Biodiversity & Taxonomy: Uncertainties and Tools

ELI Seminar, 2023-3-2

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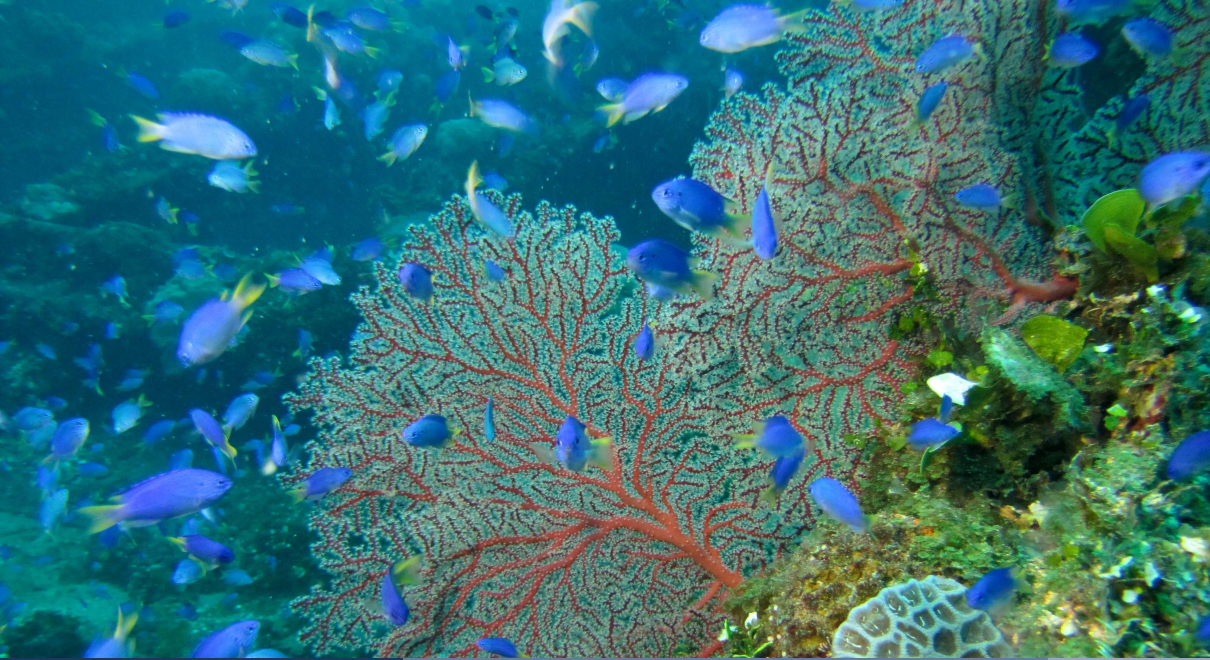
Outline

1. Ambiguity and disagreement in biodiversity and taxonomy
2. What do we do about it?
3. Empirical analyses: taxonomy corpus
   - 3.1 Corpus construction
   - 3.2 A few ways to analyze a corpus
   - 3.3 Future ideas

The take-home: There's a strong sentiment in biology and philosophy that disagreement is a serious problem for conservation: let's test it!

Biodiversity and Taxonomy



A Balance

The concept of biodiversity has to be:

- Larger than just single (charismatic) species (to capture ecological relations)
- Smaller than “life itself” (to give us something that it is possible to conserve)

The Hunt for Indicators

- species richness (with phylogenetic-distance corrections?)
- diversity of traits or characters
- structural diversity of ecological communities
- diversity of ecological niches
- genetic diversity

Biodiversity and Taxonomy

And any biodiversity studies relying on species inventory will inherit the **rampant uncertainty and disagreement** found in taxonomy!

Part of the vast ornithology collection at the American Museum of Natural History.

Taxonomy anarchy hampers conservation

The classification of complex organisms is in chaos. **Stephen T. Garnett** and **Les Christidis** propose a solution.

What to Do?

Response 1: Fundamentalism

In the biological and biomedical sciences, what we will call the Definitional Consensus Principle has dominated the design of data discovery and integration tools:

> **Definitional Consensus Principle (DCP):** The design of a formal classificatory system for expressing a body of data should be grounded in a consensus about the definitions of the entities that are being classified. (Sterner et al. 2020, p. 2)

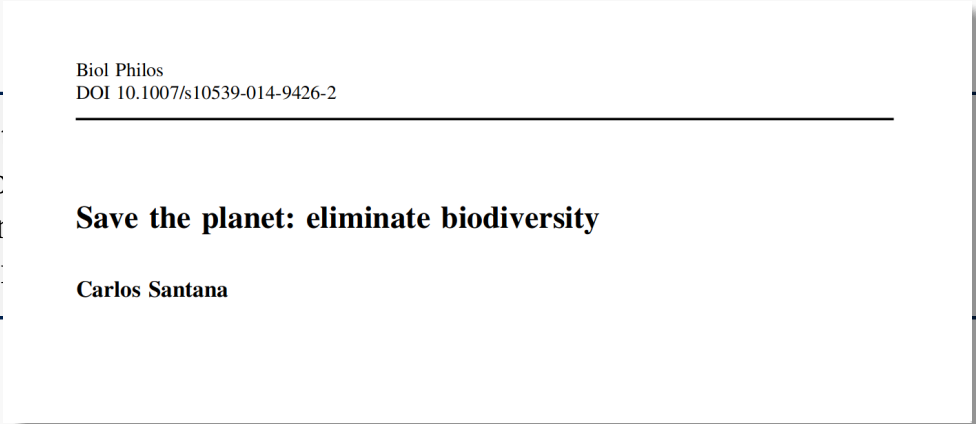
Response 1: Fundamentalism

> We may, then, start from the observations there made [in the *Poetics*], and the stipulation that language to be good must be clear, as is proved by the fact that speech which fails to convey a plain meaning will fail to do just what speech has to do. (*Rhetoric* 1404b1, Aristotle 1984)

Response 2: Skepticism

> Put bluntly, the position that this paper will argue for is that biodiversity is to be (implicitly) defined as what is being conserved by the practice of conservation biology. (Sarkar 2002, p. 132)

Response 2: Skepticism



Biol Philos
DOI 10.1007/s10539-014-9426-2

Save the planet: eliminate biodiversity

Carlos Santana

Response 3: Values in Science

HPLS (2019) 41:15
https://doi.org/10.1007/s40656-019-0252-3

Check for updates

ORIGINAL PAPER

Taxonomy and conservation science: interdependent and value-laden

Stijn Conix[1]

Response 3: Values in Science

> Conservation biology differs from most other biological sciences in one important way: **it is often a crisis discipline.** Its relation to biology, particularly ecology, is analogous to that of surgery to physiology and war to political science. In crisis disciplines, one must act before knowing all the facts; crisis disciplines are thus a mixture of science and art, and their pursuit requires intuition as well as information. (Soulé 1985)

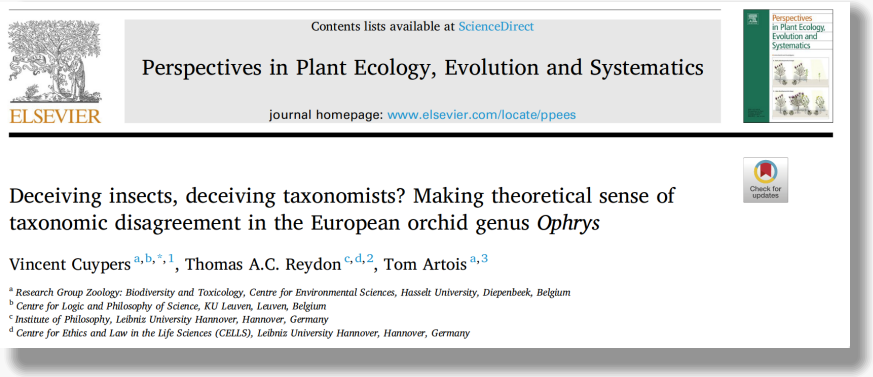
Response 3: Values in Science

Common response: Ethical value judgments are acceptable in conservation, but should be **kept out of** taxonomy.

But what if taxonomy is **just as value-laden** as conservation biology?

Response 3: Values in Science

Now in progress: case studies and empirical exploration



Contents lists available at ScienceDirect

Perspectives in Plant Ecology, Evolution and Systematics

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

Deceiving insects, deceiving taxonomists? Making theoretical sense of taxonomic disagreement in the European orchid genus *Ophrys*

Vincent Cuypers [a,b,*,1], Thomas A.C. Reydon [c,d,2], Tom Artois [a,3]

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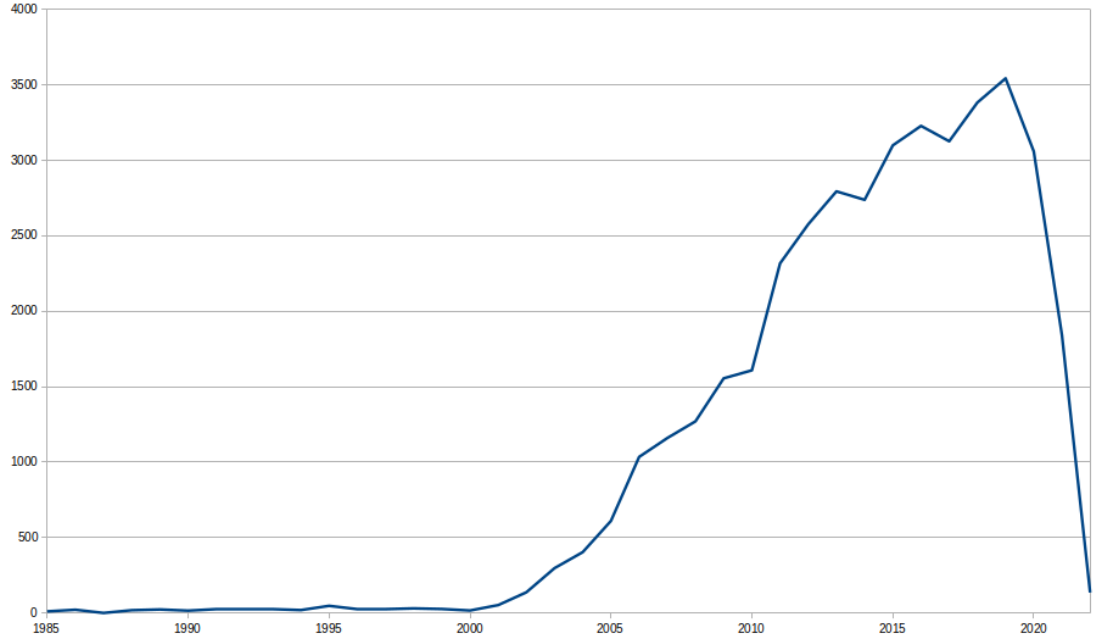
Empirical Tools

Journal	Publisher	Size
Zootaxa	Magnolia Press	31,348
ZooKeys	Pensoft	4,940
PhytoKeys	Pensoft	820
Journal of Hymenoptera Research	Pensoft	382
MycoKeys	Pensoft	315
Zoosystematics and Evolution	Pensoft	153
Insecta Mundi	Center for Systematic Entomology	1,367
European Journal of Taxonomy	Museum National d'Histoire Naturelle	1,105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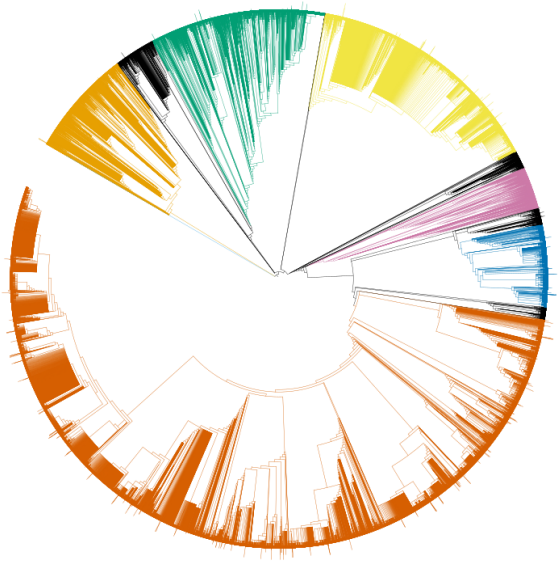
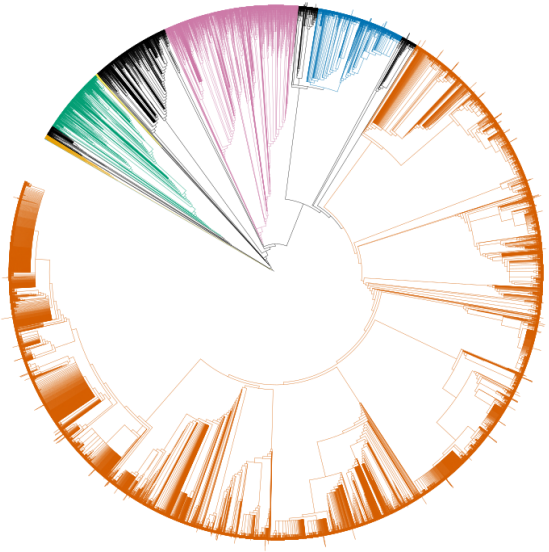
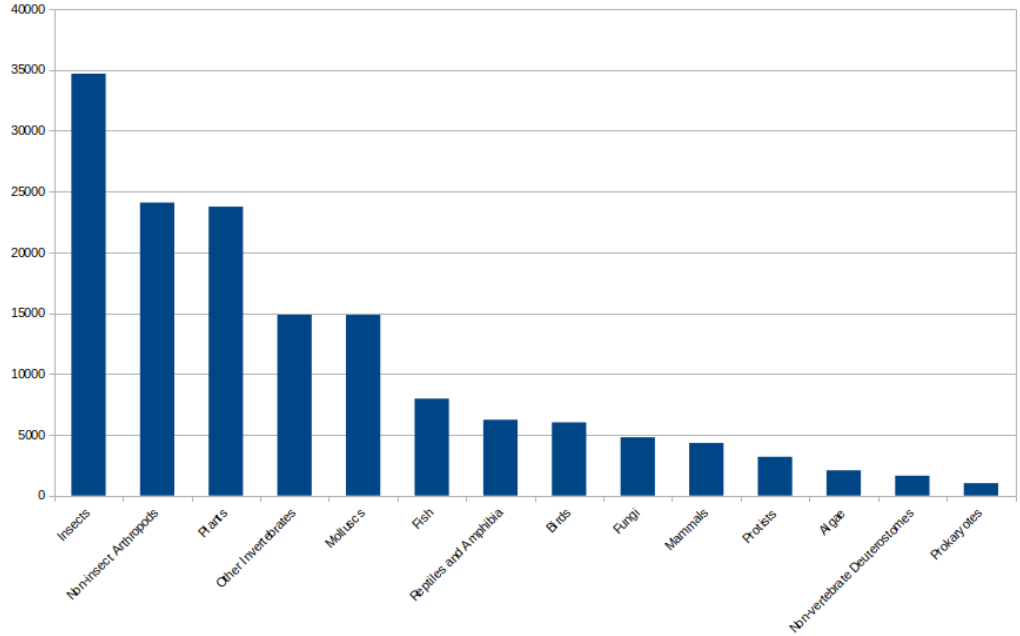
2020



Complete Open Tree of Life



Corpus


40000
35000
30000
25000
20000
15000
10000
5000
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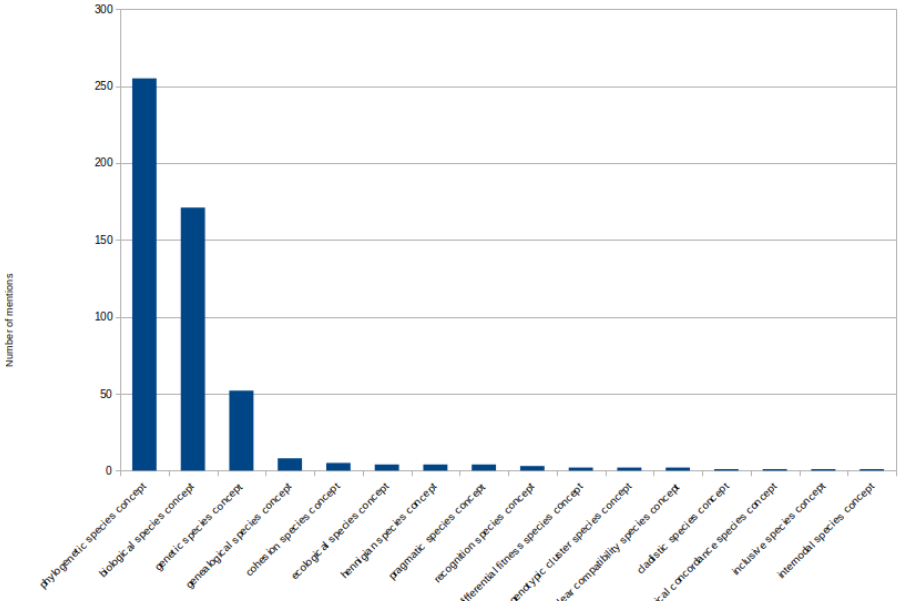
Insects
Non-insect Arthropods
Plants
Other Invertebrates
Molluscs
Fish
Reptiles and Amphibia
Birds
Fungi
Mammals
Protists
Algae
Non-vertebrate Deuterostomes
Prokaryotes

Phylo-Phenetic Species Concept
Phylogenetic Species Concept
Genic Species Concept
Cohesion Species Concept
Genealogical Concordance Species Concept
Genotypic Cluster Species Concept
Genetic Species Concept
Ecological Species Concept
Recognition Species Concept
Genealogical Species Concept

Biological Species Concept
Differential Fitness Species Concept
Compilospecies Concept
Cladistic Species Concept
Hennigian Species Concept
Internodal Species Concept
Mitonuclear Compatibility Species Concept
Pragmatic Species Concept
Inclusive Species Concept
Biosimilarity Species Concept


Number of mentions
300
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phylogenetic species concept
biological species concept
genetic species concept
genealogical species concept
cohesion species concept
ecological species concept
hennigian species concept
pragmatic species concept
recognition species concept
differential fitness species concept
genotypic cluster species concept
mitonuclear compatibility species concept
cladistic species concept
genealogical concordance species concept
inclusive species concept
intermodal species concept

Topic Modeling

Briefly: a kind of unsupervised dimensionality reduction that you can run on a corpus of text. Take documents, normally locations in a 172M-dimensional space (number of word types), and reduce that to 125-D.

(go to live graph:)

`https://cpence.codeberg.page/taxonomy-analyses/`

Interpreting a Topic

Topic 16: popular in mammals

- 0.027*"colombia"
- 0.016*"specie"
- 0.013*"type"
- 0.013*"peru"
- 0.010*"locality"
- 0.010*"venezuela"
- 0.010*"ecuador"
- 0.009*"panama"
- 0.008*"distribution"
- 0.007*"brazil"
- 0.007*"key"
- 0.006*"rica"
- 0.006*"del"
- 0.006*"costa"
- 0.006*"genus"
- 0.006*"male"
- 0.006*"america"
- 0.006*"san"
- 0.006*"neotropical"
- 0.005*"cat"

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- 0.005*"cat"

Okay: Central and South American collection sites

Topic 31:

- 0.016*"male"
- 0.016*"genitalia"
- 0.013*"specie"
- 0.009*"female"
- 0.009*"fig"
- 0.008*"brown"
- 0.008*"lepidoptera"
- 0.007*"scale"
- 0.007*"long"
- 0.006*"slide"
- 0.006*"white"
- 0.006*"line"
- 0.006*"new"
- 0.006*"bursae"
- 0.006*"short"
- 0.005*"dark"
- 0.005*"coll"
- 0.005*"forewing"
- 0.005*"holotype"
- 0.005*"leg"

Cautious hypothesis: Lepidopteran anatomy, especially reproductive

Interpreting a Topic

But wait.

Our lepidopteran reproductive anatomy topic is unusually significant in one group... **in papers that mention molluscs.**

Interpreting a Topic

But wait.

Our lepidopteran reproductive anatomy topic is unusually significant in one group... **in papers that mention molluscs.**

...too many bursas!

Some Cool Topics

Topic 9: traditional specimen collection terms

- 0.029*"specie"
- 0.012*"forest"
- 0.012*"habitat"
- 0.010*"area"
- 0.008*"find"
- 0.007*"collect"
- 0.007*"site"
- 0.007*"study"
- 0.007*"record"
- 0.006*"population"
- 0.006*"range"
- 0.006*"high"
- 0.005*"specimen"
- 0.005*"occur"
- 0.005*"know"
- 0.004*"individual"
- 0.004*"region"
- 0.004*"number"
- 0.004*"sample"
- 0.004*"distribution"

Popular in every taxon **except** non-insect arthropods, fish, and fungi.

Some Cool Topics

Topic 64: molecular phylogenetics

- 0.021*"specie"
- 0.017*"sequence"
- 0.016*"analysis"
- 0.011*"molecular"
- 0.010*"dna"
- 0.008*"phylogenetic"
- 0.007*"tree"
- 0.007*"clade"
- 0.007*"gene"
- 0.007*"specimen"
- 0.007*"study"
- 0.007*"morphological"
- 0.006*"support"
- 0.006*"group"
- 0.006*"genetic"
- 0.006*"coi"
- 0.006*"datum"
- 0.006*"base"
- 0.005*"table"
- 0.005*"population"

Among the **top-20 most significant probabilities** in reptiles and amphibia, birds, fish, fungi, and mammals; top-5% in every other group

How about disagreement?

Ask the model: what topics are likely to pick words like "disagree," "disagreement," or "dispute"?

For disagreement terms: topics 120 and 43

What are those topics about?

Topic 120 (disagreement)

- 0.018*"character"
- 0.013*"genera"
- 0.011*"taxon"
- 0.011*"group"
- 0.010*"specie"
- 0.010*"genus"
- 0.009*"phylogenetic"
- 0.008*"include"
- 0.007*"analysis"
- 0.007*"family"
- 0.007*"relationship"
- 0.005*"phylogeny"
- 0.005*"clade"
- 0.005*"morphological"
- 0.005*"classification"
- 0.005*"support"
- 0.005*"press"
- 0.005*"new"
- 0.005*"consider"
- 0.004*"present"

The terms you use to **argue about ranking of a clade**

Topic 43 (disagreement)

- 0.015*"specie"
- 0.011*"name"
- 0.010*"description"
- 0.010*"new"
- 0.008*"publish"
- 0.007*"author"
- 0.007*"nomenclature"
- 0.007*"code"
- 0.007*"publication"
- 0.006*"type"
- 0.006*"article"
- 0.006*"zoological"
- 0.006*"original"
- 0.006*"synonym"
- 0.006*"work"
- 0.006*"list"
- 0.006*"valid"
- 0.005*"international"
- 0.005*"available"
- 0.005*"note"

The terms you use to **present a new species**

Coming Soon

Geocoding: how do taxa, topics, and species concepts correlate with mentions of geographic locations?

Questions?

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