Oikos

OIK-07308

Belinchón, R., Hemrová, L. and Münzbergová, Z. 2020. Functional traits determine why species belong to the dark diversity in a dry grassland fragmented landscape. – Oikos doi: 10.1111/oik.07308

Appendix 1

Table A1. List of vascular plant dry grassland species used in this study, including incidence in observed, dark and species pool diversity. PDD is the probability to belong to the dark diversity calculated as (no. of times in the dark diversity/ no. of times in species pool). The taxonomy and nomenclature of species in this paper follow Tutin, T. G et al. (eds) 1964-1983. Flora Europaea. – Cambridge Univ. Press.

	No times in observed	**No times in dark**	**No times in species pool**	**PDD**
Agrimonia eupatoria	254	10	264	0.04
Anemone sylvestris	42	114	156	0.73
Anthericum ramosum	18	34	52	0.65
Anthyllis vulneraria	67	88	155	0.57
Artemisia campestris	5	6	11	0.54
Asperula cynanchica	45	48	93	0.512
Asperula tinctoria	23	59	82	0.72
Aster amellus	26	118	144	0.8112
Aster linosyris	15	45	60	0.75
Astragalus cicer	109	88	197	0.45
Astragalus glycyphyllos	175	50	225	0.22
Brachypodium pinnatum	229	28	257	0.11
Briza media	127	88	215	0.41
Bromus erectus	119	88	207	0.425
Bupleurum falcatum	187	40	227	0.178
Campanula rotundifolia	8	96	104	0.92
Carex flacca	113	90	203	0.44
Carex humilis	46	74	120	0.62
Carex tomentosa	72	120	192	0.62
Carlina vulgaris	78	92	170	0.54
Centaurea jacea	202	47	249	0.19
Centaurea rhenana	7	129	136	0.95
Centaurea scabiosa	187	47	234	0.20
Cirsium acaule	80	67	147	0.46
Cirsium eriophorum	30	79	109	0.72
Cirsium pannonicum	9	24	33	0.73
Coronilla vaginalis	3	77	80	0.96
Dianthus carthusianorum	43	94	137	0.69
Eryngium campestre	130	64	194	0.33
Euphrasia rostkoviana.	14	35	49	0.71
Falcaria vulgaris	135	104	239	0.43
Festuca rupicola	218	26	244	0.11
Filipendula vulgaris	9	52	61	0.85
Fragaria viridis	233	20	253	0.08
Galium verum	206	46	252	0.18
Genista tinctoria	28	66	94	0.70
Gentiana cruciata	60	112	172	0.65

Geranium sanguineum	25	38	63	0.60
Globularia punctata	15	35	50	0.70
Gymnadenia conopsea	3	2	5	0.40
Helianthemum grandiflorum	58	105	163	0.64
Hieracium pilosella	76	71	147	0.48
Hypericum perforatum	200	54	254	0.21
Inula hirta	11	96	107	0.89
Inula salicina	199	53	252	0.21
Knautia arvensis	239	16	255	0.06
Koeleria pyramidata	58	118	176	0.67
Lathyrus pratensis	71	88	159	0.55
Leontodon hispidus	147	73	220	0.33
Leucanthemum vulgare	79	122	201	0.61
Linum catharticum	195	48	243	0.19
Linum flavum	10	16	26	0.61
Linum tenuifolium	15	85	100	0.85
Listera ovata	10	15	25	0.60
Lotus corniculatus	223	23	246	0.09
Medicago falcata	103	102	205	0.50
Melampyrum arvense	25	140	165	0.845
Melampyrum nemorosum	15	66	81	0.81
Onobrichis vicifolia	10	59	69	0.85
Ononis spinosa	61	114	175	0.65
Origanum vulgare	145	83	228	0.36
Peucedanum cervaria	43	95	138	0.69
Peucedanum oreoselinum	11	21	32	0.66
Pimpinella saxifraga	137	68	205	0.33
Plantago lanceolata	182	55	237	0.23
Plantago media	187	59	246	0.24
Platanthera bifolia	18	96	114	0.84
Potentilla arenaria	35	108	143	0.75
Potentilla heptaphylla	114	85	199	0.43
Primula veris	89	105	194	0.54
Prunella grandiflora	85	100	185	0.54
Prunella vulgaris	94	113	207	0.55
Pulsatilla pratensis	3	5	8	0.62
Salvia nemorosa	42	121	163	0.74
Salvia pratensis	185	41	226	0.18
Salvia verticillata	146	78	224	0.35
Sanguisorba minor	195	26	221	0.12
Scabiosa ochroleuca	148	47	195	0.24
Scorzonera hispanica	4	14	18	0.78
Securigera varia	246	11	257	0.04
Seseli hippomarathrum	7	10	17	0.59
Sesleria caerulea	20	110	130	0.85
Silene vulgaris	114	124	238	0.52
Solidago virgaurea	26	90	116	0.78
Stachys recta	102	101	203	0.50
Tanacetum corymbosum	43	158	201	0.79
Teucrium chamaedris	61	130	191	0.68
Thesium linophyllon	4	17	21	0.81
Thymus praecox	78	53	131	0.40
Trifolium medium	183	48	231	0.21
Trifolium montanum	45	150	195	0.79
Veronica teucrium	33	186	219	0.85
Vicia cracca	154	93	247	0.378
Vicia sepium	72	125	197	0.63
Viola hirta	60	149	209	0.71

Table A2. Minimum, maximum and mean values (± SE) for independent variables for the dry grasslands. I2000, Isolation based on the present-day area of the surrounding dry grasslands (higher values for more isolated sites, when the source dry grasslands were smaller); Dry grassland age, number of years of continuous existence; I1843, Isolation based on the area of the surrounding potential grassland habitats in 1843; I1980, Isolation based on the area of the surrounding potential grassland habitats in 1980s; A1843, Area of the surrounding potential grassland habitats in 1843; A1980, Area of the surrounding potential grassland habitats in 1980s.

	MIN	MAX	MEAN	SE
wetness index	5.97	13.60	8.31	1.08
slope	0.96	28.39	11.89	5.01
elevation	14.83	173.62	70.26	33.81
solar irradiation_June	4635.91	5809.36	5541.57	204.58
Area (m2)	66.27	189304.18	6497.75	15018.31
Log (area)	1.82	5.28	3.31	0.68
I2000	-5.40	1.88	-2.18	1.80
Dry grassland age	13.00	221.50	123.56	95.80
I1843	-6.75	0.38	-3.12	1.24
I1980	-7.92	-0.01	-3.55	1.31
A1843	0.00	1.00	0.21	0.31
A1980	0.00	1.00	0.50	0.42

Table A3. List of diversity metrics for the observed and the dark communities. Bold variables were significant at $p < 0.05$, according to a t-test to compare difference in means. Data show species, functional and phylogenetic diversity ('SD', 'FD' and 'PD' respectively).

	observed	dark
	mean ± SD (max-min)	mean ± SD (max-min)
SD	**30.56 ± 11.76 (3-66)**	**25.29 ± 10.07 (4-66)**
FD	**0.243 (0.20-0.28)**	**0.255 (0.19-0.29)**
PD	0.752 (0.63-0.82)	0.753 (0.62-0.82)

Table A4. Community mean traits (CM) for traits and ecological preference variables used in this study that were significantly different between observed and dark diversity. The difference between observed and dark diversity was tested by a Welch two sample t-test (p-value < 0.001).

	Observed diversity	Dark diversity	t	p-values
Functional traits				
Terminal velocity	2.69	2.11	-13.41	< 0.001
Rate of epizoochory	16.70	14.06	-8.48	< 0.001
Rate of endozoochory	71.55	67.12	-13.34	< 0.001
Seed bank longevity	0.16	0.15	-3.39	< 0.001
Beginning of flowering	3.23	3.29	-3.56	< 0.001
End of flowering	8.05	7.93	-5.28	< 0.001
Duration of flowering	5.82	5.63	-13.02	< 0.001
Seed mass	0.02	-0.08	-8.11	< 0.001
Plant height	-0.40	-0.45	-11.23	< 0.001
SLA	1.30	1.31	0.66	0.509
Clonality	0.37	0.50	3.13	< 0.01
Perenniality	0.66	0.40	-6.12	< 0.001
Ecological preference				
Light	7.21	7.20	-0.49	0.619
Moisture	3.88	3.77	-3.92	< 0.001

Table A5. List of functional traits and ecological preference (Ellenberg's values) for species with low (< 20%) and high (> 85%) probability to belong to the dark diversity. Bold variables were significant at $p < 0.05$, according to a t-test to compare difference in means.

	High probability mean ± SD	Low probability mean ± SD	p-values
Vegetative traits			
Plant height	-0.48 ± 0.24	-0.38 ± 0.23	0.36
SLA	1.30 ± 0.07	1.29 ± 0.17	0.89
Perenniality	0.42 ± 0.53	0.53 ± 0.51	0.66
Clonality	0.42 ± 0.53	0.53 ± 0.51	0.66
Phenology traits			
Beginning of flowering	5.43 ± 0.79	5.85 ± 0.80	0.28
Duration of flowering	3.71 ± 1.11	2.92 ± 0.86	0.13
End of flowering	8.14 ± 1.07	7.77 ± 1.16	0.48
Seed traits			
Rate of endozoochory	60.74 ± 24.54	70.04 ± 13.46	0.38
Rate of epizoochory	3.85 ± 6.03	20.39 ± 26.96	0.06
Seed bank longevity	0.12 ± 0.16	0.16 ± 0.15	0.63
Seed mass	-0.16 ± 0.87	0.18 ± 0.64	0.39
Terminal velocity	2.05 ± 0.95	2.52 ± 0.70	0.28
Ecological preference			
Light	7.57 ± 0.98	7.15 ± 0.80	0.35
Moisture	**2.86 ± 0.90**	**3.92 ± 1.12**	**0.03**

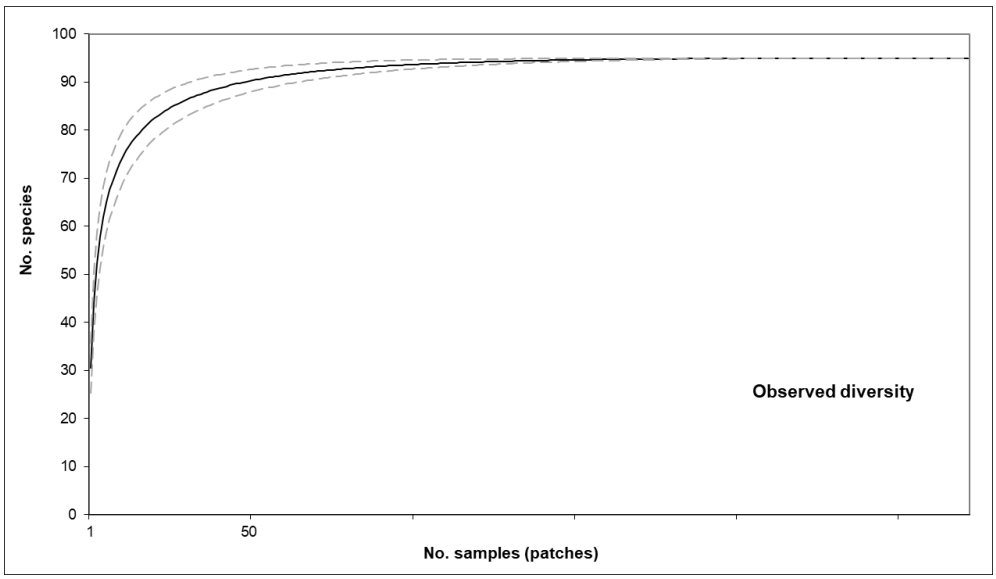
Table A6. Results for generalized linear models (GLM) which investigated the relationship between the species pool and completeness of dry grasslands and three groups of explanatory variables separately (abiotic, present-day and historical landscape configuration). Species pool (pool) was calculated as the sum of observed and dark diversity (Pärtel et al. 2013). Community completeness (comp) as the ln (observed/ dark diversity) to show how much of the site-specific species pool is realized at the site.

I2000, Isolation based on the present-day area of the surrounding dry grasslands (higher values for more isolated sites, when the source dry grasslands were smaller); Dry grassland age, number of years of continuous existence; I1843, Isolation based on the area of the surrounding potential grassland habitats in 1843; I1980, Isolation based on the area of the surrounding potential grassland habitats in 1980s; A1843, Area of the surrounding potential grassland habitats in 1843; A1980, Area of the surrounding potential grassland habitats in 1980s. z-values shown. p-values: *** 0.001, ** 0.01, * 0.05, ns > 0.05.

	SD_{pool}	SD_{comp}
Abiotic		
wetness index	-5.14***	
slope	12.23***	
elevation	-2.77**	
Solar irradiation_June	5.35***	
Present-day		
Log (area)		6.32***
I2000	-6.83***	
Historical		
I1843	-2.40*	
I1980		
A1843	2.23*	-2.12*
A1980	5.17***	
dry grassland age	9.55***	

Table A7. Explained variance of the significant explanatory variables used in the redundancy analysis (RDA) using observed and dark diversity datasets. I2000, Isolation based on the present-day area of the surrounding dry grasslands (higher values for more isolated sites, when the source dry grasslands were smaller); dry grassland age, number of years of continuous existence; I1843, Isolation based on the area of the surrounding potential grassland habitats in 1843; I1980, Isolation based on the area of the surrounding potential grassland habitats in 1980s; A1843, Area of the surrounding potential grassland habitats in 1843; A1980, Area of the surrounding potential grassland habitats in 1980s. p-values: *** 0.001, ** 0.01, * 0.05, ns > 0.05.

	Observed			**Dark**		
	Variance (%)	F value	p	Variance (%)	F value	p
Abiotic						
wetness index	8.30	1.75	*	9.43	1.64	*
elevation	25.65	5.40	***	20.55	3.57	***
slope	23.35	4.92	***	33.26	5.79	***
solar irradiation_June	25.06	5.28	***	20.12	3.49	***
Explained variation		7.69 %			7.15 %	
Present-day						
Log (area)	20.93	4.21	***	13.65	2.25	**
I2000	9.17	1.84	*	8.74	1.44	*
Explained variation		2.69 %			1.44 %	
Historical						
dry grassland age	20.43	4.14	***	19.60	3.29	***
I1843	---	---	---	---	---	---
I1980	---	---	---	---	---	---
A1843	9.44	1.91	*	10.14	1.70	*
A1980	8.24	1.67	*	11.71	1.96	**
Explained variation		4.61 %			4.19 %	



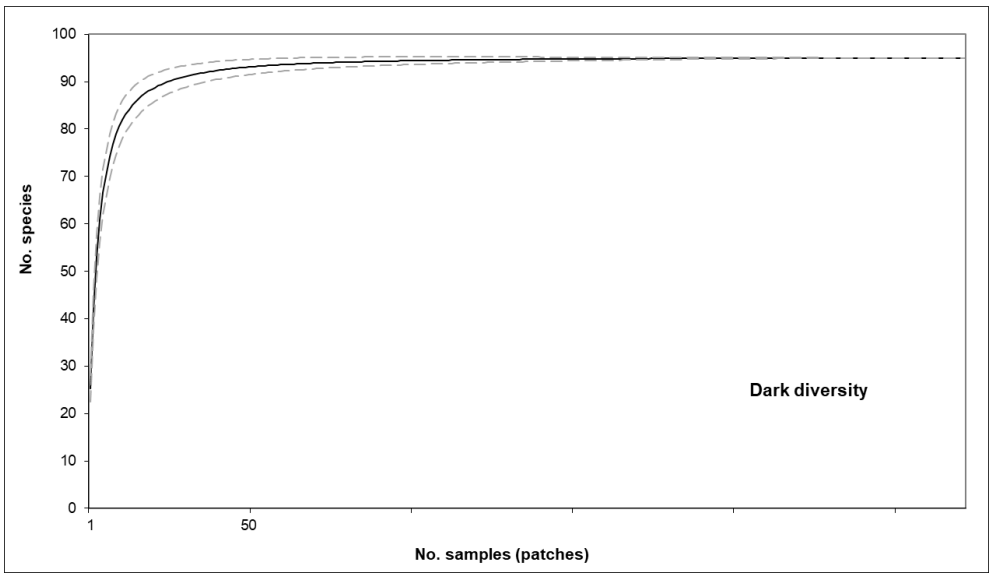


Figure A1. Sample-based accumulation curves comparing species richness per site. The curves show the cumulative number of species with increasing sampling effort. The curves were produced by EstimateS version 9.1. 0 (Colwell 2013) and calculated with 100 random resamples among units (stems).