Changes in Collembola diversity along a Neotropical elevation gradient

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Biogeographical trends have been studied by ecologists wanting to understand how environmental factors influence species occurrence.

Patterns in diversity have been observed across large distances along latitudinal gradients.

However, similar patterns are observed along elevation gradients, at a smaller spatial scale.
Abiotic Factors and Elevation

As elevation increases:

- Soil temperature decreases and becomes less variable
- Mean annual precipitation and % water volume of the soil increases
Abiotic Factors Summary

- Large change in abiotic factors over a 30 km distance
- Forest composition changes as elevation increases
- Expect that these changes will have an effect on Collembola diversity
Collembola

**Habitat:**
- Leaf litter, soil, vegetation
- Found in most ecosystems

**Important in the ecosystem:**
- Prey for predatory arthropods
- Assist in decomposition

**Sensitive to environmental conditions that change along elevation gradients:**
- At risk of desiccation
- Influenced by temperature
Taxonomic Impediment

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Cryptic Diversity in the Ubiquist Species Parisotoma notabilis (Collembola, Isotomidae): A Long-Used Chimeric Species?

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Abstract

Parisotoma notabilis is the most common species of Collembola in Europe and is currently designated as ubiquist. This species has been extensively used in numerous studies and is considered as well characterized on a morphological ground. Despite the homogeneity of its morphology, the sequencing of the barcoding fragment (5’ end of COI) for several populations throughout Europe and North America revealed four distinct genetic lineages. The divergence found between these lineages was similar to the genetic distance among other species of the genus Parisotoma included in the analysis. All four lineages have been confirmed by the nuclear gene 28S. This congruence between mitochondrial and nuclear signals, as well as the geographical distribution pattern of lineages observed in Europe, supports the potential specific status of these lineages. Based on specimens from the type locality (Hamburg), the species name was successfully assigned to one of these lineages. This finding raises several problems as Parisotoma notabilis has been widely used in many ecological studies. Accumulation of new data for the different lineages detected, especially ecological information and life history traits, is needed to help resolve this situation.


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Objectives

Diversity Pattern
- Differences between morphological and molecular based analyses

Phylogenetic structure
- Indication of possible environmental filtering
Diversity Measurements

- Morphospecies Richness
- MOTU Richness
- Faith’s Phylogenetic Diversity
- Nearest Taxon Index

Morphospecies 1:

Morphospecies 2:
Diversity Measurements

- Morphospecies Richness
- MOTU Richness
- Faith’s Phylogenetic Diversity
- Nearest Taxon Index

MOTU 1: ATAGTAGGAACCTGCTTTTG...
MOTU2: ATAGTAGGAACCTGCTTTTG...

2% divergence
Diversity Measurements

- Morphospecies Richness
- MOTU Richness
- Faith’s Phylogenetic Diversity
- Nearest Taxon Index
Diversity Measurements

- Morphospecies Richness
- MOTU Richness
- Faith’s Phylogenetic Diversity
- Nearest Taxon Index
If Collembola have difficulty persisting in hot dry areas, then Collembola diversity will increase with elevation.
Hypotheses and Predictions

Phylogenetic Structure

- If specialized traits are needed to exploit dry environmental, then areas at low elevations will be phylogenetically clustered.
Collections

Collected along Volcán Cacao in the Área de Conservación Guanacaste, Costa Rica at eight elevations using standardized protocols

- Sampled during dry and wet seasons from 2008-2014
Specimen Identification

Morphospecies
- Interim proxy for formal species names
- Based on morphological characteristics

MOTUs
- COI = 5’ COI mitochondrial gene
- Concatenated = 18S & 28S & COI
Diversity Analysis

For PD and NTI estimates:

- Neighbor-Joining tree
  - K2P distances
  - Pairwise deletions
- Maximum Likelihood
  - K2P distances
  - Partial deletions
Morphospecies and MOTU

Richness

Diversity Pattern

- No apparent relationship between elevation and diversity
Morphospecies and MOTU

Richness

Diversity Pattern

Richness vs. Elevation

Entomobryomorpha

Poduromorpha

Symphypleona

Elevation (m)

Richness

p<0.05
Phylogenetic Diversity

- No apparent relationship between elevation and diversity
Phylogenetic Diversity
Phylogenetic Structure

Phylogenetic structure

![Graph showing NTI values across different elevations](image)

- **Concatenated sequences**
- **COI sequences**

- * p<0.05
- † 0.05<p<0.1
Phylogenetic Structure

![Bar charts showing NTI values against elevation (m).](image)
Summary

Diversity

- Lack of a diversity-elevation trend
  - Abiotic factors as measured do not reflect the conditions Collembola experience
  - Collembola may be able to exploit microhabitats that shelter them from the impacts of moisture and temperature gradients
Summary

Phylogenetic Structure
- No evident difference between phylogenetic structure of low and high elevations
  - Specific site effects influencing non-random phylogenetic structure

Ordinal differences
- Orders differ in their response to elevation gradients both in terms of morphospecies richness, COI MOTU richness, PD and NTI
  - Reflects the different habitat niches orders fill
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Questions?

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Elevation - Diversity Patterns

Decrease

Increase

Mid-elevation peak
Diversity Analysis

- MOTU Richness
- COI
- Concatenated (18S & 28S & COI)
Sampling Effort (Morphospecies)

- Abundance
- Number of collection units sampled per elevation

![Graph showing sampling effort vs. elevation with markers for morphospecies richness, lots sampled, and abundance.](image-url)
Sampling Effort (Morphospecies)

- Controlling the effect of differing abundance and collection units
Sampling Effort (Morphospecies)

- However, evidence that abundance decreases independently of the number of collection units.
Sampling Effort (Molecular Sequences)

- Number of individuals with COI and concatenated sequences
Sampling Effort (Molecular Sequences)

- Number of individuals with COI and concatenated sequences

![Graph showing the relationship between elevation and number of individuals with COI and concatenated sequences. The graph plots elevation in meters on the x-axis and the number of individuals with sequences on the y-axis. Two data sets are represented: COI MOTUs (yellow circles) and Concatenated MOTUs (purple circles). The data points show a general decrease in the number of individuals with sequences as elevation increases.]