Ecography

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Supplementary material

Appendix 1. **Table A1.** List of species, population growth rates and main trait predictors used in the final analysis

Common name	Latin name	Instant growth rate	Standard error	Migratory behaviour	Average first clutch laying period (no. days)	Productivity (no.eggs/ year)	Average laying date (Julian date)	Diet group	Habitat	Average body weight (g)	Average Nesting period (no. days)	Nesting location	Mean change in arrival date (no.days)	Mean distance (° latitude)
Blackbird	*Turdus merula*	2.116	0.270	Partial migrant	23	10	112	Generalist	Urban	102.5	28.5	vegetation	-	-
Blackcap	*Sylvia atricapilla*	5.159	0.676	Migrant	54	7.125	130	Generalist	Woodland	20	25	vegetation	-0.41	19.63
Blue Tit	*Cyanistes caeruleus*	0.964	0.404	Partial migrant	29	10.5	116	Generalist	Urban	11	33.5	hole	-	-
Bullfinch	*Pyrrhula pyrrhula*	-0.986	0.856	Resident	83	11.875	137	Large seed	Generalist	21	31	vegetation	-	-
Chaffinch	*Fringilla coelebs*	1.157	0.167	Resident	48	4.5	120	Large seed	Generalist	23.5	27	vegetation	-	-
Chiffchaff	*Phylloscopus collybita*	3.159	1.289	Migrant	59	11.5	122	Highly specialist	Woodland	8	28.5	vegetation	-0.39	22.55
Corn Bunting	*Emberiza calandra*	-2.681	0.663	Resident	61	9	167	Highly specialist	Farmland	47	25	ground	-	-
Carrion Crow	*Corvus corone*	1.195	0.374	Resident	46	3.5	97	Generalist, carrion	Urban	510	48.5	vegetation	-	-
Dunnock	*Prunella modularis*	2.129	0.273	Resident	75	10	117	Small seed	Generalist	20.5	28	vegetation	-	-
Garden Warbler	*Sylvia borin*	-1.867	0.544	Migrant	44	4.25	141	Generalist	Woodland	19	24	vegetation	-	-
Goldcrest	*Regulus regulus*	2.357	1.118	Resident	60	19.5	122	Invertebrate	Woodland	5.75	35	vegetation	-	-
Goldfinch	*Carduelis carduelis*	3.393	0.488	Partial migrant	84	12.5	145	Large seed	Farmland	16.5	29.5	vegetation	-	-
Greenfinch	*Carduelis chloris*	3.018	0.476	Resident	91	10	130	Large seed	Urban	27.6	29.5	vegetation	-	-
Great Tit	*Parus major*	3.943	0.324	Resident	37	9	116	Generalist	Generalist	18	33.5	ground	-	-
Grey Wagtail	*Motacilla cinerea*	4.088	2.004	Resident	77	10	117	Invertebrate	Generalist	18	27.5	vegetation	-	-
House Sparrow	*Passer domesticus*	-0.462	0.266	Resident	106	10.625	134	Small seed	Urban	31	30	ground	-	-
Jackdaw	*Corvus monedula*	2.591	0.368	Resident	37	5	89	Generalist, carrion	Generalist	222.5	52.5	hole	-	-
Jay	*Garrulus glandarius*	0.916	0.425	Resident	60	6.25	90	Generalist, carrion	Woodland	166.25	39.5	vegetation	-	-
Lesser Whitethroat	*Sylvia curruca*	-0.570	1.012	Migrant	51	4.75	139	Insect	Woodland	12	24	vegetation	-0.17	27.79
Linnet	*Carduelis cannabina*	-1.690	0.492	Partial migrant	84	7.5	133	Large seed	Farmland	18.75	27	vegetation	-	-
Long-tailed Tit	*Aegithalos caudatus*	0.080	0.613	Resident	36	10.25	98	Highly specialist	Generalist	8.5	33	vegetation	-	-
Magpie	*Pica pica*	-0.264	0.287	Resident	26	6.25	112	Generalist, carrion	Urban	219.5	48.5	vegetation	-	-
Marsh Tit	*Poecile palustris*	-0.702	0.952	Resident	27	8	110	Highly specialist	Woodland	11.5	34.5	vegetation	-	-
Meadow Pipit	*Anthus pratensis*	-1.043	0.390	Partial migrant	59	8	127	Small seed	Upland	18.5	27	ground	-	-

Mistle Thrush	*Turdus viscivorus*	-0.453	0.381	Partial migrant	66	9	97	Invertebrate	Generalist	119	31	vegetation	-	-
Nuthatch	*Sitta europaea*	4.643	0.681	Resident	26	8.75	113	Highly specialist	Woodland	23.5	41	vegetation	-	-
Pied Wagtail	*Motacilla alba*	0.650	0.515	Partial migrant	77	11	137	Invertebrate	Wetland	21	27.5	vegetation	-	-
Raven	*Corvus corax*	8.110	1.547	Resident	45	4.75	64	Generalist, carrion	Upland	1188.75	61.5	vegetation	-	-
Redstart	*Phoenicurus phoenicurus*	-0.404	0.823	Migrant	36	9.375	133	Insect	Woodland	15	30	vegetation	-0.1	33.93
Reed Bunting	*Emberiza schoeniclus*	2.508	0.530	Resident	66	7.5	132	Small seed	Wetland	20.25	26	ground	-	-
Reed Warbler	*Acrocephalus scirpaceus*	2.638	0.581	Migrant	67	6.375	161	Highly specialist	Wetland	13	24.5	vegetation	-0.39	44.6
Robin	*Erithacus rubecula*	1.620	0.464	Partial migrant	83	7.5	108	Generalist	Urban	17.25	29.5	vegetation	-	-
Sedge Warbler	*Acrocephalus schoenobaenus*	0.031	1.358	Migrant	59	5.5	143	Insect	Wetland	12	27.5	vegetation	-0.27	62.1
Skylark	*Alauda arvensis*	-0.900	0.208	Resident	77	12.75	139	Small seed	Farmland	38.25	27	ground	-	-
Song Thrush	*Turdus philomelos*	2.162	0.447	Partial migrant	92	10	111	Generalist	Urban	82.5	29	vegetation	-	-
Spotted Flycatcher	*Muscicapa striata*	-3.211	0.624	Migrant	55	7.125	157	Insect	Woodland	17	28.5	vegetation	-0.01	64.4
Starling	*Sturnus vulgaris*	-2.645	0.412	Resident	54	5.25	109	Highly specialist	Farmland	77.5	34	hole	-	-
Stonechat	*Saxicola torquata*	19.766	2.477	Partial migrant	93	11.875	115	Highly specialist	Generalist	15	29.5	ground	-	-
Swallow	*Hirundo rustica*	2.904	0.511	Migrant	83	9	156	Invertebrate	Farmland	19	39	hole	-0.2	42.34
Treecreeper	*Certhia familiaris*	0.072	0.611	Resident	54	11.5	117	Highly specialist	Woodland	9.5	31	hole	-	-
Tree Pipit	*Anthus trivialis*	-1.439	1.111	Migrant	49	6	132	Highly specialist	Woodland	23.5	26.5	vegetation	-0.23	47.07
Tree Sparrow	*Passer montanus*	4.860	1.546	Resident	84	12.5	137	Small seed	Farmland	23.25	29	hole	-	-
Wheatear	*Oenanthe oenanthe*	-1.625	0.862	Migrant	48	8.25	131	Insect	Upland	23.5	30.5	Hole	-0.17	38.17
Whinchat	*Saxicola rubetra*	-3.687	0.864	Migrant	32	5	145	Invertebrate	Upland	16.5	27.5	ground	-0.11	34.84
Whitethroat	*Sylvia communis*	1.845	0.531	Migrant	62	6.375	142	Insect	Farmland	15	25.5	vegetation	-0.14	53.05
Willow Tit	*Poecile montanus*	-5.740	0.725	Resident	32	7.5	118	Highly specialist	Woodland	11.25	32.5	vegetation	-	-
Willow Warbler	*Phylloscopus trochilus*	-1.693	0.622	Migrant	40	6	132	Insect	Woodland	9.5	28	vegetation	-0.19	68.09
Wren	*Troglodytes troglodytes*	2.159	0.832	Resident	68	12.5	122	Invertebrate	Generalist	9.5	33.5	vegetation	-	-
Yellowhammer	*Emberiza citrinella*	-3.886	0.757	Resident	81	8	149	Small seed	Farmland	30.5	28	ground	-	-
Yellow Wagtail	*Motacilla flava*	-1.211	0.212	Migrant	57	7.875	144	Invertebrate	Generalist	17.5	28	ground	-0.06	40.98

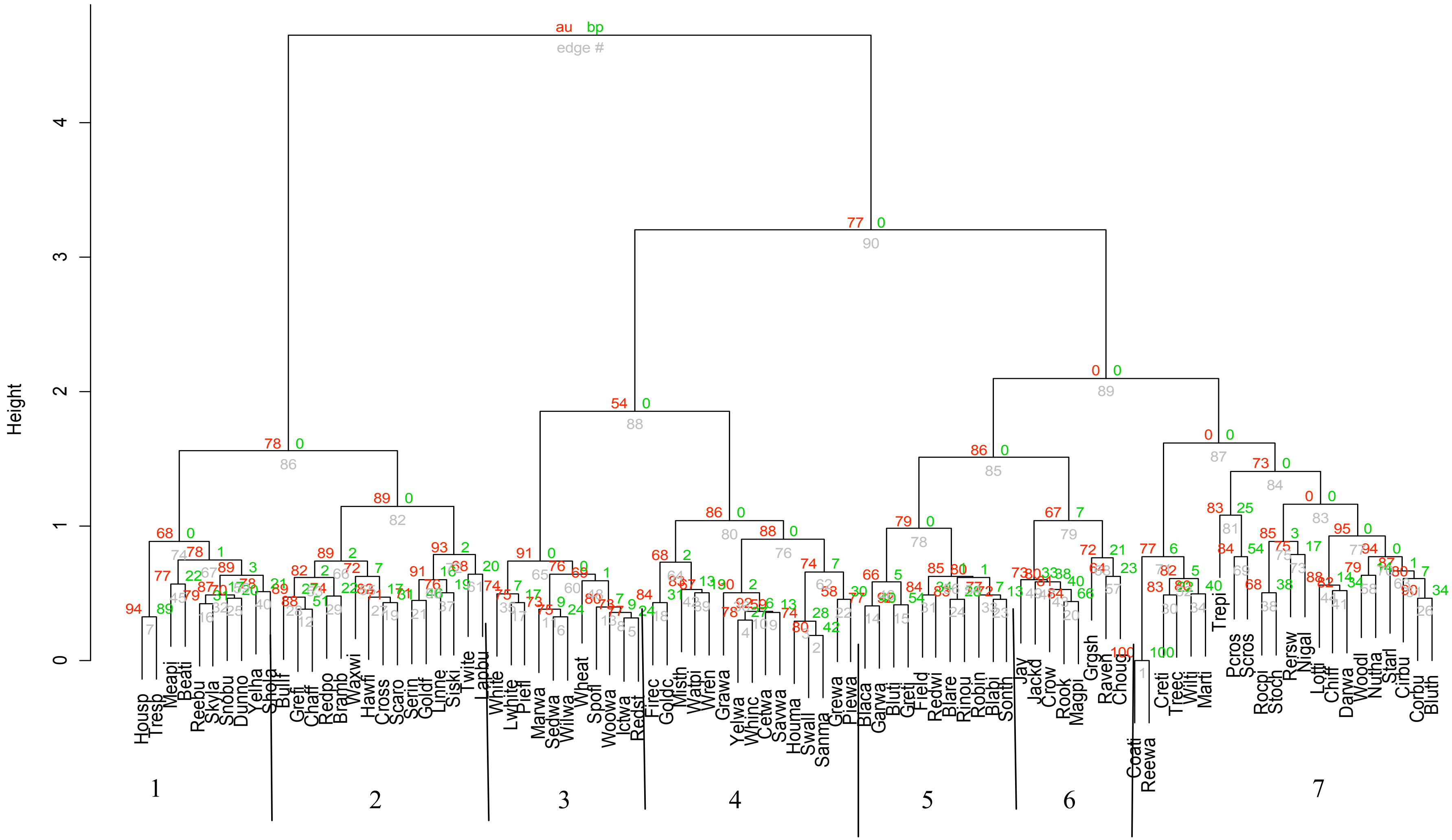
Appendix 2. Supplementary information

Multivariate analysis of diet data

Data on presence or absence of food items in the diet of each species was analysed using hierarchical cluster analysis to group species that shared similar patterns of food used (i.e. diet types) together.

The analysis was run in R using the package *pvclust* (Suzuki &Shimodaira, 2006). This package can be use to assess the uncertainty in hierarchical cluster analysis using approximately unbiased p-values (AU) as well as bootstrap probability values (BP) for each node of the selected optimum tree. In this case, the most parsimoniously tree was obtained with 50,000 bootstrap replications using *binary* as the distance measure and *ward* as the agglomerative method for the hierarchical clustering.

Figure A1. Cluster dendrogram for detailed diet data analysis. The approximate p-value (au) for each node is given in red and the boostrap probability (bp) in green. One can consider that clusters (edges) with high AU values (e.g. 95%) are strongly supported by data (Shimodaira, 2002). Figures in blue identify the 7 diet groups (DS): (1) Small seed eaters (some insects in summer); (2) Large seed eaters; (3) Insect (including spiders) eaters; (4) Invertebrate eaters; (5) generalist species; (6) generalist species also eating carrion; (7) highly specialise eater



Collinearity and univariate analysis

These tables present the Generalized Variance Inflation Factors (GVIF) (Table A2 and A3) and univariate analysis (Table A4) for the predictor pool used in the population trend analysis for UK passerine birds.

Table A1. Generalized Variance Inflation Factor (GVIF) values for the candidate predictors of population trends for all UK passerines. GVIF^(1/2df) adjusts the GVIF values for the dimensions of the confidence ellipsoids.

Predictor	**GVIF**	**Df**	**GVIF^(1/2df)**
Average body weight	5.7	1	2.4
Average nesting period	14.7	1	3.8
Average clutch size	32.0	1	5.7
Average number of broods	95.2	1	9.8
Productivity	71.2	1	8.4
Average layind date	9.4	1	3.1
Average 1st clutch laying period	2.8	1	1.7
Migration strategy	31.1	2	2.4
Nesting location	8.9	2	1.7
Diet type	1373.5	6	1.8
Habitat preference	38.1	5	1.4

Table A2. Results of correlation analysis for pairs of trait predictors suspected to hold similar biological information.

Predictor pairs	**Pearson coefficient**	**t**	**df**	**p**
Productivity, Average clutch size	0.35	2.55	48	0.014
Productivity, Number of brood per year	0.71	6.94	48	< 0.0001
Average clutch size, Number of brood per year	-0.38	-2.81	48	0.007
Average nesting period, Average body weight	0.85	11.39	48	< 0.0001
Diet type, Diet richness	0.01	2.40	48	0.02

Table A3. Results of univariate analysis of the initial pool of predictors for all passerine species in the UK (shaded rows indicate predictors selected for the relative importance analysis and subsequent final model analysis).

	Unweighted model		Weighted model	
Predictor	F	p	F*	p*
Average laying date	5.01	0.03	6.02	0.02
Average 1st clutch laying period	3.41	0.07	0.40	0.53
Diet richness	2.04	0.16	0.20	0.65
Average body weight	2.82	0.09	0.76	0.39
Productivity	0.02	0.89	3.47	0.07
Average clutch size	0.001	0.97	1.14	0.29
Number of brood per year	3.04	0.09	0.28	0.60
Average nesting period	2.45	0.12	1.44	0.23
Migratory behaviour	1.62	0.21	1.30	0.28
Diet type	0.51	0.79	2.21	0.06
Nest location	1.04	0.36	0.19	0.83
Habitat	0.93	0.47	1.34	0.26

Impact of model weighting

Models reported in the main text were weighted by the standard error of the growth rate estimates. Here we present the model performance and coefficients for the unweighted models for all species and migrant species. The unweighted models contained fewer predictors and explained less variance in population trends than weighted models particularly for all passerines. Where predictors were common between weighted and unweighted models, the magnitude of coefficients were broadly similar. In contrast to weighted models however, the unweighted model residuals were not normal, further indicating the value of the weighting procedure in accounting for the errors in estimation of species growth rates.

Table A4. Model performance and coefficients for the final unweighted model for all species.

Predictor	Coefficient (SE)	AIC_c	Adj D^2
Average laying date	-0.08(0.03)**	269.4	0.195
Average laying period	-0.07(0.02)**		

Table A6. Model performance and coefficients for the final unweighted model for migrant species.

Predictor	Coefficient (SE)	AIC_c	Adj D^2
Average laying period	0.09(0.03)	54.25	0.754
Mean change in arrival date	10.88(3.37)		
Mean distance	-0.05(0.03)		

Phylogenetic analysis

Phylogenetic comparative methods are widely used to control for the lack of statistical independence among related species (Freckleton et al., 2002). A suite of comparative tests have been developed to deal with issues of non-independence, including phylogenetic generalized least squares (PGLS) (Pagel, 1997), where the expected covariance due to relatedness between species is included as an error matrix.

Pagel (1999) suggested a method to adjust analyses for varying levels of phylogenetic dependence by weighting the covariance matrix by λ (where $\lambda=0$ indicates no covariance and $\lambda=1$ indicates high covariance). Optimal *lambda* values can be estimated using a maximum likelihood approach. Martins (1996) argued that finding evidence for phylogenetic dependence of traits (equivalent to finding $\lambda > 0$) may be used to justify the need for phylogenetic analysis.

As described in the main text, PGLMs had higher AIC_c values than GLMS and estimated values of lambda were low and not significantly different from 0 (i.e. in both cases $\lambda<0.001$ with the test against $\lambda=1$ significantly different $p<0.001$ and the test againt $\lambda=0$ non significant $p=1$). PGLM

Table A7. Comparison of model performance and characteristics between phylogenetic and non-phylogenetic models for (a) all species and (b) migrants.

(a) All species			(b) Migrants	
Model	**AIC_c**	**λ**	**AIC_c**	**λ**
Pglm.lam	332.01	0	68.32	0
Pglm.lam	334.62	1	68.32	1
Pglm.estimated	332.01	~0	68.89	~0
Non-phylo(no weights)	269.4	-	54.67	-
Non-phylo(weights)	271.5	-	53.41	-

Table A8. Comparison of predictor coefficients between phylogenetic and non-phylogenetic models for all species.

Predictor (from final model)	Coefficient (SE) GLM no weights	Coefficient (SE) GLM weights	Coefficient (SE) PGLM (λ=0)	Coefficient (SE) GLM (λ=1)	Coefficient (SE) GLM (λ=opt)
Average body weight	-	0.005(0.004)	0.006(0.005)	0.006(0.004)	0.006(0.005)
Productivity	-	0.48(0.14)***	0.61(0.24)**	0.80(0.27)**	0.61(0.24)**
Average laying date	-0.08(0.03)**	-0.07(0.03)*	-0.04(0.05)*	-0.09(0.05)*	-0.04(0.05)*
Average laying period	0.07(0.02)**	-0.001(0.02)	-0.033(0.05)	-0.001(0.05)	-0.033(0.05)
Migration strategy(partial migrant) ¨	-	-2.26(2.24)	-1.68(5.19)	-2.2(4.7)	-1.68(5.19)
Migration strategy (migrant) ¨	-	-7.57(3.56)**	-0.33(6.01)	-6.2(7.47)	-0.33(6.01)
Habitat preference(Farmland) ˙	-	-1.5(1.03)	-3.19(2.06)	-1.98(2.04)	-3.19(2.06)
Habitat preference(Woodland) ˙	-	-0.84(1.03)	-3.38(1.74)*	-2.73(1.94)	-3.38(1.74)*
Habitat preference(Wetland) ˙	-	2.67(1.45)*	-1.13(2.46)	0.63(2.66)	-1.13(2.46)
Habitat preference(Urban) ˙	-	-1.12(1.05)	-3.43(2.06)	-2.49(1.88)	-3.43(2.06)
Habitat preference(Upland) ˙	-	0.26(1.56)	-2.87(2.7)	-3.94(2.61)	-2.87(2.7)
Diet type(large seeds) ˇ	-	2.64(1.06)**	-0.39(2.25)	-0.07(3.22)	-0.39(2.25)
Diet type(insects) ˇ	-	0.35(1.73)	-0.3(2.85)	1.58(2.92)	-0.3(2.85)
Diet type(invertebrates) ˇ	-	-1.87(1.32)	-2.37(2.29)	-2.74(2.51)	-2.37(2.29)
Diet type(generalist) ˇ	-	2.64(1.41)*	1.9(2.87)	2.63(2.96)	1.9(2.87)
Diet type(generalist + carrion) ˇ	-	0.17(1.95)	2.06(3.78)	0.42(5.03)	2.06(3.78)
Diet type(highly specialist) ˇ	-	-0.65(1.34)	1.42(2.46)	1.22(2.32)	1.42(2.46)
*Average laying period*Migration strategy(partial migrant)* ¨	-	0.02(0.03)	0.05(0.07)	0.04(0.06)	0.05(0.07)
*Average laying period*Migration strategy(migrant)* ¨	-	0.18(0.06)***	0.06(0.09)	0.15(0.11)	0.06(0.09)

Table A9. Comparison of predictor coefficients between phylogenetic and non-phylogenetic for migrant species.

Predictor	Coefficients(SE)				
Predictor (from final model)	**GLM no weights**	**GLM weights**	**PGLM (λ=0)**	**PGLM (λ=1)**	**PGLM (λ=opt)**
Mean change in arrival date	10.88(2.32)**	12.05(2.32)*	11.25.(3.78)*	12.06(3.99)*	11.35(3.78)*
Average 1st clutch laying period	0.09(0.03)**	0.13(0.03)*	0.11(0.04)*	0.11(0.04)*	0.11(0.04)*
Average laying date		0.08(0.04)	0.05(0.04)	0.03(0.05)	0.05(0.04)
Mean distance	-0.05(0.03)	-	-	-	-

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