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# DNA Barcodes for Soil Fauna Taxonomy

T. Decaëns,  
D. Porco, R. Rougerie

# OUTLINE

## *Introduction*

- Soil biodiversity: the final frontier
- DNA barcoding for the sensus of soil biodiversity

## **Applications and perspectives**

- Species id, biodiversity estimates, taxonomy, biogeography, ecology

# *Introduction: Soil biodiversity, the final frontier*

## Importance of soil fauna

- **Ecological importance:** regulators of soil processes
- **Economic importance:** maintenance of soil fertility
- **Strategic importance:** highly diverse communities
- **Strategic importance:** invasive species
- **Practical importance:** used as bioindicators of soil quality or pollution



# *Introduction: Soil biodiversity, the final frontier*

## Problems with the study of soil biodiversity



## Difficulties for species identifications

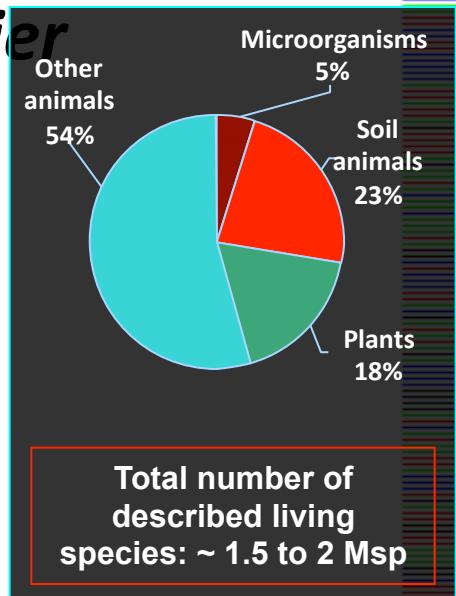
→ Very high biodiversity

→ High level of expertise required

→ Small size, minute characters

→ Phenotypic plasticity

→ Non-diagnosable life stages



# *Introduction: Soil biodiversity, the final frontier*

## The taxonomic deficit

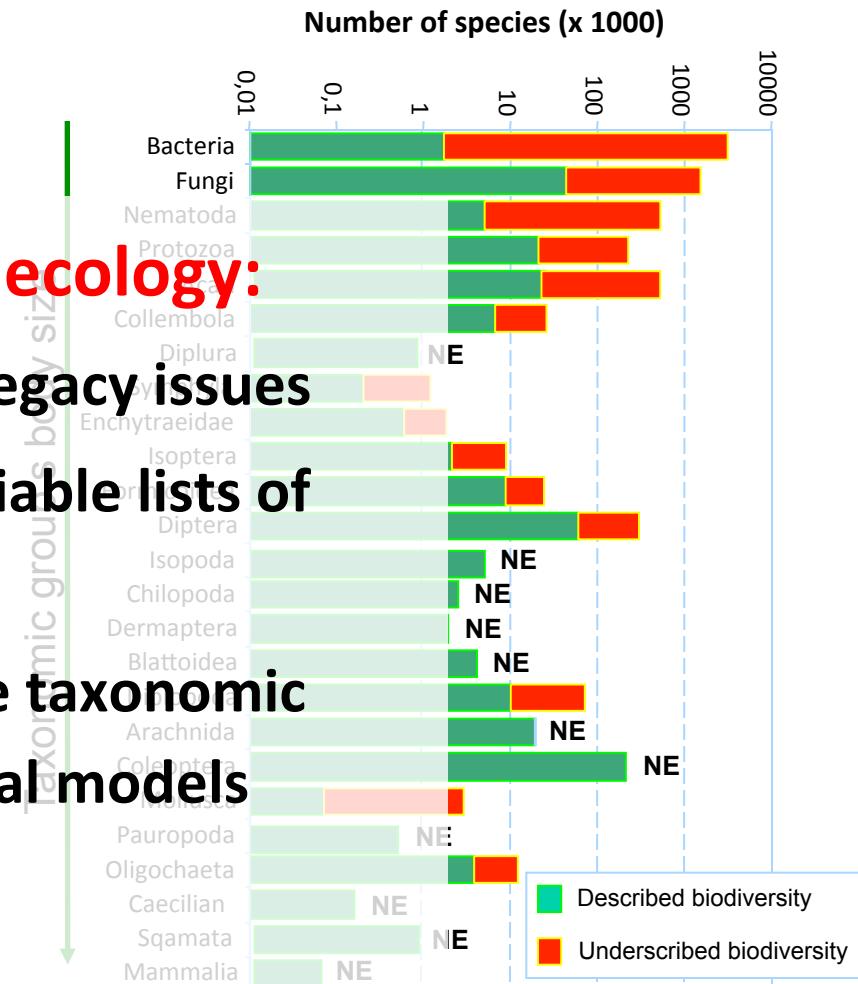
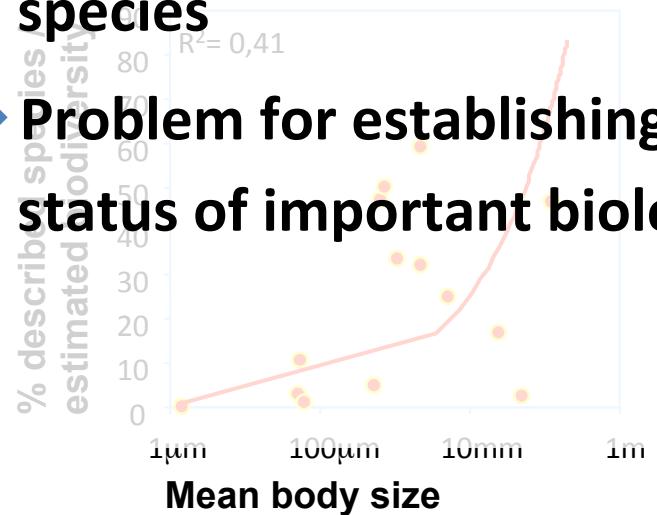
- Known biodiversity = small fraction of real diversity

### Important limitations for soil ecology:

→ Deficit of taxonomists and legacy issues  
body sized groups of soil organisms

→ Problem for establishing reliable lists of species

→ Problem for establishing the taxonomic status of important biological models



# *Introduction: What is DNA barcoding?*



Received 29 July 2002  
Accepted 30 September 2002  
Published online 8 January 2003

## **Biological identifications through DNA barcodes**

Paul D. N. Hebert\*, Alina Cywinska, Shelley L. Ball  
and Jeremy R. deWaard

**DNA Barcoding** = the use of a short  
standardized gene fragment for species  
identification and biodiversity exploration

Cytochrome c oxidase I (COI) is the  
selected standard ‘barcode’ in animals

→ ***A standardized identification  
method for animals***



# *Introduction: What is DNA barcoding?*

Some controversy regarding the reliability of the method

- **Potential false negatives:** identical barcodes in two actually different species (short divergence time, gene introgression);
- **Potential false positives:** different barcodes within a single species (ancestral polymorphism, genetic introgression)

Now recognized as a reliable and straightforward tool for species discrimination

Hebert proposed the idea of a global barcode library for the animal kingdom

Rubinoff & Holland (2005), Trewick (2007), Wiemers & Fiedler (2007), Will et al (2005), Hebert et al (2003, 2004, 2010)

## DNA barcodes for 1/1000 of the animal kingdom

Paul D. N. Hebert<sup>1,\*</sup>, Jeremy R. deWaard<sup>2,3</sup>  
and Jean-François Landry<sup>4</sup>

<sup>1</sup>*Biodiversity Institute of Ontario, University of Guelph, Guelph, Ontario, Canada N1G 2W1*

<sup>2</sup>*Department of Forestry Science, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z4*

<sup>3</sup>*Entomology, Royal British Columbia Museum, Victoria, British Columbia, Canada V8W 9W2*

<sup>4</sup>*Research Centre, Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada K1A 0C6*

\*Author for correspondence ([phebert@uoguelph.ca](mailto:phebert@uoguelph.ca)).

This study reports DNA barcodes for more than 1300 Lepidoptera species from the eastern half of North America, establishing that 99.3 per cent of these species possess diagnostic barcode sequences. Intraspecific divergences averaged just 0.43 per cent among this assemblage, but most values were lower. The mean was elevated by deep barcode divergences (greater than 2%) in 5.1 per cent of the species, often involving the sympatric occurrence of two barcode clusters. A few of these cases have been analysed in detail, revealing species overlooked by the current taxonomic system. This study also provided a

# *Introduction: Building the reference library*

## The international Barcode of Life (iBOL)

- Involves a network of taxonomists for a range of taxonomic groups

The screenshot shows the homepage of the International Barcode of Life (iBOL) website. The header features the iBOL logo and navigation links for Sitemap, Contact, About Us, Working Groups, Resources, News and Events, and Get Involved. Below the header is a search bar. The main visual is a large photograph of two dark beetles rolling a large ball of earth or dung across a sandy surface. At the bottom left, there's a graphic with the text "Making Every Species Count" and illustrations of a hummingbird, an ant, and a mushroom. To the right of this graphic is the heading "Building a Bioliterate World". Below this heading is a paragraph of text. Further down is another paragraph followed by a small image of a child looking through a magnifying glass at something on the ground. At the very bottom are four small thumbnail images showing close-ups of a bee, a caterpillar, a flower, and a fish.

INTERNATIONAL  
BARCODE  
OF LIFE

About Us   Working Groups   Resources   News and Events   Get Involved   Search

Making Every Species Count

Building a Bioliterate World

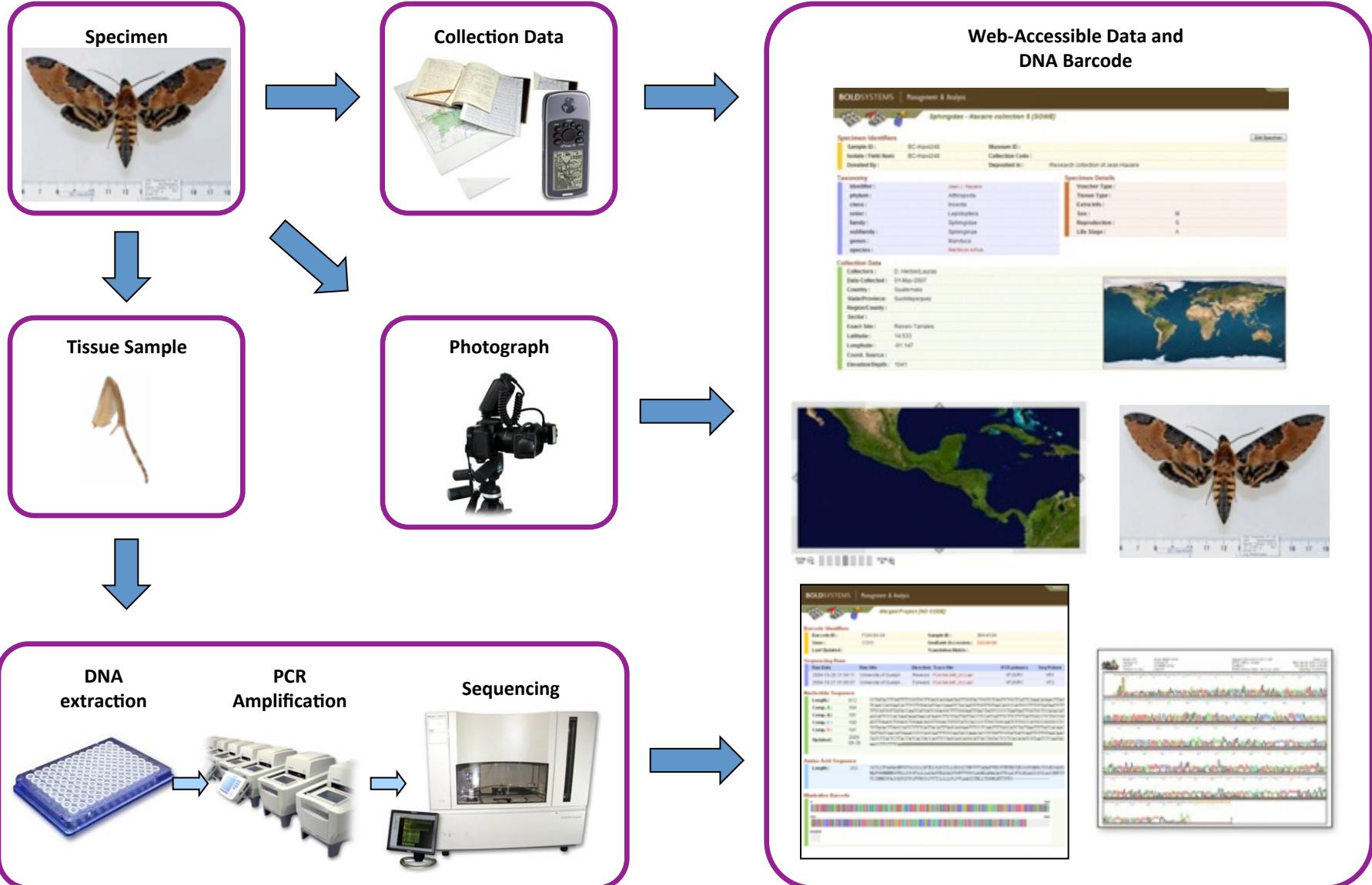
What would it be like to live in a bio-literate world - a world where you could know, in minutes, the name of any animal or plant - any time, anywhere? And not just its name but everything about it - what are its habits, is it endangered, is it dangerous, should it even be there or is it an invader from somewhere else?

How could we use that knowledge to protect our planet's biodiversity and promote human health and well-being?

The International Barcode of Life project (iBOL), the largest biodiversity genomics initiative ever undertaken, is unlocking the door to that world by creating a digital identification system for life.

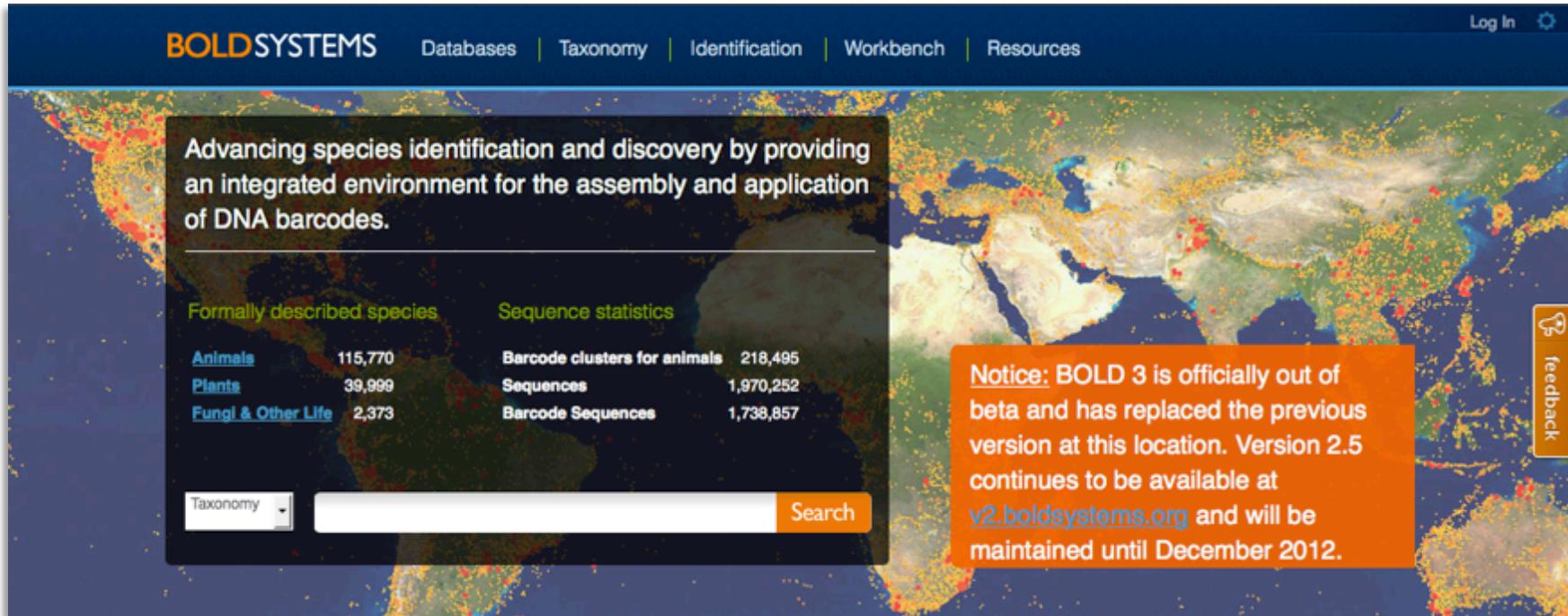
# *Introduction: Building the reference library*

## DNA barcoding workflow



# *Introduction: Building the reference library*

## A dedicated bioinformatics platform (**BOLD**)



- BOLD is used for most sequence manipulations, analyses, comparisons, mapping
- Confidentiality requirements can be managed with BOLD

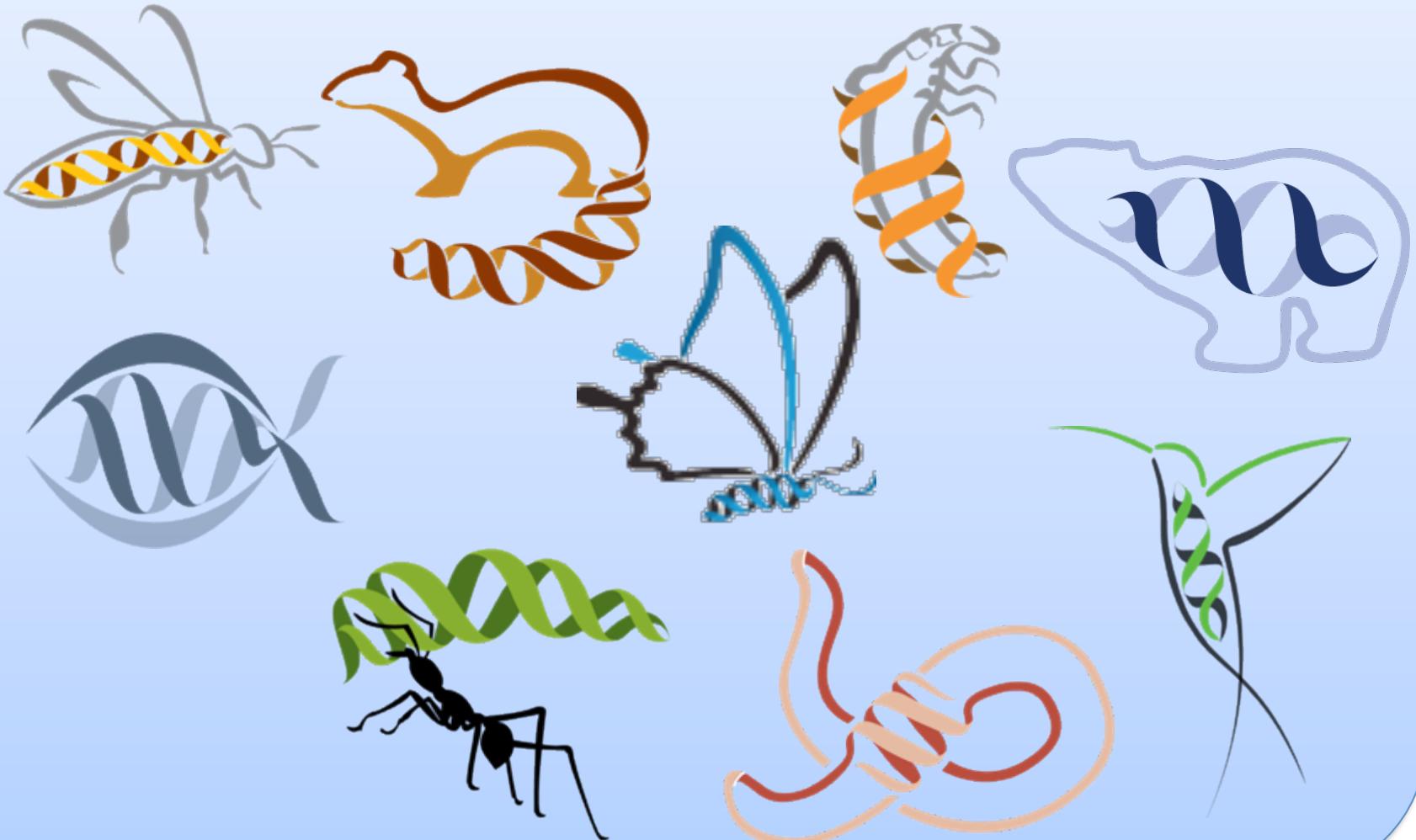
# *Introduction: Building the reference library*

**Current coverage :**  
**≈ 2200K Barcode Records; > 250K Species**



# *Barcodeing campaigns of soil invertebrates*

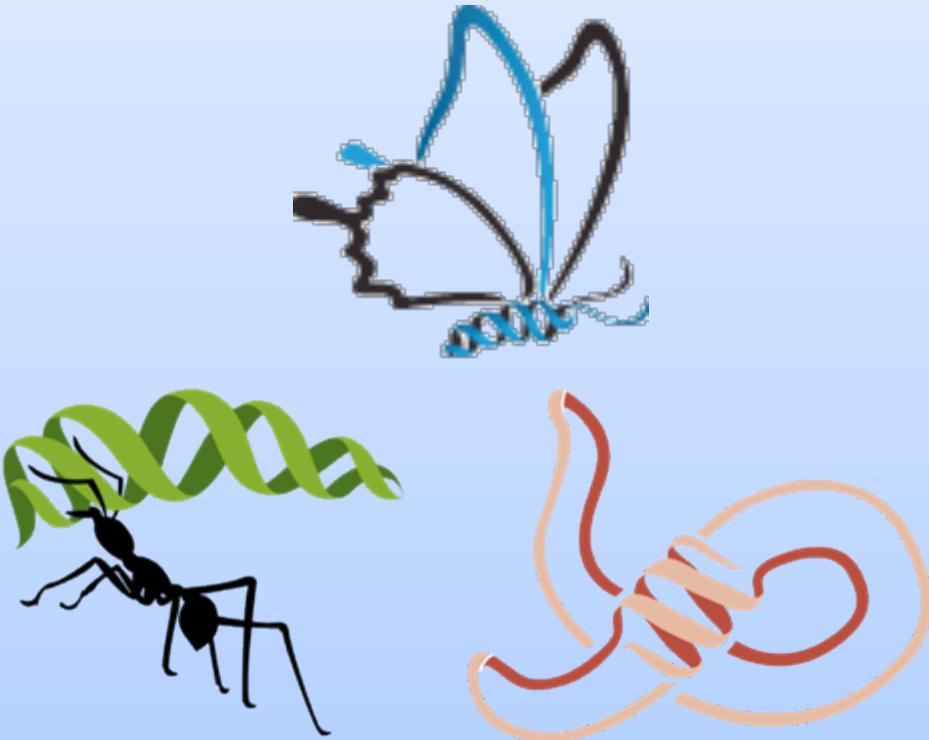
## Barcodeing campaigns



# *Barcodeing campaigns of soil invertebrates*

## Barcodeing campaigns

### WG 1.9 – Terrestrial Bio-Surveillance



# *Soil invertebrate barcoding campaigns*

## The Earthworm barcode of life

Home | About Us | Contact Us | 30/7/2012 Text size: | Search

**iBOL** | Terrestrial Biosurveillance

### Earthworm barcode of life

**Progress**

specimens barcoded:	<b>2572</b>
species barcoded:	<b>217</b>
unnamed barcode clusters found:	<b>535</b>

**Science**

- Vision
- Species Checklists
- Collection Protocols
- Submit Data BOLD SYSTEMS
- Lab Procedures

Welcome to Earthworm Barcode of Life, the campaign that aims to obtain DNA barcodes for the earthworms of the world.

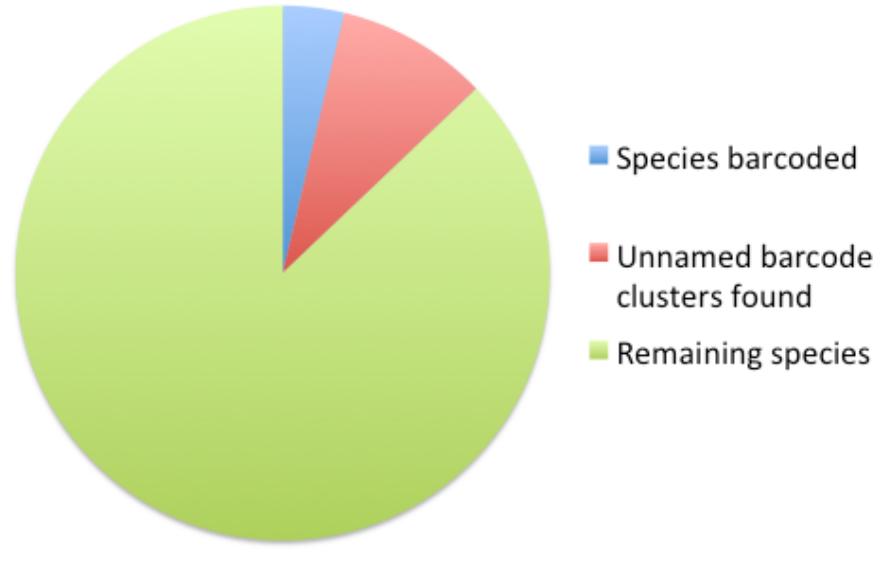
DNA barcoding promises great advances in species discovery and broad dissemination of taxonomic knowledge by providing a framework for a first-pass taxonomic screening of earthworm diversity using a single standardized gene marker - a 658 base pair fragment of the mitochondrial cytochrome oxidase subunit I gene. This is especially true considering the actual context of discovery of large portion of cryptic diversity in the group. It will be impossible to achieve our ambitious goal without the active involvement of many institutions and experts worldwide. Therefore the campaign seeks to assemble a broad global coalition of leading researchers, museums, and other institutions with interest in earthworm taxonomy and biodiversity.



## Progress

Targeted species: 5829

Specimens barcoded: 4000



# *Soil invertebrate barcoding campaigns*

## The Formicidae barcode of life

Home | About Us | Contact Us | 30/7/2012 Text size: + - Search

iBOL | Terrestrial Biosurveillance

**Formicidae barcode of life**

**progress** BARCODES

specimens barcoded: 14451

species barcoded: 1209

unnamed barcode clusters found: 2754

Progress Reports

**science**

Vision

Species Checklists

Priority Species

Collection Protocols

Submit Data BOLDSYSTEMS

Pogonomyrmex colei (queen)

Camponotus novaeboracensis

OTHER TERRESTRIAL CAMPAIGNS:

Welcome

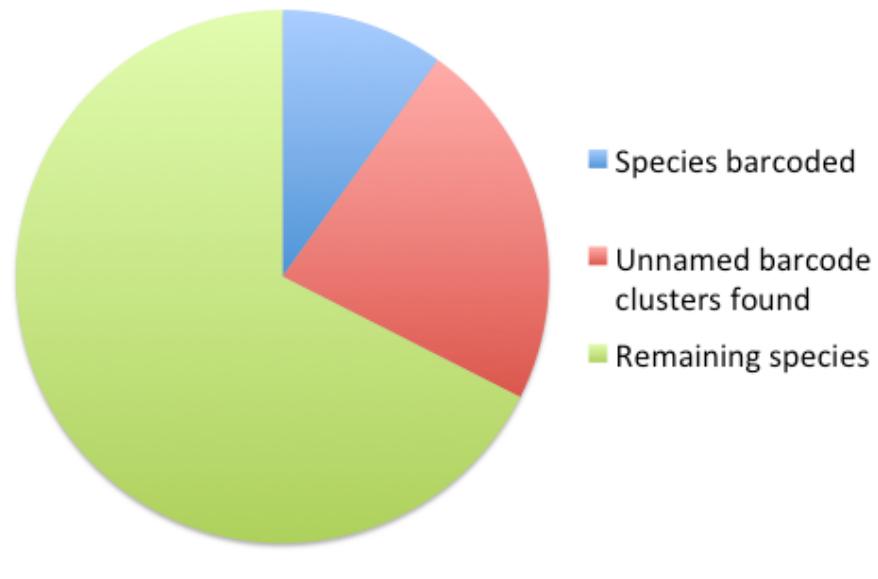
Welcome to the Ant Barcode of Life campaign website. Formally launched in mid-2008 (and building on proof of principle research ongoing since 2004), this DNA barcoding campaign aims to build a comprehensive COI barcode reference library for all ant species in the world (more than 12,000 species). Fulfilling such an ambitious goal is not an easy task. This project is expected to be a long-term research program. We are fully aware of the challenges but also anticipate exciting discoveries along the progressing of the campaign. Instead of



## Progress

Targeted species: 12 205

Specimens barcoded: 14 451



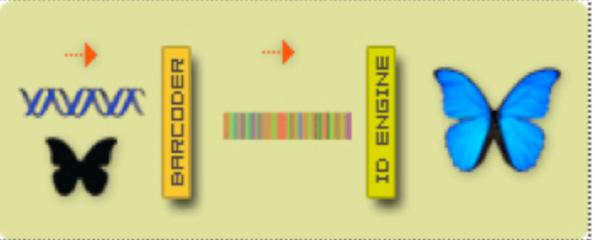
# *Applications: Species identification*

## Identification through closest match in a curated reference library



### IDENTIFICATION ENGINE

BOLD-IDS provides a species identification tool that accepts DNA sequences from the barcode region and returns a taxonomic assignment to the species level when possible.



# *Applications: Species identification*

BOLDSYSTEMS | Management & Analysis

**BOLD - ID**

Cytochrome Oxidase Subunit 1 [COX1] Intergenic Spacer Region [ITS]

The BOLD Identification System (IDS) accepts sequences from the 5' region of the mitochondrial gene COI and returns a species-level identification when one is possible. Further validation with independent genetic markers will be desirable in some forensic applications.

The reference database of validated records is used by default and is recommended for all identification purposes.

**Search Databases:**

- All Barcode Records on BOLD (434,398 sequences)  
Every COI barcode record on BOLD with a minimum sequence length of 500bp (warning: unvalidated database and includes records without species level identification). This includes many species represented by only one or two specimens as well as all species with interim taxonomy. This search only returns a list of the nearest matches and does not provide a probability of placement to a taxon.
- Species Level Barcode Records (386,161 sequences/37,849 Species)  
Every COI barcode record with a species level identification and a minimum sequence length of 500bp (warning: unvalidated dataset). This includes many species represented by only one or two specimens as well as all species with interim taxonomy.
- Reference Barcode Database (165,589 Sequences/13,774 Species)  
Validated subset of the full database with a minimum sequence length of 500bp and containing only those species represented by three or more individuals showing less than 2% sequence divergence

Enter sequences in fasta format:

```
AACTTATACCTAATTGGGGTTGAGCTGTATAAGTAGAACAGCAATTAGAGTTTAATTGTTAGAAATT  
AGGACAACCAGGTAGTTTATGGAGATGCCAAATTATAACGTAATAGTAACAGCCCCATGCTTTTATTATAAT  
TTTTTTATAGTGATACCTATTATAATCGGGGGATTGGAAACTGATTAGTACCCCTTAATAATCGGTGCCCTGA  
TATAGCCTTCCCCGAATAAAATTATGAGATTCTGGCTCTCCCCCTCTCTAACCCCTTCTTACAGGGGG  
TTTGTAGAAAGAGGGAGCCGGAACTGGTGAACAGTTATCCCCCACTTGCCGAGGAATTGCCAATGCTGGTC  
GTCAGTAGACCTTCTATTTAGCCTTCACTGGCGGGTGCTTCTTCTATTAGGAGCTGAAATTATTAC  
CACTATCAITAACATCGAACACCTGGTATATCTGAGACCAGACCCCTTTTGTGGTGGTGTGTTAAC  
AGCAATTCTCTTCTATCTTCTGTTAGCAGGAGCTTACCAACTCTAACCGATCGTAATTAAA  
TACATCGITCTCGACCCGGTGGAGGGGGAGACCCAATTATACCAACATTTATT
```

 Submit Cancel

# *Applications: Species identification*

BOLDSYSTEMS | Management & Analysis

Specimen Identification Request

Search Request:  
Type : COI FULL DATABASE

Search Result:  
A species level match has been made. This identification is solid unless there is a very closely allied congeneric species that has not yet been analyzed. Such cases are rare.

[Tree Based Identification](#) [Species Page](#)

Distance Summary :

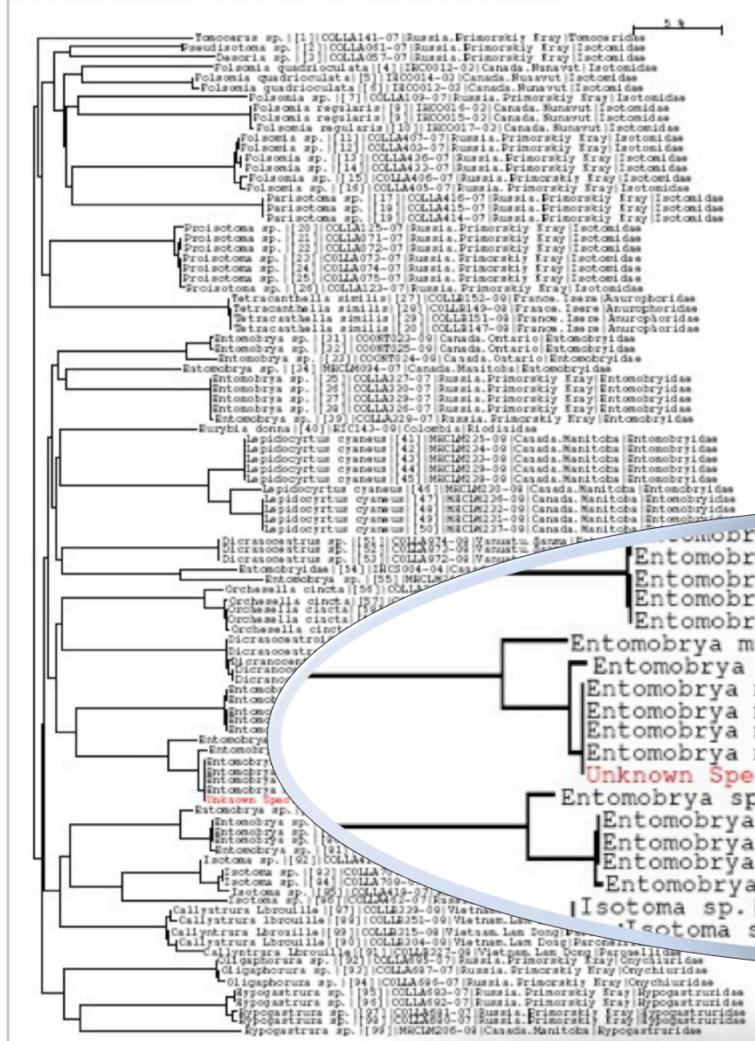
Similarity scores of the top 100 matches

TOP 20 Matches :

Phylum	Class	Order	Family	Genus	Species	Specimen Similarity (%)
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	<i>multifasciata</i>	100
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	<i>multifasciata</i>	100
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	<i>multifasciata</i>	100
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	<i>multifasciata</i>	100
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	<i>multifasciata</i>	99.22
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	<i>multifasciata</i>	96.33
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	sp.	86.09
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	sp.	85.96
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	sp.	85.85
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	sp.	85.78
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	sp.	85.78
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	sp.	85.78
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Orchesella	<i>cincta</i>	84.86
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	sp.	84.71
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Entomobrya	sp.	84.71
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Orchesella	<i>cincta</i>	84.56
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Orchesella	<i>cincta</i>	84.56
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Orchesella	<i>cincta</i>	84.4
Arthropoda	Collembola	Entomobryomorpha	Entomobryidae	Orchesella	<i>cincta</i>	84.4
Arthropoda	Insecta	Lepidoptera	Riodinidae	Eurybia	<i>donna</i>	84.25

# Applications: Species identification

COL\_FULL\_DATABASE\_Tree Wed Aug 13 06:23:42 2008 Page 1 of 1



# *Applications: Species identification*

*... anywhere, any stages*

## MOLECULAR ECOLOGY RESOURCES

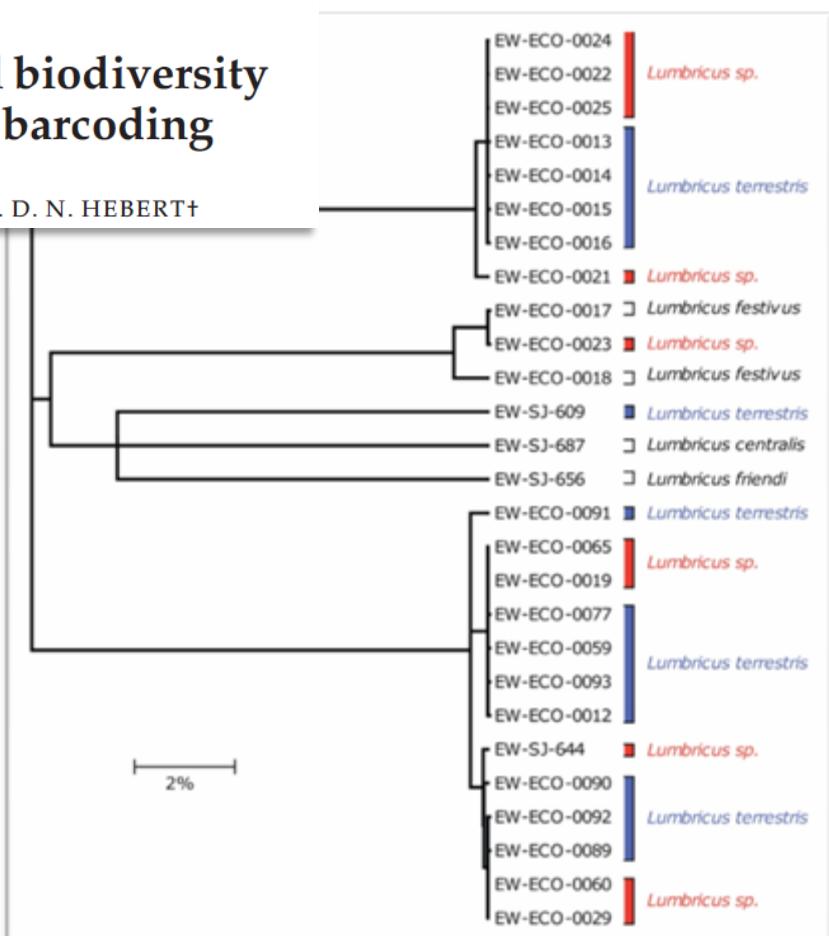
Molecular Ecology Resources (2010) 10, 606–614

doi: 10.1111/j.1755-0998.2009.02822.x

### DNA BARCODING

## Re-integrating earthworm juveniles into soil biodiversity studies: species identification through DNA barcoding

B. RICHARD,\* T. DECAËNS,\* R. ROUGERIE,† S. W. JAMES,‡ D. PORCO† and P. D. N. HEBERT†



# Applications: Cryptic diversity

**Cryptic species** = species morphologically identical but well discriminated by their barcodes

Extensive survey of earthworms from different British localities:

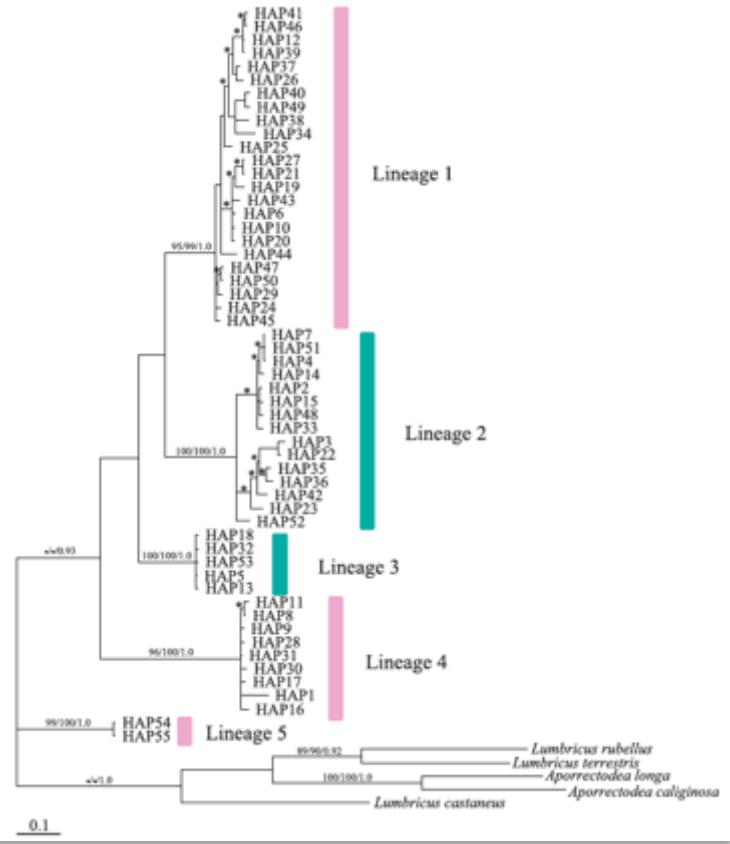
- *A. chlorotica*, *A. longa*, *A. rosea* and *L. rubellus* all comprise highly divergent lineages with species-level divergence
- AFLP markers showed that 14% of divergence at COI might not be enough to consider two lineages as distinct species

Molecular Ecology (2008) 17, 4684–4698

doi: 10.1111/j.1365-294X.2008.0931.x

## Opening a can of worms: unprecedented sympatric cryptic diversity within British lumbricid earthworms

R. ANDREW KING, AMY L. TIBBLE and WILLIAM O. C. SYMONDSON



Pedobiologia 54 (2011) 217–224

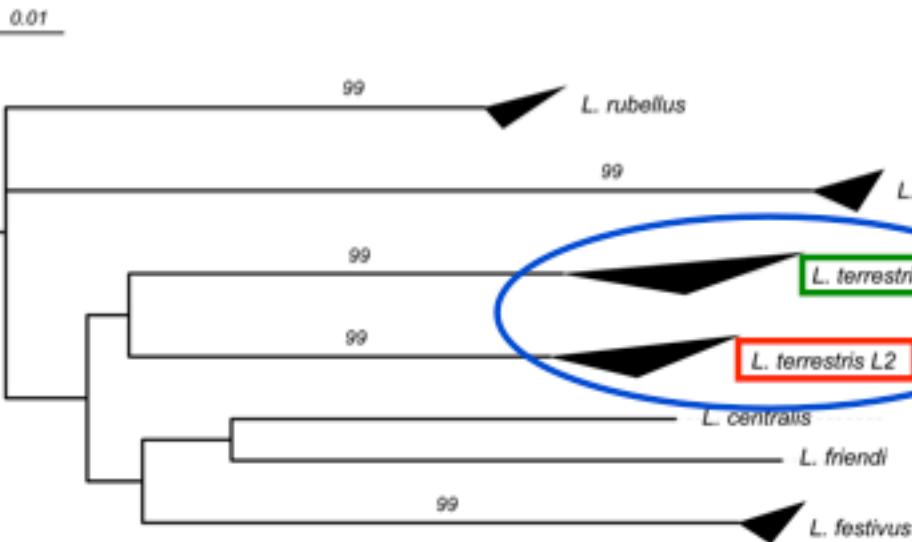
New insight into the genetic structure of the *Allolobophora chlorotica* aggregate in Europe using microsatellite and mitochondrial data

L. Dupont<sup>a,\*</sup>, F. Lazrek<sup>a</sup>, D. Porco<sup>b,d</sup>, R.A. King<sup>c,e</sup>, R. Rougerie<sup>b,d</sup>, W.O.C. Symondson<sup>c</sup>, A. Livet<sup>a</sup>, B. Richard<sup>d,h</sup>, T. Decaëns<sup>d</sup>, K.R. Butt<sup>e</sup>, J. Mathieu<sup>f</sup>

# Applications: Cryptic diversity

## The *L. terrestris* / *herculeus* complex

200 specimens from:  
France, Scandinavia, Canada and USA



Risk of  
« chimerical biology »

OPEN ACCESS Freely available online

## DNA Barcoding Reveals Cryptic Diversity in *Lumbricus terrestris* L., 1758 (Clitellata): Resurrection of *L. herculeus* (Savigny, 1826)

Samuel W. James<sup>1,3\*</sup>, David Porco<sup>2,3</sup>, Thibaud Decaëns<sup>3</sup>, Benoit Richard<sup>3</sup>, Rodolphe Rougerie<sup>2,3</sup>, Christer Erséus<sup>4</sup>

L1 = *Lumbricus terrestris*



L2 = *Lumbricus herculeus*



# Applications: Alpha taxonomy

Zootaxa 2639: 59–68 (2010)  
www.mapress.com/zootaxa/  
Copyright © 2010 · Magnolia Press

## Article

ISSN 1175-5326 (print edition)  
**ZOOTAXA**  
ISSN 1175-5334 (online edition)

Description and DNA barcoding assessment of the new species  
*Deutonura gibbosa* (Collembola: Neanuridae: Neanurinae),  
a common springtail of Alps and Jura

DAVID PORCO<sup>1</sup>, ANNE BEDOS<sup>2</sup> & LOUIS DEHARVENG<sup>2</sup>



Available online at www.sciencedirect.com



Organisms, Diversity & Evolution 7 (2007) 231–240

ORGANISMS  
DIVERSITY &  
EVOLUTION

www.elsevier.de/ode

Taxonomic re-evaluation of the Taiwanese montane earthworm *Amynthas wulinensis* Tsai, Shen & Tsai, 2001 (Oligochaeta: Megascolecidae):  
Polytypic species or species complex?

Chih-Han Chang<sup>a</sup>, Yu-Hsung Lin<sup>b</sup>, I.-Han Chen<sup>b</sup>, Shu-Chun Chuang<sup>b</sup>,  
Jiun-Hong Chen<sup>a,b,\*</sup>

OPEN ACCESS Freely available online



A Revision of Malagasy Species of *Anochetus* Mayr and  
*Odontomachus* Latreille (Hymenoptera: Formicidae)

Brian L. Fisher<sup>1\*</sup>, M. Alex Smith<sup>2\*</sup>



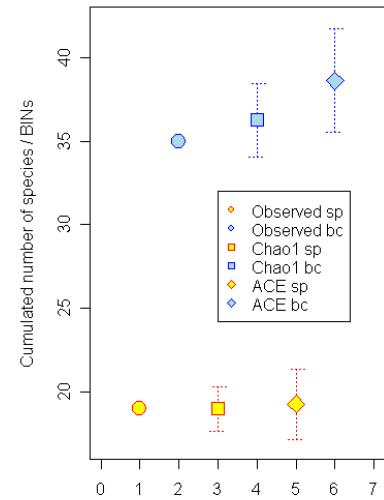
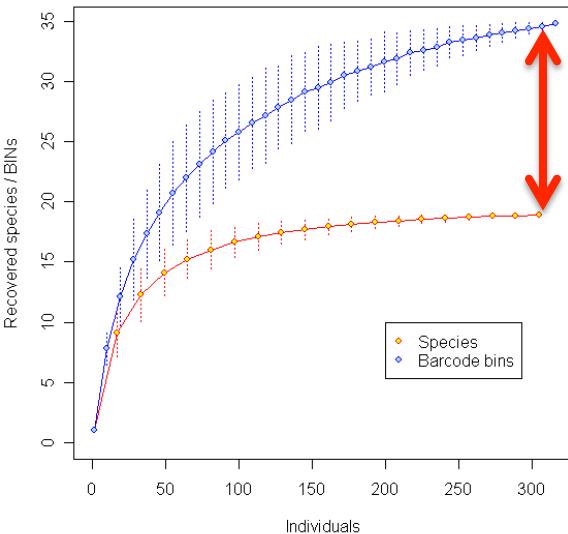
# *Applications: Biodiversity estimates*



- “Earthworms of Normandy” sub-project
  - “Earthworms of Canada” sub-project
- About 800 sequences

Molecular Ecology Resources (2009) 9 (Suppl. 1), 208–216

doi: 10.1111/j.1755-0998.2009.02646.x



## BARCODING ARTHROPODS

### DNA barcode accumulation curves for understudied taxa and areas

M. ALEX SMITH,\* JOSE FERNANDEZ-TRIANA,\* ROB ROUGHLEY† and PAUL D. N. HEBERT\*

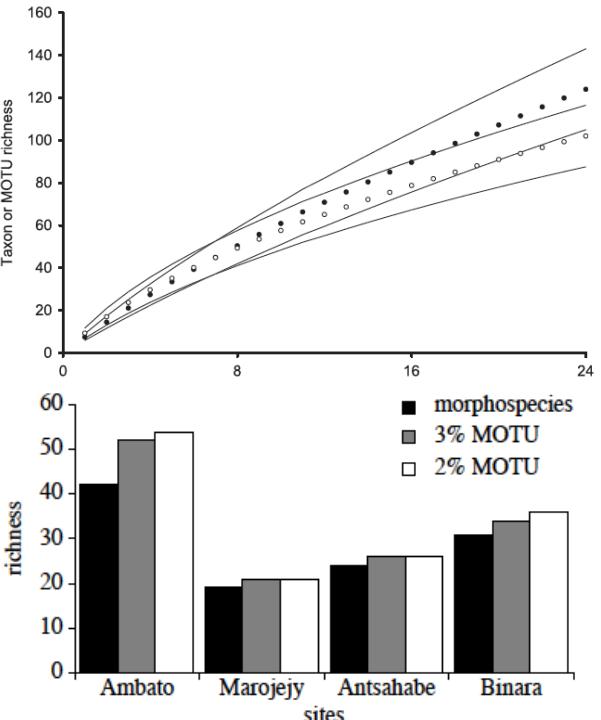


Phil. Trans. R. Soc. B (2005) 360, 1825–1834  
 doi:10.1098/rstb.2005.1714  
 Published online 8 September 2005

### DNA barcoding for effective biodiversity assessment of a hyperdiverse arthropod group: the ants of Madagascar

M. Alex Smith<sup>1,\*†</sup>, Brian L. Fisher<sup>2,\*†</sup> and Paul D. N. Hebert<sup>1</sup>

Decaëns et al (accepted), Porco et al. (in prep), Smith et al (2005, 2009)



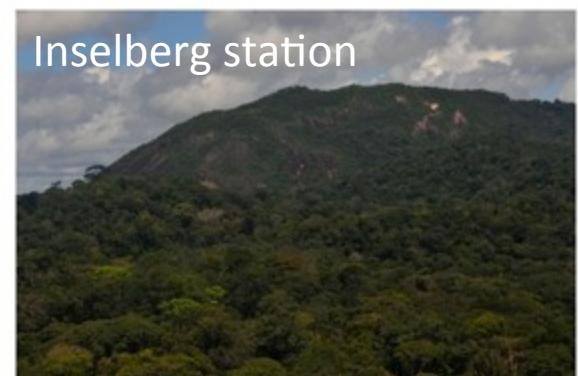
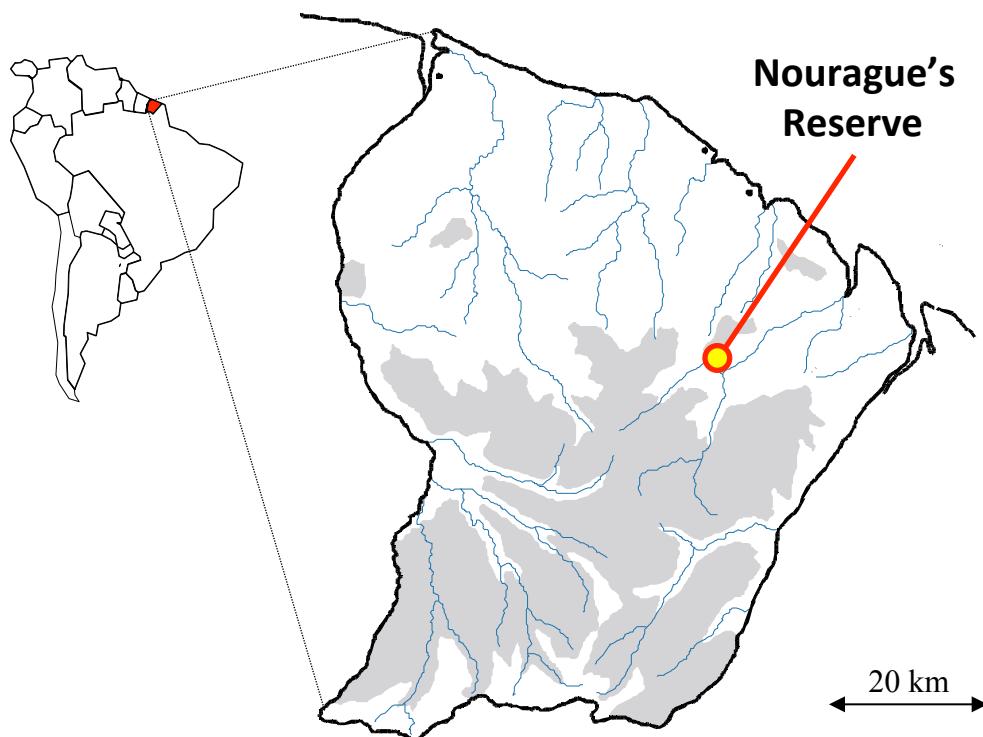
# *Applications: Ecology*

## DNA barcoding to estimate underground biodiversity - a case study with earthworms in the Nouragues Research Station (French Guyana)

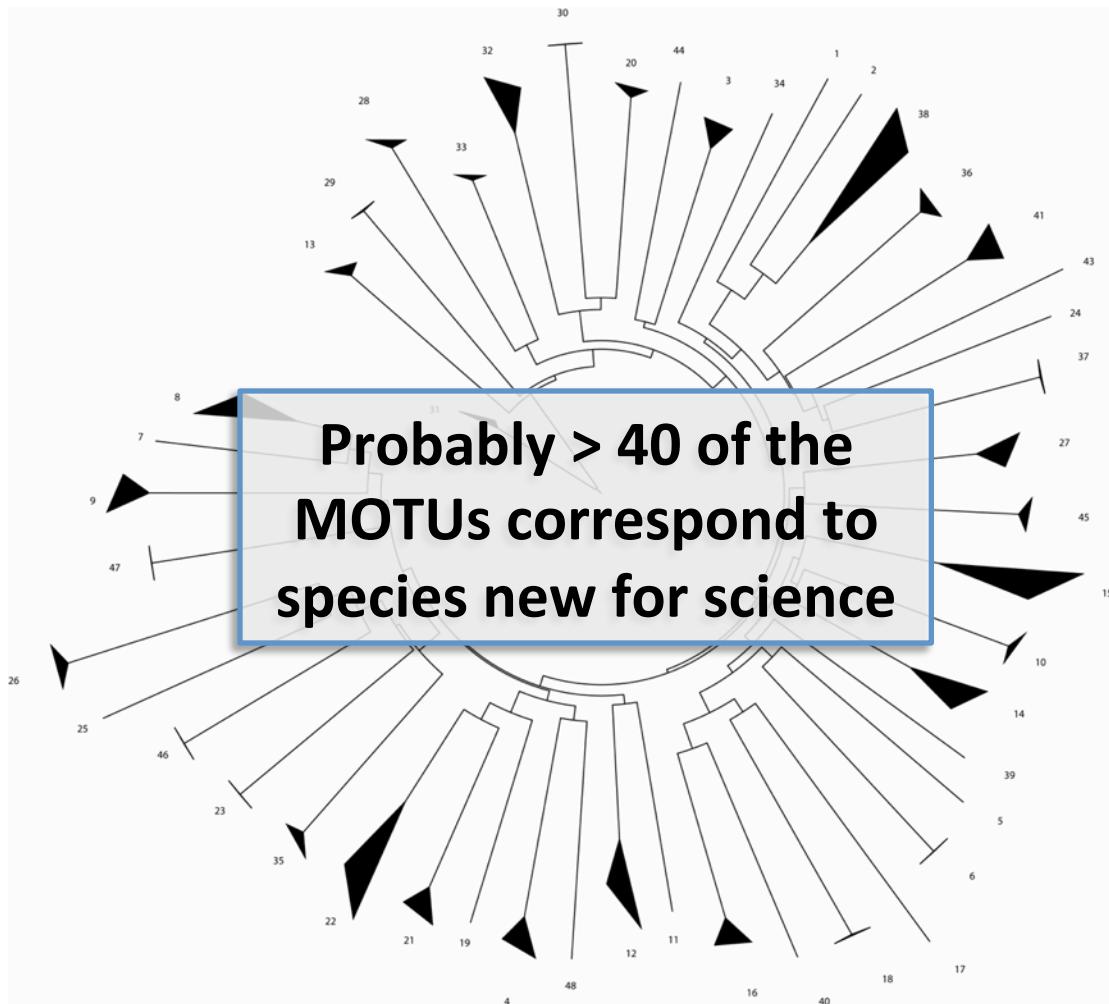
T. Decaëns<sup>1</sup>, S.W. James<sup>2</sup>, V. Chassany<sup>3</sup>, L. Dupont<sup>4</sup>, E. Lapiède<sup>5</sup>, R. Rougerie<sup>1</sup>, V. Roy<sup>4</sup>, J.-P. Rossi<sup>6</sup>, D. Porco<sup>1</sup>

### **Objective:**

To describe earthworm biodiversity patterns in the hyperdiverse ecosystems of the Nourague's natural reserve, French Guiana



# *Applications: Ecology*



- 748 earthworms
- 4 families: Glossoscolecidae, Octochaetidae, Ocnerodrilidae, Haplotaxidae
- 605 sequences  
→ > 80% success
- ~ 30% of singletons

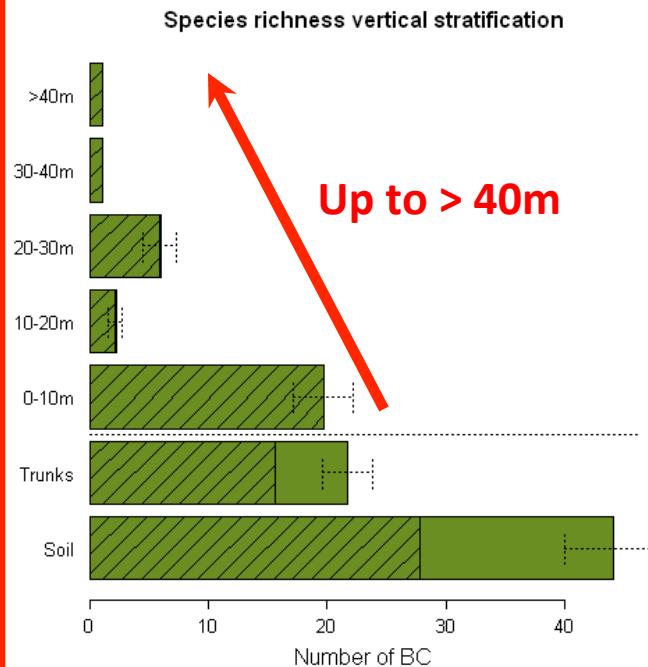
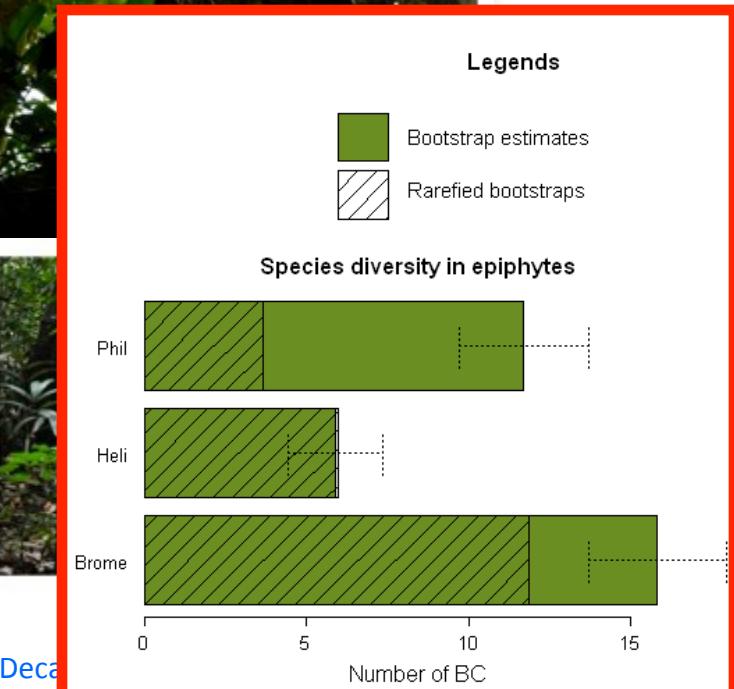
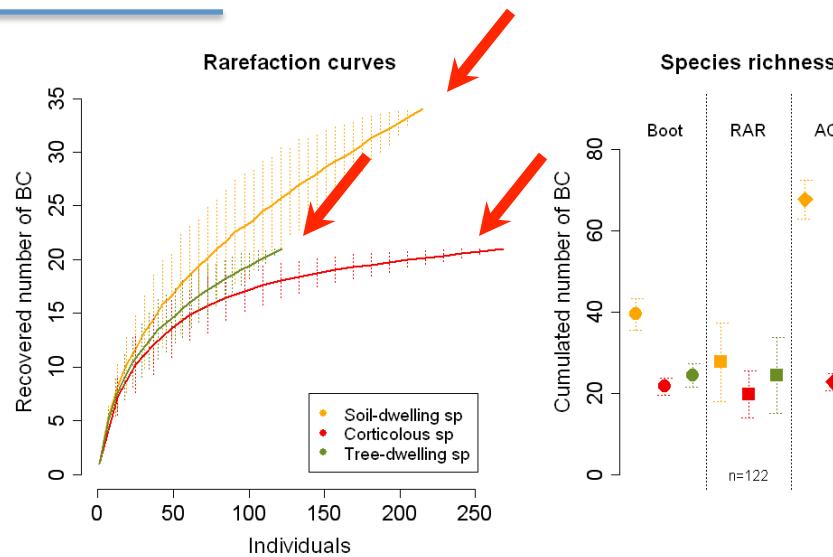
**15% threshold**

→ **50 MOTUs**

• ~ 30% of singletons

**Locality with the highest species richness worldwide !**

# Applications: Ecology

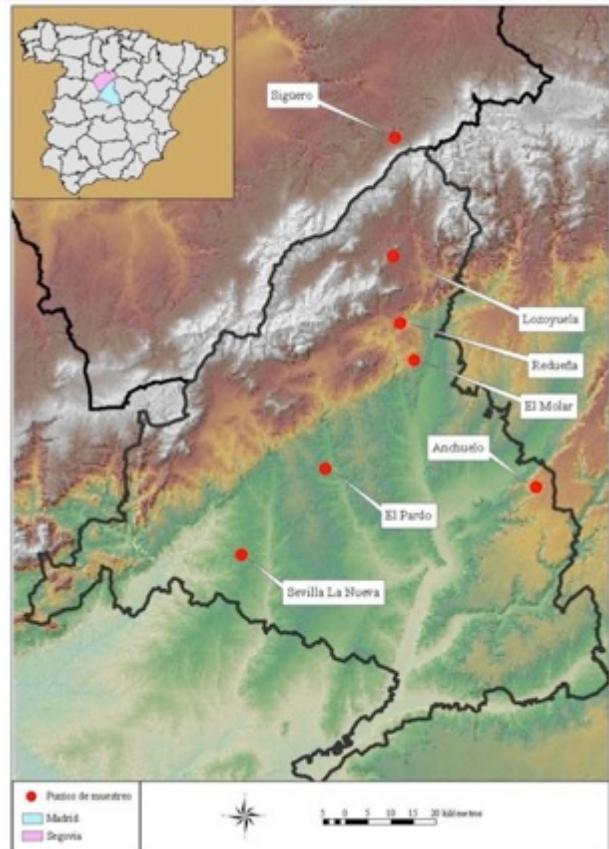


# Applications: Phylogeography

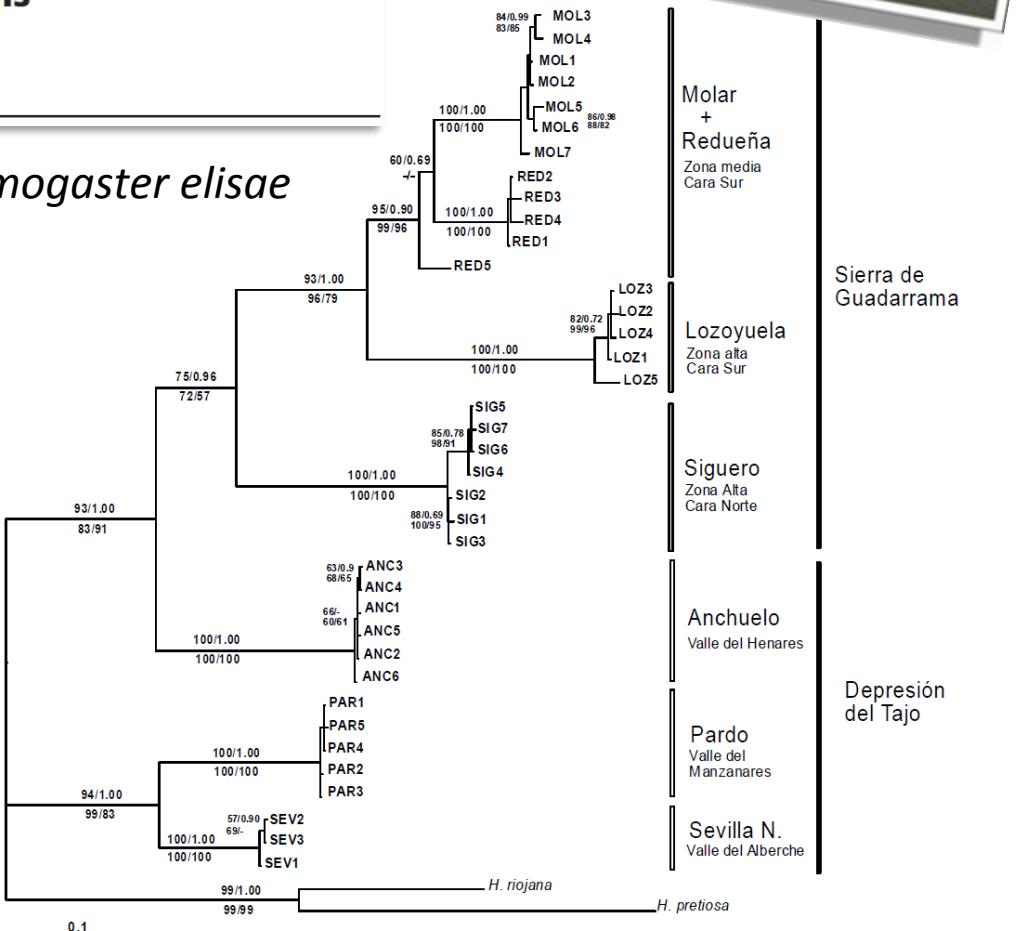
Zoologica Scripta, 38, 5, September 2009, pp 537–552

## High genetic divergence of hormogastrid earthworms (Annelida, Oligochaeta) in the central Iberian Peninsula: evolutionary and demographic implications

MARTA NOVO, ANA ALMODÓVAR & DARÍO J. DÍAZ-COSÍN



### *Hormogaster elisae*



# Applications: Phylogenetics

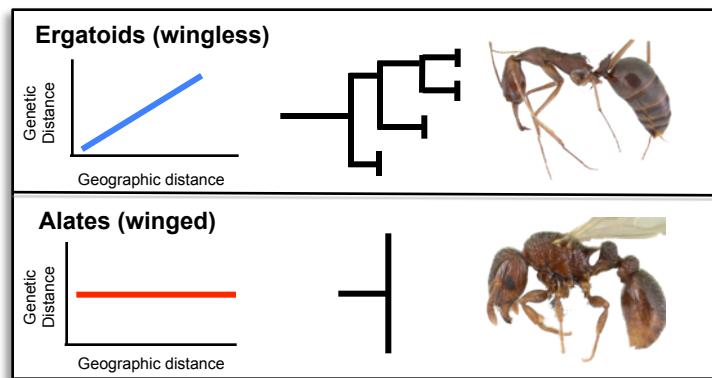


## Objectives:

To predict female reproductive dispersal patterns using phylogeographic comparisons of DNA barcodes

**Study region:** Madagascar

## Predictions:



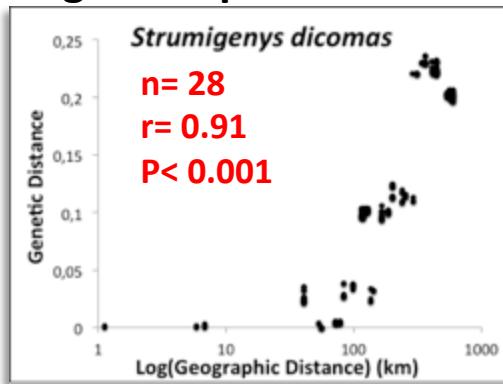
## Inferring Ant Reproductive Dispersal Through Phylogeographic Comparisons of COI

Fiona Tsoi<sup>1</sup>, Claudia Bertrand<sup>1</sup>, Brian L. Fisher<sup>2</sup> and M. Alex Smith<sup>1</sup>

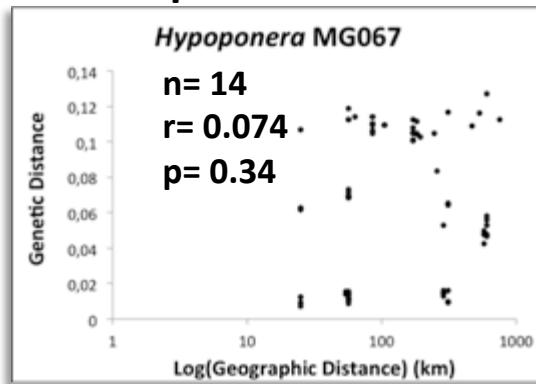
<sup>1</sup> Department of Integrative Biology, University of Guelph, <sup>2</sup> California Academy of Sciences, San Francisco

## Results:

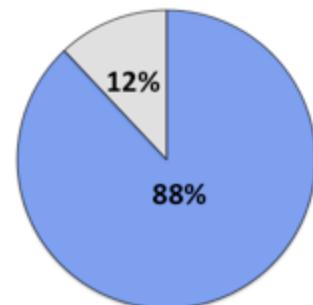
### Ergatoid species



### Alate species

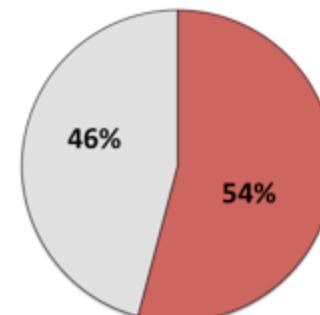


### Ergatoid



■ Significant  
□ Not Significant

### Alate



■ Significant  
□ Not Significant

# Applications: Monitoring of invasive species

Frontiers in Zoology



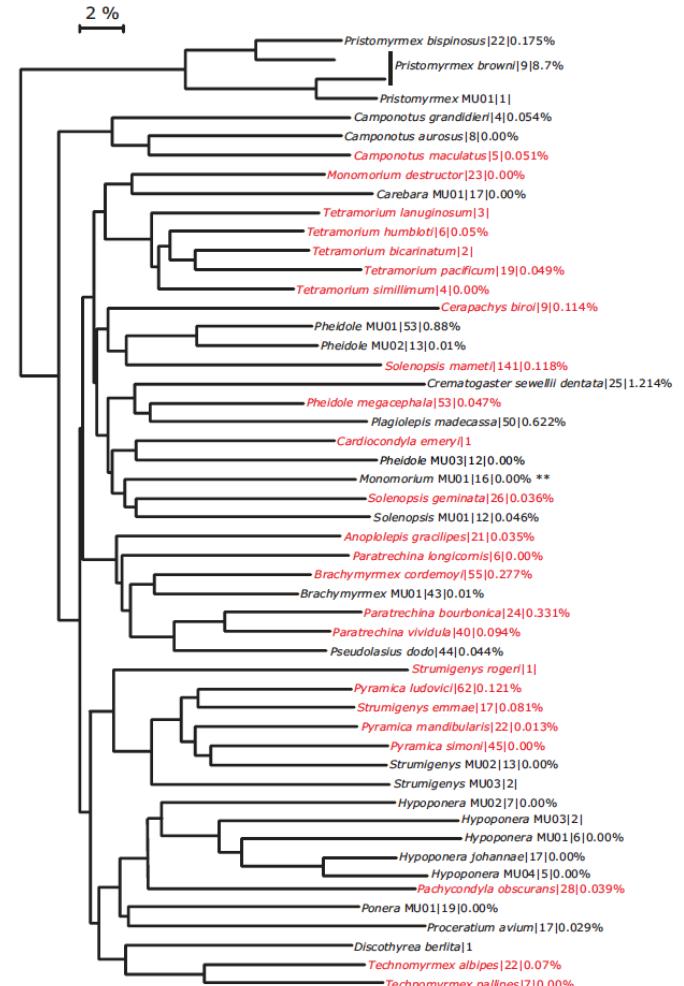
Research

Open Access

Invasions, DNA barcodes, and rapid biodiversity assessment using ants of Mauritius

M Alex Smith\*<sup>1</sup> and Brian L Fisher\*<sup>2</sup>

- 10 sites and > 1000 sequenced specimens
- 52 species / 25 introduced
  - Among which the “biological Attila”s *Pheidole megacephala*, *Anoplolepis gracilipes*, *Paratrechina longicornis*...



# *Applications: Monitoring of invasive species*

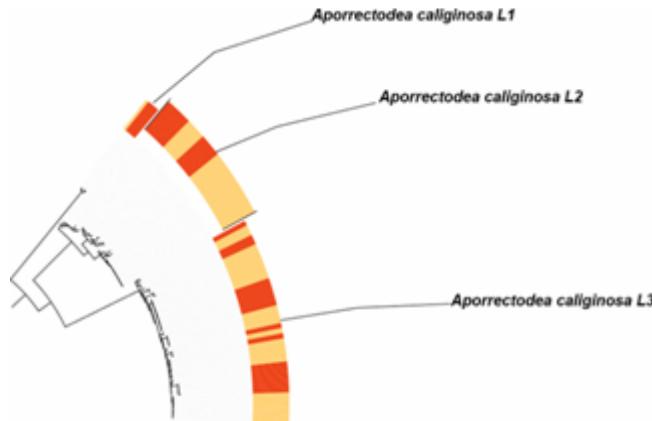
## Invasion process (origin, expansion)

Biol Invasions (2013) 15:899–910  
DOI 10.1007/s10530-012-0338-2

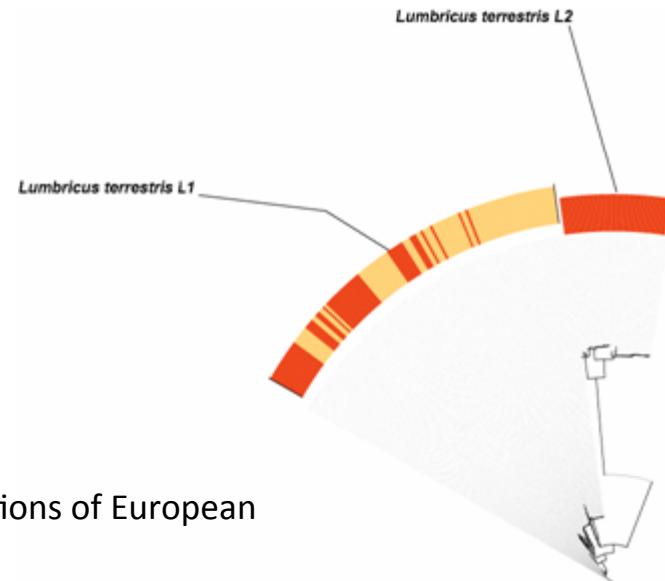
### Biological invasions in soil: DNA barcoding as a monitoring tool in a multiple taxa survey targeting European earthworms and springtails in North America

David Porco · Thibaud Decaëns · Louis Deharveng · Samuel W. James ·  
Dariusz Skarżyński · Christer Erséus · Kevin R. Butt · Benoit Richard ·  
Paul D. N. Hebert

#### *Aporrectodea caliginosa*



#### *Lumbricus terrestris / herculeus*



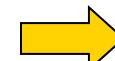
- Comparing COI variation in autochthonous versus invasive populations of European Lumbricidae and Collembola
- Genetic structure of invasive population reveals invasion history
- Most species have been introduced in North America repeatedly and massively

# Perspectives : Environmental barcodina

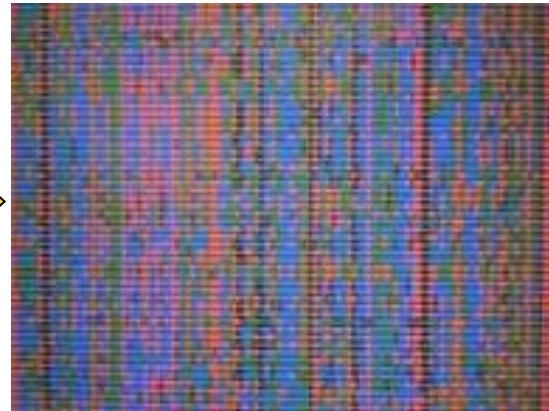
Environmental Sample



454 FLX Pyrosequencer

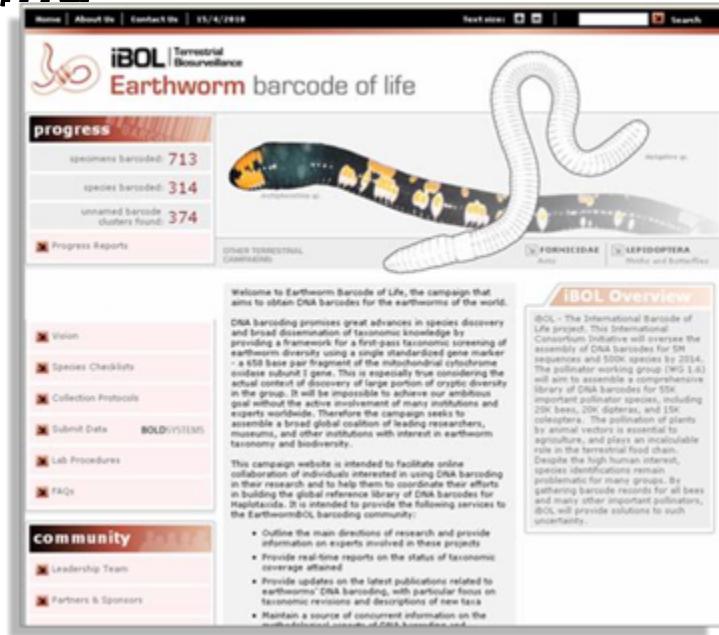


Pyrosequencing data



**Species identities  
and counts**

Target Barcode Library



**iBOL** | Terrestrial Biodiversity  
**Earthworm** barcode of life

**progress** 713

specimens barcoded: 713  
species barcoded: 314  
unnamed barcode clusters found: 374

Progress Reports

**Vision**

DNA barcoding promises great advances in species discovery and broad dissemination of taxonomic knowledge by providing a rapid, objective, and automated means of assessing earthworm diversity using a single standardized gene marker - a 650 base pair fragment of the mitochondrial cytochrome oxidase subunit I gene. This is especially true considering the relatively small size of the genome and the paucity of cryptic diversity in the group. It will be impossible to achieve our ambitious goal without the active involvement of many institutions and experts around the world. We invite you to join us and assemble a broad global coalition of leading researchers, museums, and other institutions with interest in earthworm taxonomy and biodiversity.

This campaign website is intended to facilitate online collaboration of individuals interested in using DNA barcoding to assess earthworm diversity and to contribute efforts in building the global reference library of DNA barcodes for Haplotaxida. It is intended to provide the following services to the EarthwormiBOL barcoding community:

- Outline the main directions of research and provide information on experts involved in these projects
- Provide real-time reports on the status of taxonomic assessments
- Provide updates on the latest publications related to earthworm DNA barcoding, with particular focus on taxonomic revisions and descriptions of new taxa
- Maintain a source of concurrent information on the [www.ibol.org/BarcodeofLife.html](http://www.ibol.org/BarcodeofLife.html)

**OTHER TERRESTRIAL CAMPAIGNS**

**IBOL Overview**

**BOLD SYSTEMS**

**community**

Leadership Team  
Partners & Sponsors

**FORMICIDAE**  
Ants

**LEPIDOPTERA**  
Moths and Butterflies



# *Perspectives : Environmental barcoding*

## MOLECULAR ECOLOGY

Molecular Ecology (2012) 21, 2017–2030

doi: 10.1111/j.1365-294X.2011.05407.x

### Tracking earthworm communities from soil DNA

FRIEDERIKE BIENERT,\* SÉBASTIEN DE DANIELI,† CHRISTIAN MIQUEL,\* ERIC COISSAC,\*  
CAROLE POILLOT,\* JEAN-JACQUES BRUNT and PIERRE TABERLET\*

**A high-throughput genomics approach for comprehensive biological assessment of environmental change**

Project leader: M. Hajibabaei

### The GENOSOIL-Fr project : insights from metagenomics into the study of total biodiversity of soils

T. Decaëns<sup>1</sup>, D. Porco<sup>1</sup>, D. Sebag<sup>1</sup>, J. Oswald<sup>2</sup>, R. Rougerie<sup>1</sup>, A. Husté<sup>1</sup>, L. Dupont<sup>3</sup>, S. Doledec<sup>4</sup>, J.-P. Rossi<sup>5</sup>, M. Hajibabaei<sup>6</sup>

(1) University of Rouen, France; (2) University of Rennes, France; (3) University Paris 6, France; (4) University of Lyon, France; (5) University of Montpellier, France; (6) University of Guelph, Canada; cor. auth.: [tibaud.decaens@univ-rouen.fr](mailto:tibaud.decaens@univ-rouen.fr)



# Perspectives: Education

## Hands-on DNA barcoding: Engaging students of the ECO-TROP field class for rapid invertebrate diversity assessment in Lopé National Park, Gabon

D. Porco<sup>1</sup>, N. Lepengue<sup>2</sup>, D. Sebag<sup>3</sup>, R. Rougerie<sup>1</sup>, M. Andeime Eyene<sup>4</sup>, L. Bremond<sup>5</sup>, S. Dufour<sup>6</sup>, P. Le Gall<sup>7</sup>, J. Lebamba<sup>2</sup>, G. Moussavou<sup>8,9</sup>, Makaya Mvoubou<sup>2</sup>, R. Oslisly<sup>7</sup>, J. Oswald<sup>6</sup>, C. Paupy<sup>7,9</sup>, O. Scholtz<sup>10</sup>, M. Tindo<sup>11</sup>, M. Veullie<sup>12</sup>, T. Decaëns<sup>1</sup>



- In February 2011 and March 2012-2013
- In the National Park of La Lopé (Gabon)
- Invertebrate diversity assessment using DNA barcoding

# Perspectives: Education

## DNA barcoding: para quê e para quem?

Improve our taxonomic knowledge of soil fauna:

- Taxonomy and systematics
- Community ecology
- Functional ecology
- Conservation biology



# *Perspectives: Education*

## DNA barcoding: para quê e para quem?



### In the context of Brazil:

- Describe soil invertebrate biodiversity in the main natural ecosystem
- Provide new insights for the monitoring of this biodiversity in deforested and agricultural landscapes
- Participate to high level education in biodiversity research and environmental sciences



# Obrigado pela atenção

