Co-occurrence based measure of habitat specialization for species of Czech flora

David Zelený

Masaryk University, Brno, Czech Republic

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Co-occurrence based assessment of habitat generalists and specialists: a new approach for the measurement of niche width

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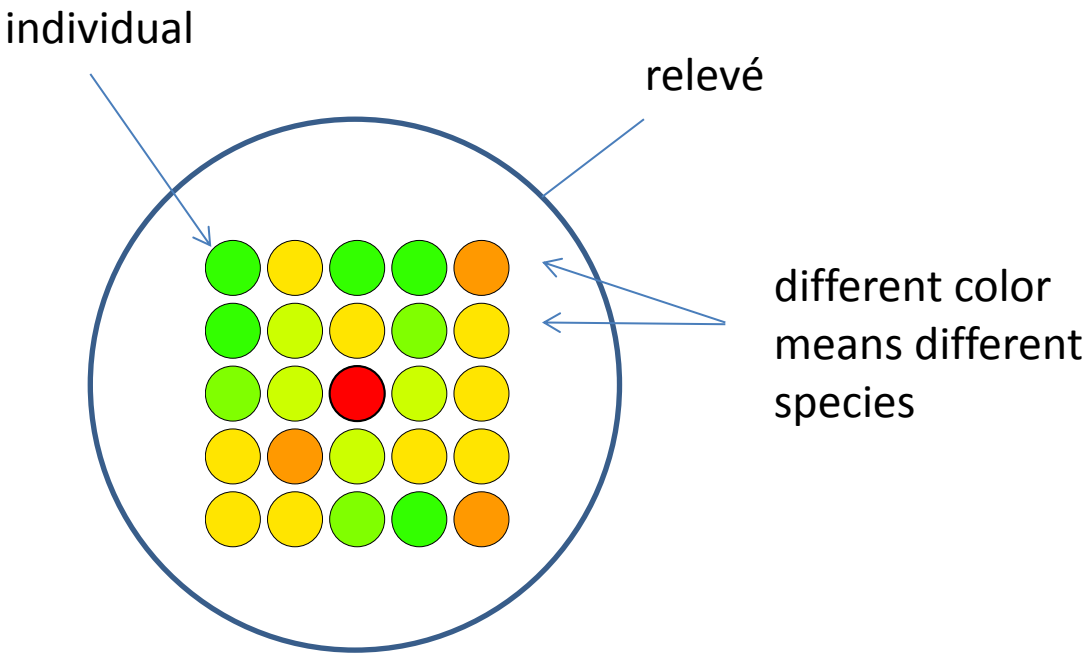
Summary

1 Much ecological theory is based on the characterization of ecological habits of species as 'generalist' or 'specialist', but standard measures for placing species along a generalist-specialist gradient do not exist.

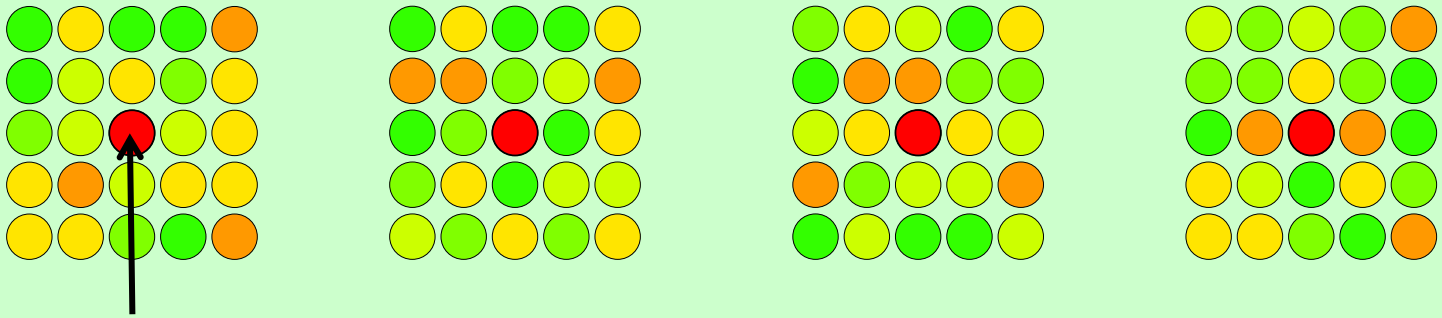
2 We introduce a method for quantifying habitat specialization (i.e. relative niche widths) using species co-occurrence data. Generalists should co-occur with many species, whereas specialists should co-occur with relatively few species, given equal plot occurrences. We quantify this concept using a generalist-specialist metric (θ) derived from a beta diversity statistic.

3 We evaluate the ability of our generalist-specialist metric to correctly rank species according to simulated (known) niche widths. Our technique is generally robust to a wide variety of niche distribution structures and sampling designs, but surveys strongly

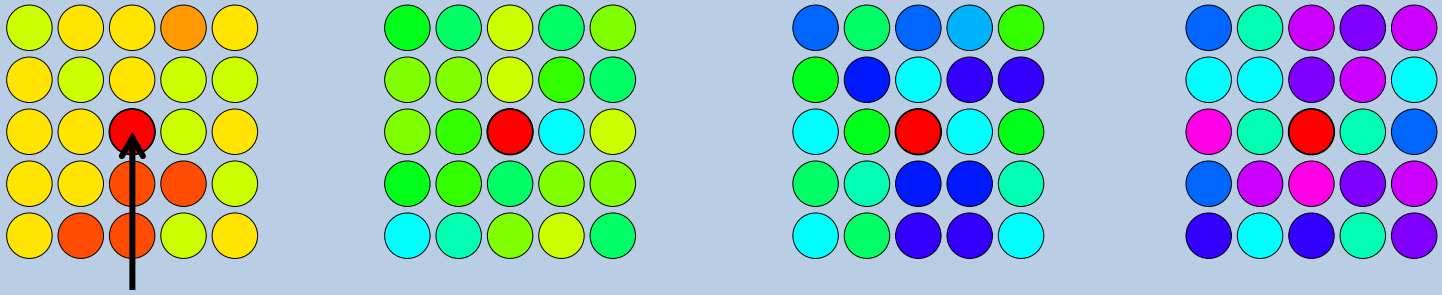
Co-occurrence based method of species habitat specialization – the principle



Co-occurrence based method of species habitat specialization – the principle

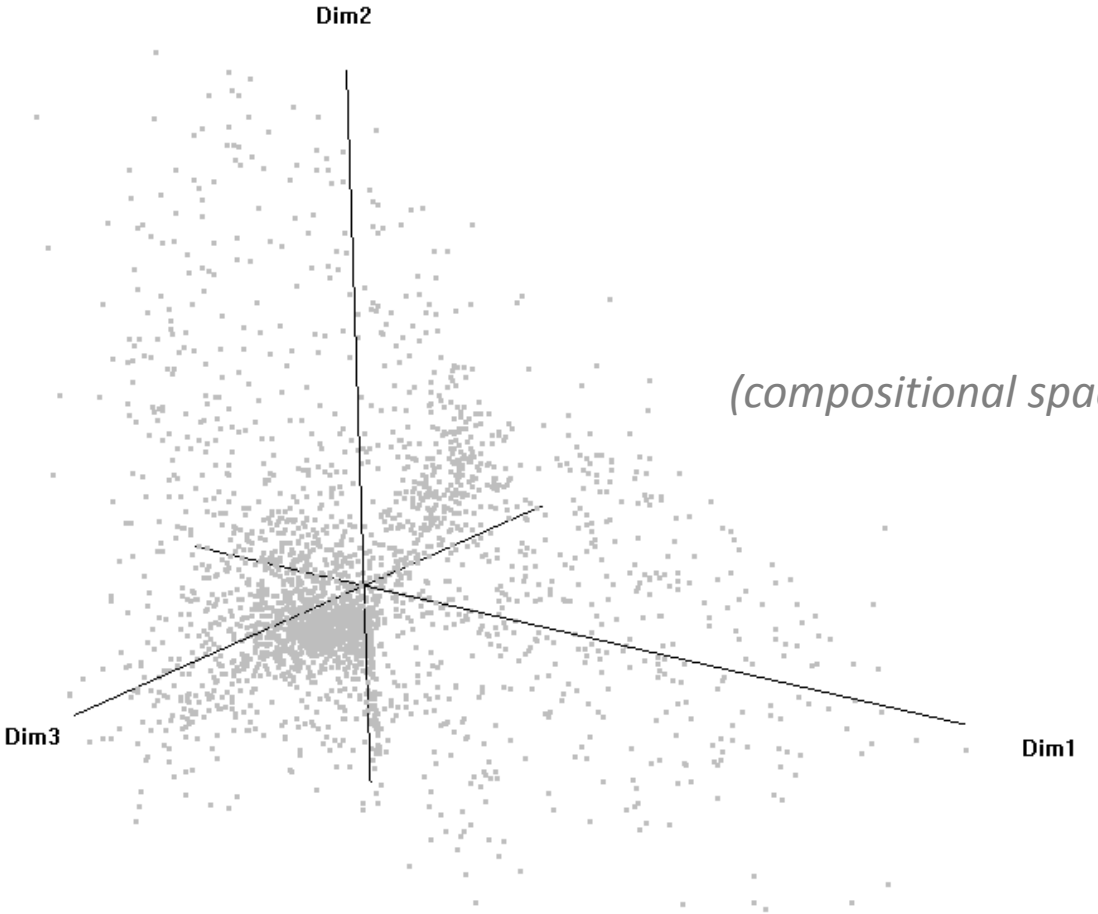


specialist – occurs on **similar** habitats with **similar** species composition



generalist – occurs on **different** habitats with **different** species composition

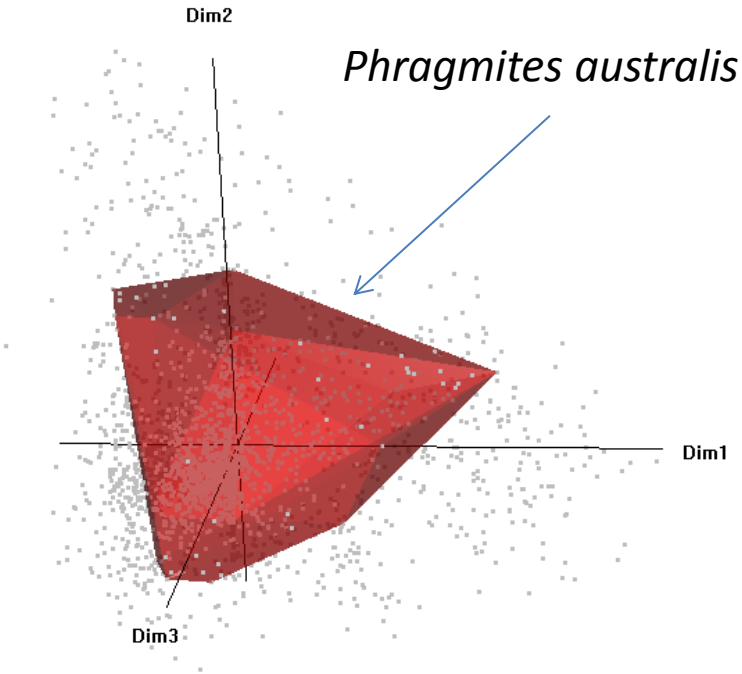
3D ordination diagram on the stratified subset of data from Czech National Phytosociological Database



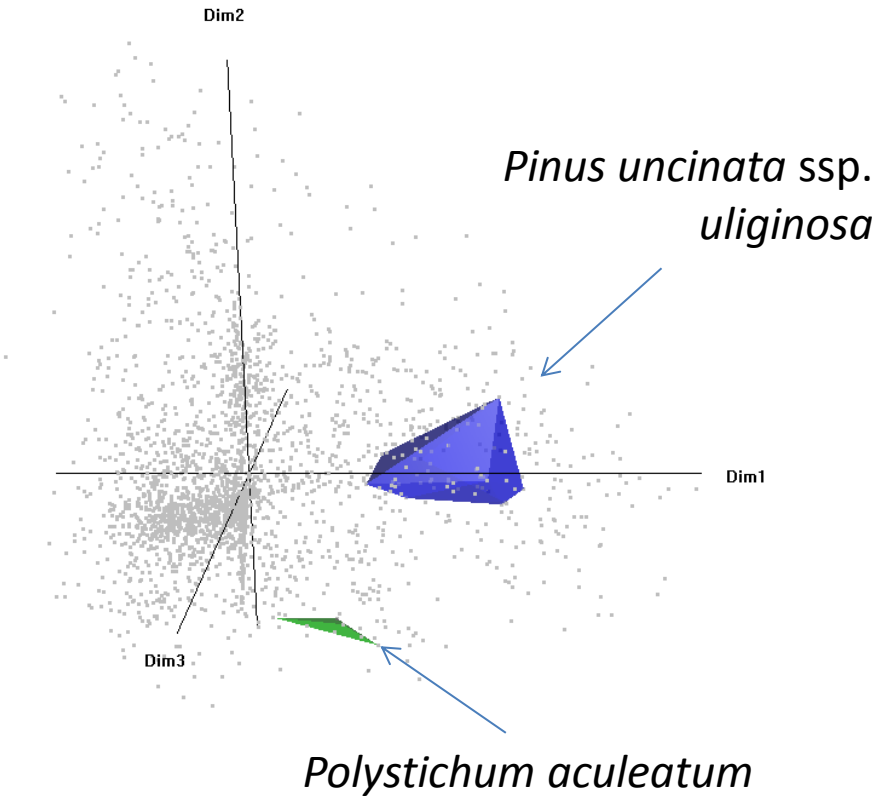
(compositional space)

(PCoA + Bray-Curtis distance, 1000 samples)

Generalist



Specialist



Volume of the convex hull

≈

measure of species generalization

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Journal of Ecology 2009, **97**, 10–17 doi: 10.1111/j.1365-2745.2008.01394.x

FORUM

Co-occurrence based assessment of species habitat specialization is affected by the size of species pool: reply to Fridley *et al.* (2007)

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Summary

1. Fridley *et al.* (2007) introduced a technique of species habitat specialization assessment based on co-occurrence analysis of large species-plot matrixes, with a continuous metric (θ value) intended to reflect relative species niche width.
2. They used simulated data in order to demonstrate the functionality of the new method. I repeated their simulation and introduced three alternative scenarios with various patterns of species pool size along a simulated gradient. Results indicated that the co-occurrence based estimation of species niche width is dependent on the size of species pool at the position of species optima. This relationship was also revealed in an analysis of a real data set with Ellenberg indicator values as surrogates for environmental gradients.

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FORUM

Co-occurrence specialization i reply to Fridley

David Zelený*

Department of Botany and Zool of Botany, Faculty of Sciences, Republic

Summary

1. Fridley *et al.* (2007) co-occurrence analysis to reflect relative speci
2. They used simulat repeated their simulati pool size along a simul species niche width is relationship was also surrogates for environ

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Journal of Ecology 2009, **97**, 18–22 doi: 10.1111/j.1365-2745.2008.01450.x

FORUM

Beta diversity metrics and the estimation of niche width via species co-occurrence data: reply to Zeleny

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Summary

1. Zeleny (2008) demonstrated that the co-occurrence based assessment of species habitat specialization (introduced by Fridley *et al.* 2007) depends on the size of the species pool. To correct for the effect of the species pool on the estimation of species niche width, Zeleny suggested a modification of the original algorithm by replacing additive partitioning as a measure of beta diversity with Whittaker's beta.
2. We used simulated data to show that the alternative index proposed by Zeleny (2008) will poorly represent the niche widths of species inhabiting a set of plots with a highly skewed distribution of local richness values. We therefore expand on Zeleny's (2008) analysis by considering two additional metrics of beta diversity based on compositional similarity and by testing the performance of these indices under different local-regional richness relationships.
3. *Synthesis.* None of the four tested metrics of beta diversity produced unbiased estimates of niche

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Co-occurrence
specialization i
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of niche width
Zeleny

Id, Germany; and [2]*Department*

IAVS

Journal of Vegetation Science **23** (2012) 201–207

Co-occurrence-based measure of species' habitat specialization: robust, unbiased estimation in saturated communities

Zoltán Botta-Dukát

Keywords
Generalists; Niche width; Saturation; Simulation; Spedalists; Species pool; Whittaker's β; β-diversity

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Abstract

Aims: Large vegetation plot databases enable the estimation of niche width from species co-occurrence data. Different indices have been proposed for this purpose, but do not give unbiased (i.e. independent of species pool size) and robust estimates over a wide range of conditions. The aims of the paper are to: (1) demonstrate the limitations of different methods, and (2) propose a new algorithm that results in unbiased and robust estimates.

Results: Whittaker's β-diversity, calculated from raw data, is an unbiased niche width measure only if the relationship between γ-diversity and local richness is

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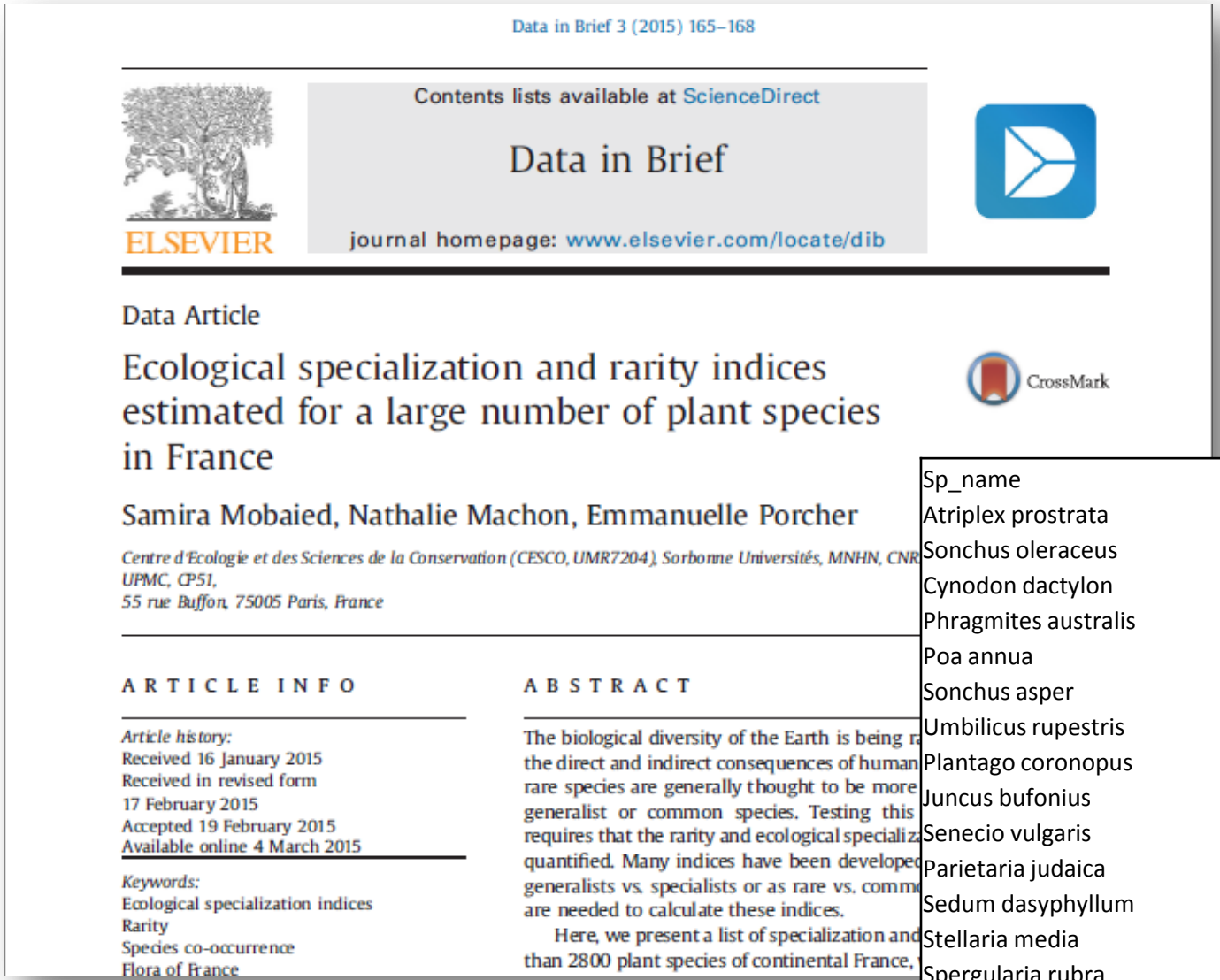

Data in Brief 3 (2015) 165–168

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Data in Brief

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

Data Article

Ecological specialization and rarity indices estimated for a large number of plant species in France

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Rarity
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ABSTRACT

The biological diversity of the Earth is being r
the direct and indirect consequences of human
rare species are generally thought to be more
generalist or common species. Testing this
requires that the rarity and ecological specializ
quantified. Many indices have been develope
generalists vs. specialists or as rare vs. comm
are needed to calculate these indices.

Here, we present a list of specialization and
than 2800 plant species of continental France,

Sp_name	ind_Theta_WB
Atriplex prostrata	27.67069645
Sonchus oleraceus	27.64496778
Cynodon dactylon	26.61783944
Phragmites australis	26.59411406
Poa annua	26.12351233
Sonchus asper	25.7456223
Umbilicus rupestris	25.60009256
Plantago coronopus	25.4290962
Juncus bufonius	25.30467712
Senecio vulgaris	25.14551185
Parietaria judaica	24.98967488
Sedum dasyphyllum	24.35938002
Stellaria media	24.34915863
Spergularia rubra	24.31230454
Lysimachia arvensis	24.27950632
Agrostis stolonifera	24.2724285

Measure of species habitat specialization (θ, *theta*)

Different beta diversity metrics:

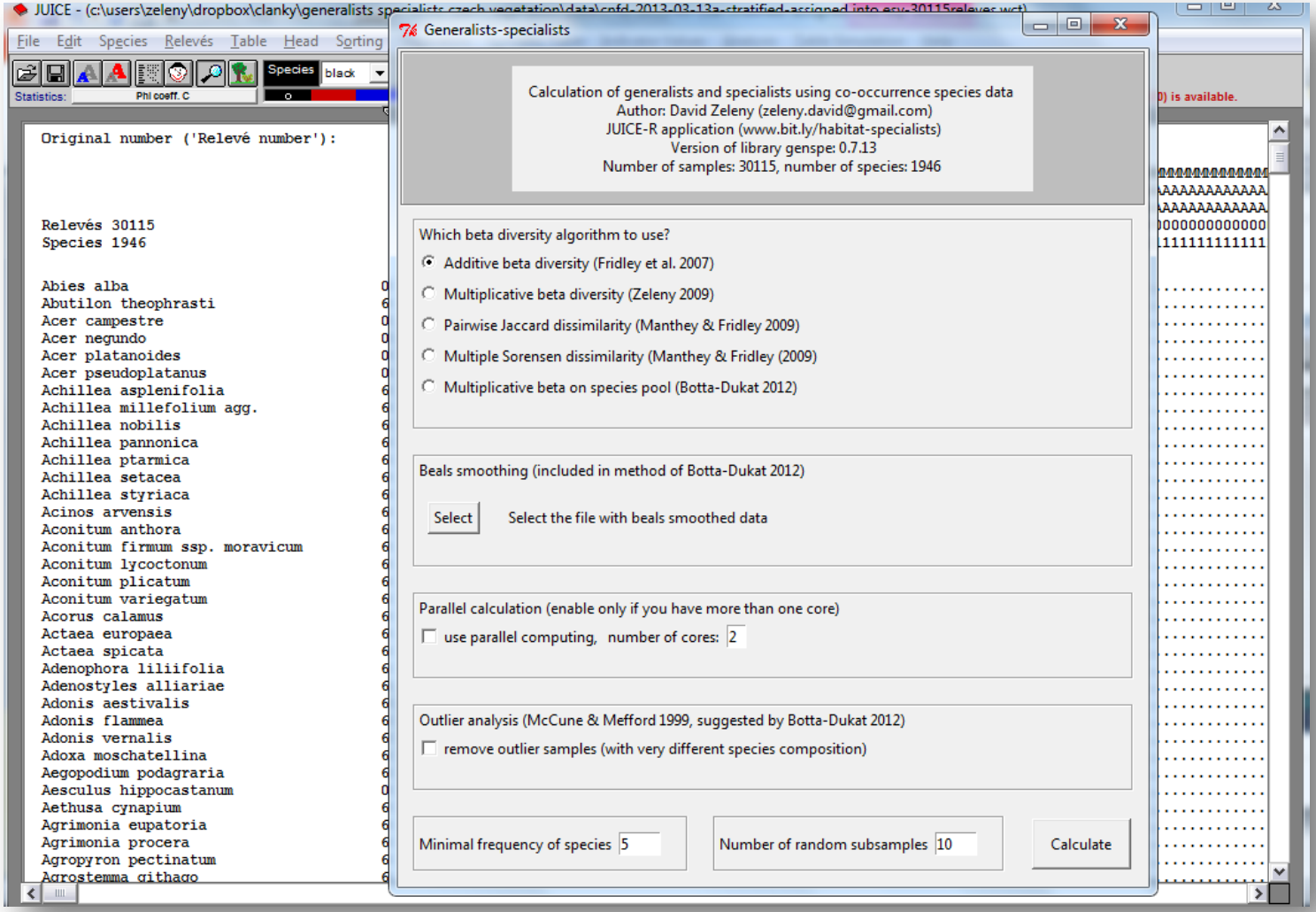
- additive beta (Fridley et al. 2007)
- Whittaker's (multiplicative) beta (Zelený 2009)
- pairwise Jaccard (Manthey & Fridley 2009)
- multiplicative Sorensen (Manthey & Fridley 2009)
- Whittaker's beta on species pool (Botta-Dukát 2012)

Other algorithm modifications:

- remove (or not) relevés with very different species composition (removal of outliers *sensu* Botta-Dukát 2012)

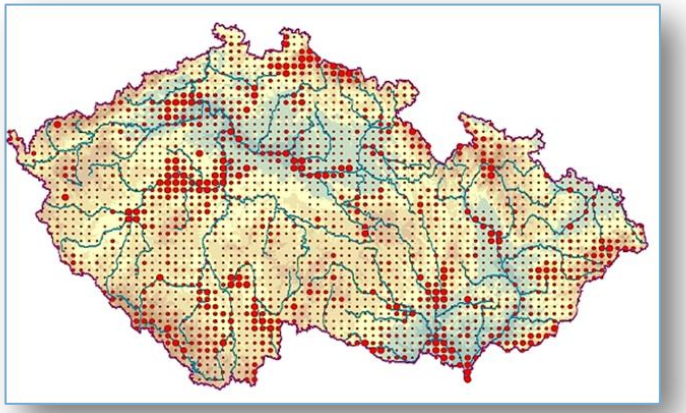
Whittaker's beta diversity = theoretical number of compositionally non-overlapping community (or habitat) types

R package *genspe* and JUICE-R function (www.bit.ly/habitat-specialists)



Used vegetation data

- **93k** – almost complete vegetation dataset from *Czech National Phytosociological Database* (GIVD ID EU-CZ-001)
  - 93 704 relevés x 2 126 species
- **30k** – geographically stratified vegetation dataset of relevés classified on association level according to Cocktail formulas following *Vegetation of Czech Republic*
  - 30 115 relevés x 1 946 species
- **forest subset of 30k** – relevés from forest associations only
  - 5 403 relevés x 1 266 species



Calamagrostis epigejos (θ_{multi} = 7.29, freq = 4444 relevés in 93k)

Phragmites australis (θ_{multi} = 7.23, freq = 3973 relevés in 93k)

Urtica dioica (θ_{multi} = 6.97, freq = 15.186 relevés in 93k)

Galium aparine (θ_{multi} = 6.85, freq = 8716 relevés in 93k)

Pinus uncinata ssp. *uliginosa* (θ_{multi} = 2.60, freq = 203 relevés in 93k)

Rhododendron tomentosum (θ_{multi} = 2.68, freq = 211 relevés in 93k)

Coleanthus subtilis (θ_{multi} = 3.06, freq = 295 relevés in 93k)

Polystichum aculeatum (θ_{multi} = 3.52, freq = 357 relevés in 93k)

Top 20 from Czech Database

generalists...

	θ_{multi}	freq. (93k)
Calamagrostis epigejos	7.29	4444
Phragmites australis	7.23	3973
Urtica dioica	6.97	15186
Galium aparine	6.85	8716
Glyceria fluitans	6.85	2312
Viola tricolor	6.85	576
Senecio viscosus	6.84	798
Persicaria amphibia	6.83	2074
Galeopsis tetrahit agg.	6.83	4973
Phalaris arundinacea	6.82	5408
Agrostis gigantea	6.80	759
Epilobium collinum	6.79	305
Epilobium tetragonum agg.	6.78	394
Verbascum thapsus	6.71	249
Verbascum densiflorum	6.71	142
Tussilago farfara	6.68	2143
Rumex acetosella	6.68	3644
Poa compressa	6.67	2179
Rubus caesius	6.66	2276
Agrostis stolonifera	6.64	5520

specialists...

	θ_{multi}	freq. (93k)	Red list
Pinus uncinata ssp. *uliginosa*	2.60	203	C2
Rhododendron tomentosum	2.68	211	C3
Pinus strobus	2.69	121	
Empetrum nigrum agg.	2.85	384	C3
Andromeda polifolia	3.02	510	C2
Coleanthus subtilis	3.05	295	C3
Carex bigelowii ssp. *dacica*	3.12	390	C2
Hieracium alpinum agg.	3.26	361	C2
Elatine triandra	3.30	186	C3
Trifolium spadiceum	3.32	133	C2
Carex pauciflora	3.32	335	C3
Senecio aquaticus	3.40	228	
Trifolium rubens	3.43	160	C3
Trichophorum cespitosum	3.50	241	C3
Lathyrus latifolius	3.52	189	C3
Pulsatilla alpina ssp. *alba*	3.52	150	C2
Polystichum aculeatum	3.52	357	C4
Onobrychis arenaria	3.56	271	C4
Hypochaeris uniflora	3.58	140	C3
Aphanes arvensis	3.64	431	C3

Top 20 from French SOPHY (~ 200 000 relevés)

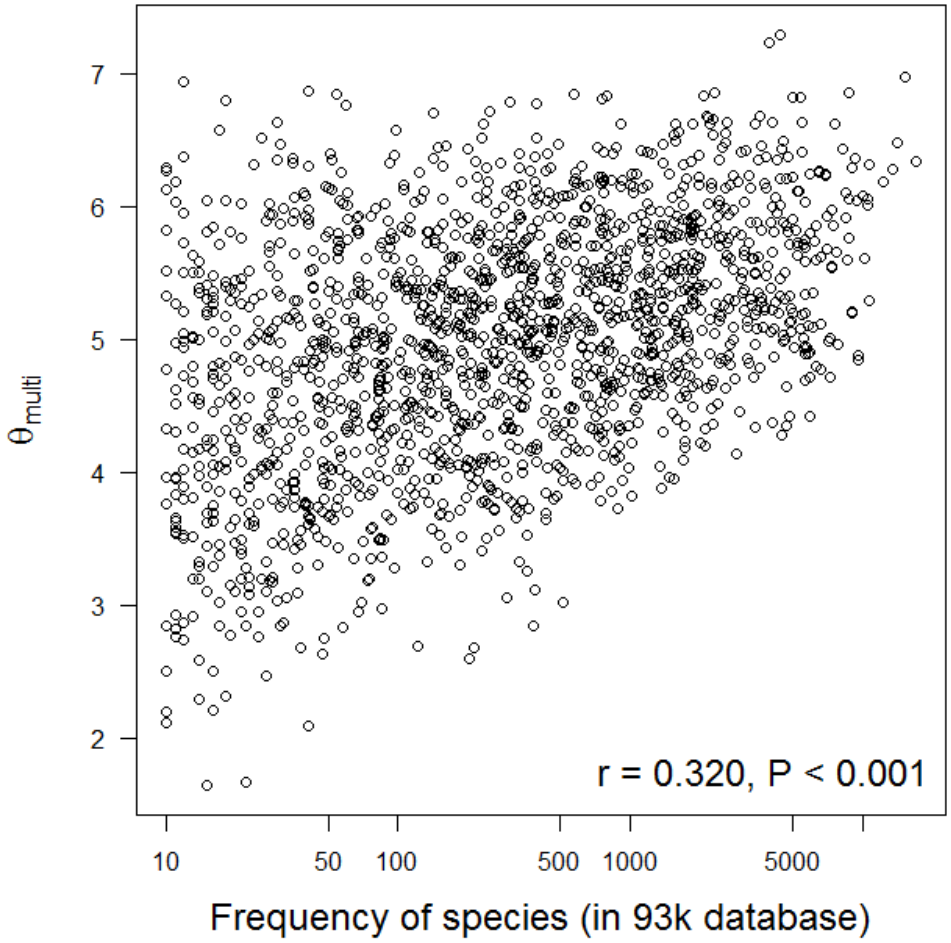
generalists...

	θ_{multi}	freq. (200k)
Atriplex prostrata	27.67	2221
Sonchus oleraceus	27.64	1242
Cynodon dactylon	26.62	1960
Phragmites australis	26.59	5519
Poa annua	26.12	1557
Sonchus asper	25.75	927
Umbilicus rupestris	25.60	754
Plantago coronopus	25.43	2587
Juncus bufonius	25.30	1040
Senecio vulgaris	25.15	912
Parietaria judaica	24.99	285
Sedum dasyphyllum	24.36	592
Stellaria media	24.35	959
Spergularia rubra	24.31	346
Lysimachia arvensis	24.28	1447
Agrostis stolonifera	24.27	7344
Dittrichia viscosa subsp. *viscosa*	24.24	1202
Cardamine hirsuta	24.08	521
Elytrigia atherica	24.06	955
Rumex scutatus	23.88	570

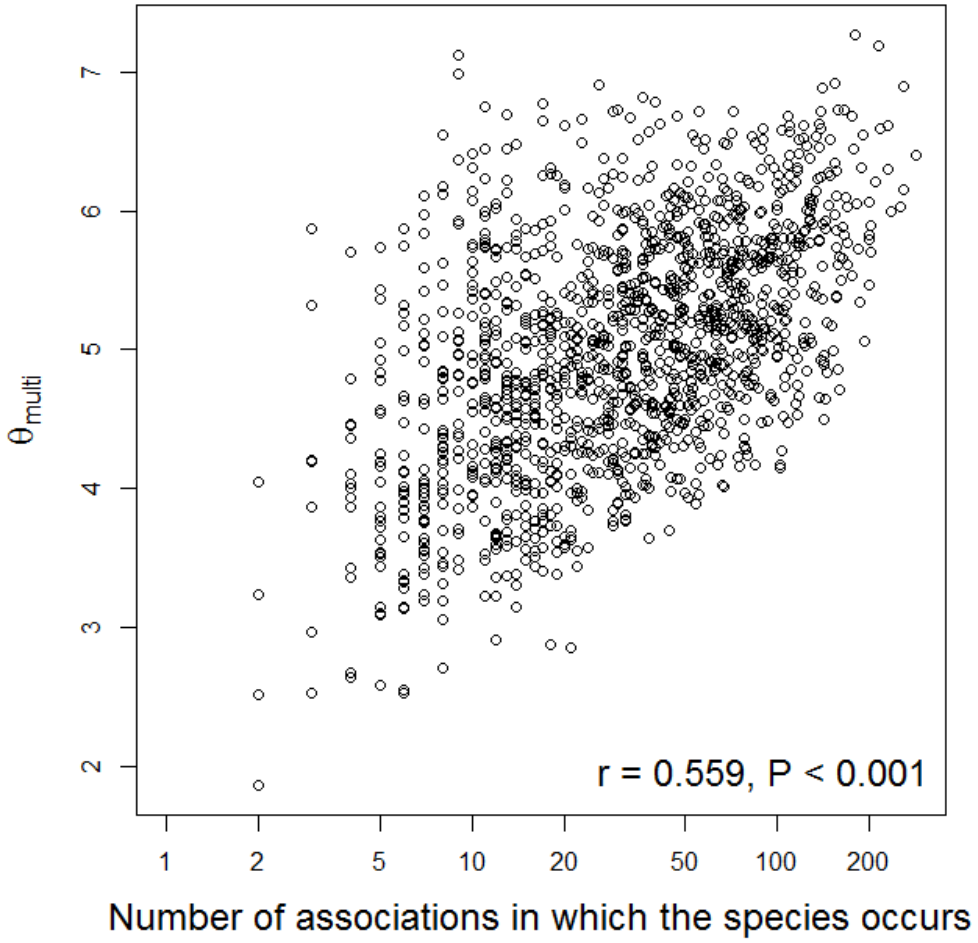
specialists...

	θ_{multi}	freq. (200k)
Alchemilla colorata	4.94	131
Cochlearia anglica	5.52	154
Festuca heteropachys	5.68	104
Salicornia obscura	5.79	194
Lemna minuta	6.01	176
Amaranthus blitum subsp. *emargin.*	6.07	110
Elodea callitrichoides	6.09	222
Euphrasia officinalis subsp. *campest.*	6.15	103
Asperula purpurea subsp. *purpurea*	6.27	814
Stachys heraclea	6.48	364
Linum viscosum	6.48	145
Alopecurus rendlei	6.49	108
Dianthus hyssopifolius subsp. *gallicus*	6.55	110
Xanthoselinum alsaticum subsp. *ven.*	6.57	224
Salicornia procumbens var. *stricta*	6.66	269
Limonium ovalifolium	6.72	100
Corydalis cava	6.77	106
Sesleria autumnalis	6.87	378
Ferulago campestris	6.87	115
Thymus dolomiticus	6.88	128

Relationship between θ_{multi} and species frequency in 93k database



Relationship between θ_{multi} and number of associations, in which the species occurs (calculated on 30k dataset)



Other relationships

- θ and species diagnostic for associations
  - diagnostic species are often specialists
- θ and species groups from COCKTAIL formulas
  - not clear relationship – some groups contain specialists, other not
- θ and species dispersal
  - positive correlation with dispersal traits – generalists have more lighter seeds, specialists have less but heavier seeds (works on forest data only)

Thank you for your attention!

An attempt to visualize associations of Czech vegetation in 3D space of ordination diagram (not useful for anything, but looks quite fancy...)

email: zeleny.david@gmail.com, http://www.davidzeleny.net