Do rare herbs have large seeds?
The seed size – distribution range trade-off hypothesis

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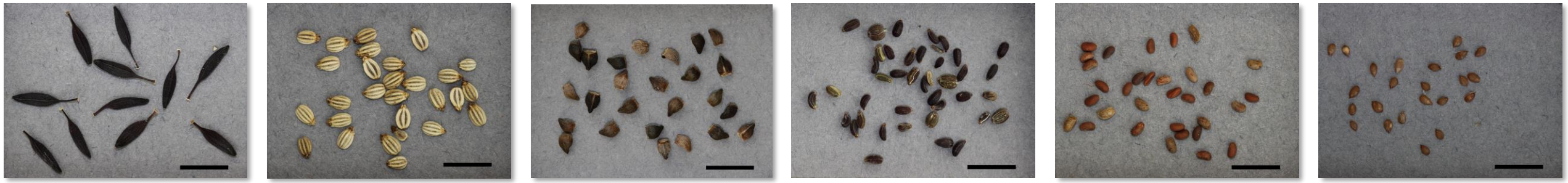


14th Eurasian Grassland Conference
4-11 July 2017, Riga

Rarity

- the term ’rare’ can be used to define different patterns
- correlations between the different measures of rarity (range size is positively correlated to e.g. local abundance and niche breadth)
- geographical range size is the most frequently used measure is it
- range size has conservational importance (extinction risk, invasive species etc.)

Introduction

There is a great variance in species' range size

Possible general explanations:

- variance in environmental tolerance and/or habitat breadth
- differences in dispersal ability
- latitude of the geographical location

Explanations in case of plants:

- growth form or plant height
- seed size
- seed production patterns
- seed longevity

A generally acceptable and supported hypothesis for this great variance has not been established yet

Introduction

Range size and dispersal ability

- Higher dispersal ability – better chance to colonise new habitats
- Poor dispersal capacity – rapid adaptation to local conditions – rapid speciation – smaller range size

Direct quantification of dispersal ability can be very difficult

Different proxies are often used instead of a direct measure of it

Seed size is the most usual proxy for dispersal ability

- Numerosity of small seeds (seed size/number trade-off)
- Smaller seeds are more easily transported by wind and also by other agents

Introduction

Contrasting results of previous studies

- The expected negative relationship has been demonstrated in previous studies (e.g. Guo et al. 2000; Walck et al. 2001; Morin & Chuine, 2006; Procheş et al., 2012)
- There are some counterexamples as well (Lavergne et al. 2003, 2004; Kolb et al. 2006)

Possible explanation:

Competition – colonization trade-off: smaller seeds have a greater chance to colonise new sites, but they have a lower probability of survival there, which acts against range expansion

A general relationship between seed size and range size has not been demonstrated yet

Environmental conditions

Seed size – previous results

- Larger seeds in shaded habitats
- Smaller seeds in wet habitats
- Largers seeds at high soil pH
- Larger seeds in fertile habitats

Range size – previous results

- Much less information
- Larger range of wetland species
- Larger range of species of infertile habitats

Hypotheses

We hypothesised that

i. Seed mass is negatively related to range size
ii. Seed mass is related to environmental factors (soil moisture, light intensity, nutrient supply)
iii. Range size is related to environmental factors (soil moisture, light intensity, nutrient supply)

Revealing underlying mechanisms
that shape the rarity of plants

Data collection

Checklist of plant species of the Pannonian Ecoregion
(2516 species; Flora Database – Horváth et al. 1995)

Excluding certain species groups

- Woody species (204 species)
- Adventive species (337 species)
- Aquatic plants (182 species)

Obtaining thousand-seed mass values from the literature
(Török et al. 2016, 2017; Schermann 1967; Csontos et al. 2003, 2007; LEDA Traitbase – Kleyer et al. 2008; SID – Liu et al. 2008)

Obtaining soil moisture, light intensity and nutrient supply indicator values
(Flora Database – Horváth et al. 1995)

- Flora Database
- eMonocot
- Encyclopedia of Life
- Global Biodiversity Information Facility
- PESI Portal
- Euro+Med PlantBase

Distribution	Range size category	Species number
Carpathian	1	10
Dacic	1	6
Illyric	1	5
Pannonic	1	37
Alpine-Balcanic	2	7
Balcanic	2	12
Central-European	2	118
Central-European-Alpine	2	15
East-Submediterranean	2	13
Pannonic-Balcanic	2	22
Pontic	2	40
Pontic-Mediterranean	2	79
Pontic-Pannonic	2	59

Distribution	Range size category	Species number
Turanian	2	8
Alpine	3	8
Atlantic-Submediterranean	3	63
Boreal	3	7
Continental	3	89
European	3	167
Mediterranean	3	12
Sarmatian	3	5
Subatlantic	3	19
Submediterranean	3	138
Eurasian	4	400
Circumpolar	5	139
Cosmopolitan	5	122

1600 species in total

Statistical analyes

Generalized Linear Mixed Models (GLMMs):

- Effect of species range, soil moisture, light intensity and nutrient supply on the thousand-seed mass of the studied species
- Effect of soil moisture, light intensity and nutrient supply on range size
- Genus nested in family as a random factor

Spearman’s rank correlations:

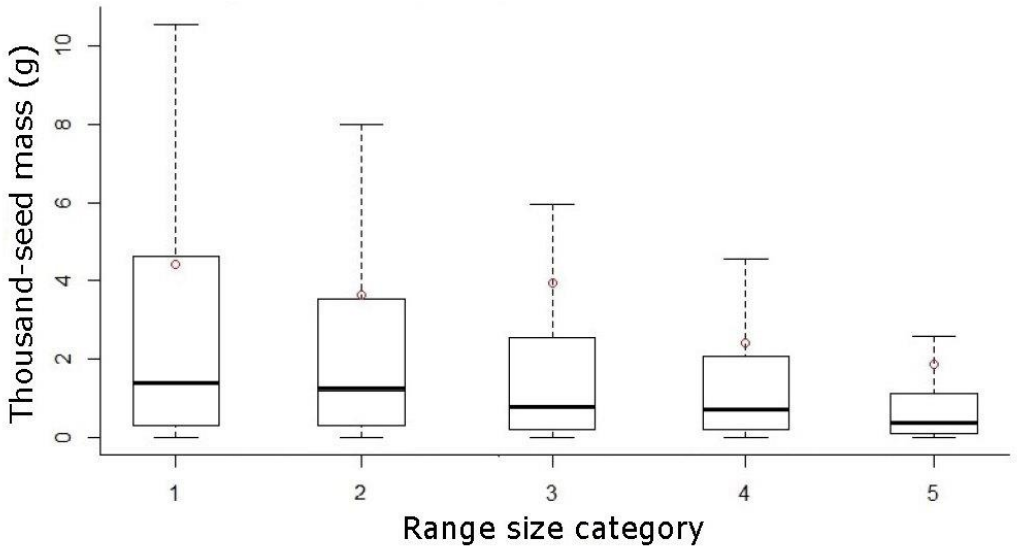
- Direction and steepness of relationships between variables

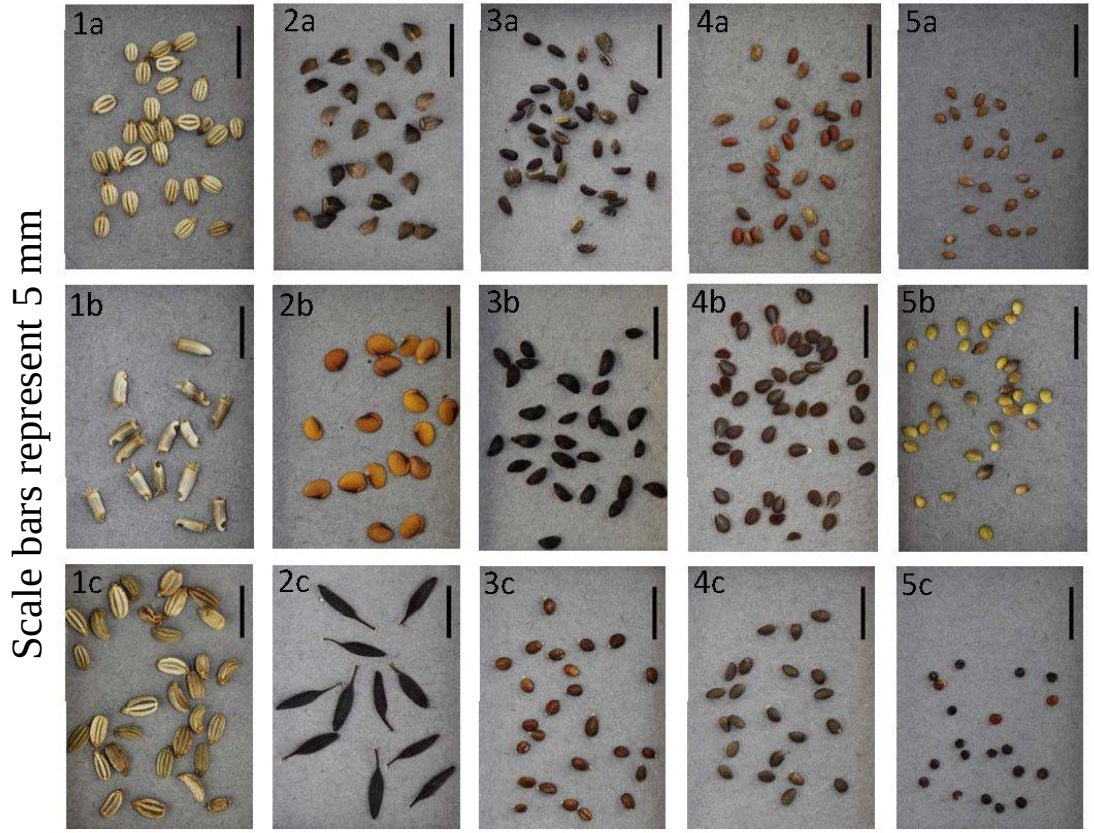
Results

Effects on seed mass	*F*	*p*
Range size	4.613	0.001
Soil moisture	2.884	0.001
Light intensity	2.789	0.007
Nutrient supply	2.978	0.003

Effects on range size	*F*	*p*
Soil moisture	19.845	<0.001
Light intensity	6.747	<0.001
Nutrient supply	14.273	<0.001





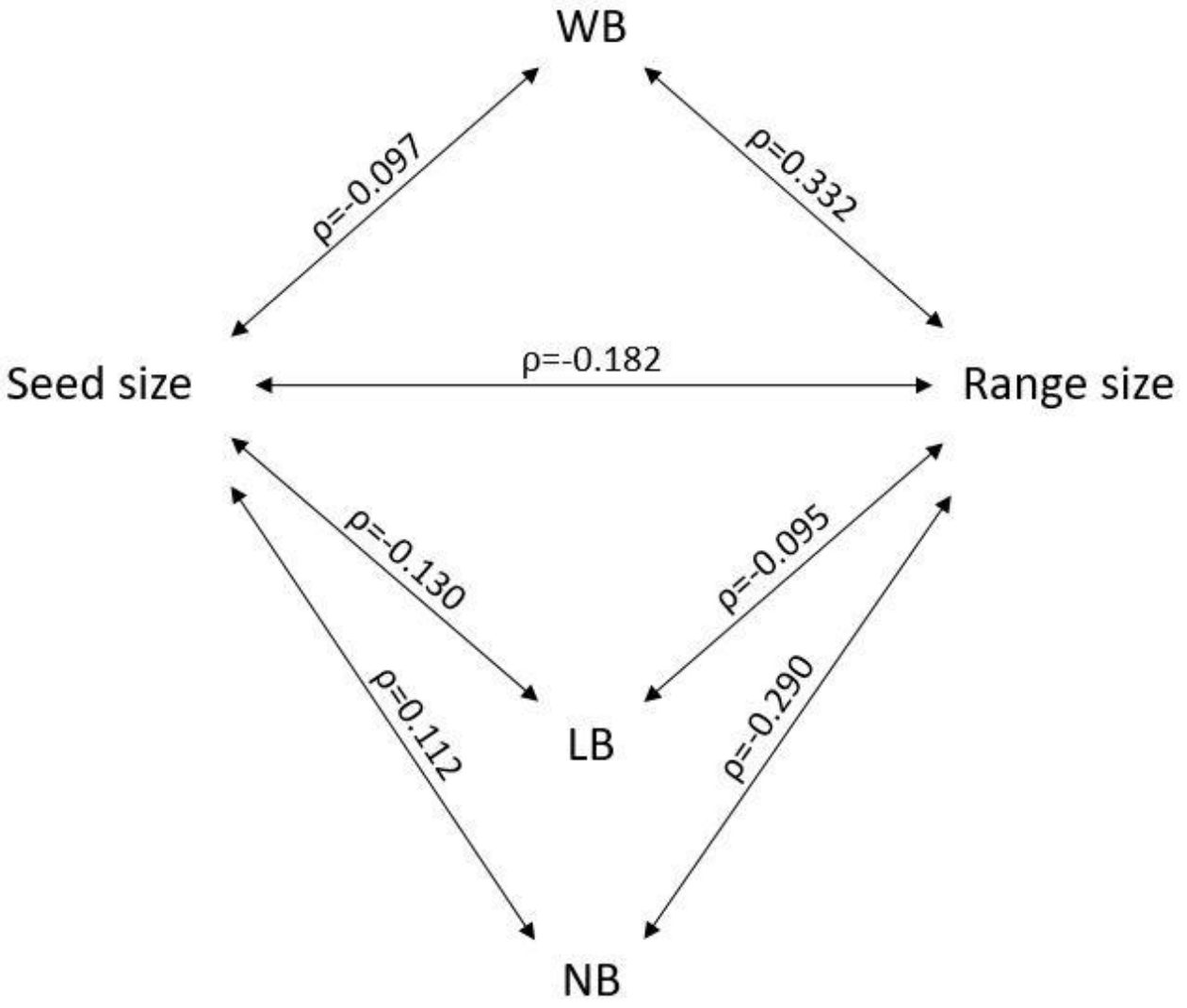
1a – *Seseli osseum*
1b – *Centaurea indurata*
1c – *Seseli leucospermum*

2a – *Echium maculatum*
2b – *Biscutella laevigata*
2c – *Lactuca quercina*

3a – *Bupleurum praealtum*
3b – *Vaccinium oxycoccos*
3c – *Prunella grandiflora*

4a – *Geranium dissectum*
4b – *Lepidium perfoliatum*
4c – *Marrubium peregrinum*

5a – *Briza media*
5b – *Ranunculus flammula*
5c – *Chenopodium botrys*



Rank correlations (Spearman's rho)

WB – soil moisture
LB – light intensity
NB – nutrient availability

Discussion

A trade-off between seed mass and range size exists in the studied 1600 species

The key factor is dispersal ability,

BUT:

- High number of small seeds (seed size/number trade-off)
- Small seeds have a lower probability of being eaten
- Small seeds persist longer in the soil
- Narrow range – narrow habitat requirements –

– bigger seeds are more advantageous

Discussion

Accordance with some of the former results ⟷ Contradiction with some other former results → Regional differences?

We used

- the highest number of species to date
- the global range size of species

Some factors counteract the effects of better dispersal ability of smaller seeds:

- The competition – colonization trade-off
- Effectively dispersed seed can get far away from the suitaible habitat
- Evolutionary age of a species

Discussion

Light intensity ↑ and soil mositure ↓ → Range size ↓

↓

Plant species of dry grasslands have high conservation value

Nutrient availability ↑ → Range size ↑

↓

Common species are mostly associated with fertile, degraded habitats, while rare species are associated with less fertile and less disturbed ones

Conclusions

Widespread species have small seeds

↓

Small, easily dispersed seeds are not always advantageous in isolated habitat

↓

Widespread species may face more and more local extinctions in the future?

Thank you for your attention!

The authors were supported by OTKA K108992 (AMV), OTKA K116639 (BT), NKFIH K 119225 (PT) and OTKA PD 115627 (BD) projects. JS and OV were supported by the Human Capacities Grant Management Office and the Hungarian Ministry of Human Capacities (NTP-NFTÖ-16-0107). BD and OV were supported by the Bolyai János Research Scholarship of the Hungarian Academy of Sciences.