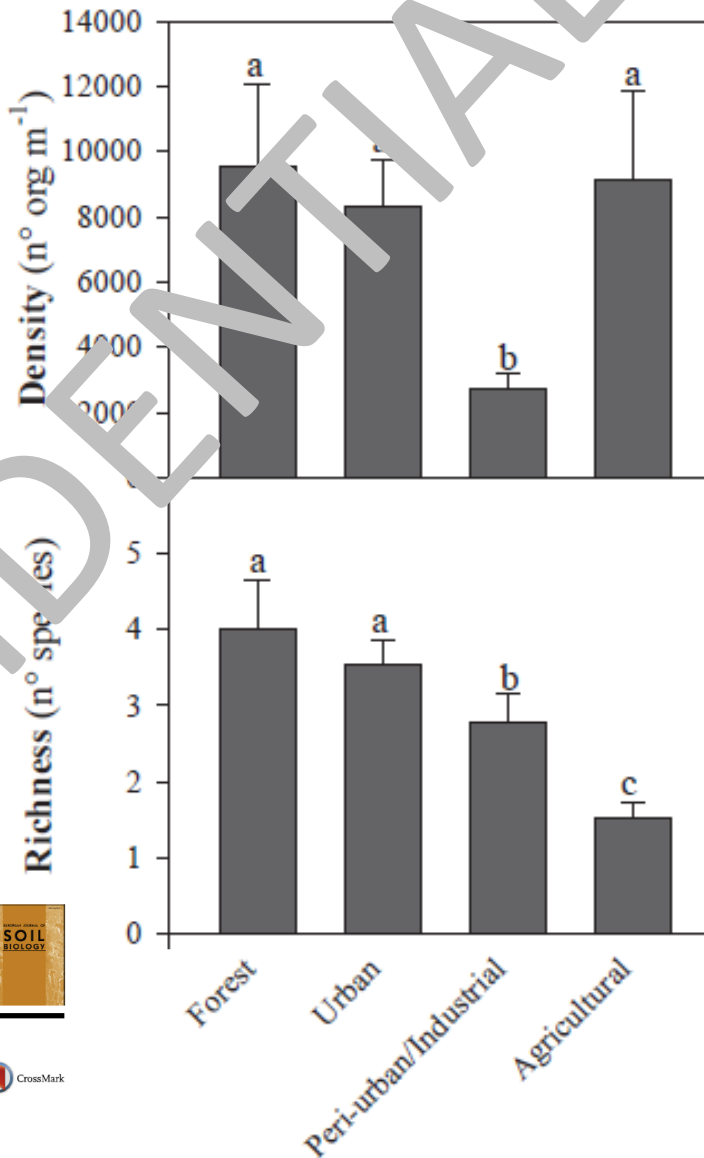
Collembola optimum habitat

Which change in collembolan community?

Study area: Napoli district

4 Types of land uses

N° samples = 90



Contents lists available at ScienceDirect

European Journal of Soil Biology

journal homepage: <http://www.elsevier.com/locate/ejsobi>



Original article

Responses of functional and taxonomic collembolan community structure to site management in Mediterranean urban and surrounding areas



Lucia Santorufo ^{a,b,c,*}, Jérôme Cortet ^d, Johanne Nahmani ^e, Céline Pernin ^f, Sandrine Salmon ^g, Audrey Pernot ^b, Jean Louis Morel ^{b,c}, Giulia Maisto ^a

Characteristics of collembolans

Ecology of collembolans

Bioindication: Land use

Conclusions

Forest

Urban

Industrial

Agricultural

Bulk density

Organic matter

Water holding capacity

Contamination

Land use change the soil physical and chemical properties



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Responses of functional and taxonomic collembolan community structure to site management in Mediterranean urban and surrounding areas

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Characteristics of
collembolans

Ecology of
collembolans

Bioindication:
Land use

Conclusions



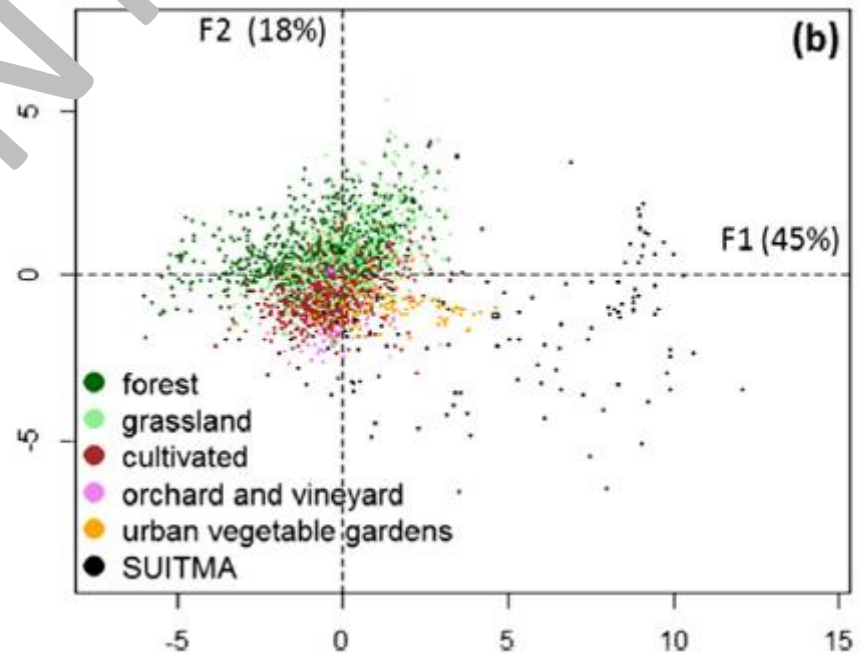
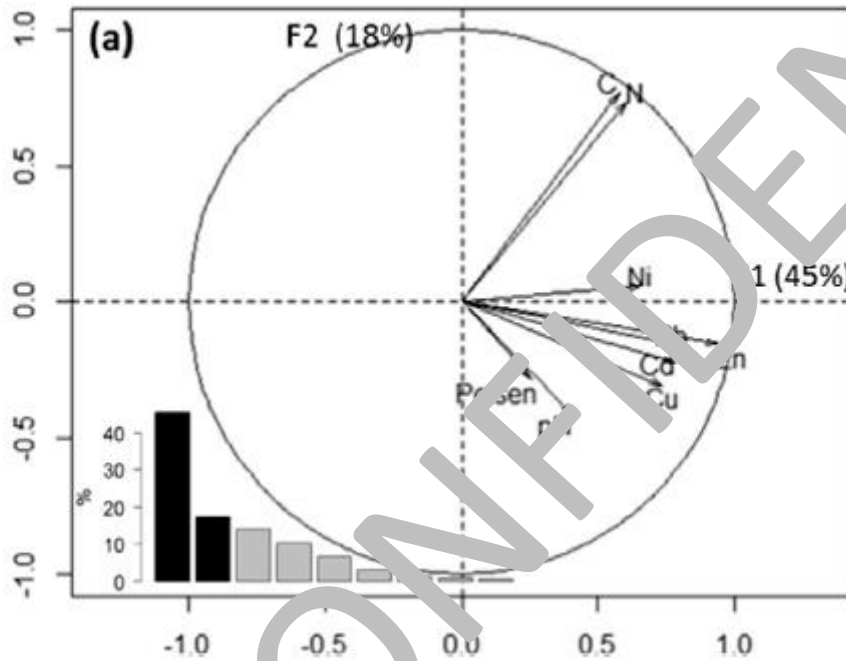
Do soil abiotic and biotic properties always agree???

Soil physical and chemical properties

Study area: France

6 Types of land uses

N° samples= 3,000



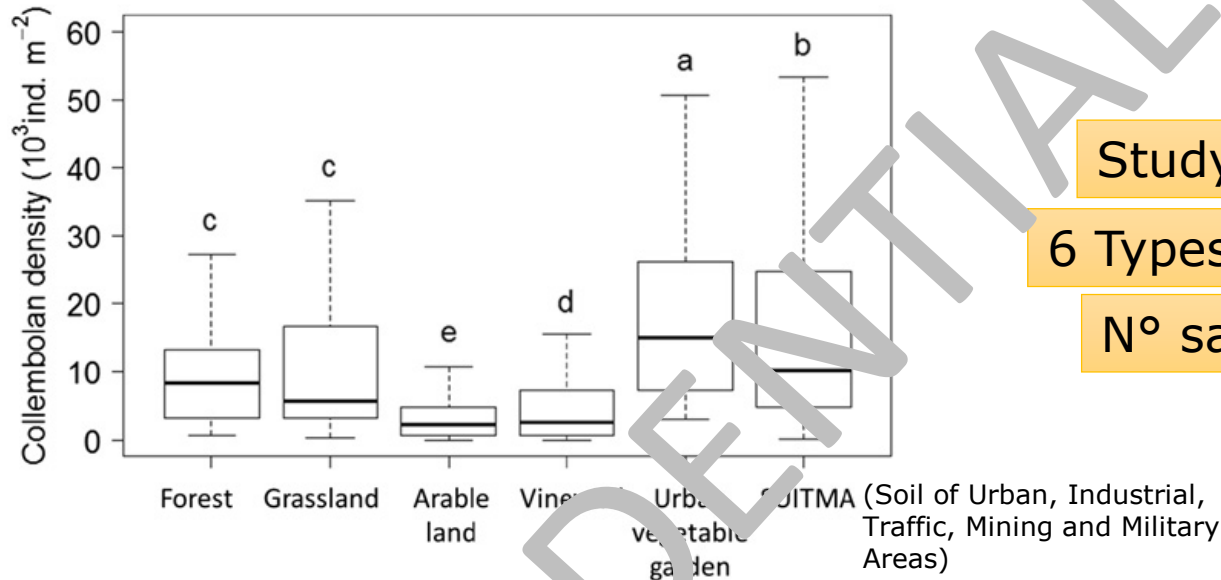
SUITMA=(Soil of Urban, Industrial, Traffic, Mining and Military Areas)

Characteristics of collembolans

Ecology of collembolans

Bioindication: Land use

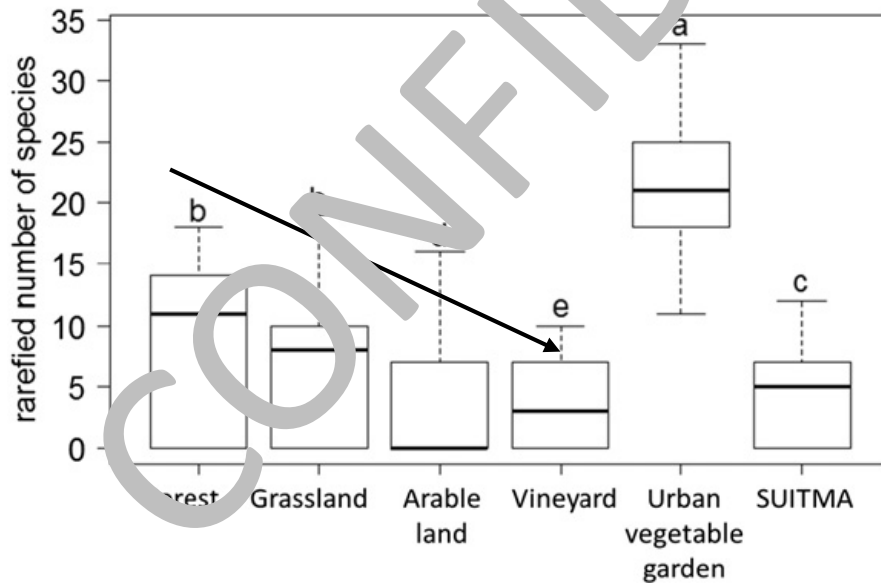
Conclusions



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Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv



Urban and industrial land uses have a higher soil biological quality than expected from physicochemical quality



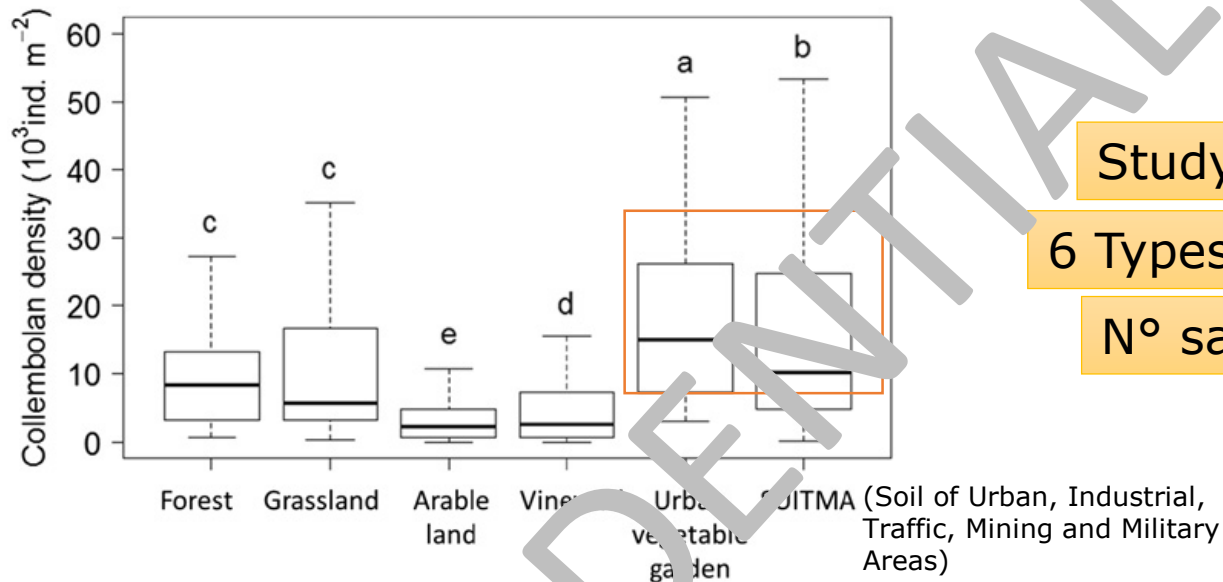
Sophie Joimel ^{a,b,c,*}, Christophe Schwartz ^{a,b}, Mickaël Hedde ^c, Sayuri Kiyota ^d, Paul Henning Krogh ^e, Johanne Nahmani ^d, Guénola Pérès ^{f,g}, Alan Vergnes ^d, Jérôme Cortet ^d

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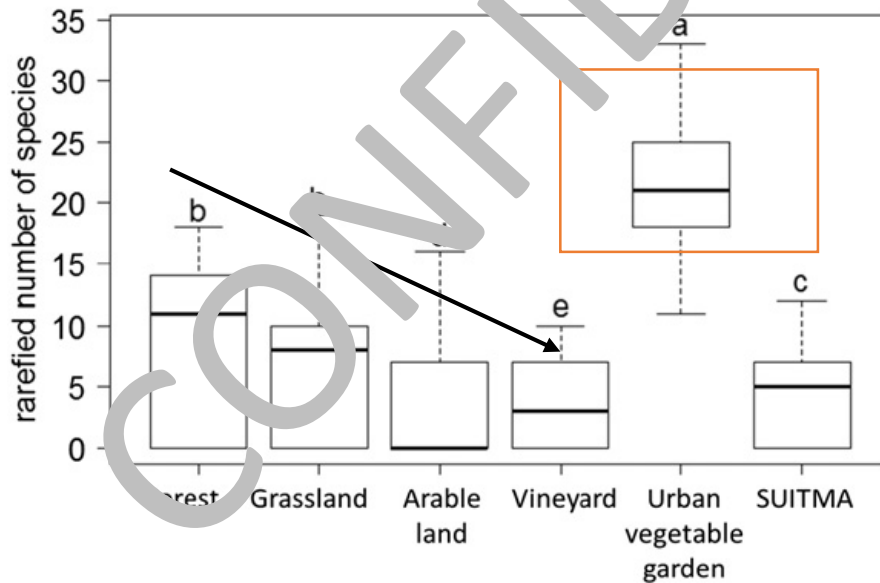
Conclusions



Study area: France

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Characteristics of
collembolans

Ecology of
collembolans

Bioindication:
Agricultural
practices

Conclusions

Different agricultural
practices

Study area: France

4 Types of
agricultural practices

N° samples= 96

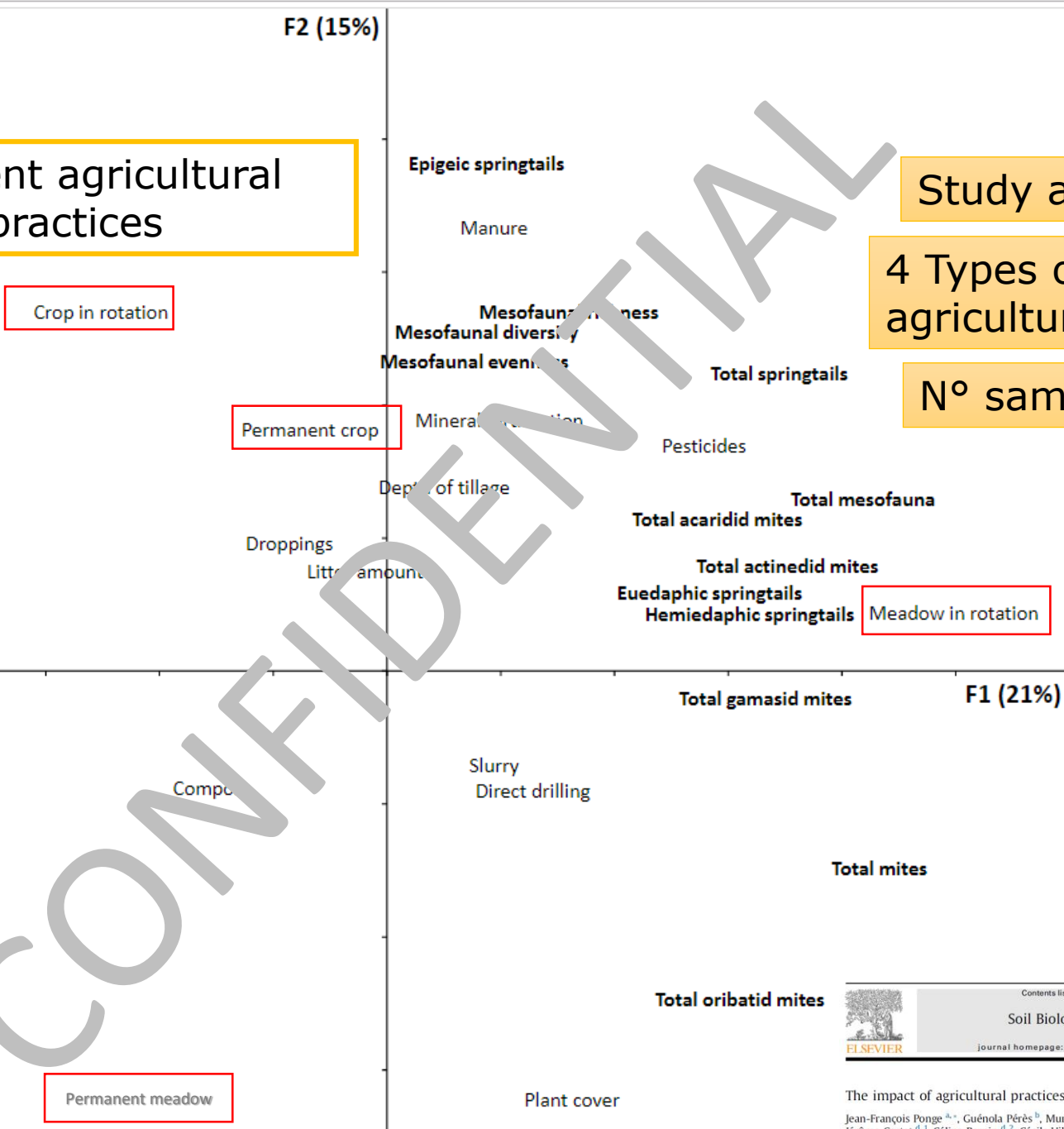
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Different agricultural practices

Study area: France

4 Types of agricultural practices

N° samples= 96



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Different agricultural practices

Study area: France

4 Types of agricultural practices

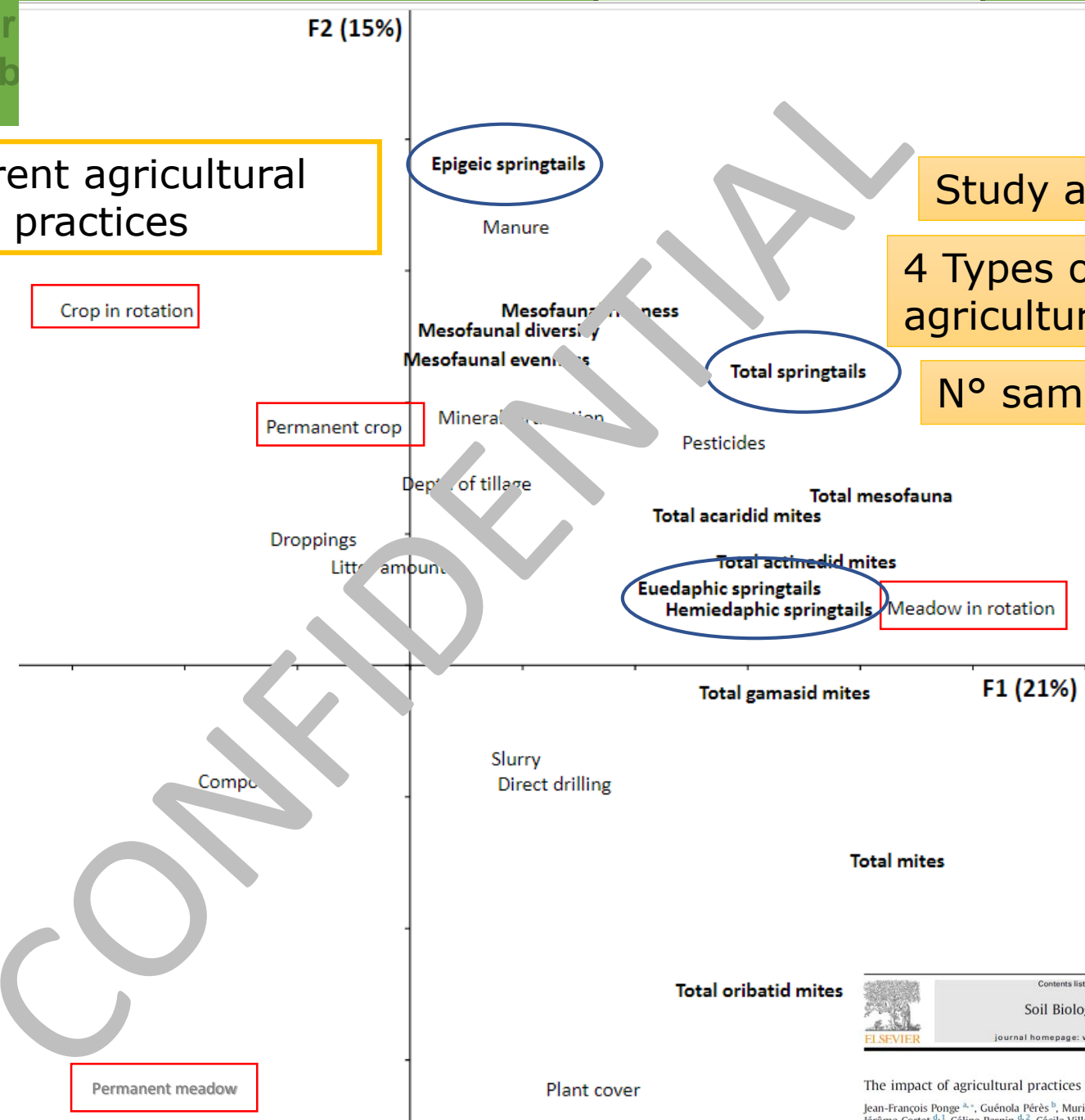
N° samples= 96

Crop in rotation

Permanent crop

Meadow in rotation

Permanent meadow



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Characteristics of
collembolans

Ecology of
collembolans

Bioindication:
Contamination

Conclusions

Forest

Urban

Industrial

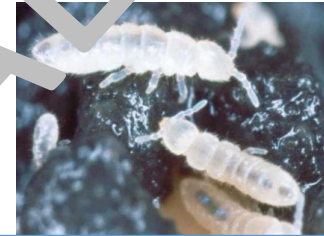
Agricultural

Contamination

Does contamination exert any effect on
collembolans?

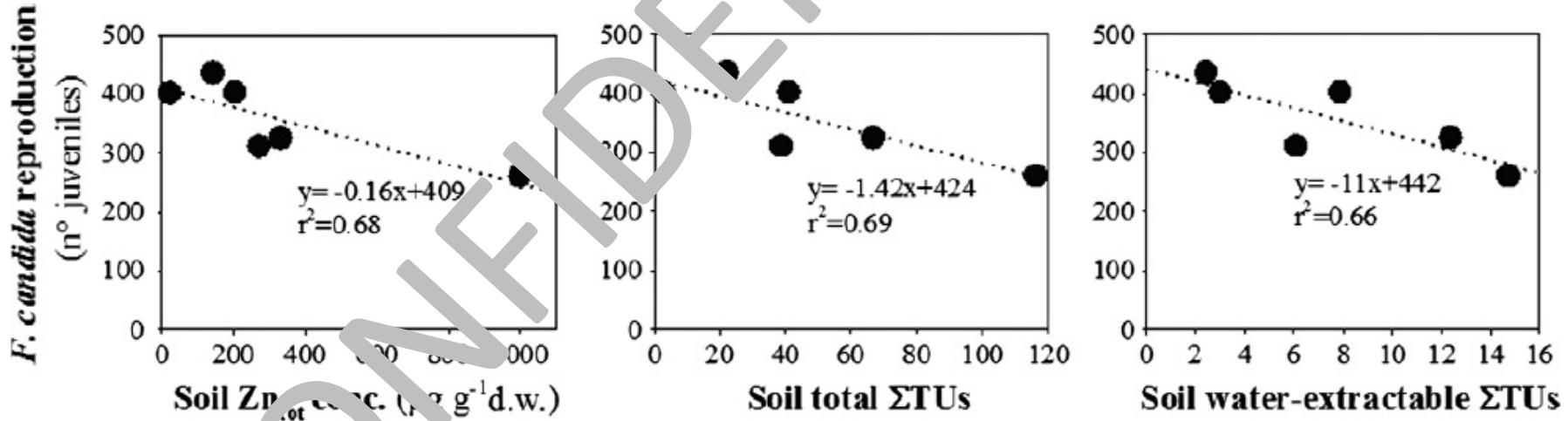
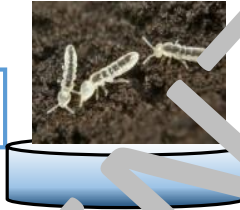
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Collembola standard organism: *F. candida*



Hemi-edaphic

Laboratory test exposure



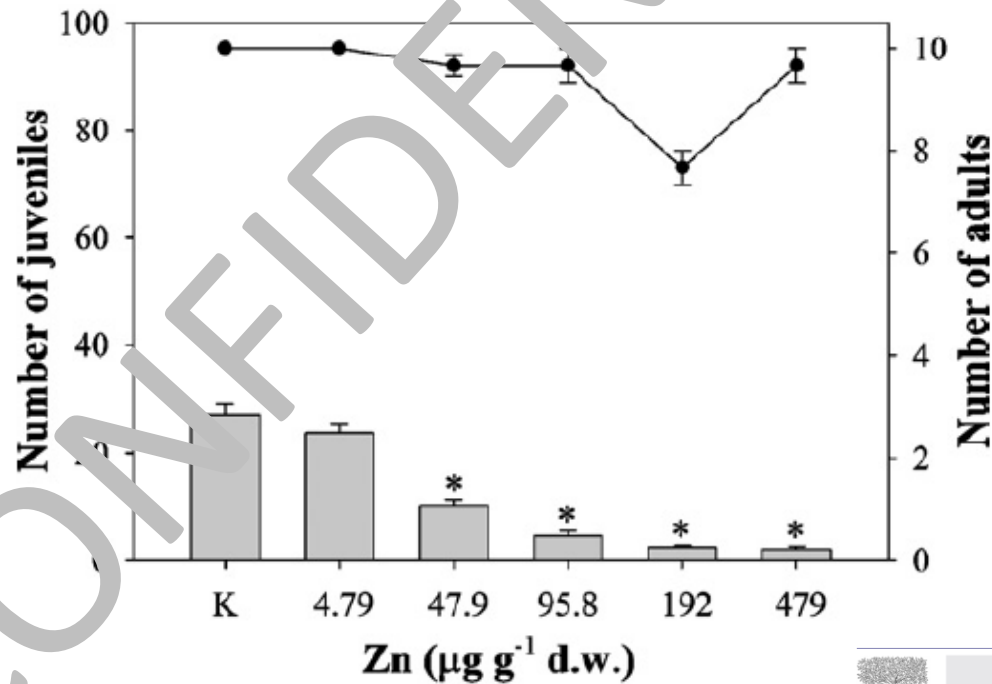
Negative relationship between soil metal contamination and reproduction

Collembola NON-standard organism: *O. pseudostachianus*

Laboratory test exposure



Eu-edaphic



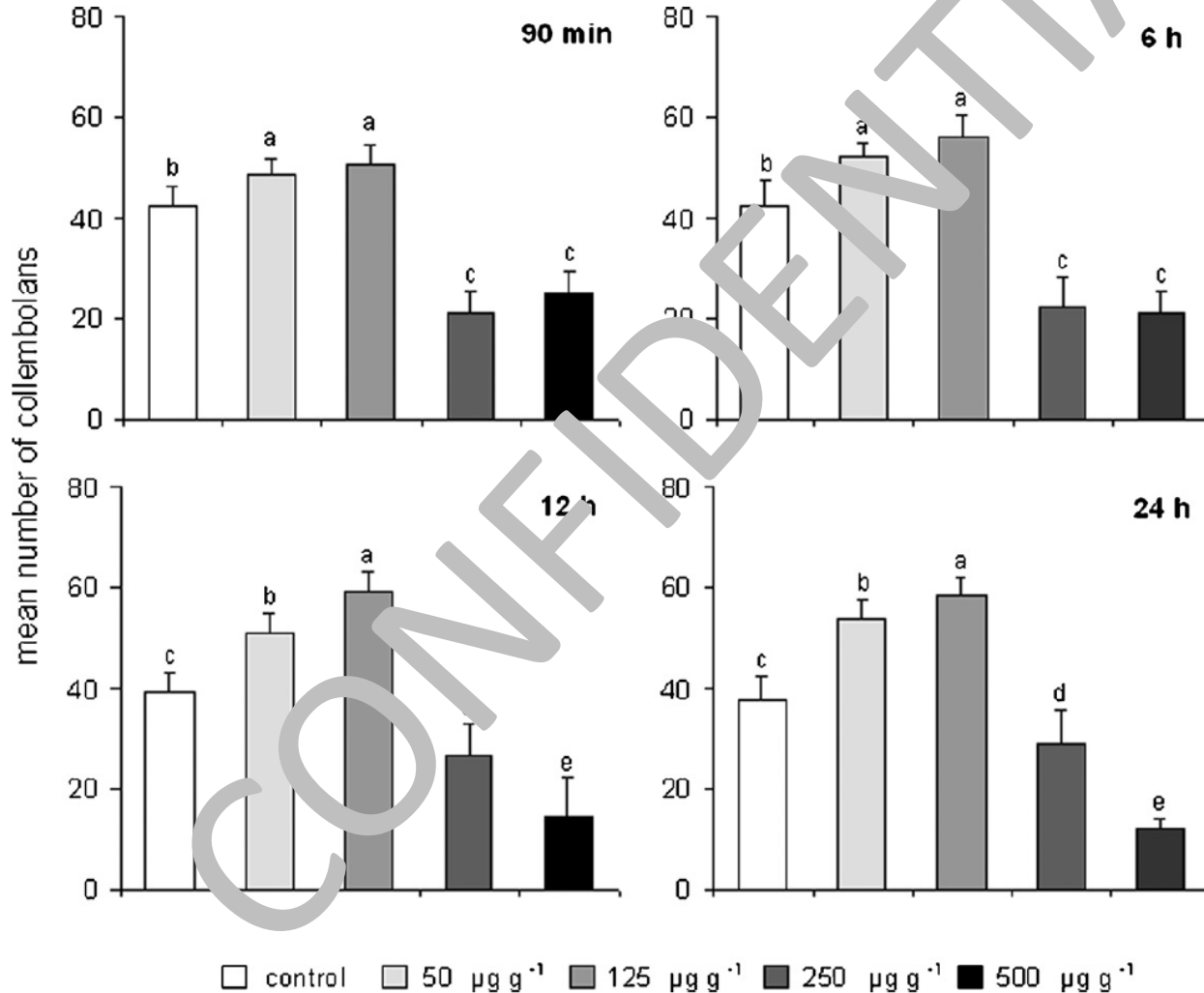
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Applied Soil Ecology

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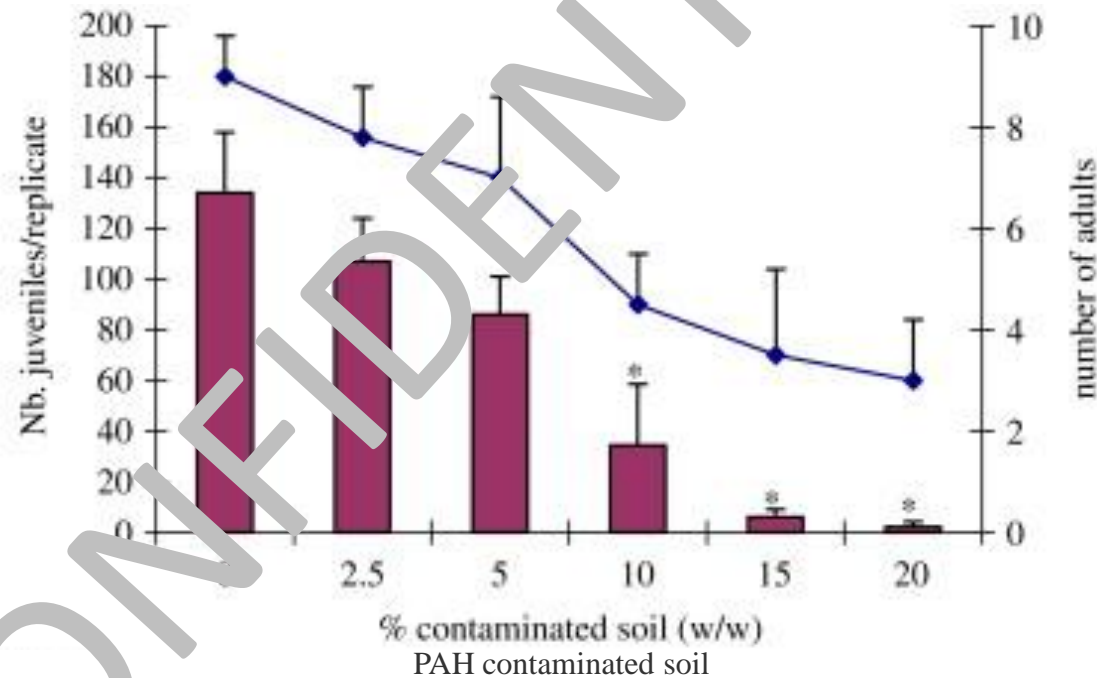


Preference of collembolan on metal contaminated food



Collembola avoid higher contaminated food

Collembolan exposed to increasing PAH concentrations



Available online at www.sciencedirect.com



Ecotoxicology and Environmental Safety 67 (2007) 190–205

Ecotoxicology
and
Environmental
Safety

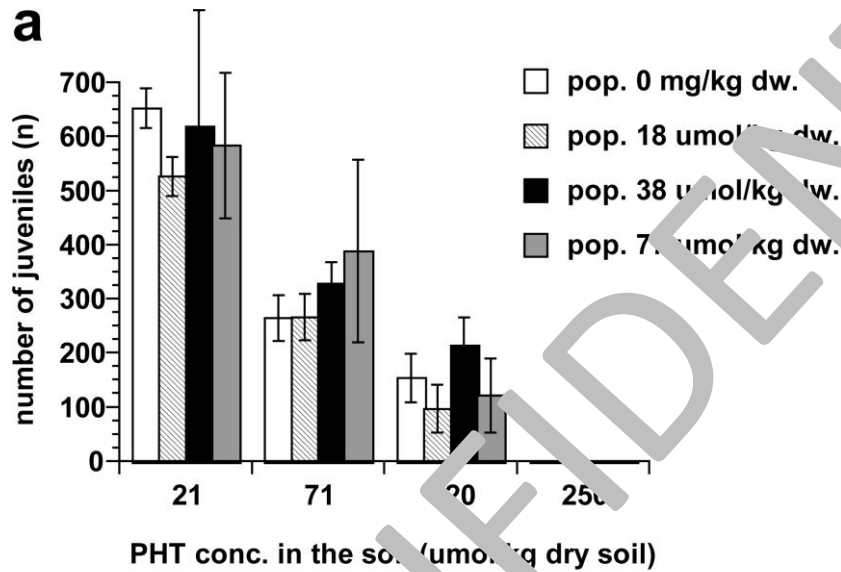
www.elsevier.com/locate/eoenv

Highlighted article

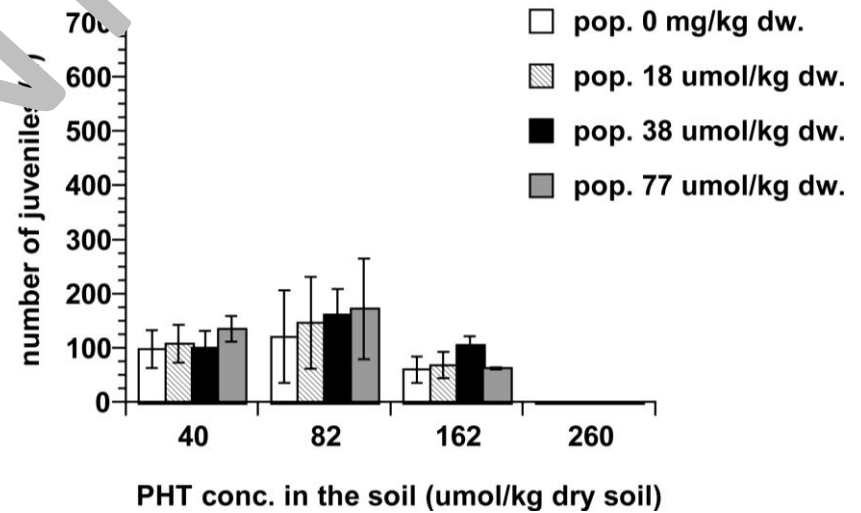
Ecotoxicity of a polycyclic aromatic hydrocarbon (PAH)-contaminated soil

I.C. Eom^{a,*}, C. Rast^b, A.M. Veber^b, P. Vasseur^{b,*}

Multigeneration exposure of collembolan to PAH concentrations



Reproduction after 5 generations



Reproduction after 10 generations

Paumen et al., 2008

Chapter 6

Multi-generation exposure of the springtail *Folsomia candida* to phenanthrene: from dose-response relationships to threshold concentrations

Functional traits of organisms

Functional trait is any morphological, physiological or phenological feature measurable at the individual level, from the cell to the whole-organism level (Violle et al., 2007)

Functional trait

Only when a trait influences a performance can be defined “functional” and it can affect ecosystem functions

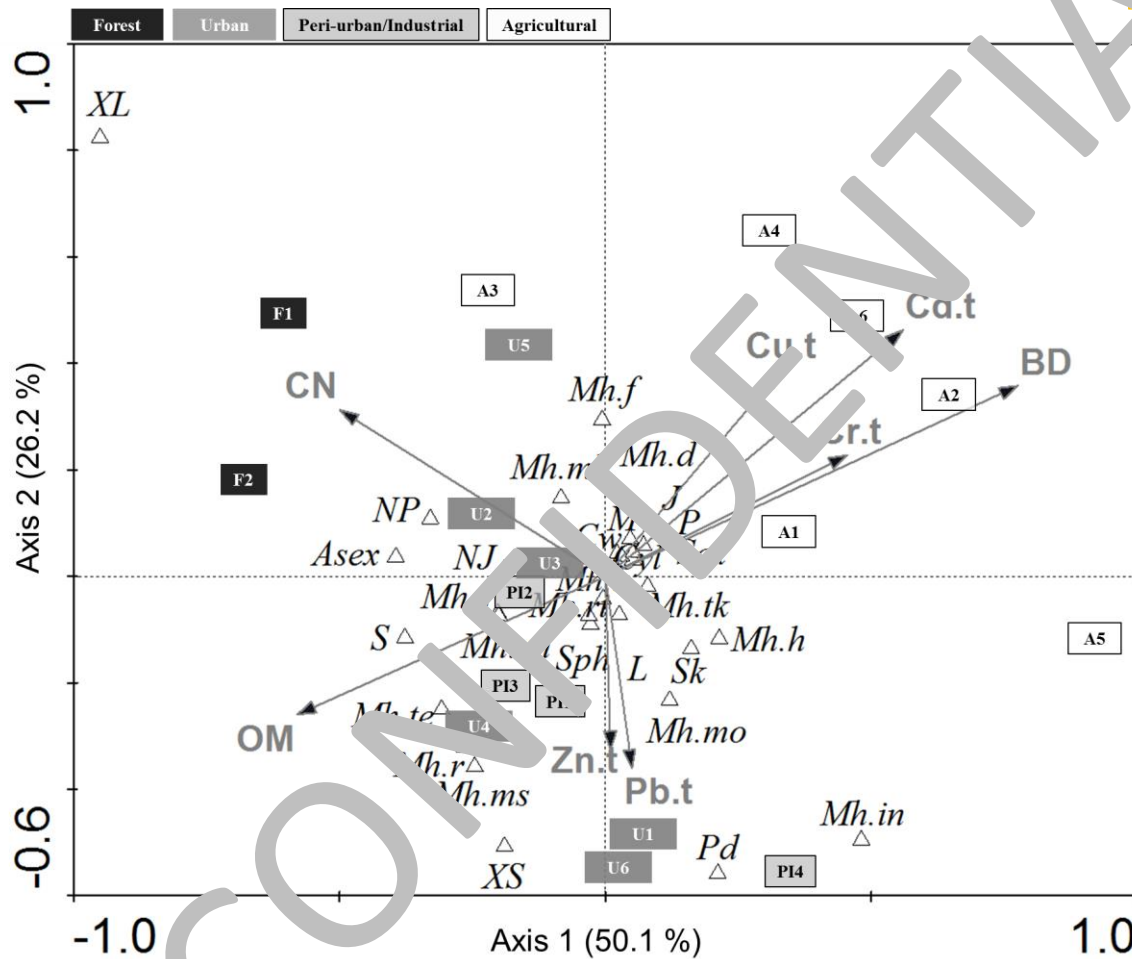
Performance

- the ability of an organism to grow, reproduce or survive
- linked to the fitness
- expression of one or more functional traits

Study area: Napoli district

4 Types of land uses

N° samples = 90



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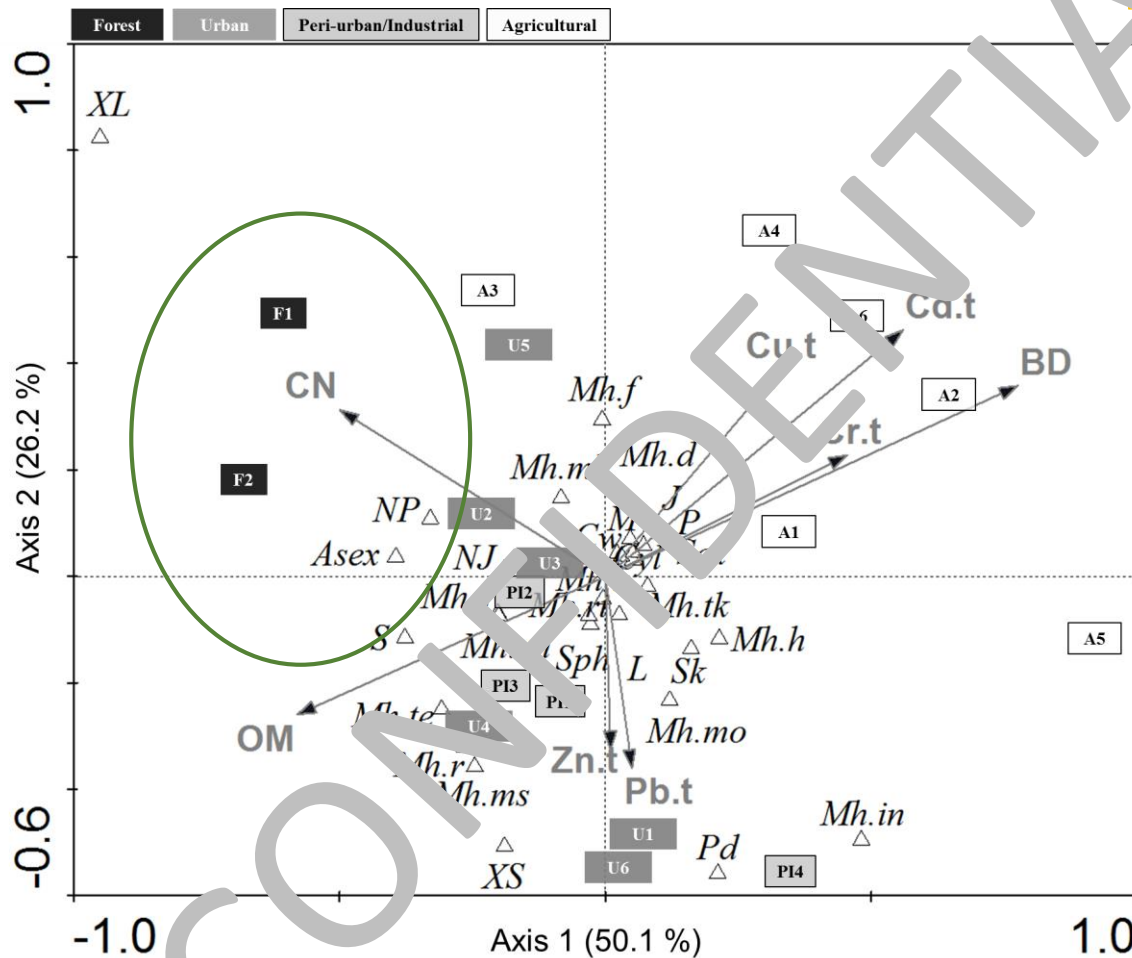
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Forest = functional traits related to stable environments



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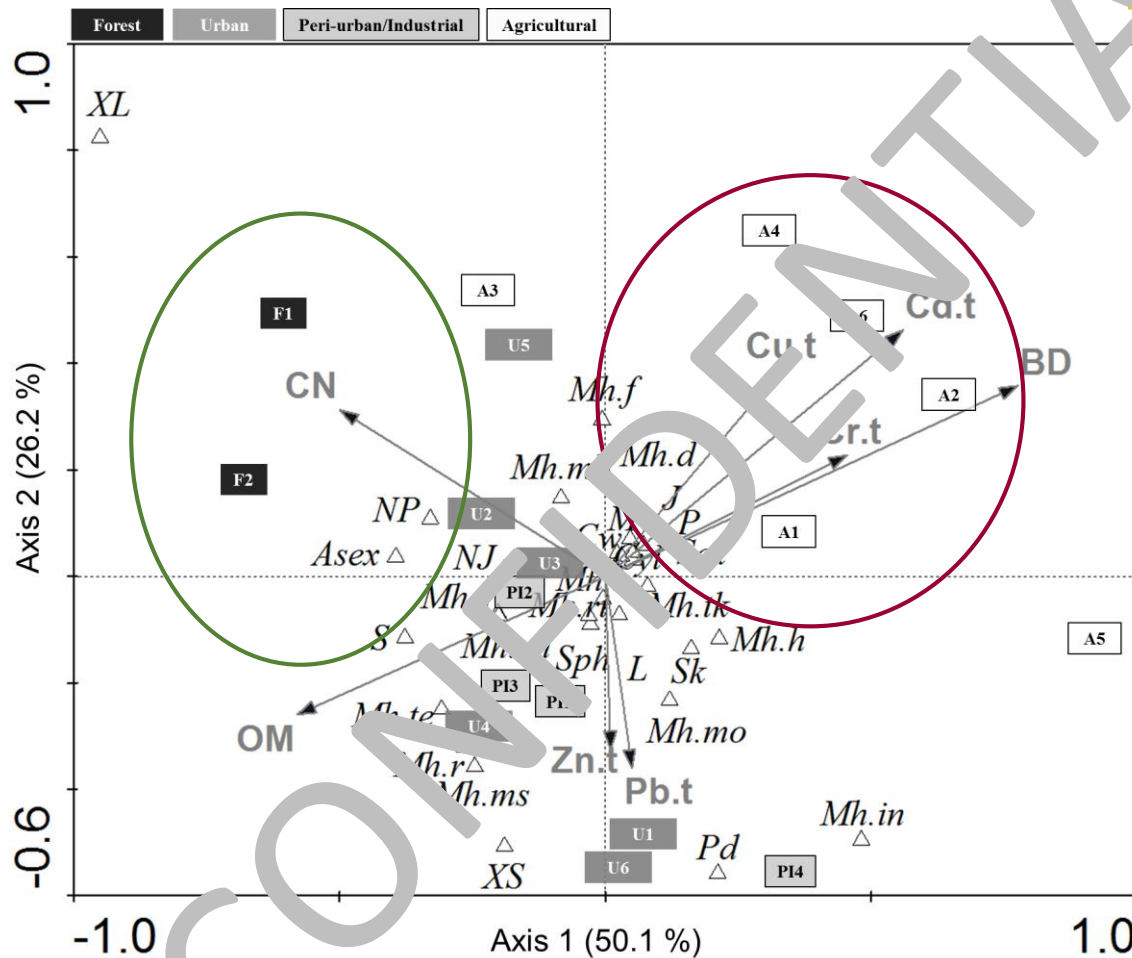
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Study area: Napoli district

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Agriculture=functional traits related to disturbed environments

Forest=functional traits related to stable environments



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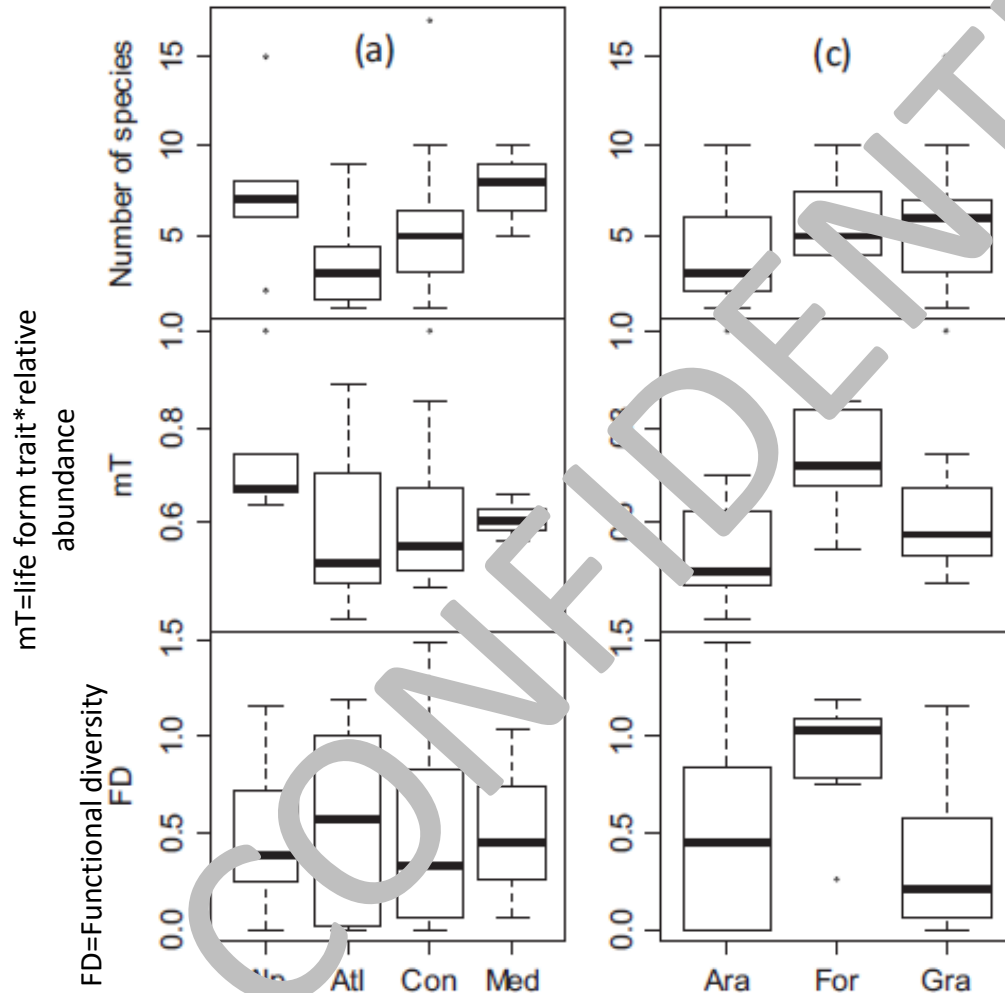
Responses of functional and taxonomic collembolan community structure to site management in Mediterranean urban and surrounding areas

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Study area: Europe (10 countries)

N° samples = 88



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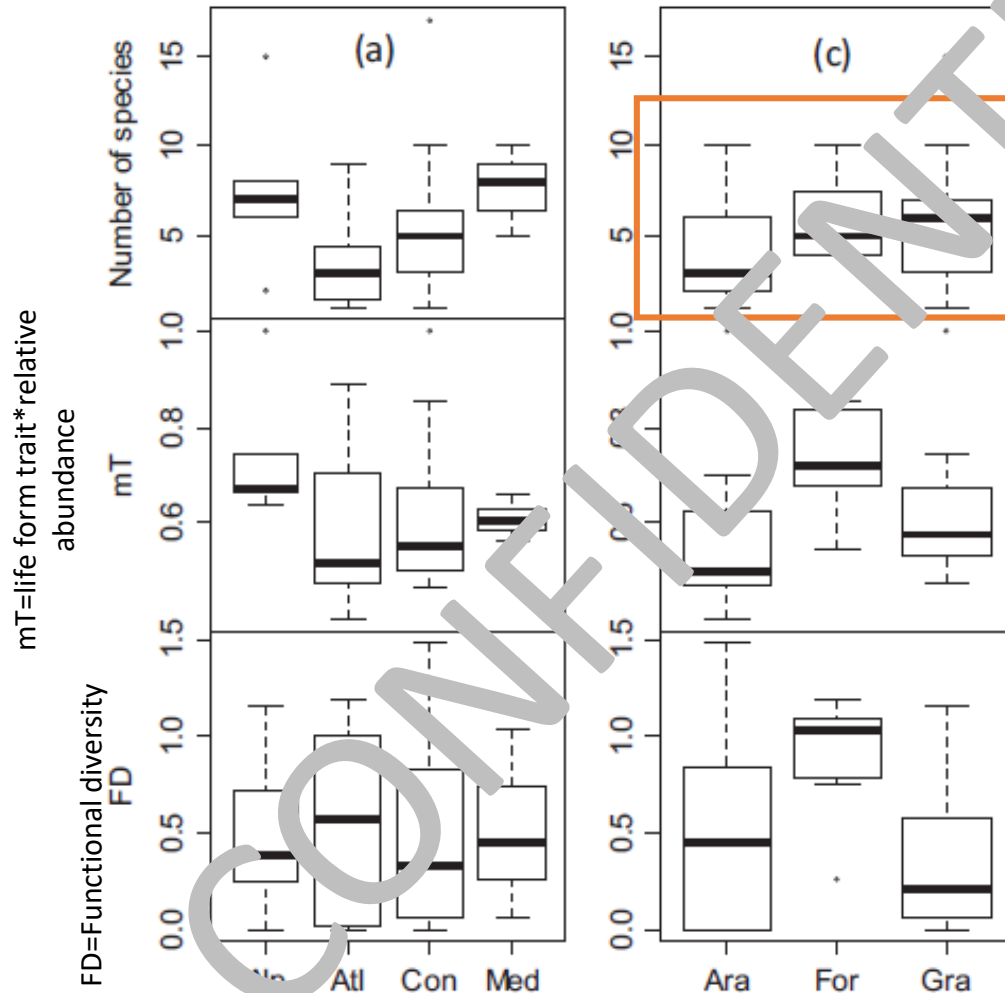
Traits of collembolan life-form indicate land use types and soil properties across an European transect

Pedro Martins da Silva^{1,a,b,*}, Filipe Carvalho^{1,a,b}, Tara Dirilgen^c, Dorothy Stone^{d,e}, Rachel Creamer^c, Thomas Bolger^c, José Paulo Sousa^{a,b}



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Taxonomic index does not highlight differences among land uses



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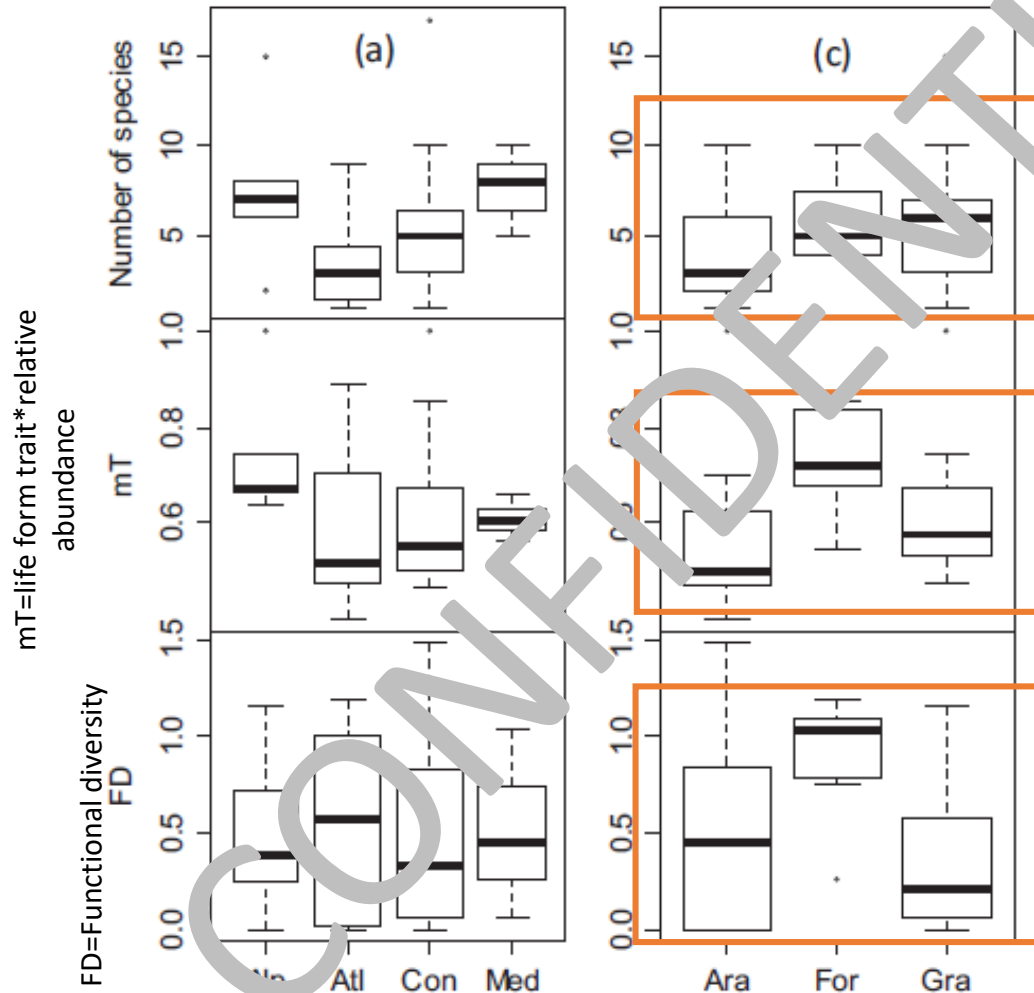
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Functional index highlight differences among land uses



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Conclusions

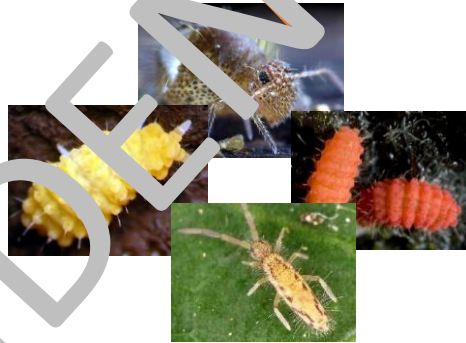


Characteristics of collembolans

Ecology of collembolans

Bioindication

Conclusions



Collembolan group is bioindicator of several soil alterations

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Characteristics of collembolans

Ecology of collembolans

Bioindication

Conclusions



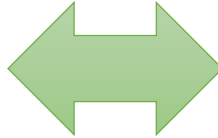
Collembolon group is bioindicator of several soil alterations

Density

Biodiversity

Species assemblages

Taxonomic parameters



Functional parameters

Traits assemblages

Reproduction

Feeding habits

Sensitivity of collembolans depends on their functional traits

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Sensitivity of collembolans depends of their functional traits



Epi-edaphic

Easily found in disturbed environments

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Sensitivity of collembolans depends of their functional traits



Epi-edaphic

Easily found in disturbed environments



Hemi-edaphic

Sensitive to amount of organic matter

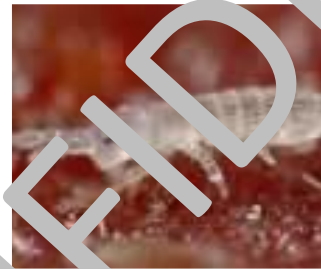
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Sensitivity of collembolans depends of their functional traits



Epi-edaphic

Easily found in disturbed environments



Hemi-edaphic

Sensitive to amount of organic matter



Eu-edaphic

Absent in very degraded soils