Ecography

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Supplementary material

Appendix 1. Complementary description of the design for sampling seed deposition by birds.

Figure A1. Distribution of 125 cells selected for sampling of seed rain in the study plots in different study years (dots indicate the centroids of the selected cells).

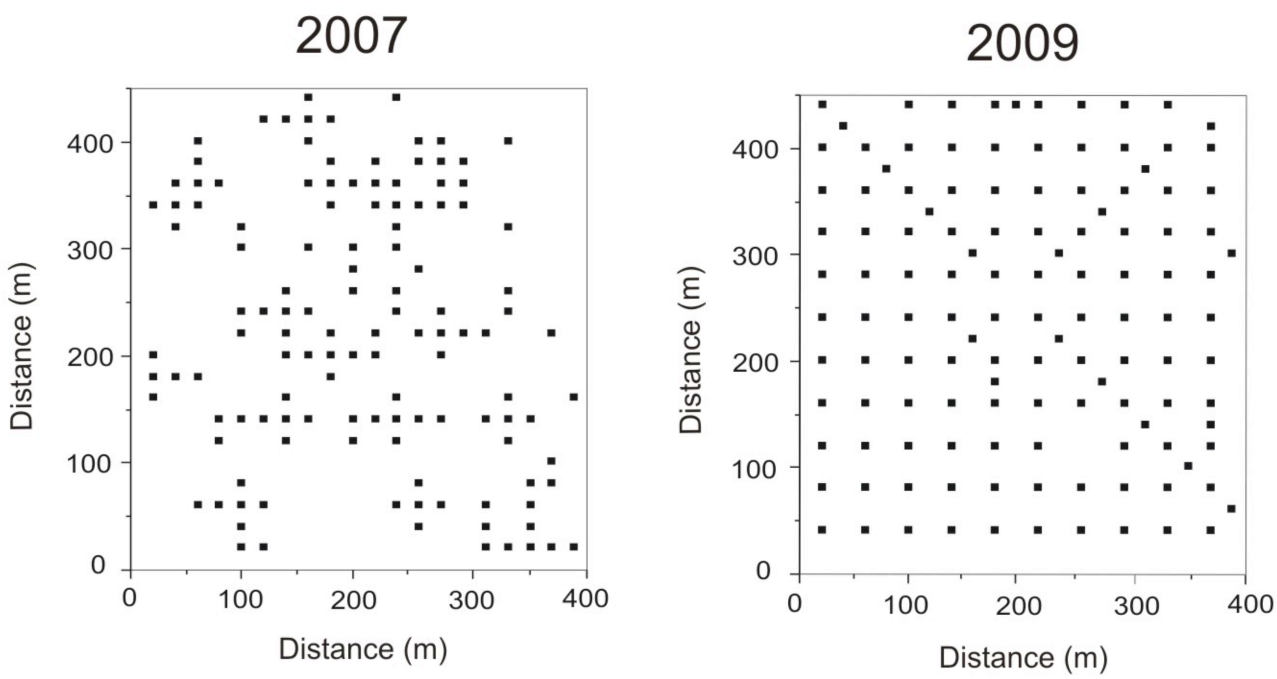


Table A1. Descriptive statistics of the spatial coordinates (X,Y) of the centroids of the 125 cells selected for sampling of seed rain in the study plots in different study years, and the value of forest cover represented by each set of cells. The values of F and p corresponding to one-way ANOVAs comparing average values between years are also shown.

		2007	2009	F	p
Coordinate X	Mean±SE	187.5±9.1	186.7±10.3	0.01	0.95
	Range	380	380		
	cv (%)	54.2	60.8		
Coordinate Y	Mean±SE	202.7±10.9	222.1±11.1	1.53	0.22
	Range	420	400		
	cv (%)	59.3	57.2		
Forest cover (%)	Mean±SE	29.7±3.1	26.2±3.1	0.66	0.42
	Range	100	100		
	cv (%)	116.3	130.5		

Appendix 2. Description of Analysis of Principal Components (PCA) of frugivore diet.

We used a Principal Component Analysis in order to search for major trends of variability between bird species and years in the composition of diet. PCA was conducted on the proportions of fruits of *C. monogyna*, *I. aquifolium* and *T. baccata* consumed by the different bird species in different years. Proportions were calculated with respect to the total number of fruits consumed per bird species per year (N = 16 cases combining different species and years in which consumption data were available; Table A2.1) and arcsin-square root transformed prior to analysis.

PCA extracted two components that accounted for 99% of global variance in the original variables. The first component (PC1) represented a gradient of increasing proportion of *C. monogyna* and decreasing proportion of *I. aquifolium* in the diet, whereas the second component (PC2) was related to increasing proportion of *T. baccata* (Table A2.2). Rotated factor scores were calculated for each combination of bird species and year (Figure A2). These factor scores were used to compare diet composition between species and years by means of two-way ANOVA models with species and year as predictor variables and PC1 and PC2 scores as response variables (no interaction term was considered as no data from all years were available for all species).

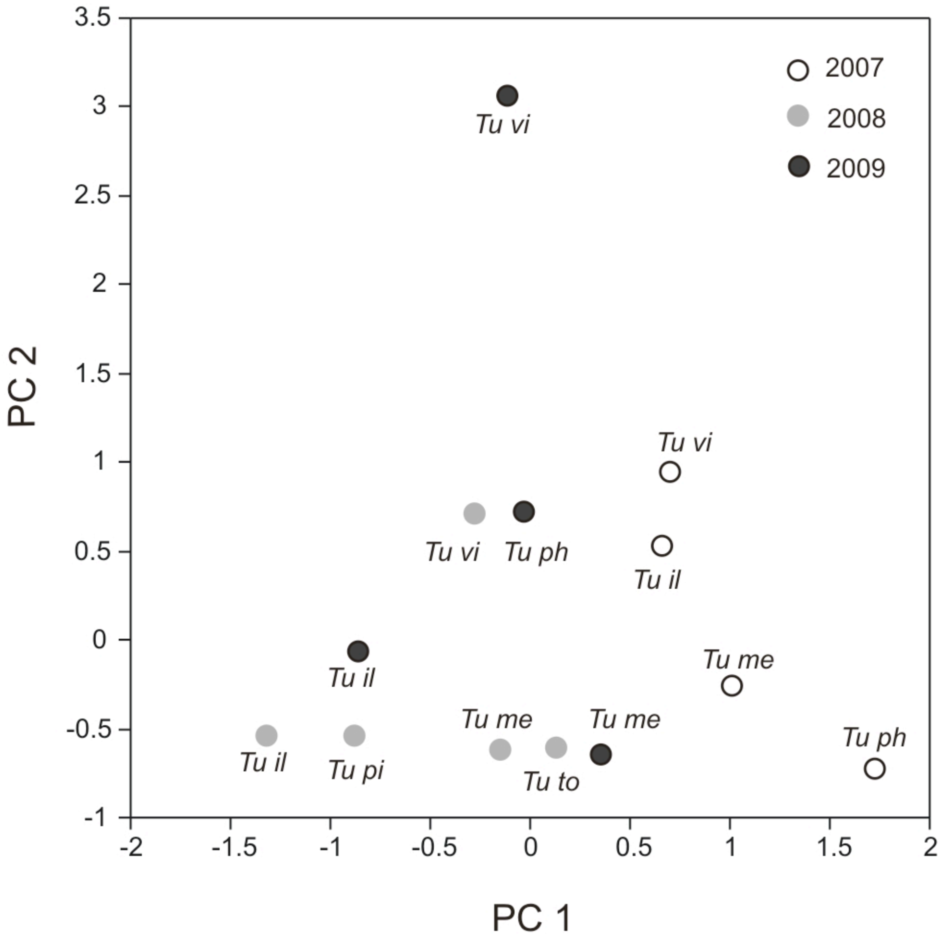
Table A2. Number of fruits of different tree species consumed by thrushes in different years. Observations of fruit consumption were recorded in foraging sequences of individual birds (the number of observed birds is indicated in parentheses).

Bird species	Year	*Crataegus monogyna*	*Ilex aquifolium*	*Taxus baccata*
T. iliacus	2007	162 (38)	37 (9)	31 (4)
T. iliacus	2008	0	125 (16)	0
T. iliacus	2009	7 (3)	116 (22)	3 (1)
T. merula	2007	433 (70)	56 (13)	10 (2)
T. merula	2008	65 (13)	144 (18)	0
T. merula	2009	108 (19)	82 (14)	0
T. philomelos	2007	72 (9)	0	0
T. philomelos	2008	0	7 (1)	0
T. philomelos	2009	17 (3)	21 (2)	8 (3)
T. pilaris	2008	2 (1)	41 (5)	0
T. pilaris	2009	16 (3)	0	0
T. torquatus	2008	10 (2)	12 (2)	0
T. torquatus	2009	0	6 (1)	0
T. viscivorus	2007	54 (9)	6 (2)	18 (3)
T. viscivorus	2008	28 (7)	73 (11)	20 (3)
T. viscivorus	2009	11 (5)	5 (1)	68 (14)

Table A3. Results of Principal Component Analysis constructed on the proportions of fruits from different species consumed by different bird species in different years.

Factor	**Eigenvalue**	**% Variance**
PC1	1.97	65.63
PC2	1.02	33.12
Eigenvectors		
Prop. of fruits consumed	PC1	PC2
Crataegus monogyna	0.65	-0.39
Ilex aquifolium	-0.71	-0.02
Taxus baccata	0.26	0.91
Standardized Score Coefficients		
Prop. of fruits consumed	PC1	PC2
Crataegus monogyna	0.56	-0.23
Ilex aquifolium	-0.47	-0.17
Taxus baccata	-0.09	0.92

Figure A2. Values of rotated factor scores extracted from PCA corresponding to different bird species and different years (Tu il: *Turdus iliacus*; Tu me: *T. merula*; Tu ph: *T. philomelos*; Tu pi: *T. pilaris*; Tu to: *T. torquatus*; Tu vi: *T. viscivorus*).



Appendix 3. Complementary description on Spatial Analysis by Distance Indices (SADIE).

Spatial Analysis by Distance Indices (SADIE; Perry 1995; Perry et al. 1999; Perry et al. 2002) was used to characterize and quantify the degree of spatial aggregation (patchiness) of the abundances of fleshy fruits of the different tree species, the abundances of different species of thrushes and the abundance of dispersed seeds, in the study plots and for the different study years. SADIE describes the spatial structure of ecological data sampled in the form of spatially geo-referenced counts, seeking to identify and locate the areas where patches of high- or low density occur.

In our case, we considered plot cells as sampling points, referenced in space by the x,y coordinates of the corresponding cell centroids. Based on estimates of distance to regularity (i.e. the difference between the true count value in a given point and a count value assuming a regular distribution of all counts across sampling points), SADIE provides an aggregation index (Ia) to measure the degree of overall spatial clumpiness across the whole extent. Ia represents random (Ia = 1), regular (Ia < 1) or aggregated (Ia > 1) distribution patterns, and the degree of significance is checked by means of a randomization procedure based on rearrangements of the observed counts amongst the sample units.

SADIE also provides a point-level parameter, the clustering index (υ), which quantifies the degree to which the count at a given point contributes to the overall clumpiness. Points with high positive υ values contain big counts which contribute greatly to the generation of high-density clusters ("patches"), whereas points with negative υ values contain small counts which contribute to low-density clusters ("gaps"). These clustering indexes may be considered weighted continuous variables that depict the spatial distribution of the raw count data, and hence are especially suitable for testing working hypotheses that deal with spatial processes (e.g. resource tracking in space, seed dispersal). In this sense, clustering vectors from different variables sampled in the same points may be related between themselves, by means of correlation or regression analyses, to verify the existence of significant spatial match between variables. In fact, clustering vectors usually show data distributions that fit the requirements of Least Squares based models better than those of count data. Nevertheless, clustering index vectors are usually highly auto-correlated in space, and thus analyses relating vectors from different variables must account for the potential effects of spatial autocorrelation in the determination of correlation strength.

References

Perry, J. N. 1995. Spatial analysis by distance index. – J. Anim. Ecol. 64: 303-314.

Perry, J. N. et al. 1999. Red-blue plots for detecting clusters in count data. – Ecol. Lett. 2: 106-113.

Perry, J. N. et al. 2002. Illustrations and guidelines for selecting statistical methods for quantifying spatial pattern in ecological data. - Ecography 25: 578-600.

Appendix 4. Interannual variation in the specific abundances of fruits, thrushes, and dispersed seeds.

Table A4. Average (±SE) values of the abundance of fruits (fruits/m^2 per cell), frugivorous thrushes (birds/10 h per cell), and dispersed seeds (seeds per quadrat) of different species across years (n. a.: data not available). Results of Generalized Linear Models (Poisson distribution and log link) comparing the abundances between years are also shown (models for fruits and thrushes include cell identity as a blocking factor; Likelihood-Ratio χ^2 values are specified; n. s.: $p > 0.05$; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$).

	2007	2008	2009	LR χ^2
Fruits				
Crataegus monogyna	5.7±0.7	2.2±0.3	1.4±0.2	50.2 ***
Ilex aquifolium	2.9±0.4	7.6±1.1	14.2±1.3	82.3 ***
Taxus baccata	0.3±0.2	0.4±0.2	1.3±0.4	6.8 *
Thrushes				
Turdus iliacus	0.86±0.11	1.08±0.21	1.85±0.27	115.8 ***
Turdus merula	0.72±0.09	0.45±0.07	0.78±0.13	57.0 ***
Turdus philomelos	0.39±0.09	0.15±0.04	0.39±0.08	72.5 ***
Turdus pilaris	0	0.22±0.05	0.06±0.02	10.9 **
Turdus torquatus	0	0.01±0.00	0.04±0.02	5.6 *
Turdus viscivorus	0.26±0.07	0.58±0.10	0.65±0.08	63.4 ***
Dispersed seeds				
Crataegus monogyna	7.9±0.9	n. a.	0.4±0.1	10.0 **
Ilex aquifolium	7.4±1.1	n. a.	17.2±3.8	71.4 ***
Taxus baccata	0.6±0.1	n. a.	1.1±0.4	2.9 n. s.