Ecography

ECOG-03573

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Appendix 1

Table A1. Field site details including location and elevation, when the nestboxes were installed, and the years in which each site was intensively studied. Dominant tree defined as the commonest deciduous tree by foliage score, but see Fig. 2 for more detailed habitat information.

Code	Name	Mean latitude (°N)	Mean longitude (°E)	Mean elevation (m.a.s.l)	Nestboxes	Installation date	2014	2015	2016	Dominant tree (%)
EDI	Edinburgh	55.98	- 3.40	54	6	04/02/2015		✓	✓	sycamore (70)
RSY	Rosyth	56.02	- 3.41	37	6	20/01/2015		✓	✓	sycamore (49)
FOF	Fordell Firs	56.06	- 3.38	87	6	09/12/2013	✓	✓	✓	sycamore (39)
BAD	Blairadam	56.12	- 3.45	170	6	29/11/2013	✓			beech (35)
LVN	Loch Leven	56.17	- 3.36	123	6	09/12/2013	✓	✓	✓	birch (66)
GLF	Glenfarg	56.30	- 3.36	100	6	10/01/2014	✓	✓	✓	beech (32)
SER	Strathearn	56.35	- 3.40	10	6	20/02/2015		✓	✓	sycamore (45)
MCH	Moncrieffe Hill	56.36	- 3.38	48	6	29/11/2013	✓		✓	sycamore (42)
PTH	Perth	56.42	- 3.47	24	6	29/11/2013	✓	✓		ash (49)
STY	Stanley	56.48	- 3.47	51	6	29/11/2013	✓	✓	✓	sycamore (30)
BIR	Birnam	56.54	- 3.53	87	6	10/01/2014	✓		✓	oak (31)
DUN	Dunkeld	56.57	- 3.62	112	6	29/11/2013	✓	✓		birch (25)
BLG	Ballinluig	56.65	- 3.66	79	6	29/11/2013	✓	✓	✓	sycamore (46)
KCK	Killiecrankie I	56.73	- 3.77	117	6	09/12/2013	✓	✓	✓	beech (51)
KCZ	Killiecrankie II	56.73	- 3.78	155	6	20/01/2015		✓	✓	oak (78)
BLA	Blair Atholl	56.76	- 3.85	175	6	09/12/2013	✓	✓	✓	beech (38)
CAL	Calvine	56.77	- 3.97	195	6	29/11/2013	✓	✓	✓	birch (58)
DNM	Dalnamein	56.80	- 4.03	248	6	29/11/2013	✓	✓	✓	birch (46)
DNC	Dalnacardoch	56.82	- 4.13	363	6	10/01/2014	✓	✓	✓	willow (42)
DNS	Dalnaspidal	56.83	- 4.22	433	4	19/02/2015		✓	✓	willow (38)
DLW	Dalwhinnie	56.92	- 4.24	377	6	13/12/2013	✓	✓	✓	willow (71)
CRU	Crubenmore	56.99	- 4.18	298	6	13/12/2013	✓	✓	✓	birch (87)
NEW	Newtonmore	57.05	- 4.13	236	6	13/12/2013	✓	✓	✓	birch (87)
INS	Insh	57.07	- 4.00	248	6	13/12/2013	✓	✓	✓	birch (68)
FSH	Feshiebridge	57.12	- 3.90	242	6	13/12/2013	✓	✓	✓	birch (88)
RTH	Rothiemurchus	57.15	- 3.85	228	6	19/01/2015		✓	✓	oak (87)
AVI	Aviemore	57.19	- 3.84	209	6	13/12/2013	✓	✓	✓	birch (100)
AVN	Avielochan	57.21	- 3.82	217	6	20/01/2015		✓	✓	oak (78)
CAR	Carrbridge	57.29	- 3.79	252	6	14/12/2013	✓	✓	✓	birch (55)
SLS	Slochd Summit	57.30	- 3.92	375	6	19/01/2015		✓	✓	birch (94)
TOM	Tomatin	57.33	- 3.98	315	6	13/12/2013	✓	✓	✓	birch (100)
DAV	Daviot	57.41	- 4.15	152	6	14/12/2013	✓	✓	✓	alder (79)
ART	Artafallie	57.51	- 4.31	60	6	13/10/2015			✓	oak (73)
MUN	Munlochy	57.55	- 4.28	54	6	14/12/2013	✓	✓	✓	oak (23)
FOU	Foulis Estate	57.64	- 4.35	17	6	14/12/2013	✓	✓	✓	sycamore (49)
ALN	Alness	57.69	- 4.29	35	6	14/12/2013	✓	✓	✓	birch (86)
DEL	Delny Muir	57.72	- 4.13	18	6	14/12/2013	✓	✓	✓	elm (21)
TAI	Tain Pottery	57.80	- 4.04	23	6	14/12/2013	✓		✓	birch (32)
SPD	Spinningdale	57.87	- 4.26	71	6	19/01/2015		✓	✓	oak (86)
DOR	Dornoch	57.89	- 4.08	28	6	14/12/2013	✓	✓	✓	alder (55)

Table A2. (A-C) Effects on blue tit fledging success along the transect once the analysis is split into the constituent years, to compare with Table 2C (showing the result for all years). (D) Effects on total number of fledglings, as opposed to fledging success as a proportion of clutch size (Table 2C). Slopes (coefficient) are shown with their associated standard errors (se) from GLMM's.

		(A) 2014	(B) 2015	(C) 2016	(D) Total fledglings
Fixed term		coefficient ± SE	coefficient ± SE	coefficient ± SE	coefficient ± SE
Intercept		2.32 ± 0.38	-0.45 ± 0.36	1.20 ± 0.30	1.92 ± 0.05
Total foliage		-0.0029 ± 0.0229	-0.0097 ± 0.0265	0.025 ± 0.023	-0.00083 ± 0.00283
Birch		0.0029 ± 0.0243	0.033 ± 0.026	0.020 ± 0.027	0.0067 ± 0.0032 *
Oak		0.073 ± 0.056	0.082 ± 0.026	0.029 ± 0.022	0.011 ± 0.003 ***
Sycamore		0.062 ± 0.030	0.053 ± 0.039	0.047 ± 0.035	0.011 ± 0.004 **
Willow		-0.031 ± 0.114	-0.20 ± 0.07	0.10 ± 0.07	-0.00032 ± 0.00794
Tree diversity		0.33 ± 0.27	0.77 ± 0.35	0.33 ± 0.33	0.10 ± 0.04 **
Latitude		0.57 ± 0.74	0.52 ± 0.35	0.60 ± 0.71	0.038 ± 0.085
Elevation		0.0045 ± 0.0064	0.0084 ± 0.0051	0.011 ± 0.005	0.0015 ± 0.0006 **
Late invertebrates		1.85 ± 0.96	2.07 ± 0.81	1.92 ± 0.82	0.39 ± 0.10 ***
Blue tit density		-3.62 ± 1.65	1.45 ± 1.65	1.53 ± 1.42	0.090 ± 0.159
Year	2015	-	-	-	-0.71 ± 0.07 ***
	2016	-	-	-	-0.30 ± 0.06 ***
Random term		variance	variance	variance	variance
Space		3.0×10^{-9}	0.3	2.2×10^{-8}	6.1×10^{-9}
Nestbox ID		3.3	7.1	7.3	0.07
Spatial autocorrelation		parameter	parameter	parameter	parameter
nu		0.5	0.5	0.5	0.5
rho		5.1	82.8	136.6	4.75

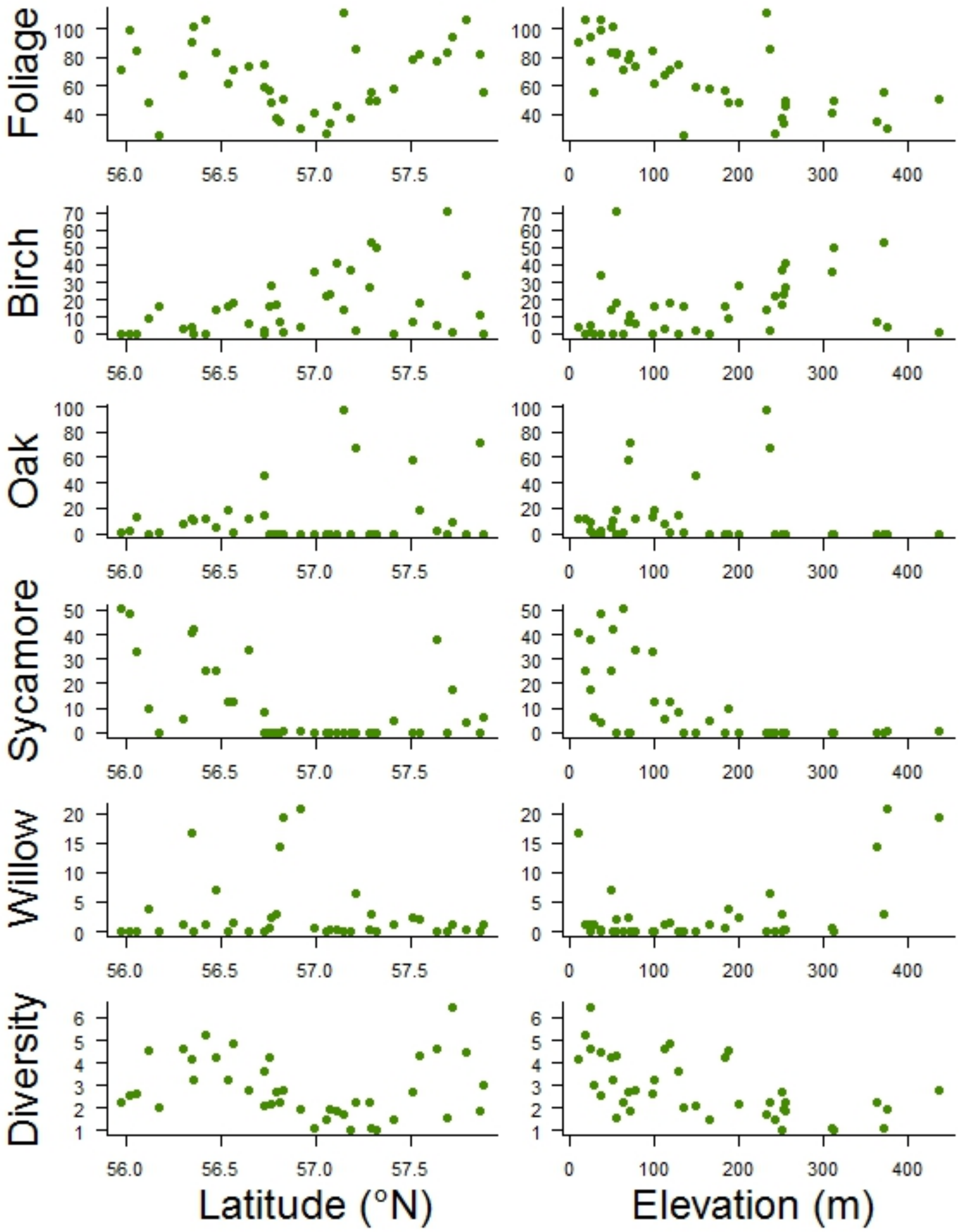

Figure A1. Site-level biogeographic patterns in habitat variables.

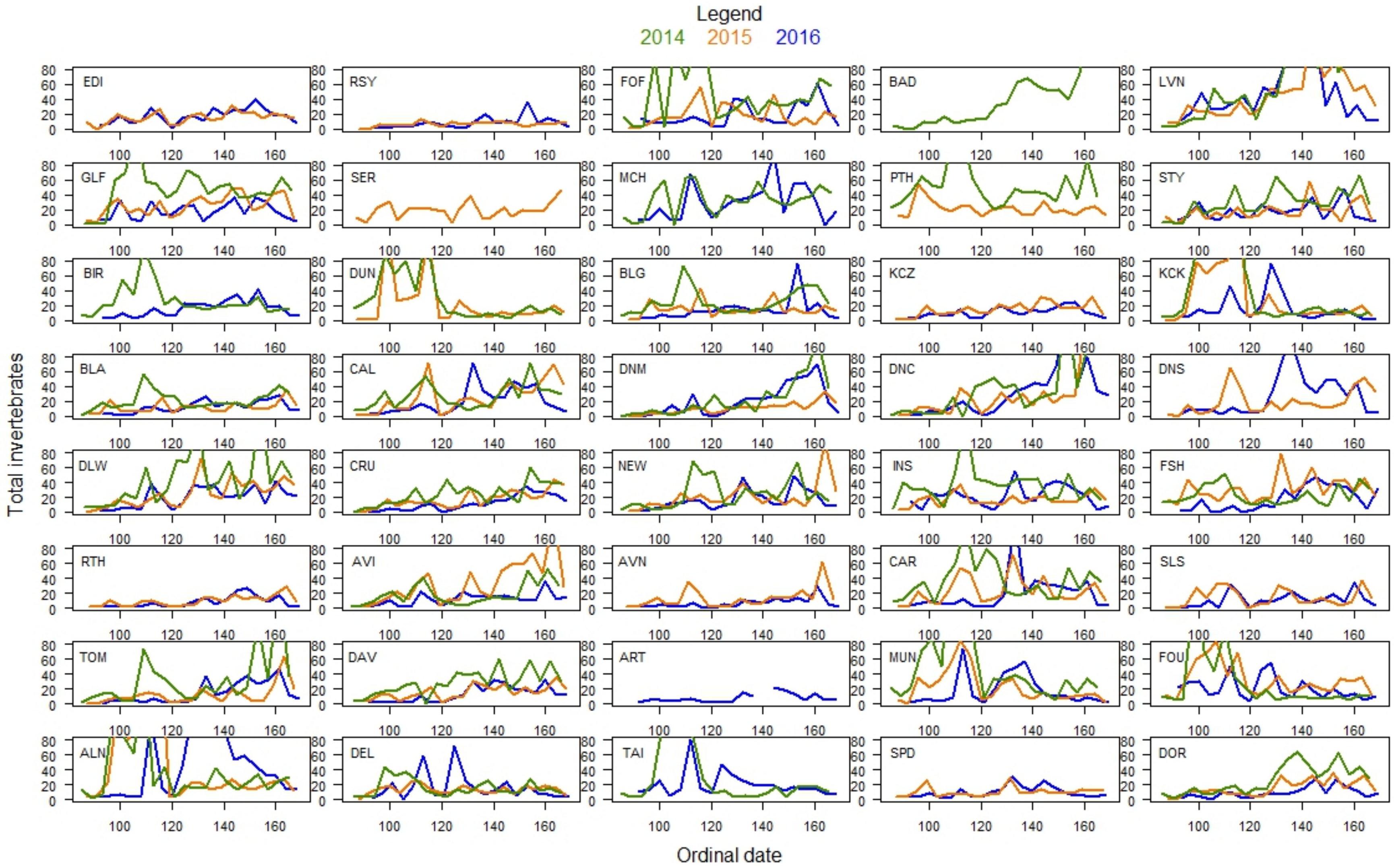

Figure A2. Raw numbers of invertebrates sampled from sticky traps at each site in each year. Some counts exceed the limits of the constant y-axis used for comparison.

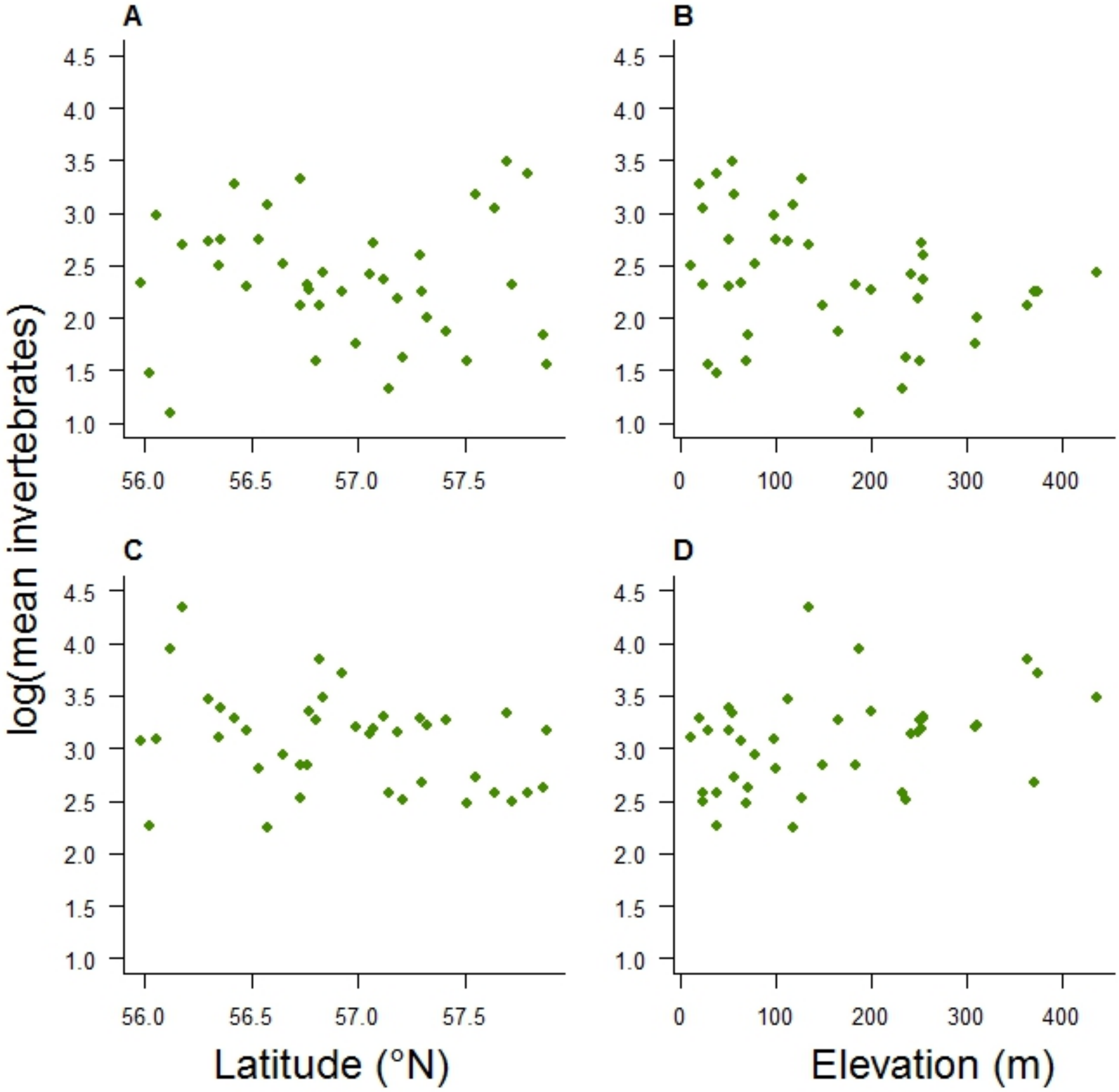

Figure A3. Site level predictions (ln-scale) of total invertebrate numbers from a GLMM (see methods). (A) Early season total invertebrates by latitude. (B) Early season total invertebrates by elevation. (C) Late season total invertebrates by latitude. (D) Late season total invertebrates by elevation.

Appendix 2

Post hoc test of the effect of spring temperature on occupancy

Methods

As biogeographic trends in occupancy were strong, we conducted a post-hoc test to examine whether latitude and elevation are simply acting as a proxy for the average spring temperatures at a site. Hourly temperature data were collected by two Thermachron iButton's (model DS1922L-F5, sensitive to 0.0625°C) installed at opposite ends of each active site throughout March and April of each study year. They were secured 1.5 m high on the north side of a tree to avoid direct sunlight in a waterproof white pot with a 20 mm-diameter hole in the bottom to allow ambient air circulation. To account for the fact that some sites were not monitored in some years, we obtained site mean spring temperatures as best linear unbiased predictors from a linear mixed model. This model included the mean March/April temperature for each logger as the response variable, year as a fixed term and site as a random term. The site mean temperature term was then added to the full occupancy model and this model was then compared to the original occupancy model via a likelihood ratio test to obtain a p-value.

Results

March/April temperature was a weak and non-significant predictor of occupancy (Supplementary material Table A3, χ^2_1 = 0.84, p = 0.36) and inclusion of this term did not diminish the effects of latitude or elevation (compare with Table 2A).

Discussion

This analysis allows us to discount a simple relationship between temperature and occupancy but it is possible that a more complex relationship may exist. For instance, perhaps minimum winter temperatures are more important than the spring temperatures that we considered. However, minimum winter temperatures and mean spring temperatures are likely to be highly correlated among sites. Alternatively, this may indicate that latitude and elevation are proxy for the effects of one or perhaps several environmental variables besides temperature.

Table A3. Effect of site-mean March/April temperature on blue tit nestbox occupancy.

		Occupancy
Fixed term		coefficient ± SE
Intercept		0.088 ± 0.227
Total foliage		0.0074 ± 0.0159
Birch		-0.0035 ± 0.0165
Oak		0.0041 ± 0.0145
Sycamore		0.019 ± 0.025
Willow		0.019 ± 0.046
Tree diversity		-0.026 ± 0.232
Latitude		$-8.5\times10^{-6} \pm 3.8\times10^{-6}$
Elevation		-0.013 ± 0.006
March/April temperature		-0.83 ± 0.90
Early invertebrates		-0.28 ± 0.35
Subsequent year		0.11 ± 0.50
Year	2015	0.88 ± 0.51
	2016	0.44 ± 0.59
Random term		variance
Space		0.6
Nestbox ID		0.2
Spatial autocorrelation		parameter
nu		0.5
rho		0.0022