Supplementary Materials

1. **Supplementary data**

Data file used for all meta-analytic and meta-regression models.

2. **Supplementary methods**

S2.1. Heterogeneity

To assess heterogeneity we computed I^2 statistic (Higgins et al., 2003). The I^2 statistic reflects the percentage of variance that is due to study heterogeneity rather than sampling error (Higgins and Thompson, 2002). An extended version of I^2 for multilevel meta-analytic models represents variation due to the random effects (e.g., species, study effect sizes) other than sampling effects (Senior et al., 2016). Higgins et al. 2003 suggested benchmarking I^2 values of 25%, 50%, and 75%, as low, moderate, and high heterogeneity, respectively. Moderate to high levels of heterogeneity warrant exploration of potential sources of heterogeneity via meta-regression (meta-analysis with moderators).

S2.2. Publication bias

We assessed the existence of publication bias in three ways. First, we visually assessed funnel plot asymmetry. In a funnel plot, the estimate of effect size in each study is plotted against an estimate of its precision (the inverse of standard error or the square-root of sampling error variance). If studies with low precision that have non-significant results are missing from the data set due to publication bias, the shape of the funnel will be asymmetric. Second, we analysed funnel plot asymmetry using Egger's regression test (Egger et al., 1997) using the *regtest* function in the *metafor* package (Viechtbauer, 2010). Egger's test indicates publication bias when an intercept of standardized residuals regressed on precision is significantly different from zero. Finally, we used trim-and-fill method to identify funnel plot asymmetry arising from publication bias. This method estimates the number of studies potentially absent from a meta-analytic dataset due to the publication bias affecting the most extreme results on one side of the funnel plot.

3. Supplementary Discussion

S3.1. Sensitivity analyses.

In the sensitivity analyses where we used the authors' scoring, the difference in survival rates of natural nests between urban and non-urban habitats was smaller when failures other than predation were included in the calculation of effect sizes than when effect sizes were calculated from predation only (Table S11). These results indicate that nest failures other than predation might be more common in urban than in rural habitats, leveling out the lower nest predation rate and resulting in a more similar overall nest failure rates in urban and rural habitats. For example, mortality due to vandalism from humans is more likely to happen in urban habitats where humans are more abundant. Higher human disturbance may also increase the chance of nest abandonment compared to habitats with lower human disturbance (Carney and Sydeman, 1999). Urban areas are also characterized by higher chemical pollution (e.g., Mayer, 1999; Wei and Yang, 2010), which can accumulate in birds (Hofer et al., 2010), and ultimately result in increased mortality of chicks (Fry, 1995). Finally, starvation due to lower quantity or quality of food can also lead to increased chick mortality in cities (Seress and Liker, 2015).

The sensitivity analyses on natural nests also revealed that cavity nests are predated significantly less in urban than in rural habitats, while open nests (both cup- and orb-shaped) show no such habitat difference. One possible biological explanation for this is the change in the composition of predator species (Rodewald and Kearns, 2011). Specialized nest predators that efficiently prey on cavity nests, such as snakes, are less abundant in cities (Patten and Bolger, 2003). Meanwhile, opportunistic nest predators that are common in cities (such as cats, crows or raccoons) are likely to chance upon open nests but unlikely to find cavity nests.

4. Supplementary Figures

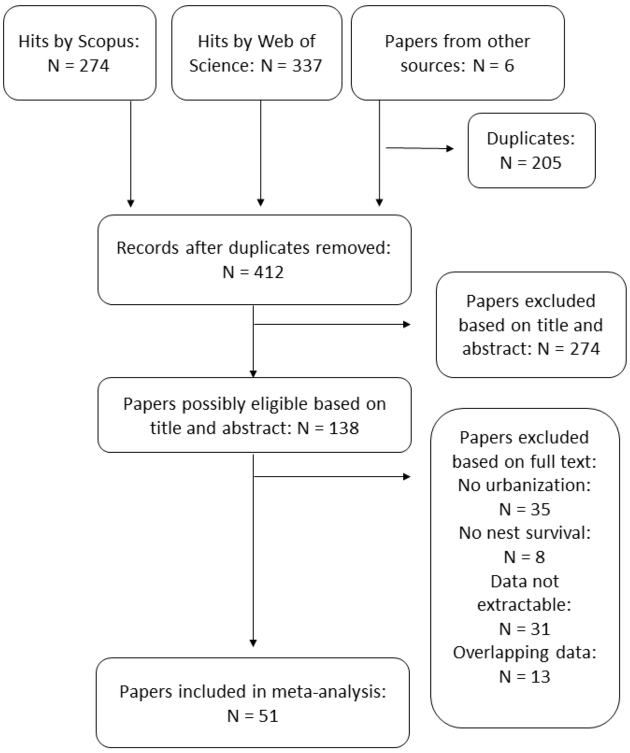

Figure S1

PRISMA diagram showing study search and selection process.

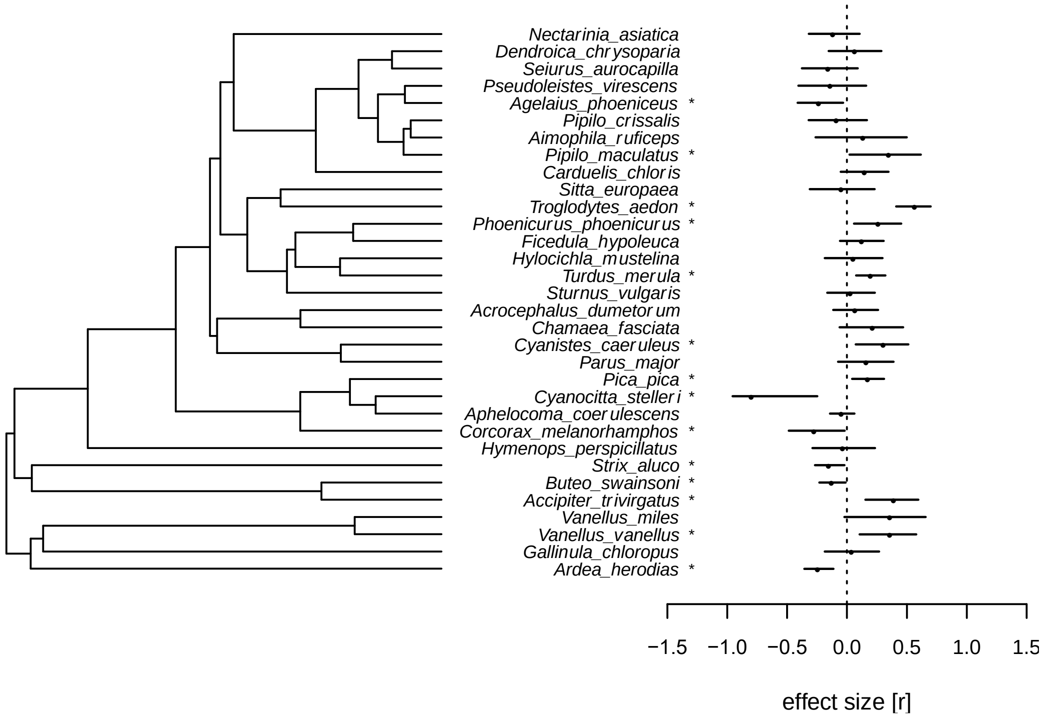

Figure S2

Phylogenetic tree of bird species represented in the studies on natural nests, on the left. Forest plot on the right shows results of analyses performed using species as a moderator in a meta-regression model on this data subset. Points represent mean estimates from the models, lines represent 95% Confidence Intervals. Stars indicate estimates that are significantly different from zero (95% Confidence Intervals not crossing zero).

5. Supplementary Tables

Table S1. Contingency table of papers initially considered by the two independent observers as potentially meeting (YES) or certainly not meeting (NO) the criteria for inclusion based on paper title and abstract. “Single-screened” papers were assessed only by one of the search engines and thus screened only by one of the observers (201 out of 406 papers).

Inclusion decision	Observer 1 - YES	Observer 1 - NO	Single-screened
Observer 2 - YES	56	31	29
Observer 2 - NO	6	112	40
Single-screened	12	120	-

Table S2. Contingency table of urbanization scores given by the two observers (columns: EV, rows: GS) for each site in each study. Between-observer repeatability *r* = 0.982 (Spearman rank correlation).

Score	**1**	**2**	**3**	**4**	**5**
1	39	0	0	0	0
2	2	30	0	0	0
3	0	2	29	4	0
4	0	0	1	34	1
5	0	0	0	2	17

Table S3. Papers excluded from meta-analysis based on full-text screening, grouped by reason for exclusion. N: Number of papers excluded for each particular reason.

Reason for exclusion	**N**	**References**
No gradient defined for urbanization (all sites on the same urbanization level)	31	Balogh et al., 2011; Baudains and Lloyd, 2007; Becker and Weisberg, 2015; Bonnington et al., 2013, 2015; Cox et al., 2013; DeGregorio et al., 2014; Eguchi and Takeishi, 1997; Engel et al., 1988; Francis et al., 2009; Górski and Antczak, 1999; Grégoire et al., 2003; Groom, 1993; Guerena et al., 2014; Guerrieri and Santucci, 1996; Jedraszko-Dabrowska, 1990; Kurucz et al., 2010, 2012, 2015; Langston et al., 2007; Major et al., 1996; Meckstroth and Miles, 2005; Møller, 2010; Morgan et al., 2011; ÓhUallacháin, 2014; Pescador and Peris, 2007; Rees et al., 2014; Robertson, 1990; Spohr et al., 2004; Stirnemann et al., 2015; Wong et al., 1998
Gradient only for non-urban (rural) anthropogenic disturbance	4	Borges and Marini, 2009; Marzluff and Neatherlin, 2006; Mezquida et al., 2004; Vierling, 2000
Nest survival not investigated (presence/absence of species, adult survival or individual offspring survival)	8	Arrowood et al., 2001; Bonnington et al., 2014; Brown and Graham, 2015; Chang and Lee, 2015; Chiron and Julliard, 2007; Cordero and Rodriguez-Teijeiro, 1990; Hedblom and Söderström, 2011; Long and Long, 1992
Nest survival – urbanization relationship not tested	6	Hadad et al., 2015; Marzluff et al., 2007; Miller et al., 2015; Sedláček and Fuchs, 2008; Sethi et al., 2011; Stout et al., 2007
Only daily nest survival reported (cannot be converted to overall survival rates)	7	Donnelly and Marzluff, 2004; Hušek et al., 2010; Morrison and Bolger, 2002; Phillips et al., 2005; Rodewald et al., 2013; Stracey, 2011; Stracey and Robinson, 2012b
Only multivariate models reported	18	Ali Chokri and Selmi, 2011; Blair, 2004; Burhans and Thompson, 2006; Buxton and Benson, 2015; Cervantes-Cornihs et al., 2009; Friesen et al., 2013; Haskell et al., 2001; Meffert et al., 2012; Mikula et al., 2014; Patterson et al., 2016; Reidy et al., 2009; Rivera-López and Macgregor-Fors, 2016; Schlossberg et al., 2011; Shipley et al., 2013; Stracey and Robinson, 2012a; Sumasgutner et al., 2014; Suvorov and Šálek, 2013; Tarvin and Smith, 1995
Data overlapping with another study	13	Bakermans and Rodewald, 2006; Borgmann and Rodewald, 2004; Leston and Rodewald, 2006; Piper and Catterall, 2006; Rodewald et al., 2015, 2011a, 2011b, 2014; Rodewald and Kearns, 2011; Rodewald and Shustack, 2008a, 2008b, Shustack and Rodewald, 2010, 2011

Table S4. Comparison of the characteristics of the artificial nests data subset and natural nests data subset.

	Artificial nests Median (Mean ± SD) [Frequencies for factors]	**Natural nests** Median (Mean ± SD)	**Difference artificial-natural nests**
Min urbanization score	1 (1.4 ±0.8)	2 (1.6 ±0.5)	*t* = -2.54, *df* = 115, *p* = 0.012
(1 / 2 / 3 / 4)	(49 /6 / 2 / 2)	(28 / 27 / 2/ 1)	χ^2= 19.42, *df* = 3, *p* < 0.001
Max urbanization score	3 (3.8 ±0.9)	4 (3.8 ±0.4)	*t* = -2.96, *df* = 115, *p* = 0.004
(3 / 4 / 5)	(42/ 4 / 13)	(16 / 30 / 12)	χ^2= 31.57, *df* = 2, p < 0.001
Predation as only source of mortality (yes / no)	[59 / 0]	[20 / 38]	χ^2= 54.30, *df* = 1, *p* < 0.001
Predation scoring (partial / complete / 1 egg)	[50 / 0 / 9]	[2 / 56 / 0]	χ^2= 109.31, *df* = 2, *p* < 0.001
Nest openness (cup / hole / orb)	[53 / 6 / 0]	[36 / 20 / 2]	χ^2= 12.78, *df* = 2, *p* = 0.002
Nest position (elevated / ground / mix)	[26 / 28 / 5]	[51 / 6 / 1]	χ^2 = 25.01, *df* = 2, *p* < 0.001
Nest height above ground [m]	0 (0.8 ±1.0)	2.8 (2.2 ±2.2)	*t* = -4.94, *df* = 84, *p* < 0.001
Egg number	2 (2.2 ±1.0)	3.8 (4.2 ±1.2)	*t* = -5.79, *df* = 98, *p* < 0.001
Number of nests	105 (200.4 ± 231.3)	87 (207.6 ±258.3)	*t* = -0.02, *df* = 113, *p* = 0.987
Study duration [days]	12 (12.2 ±5.9)	28 (41.2 ±21.1)	*t* = -7.72, *df* = 64, *p* < 0.001

Median study year	1997 (1997.8 ±5.8)	2004 (2000.5 ±15.0)	t = -2.26, df = 115, p = 0.025
Publication year	2002 (2002.2 ±4.9)	2008 (2007.8 ±7.8)	t = -4.78, df = 115, p < 0.001
Number of ES	59	58	
Number of species	0	32	

Table S5

Parameter estimates for the meta-analytic and meta-regression models run on full data set. Effect size presented is *r*. *M* – mean estimate, CI.lb – lower bound for the 95% Confidence Interval, CI.ub – upper bound for the 95% Confidence Interval, I^2_{total} – total heterogeneity. Effect size used is *Zr*. Stars indicate point estimates that are significantly different from zero (95% Confidence Intervals not crossing zero).

Model	*M*	CI.lb	CI.ub	I^2_{total}
Meta-analytic mean – all data	-0.003	-0.080	0.074	92.7%
Artificial vs. Natural nests:				
Artificial nests *	-0.116	-0.224	-0.005	
Natural nests	0.081	-0.015	0.176	
Difference: Artificial - Natural nests *	0.195	0.050	0.332	

Table S6

Parameter estimates for the meta-regression models for data from the artificial nests data subset. Effect size presented is *r*. *M* – mean estimate, CI.lb – lower bound for the 95% Confidence Interval, CI.ub – upper bound for the 95% Confidence Interval, I^2_{total} – total heterogeneity. Stars indicate point estimates that are significantly different from zero (95% Confidence Intervals not crossing zero).

Model	*M*	CI.lb	CI.ub	I^2_{total}
Meta-analytic mean – artificial nests	-0.118	-0.238	0.006	93.1%
Nest openness:				
Cup	-0.119	-0.239	0.004	
Hole	-0.036	-0.214	0.144	
Nest position:				
Elevated	-0.087	-0.221	0.050	
Ground	-0.130	-0.258	0.003	
Mix	-0.157	-0.333	0.028	
Egg number (slope)	-0.006	-0.131	0.119	
Study duration [days] (slope)	-0.073	-0.202	0.059	
Median study year (slope)	-0.041	-0.141	0.060	
Publication year (slope)	-0.016	-0.120	0.088	
Min urbanization score:				
1	-0.115	-0.273	0.049	
2	-0.176	-0.435	0.110	
3	-0.071	-0.477	0.359	
4	0.190	-0.143	0.485	
Max urbanization score:				

3	-0.103	-0.259	0.058
4 *	-0.312	-0.557	-0.017
5	-0.014	-0.262	0.236

Table S7

Parameter estimates for the phylogenetic meta-regression models for data from the natural nests data subset. Effect size presented is *r*. *M* – mean estimate, CI.lb – lower bound for the 95% Confidence Interval, CI.ub – upper bound for the 95% Confidence Interval, I^2_{total} – total heterogeneity. Stars indicate point estimates that are significantly different from zero (95% Confidence Intervals not crossing zero). Univariate meta-regressions control for shared evolutionary history of the species (i.e. phylogenetic meta-regression was used).

Model	*M*	CI.lb	CI.ub	I^2_{total}
Meta-analytic mean	0.079	-0.007	0.165	90.0%
Phylogenetic meta-analytic mean	0.034	-0.163	0.228	91.5%
Phylogeny				78.5%
Predation as only source of mortality:				
No	-0.020	-0.192	0.153	
Yes	0.107	-0.067	0.276	
Nest openness:				
Cup	0.019	-0.169	0.205	
Hole	0.131	-0.118	0.364	
Orb	-0.162	-0.462	0.172	
Nest position:				
Elevated	0.001	-0.202	0.204	
Ground	0.147	-0.114	0.389	
Mix	-0.041	-0.472	0.405	
Nest height above ground [m] (slope)	-0.091	-0.197	0.018	
Egg number (slope)	0.043	-0.046	0.131	

Study duration [days] (slope)	0.037	-0.190	0.260
Median study year (slope)	0.041	-0.014	0.096
Publication year (slope)	0.027	-0.040	0.094
Min urbanization score:			
1	0.056	-0.194	0.299
2	0.029	-0.192	0.247
3	-0.105	-0.467	0.286
4	0.181	-0.283	0.577
Max urbanization score:			
3	0.088	-0.141	0.307
4	-0.016	-0.246	0.215
5	0.005	-0.231	0.240

Table S8

Parameter estimates for the meta-regression model for the natural nests data subset with species identity used as a predictor. Effect size presented is *r*. *M* – mean estimate, CI.lb – lower bound for the 95% Confidence Interval, CI.ub – upper bound for the 95% Confidence Interval. Stars indicate point estimates that are significantly different from zero (95% Confidence Intervals not crossing zero).

Model	*M*	CI.lb	CI.ub
Species:			
Accipiter trivirgatus *	0.397	0.154	0.596
Acrocephalus dumetorum	0.074	-0.115	0.259
Agelaius phoeniceus	-0.231	-0.413	-0.033
Aimophila ruficeps	0.139	-0.263	0.499
Aphelocoma coerulescens	-0.041	-0.143	0.062
Ardea herodias *	-0.238	-0.356	-0.113
Buteo swainsoni *	-0.123	-0.231	-0.012
Carduelis chloris	0.153	-0.052	0.346
Chamaea fasciata	0.220	-0.061	0.469
Corcorax melanorhamphos *	-0.269	-0.486	-0.020
Cyanistes caeruleus *	0.310	0.074	0.512
Cyanocitta stelleri *	-0.791	-0.956	-0.249
Dendroica chrysoparia	0.070	-0.154	0.287
Ficedula hypoleuca	0.128	-0.059	0.306
Gallinula chloropus	0.044	-0.185	0.268
Hylocichla mustelina	0.059	-0.186	0.297
Hymenops perspicillatus	-0.029	-0.288	0.234
Nectarinia asiatica	-0.112	-0.319	0.106
Parus major	0.167	-0.074	0.389

Phoenicurus phoenicurus *	0.267	0.058	0.452
Pica pica *	0.179	0.042	0.310
Pipilo crissalis	-0.082	-0.321	0.167
Pipilo maculatus *	0.355	0.022	0.617
Pseudoleistes virescens	-0.134	-0.406	0.160
Seiurus aurocapilla	-0.152	-0.376	0.089
Sitta europaea	-0.043	-0.311	0.231
Strix aluco *	-0.147	-0.268	-0.022
Sturnus vulgaris	0.035	-0.165	0.233
Troglodytes aedon *	0.572	0.411	0.699
Turdus merula *	0.202	0.076	0.321
Vanellus miles	0.365	-0.021	0.656
Vanellus vanellus *	0.365	0.106	0.577

Table S9

Sensitivity analysis using alternative urbanization scores for the study sites: Parameter estimates for the meta-analytic and meta-regression models run on full data set. Effect size presented is *r*. *M* – mean estimate, CI.lb – lower bound for the 95% Confidence Interval, CI.ub – upper bound for the 95% Confidence Interval, I^2_{total} – total heterogeneity. Effect size used is *Zr*. Stars indicate point estimates that are significantly different from zero (95% Confidence Intervals not crossing zero).

Model	*M*	CI.lb	CI.ub	I^2_{total}
Meta-analytic mean – all data	-0.007	-0.085	0.071	92.8%
Artificial vs. Natural nests:				
Artificial nests *	-0.123	-0.232	-0.012	
Natural nests	0.080	-0.017	0.175	
Difference: Artificial - Natural nests *	0.201	0.056	0.338	

Table S10

Sensitivity analysis using alternative urbanization scores for the study sites: Parameter estimates for the meta-regression models for data from the artificial nests data subset. Effect size presented is *r*. *M* – mean estimate, CI.lb – lower bound for the 95% Confidence Interval, CI.ub – upper bound for the 95% Confidence Interval, I^2_{total} – total heterogeneity. Stars indicate point estimates that are significantly different from zero (95% Confidence Intervals not crossing zero).

Model	*M*	CI.lb	CI.ub	I^2_{total}
Meta-analytic mean – artificial nests	-0.125	-0.245	-0.002	92.4%
Nest openness:				
Cup	-0.126	-0.246	-0.003	
Hole	-0.046	-0.218	0.129	
Nest position:				
Elevated	-0.096	-0.228	0.040	
Ground	-0.137	-0.263	-0.005	
Mix	-0.161	-0.328	0.016	
Egg number (slope)	0.001	-0.124	0.126	
Study duration [days] (slope)	-0.079	-0.207	0.051	
Median study year (slope)	-0.042	-0.142	0.058	
Publication year (slope)	-0.017	-0.121	0.087	
Min urbanization score:				
1	-0.123	-0.281	0.041	
2	-0.172	-0.431	0.115	
3	-0.095	-0.495	0.337	
4	0.187	-0.137	0.476	

Max urbanization score:			
3	-0.103	-0.259	0.059
4	-0.324	-0.566	-0.031
5	-0.034	-0.282	0.217

Table S11

Sensitivity analysis using alternative urbanization scores for the study sites: Parameter estimates for the phylogenetic meta-regression models for data from the natural nests data subset. Effect size presented is *r*. *M* – mean estimate, CI.lb – lower bound for the 95% Confidence Interval, CI.ub – upper bound for the 95% Confidence Interval, I^2_{total} – total heterogeneity. Stars indicate point estimates that are significantly different from zero (95% Confidence Intervals not crossing zero). Notably, two moderators that were close to statistical significance in our original meta-regression models (source of mortality and nest openness) became statistically different from zero in the new models. For the interpretation of these results, see Supplementary Discussion (S3.1).

Model	*M*	CI.lb	CI.ub	I^2_{total}
Meta-analytic mean	0.079	-0.008	0.165	90.0%
Phylogenetic meta-analytic mean	0.045	-0.126	0.212	91.5%
Phylogeny				
Predation as only source of mortality:				
No	-0.016	-0.134	0.101	
Yes *	0.160	0.050	0.266	
Nest openness:				
Cup	0.059	-0.041	0.158	
Hole *	0.219	0.032	0.391	
Orb	-0.132	-0.431	0.195	
Nest position:				
Elevated	0.063	-0.034	0.158	
Ground	0.182	-0.019	0.368	
Mix	0.074	-0.379	0.499	

Nest height above ground [m] (slope)	-0.134	-0.261	-0.002
Egg number (slope)	0.043	-0.046	0.131
Study duration [days] (slope)	0.041	-0.182	0.261
Median study year (slope)	0.060	-0.013	0.133
Publication year (slope)	0.033	-0.047	0.112
Min urbanization score:			
1	0.026	-0.192	0.242
2	0.065	-0.117	0.243
3	-0.088	-0.434	0.280
4	0.127	-0.333	0.538
Max urbanization score:			
3	0.146	-0.025	0.308
4	0.058	-0.081	0.195
5	0.048	-0.116	0.208

Table S12

Sensitivity analysis using alternative urbanization scores for the study sites: Parameter estimates for the meta-regression model for the natural nests data subset with species identity used as a predictor. Effect size presented is *r*. *M* – mean estimate, CI.lb – lower bound for the 95% Confidence Interval, CI.ub – upper bound for the 95% Confidence Interval. Stars indicate point estimates that are significantly different from zero (95% Confidence Intervals not crossing zero).

Model	M	CI.lb	CI.ub
Species:			
Accipiter trivirgatus *	0.397	0.152	0.597
Acrocephalus dumetorum	0.074	-0.118	0.262
Agelaius phoeniceus	-0.203	-0.390	0.000
Aimophila ruficeps	0.201	-0.204	0.547
Aphelocoma coerulescens	-0.050	-0.153	0.054
Ardea herodias *	-0.238	-0.358	-0.110
Buteo swainsoni *	-0.123	-0.232	-0.011
Carduelis chloris	0.144	-0.064	0.340
Chamaea fasciata	0.121	-0.164	0.388
Corcorax melanorhamphos *	-0.269	-0.488	-0.018
Cyanistes caeruleus *	0.310	0.073	0.513
Cyanocitta stelleri *	-0.791	-0.956	-0.248
Dendroica chrysoparia	0.070	-0.156	0.290
Ficedula hypoleuca	0.128	-0.062	0.309
Gallinula chloropus	0.044	-0.188	0.270
Hylocichla mustelina	-0.009	-0.253	0.236
Hymenops perspicillatus	-0.029	-0.29	0.236
Nectarinia asiatica	-0.112	-0.322	0.109
Parus major	0.167	-0.076	0.391

Phoenicurus phoenicurus *	0.267	0.056	0.455
Pica pica *	0.179	0.040	0.311
Pipilo crissalis	0.135	-0.116	0.370
Pipilo maculatus *	0.357	0.023	0.619
Pseudoleistes virescens	-0.134	-0.407	0.162
Seiurus aurocapilla	-0.152	-0.379	0.091
Sitta europaea	-0.107	-0.370	0.172
Strix aluco *	-0.148	-0.269	-0.022
Sturnus vulgaris	0.035	-0.168	0.236
Troglodytes aedon *	0.572	0.410	0.700
Turdus merula *	0.201	0.074	0.322
Vanellus miles	0.365	-0.022	0.657
Vanellus vanellus *	0.365	0.104	0.578

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