Gábor Seress, Tamás Hammer, Veronika Bókony, Ernő Vincze, Bálint Preiszner, Ivett Pipoly, Csenge Sinkovics, Karl L. Evans, and András Liker. 2018. Impact of urbanization on abundance and phenology of caterpillars and consequences for breeding in an insectivorous bird. *Ecological Applications*

APPENDIX S1

Table S1. Overview of the methodology and main findings of published studies that compared the abundance and/or phenology of arboreal caterpillars between urban (U) and forest (F) habitats. Note that all of these studies investigated avian reproduction but not leaf emergence.

Study	Study sites	Study year(s)	Sampling method	Sampling intensity	Caterpillar abundance	Caterpillar phenology
Solonen 2001	4 urban parks, 1 forest	1992	frassfall traps: 50 (number of traps per study site not given)	weekly for 6 weeks	- varied greatly between sites; - no difference between U and F	Fig 2 shows seasonal changes, but habitat difference not analysed
Isaksson and Andersson 2007	2 urban, 3 forest sites	2005	1-h long active search for caterpillars per study site	2 times in May	U > F	not reported
Marciniak et al. 2007	1 parkland, 1 woodland	2003-2005	frassfall traps: 14 (5 in parkland, 9 in woodland)	every 5 days for 6 weeks	U < F	- Fig 2 shows seasonal changes, but habitat difference not analysed; - no consistent habitat difference in dates of peak caterpillar abundance (see also Wawrzyniak et al. 2015 for a longer-term analyses incorporating these data)

Wawrzyniak et al. 2015	1 parkland, 1 woodland	2003-2012	frassfall traps: 14 (5 in parkland, 9 in woodland)	every 5 days (length of study period not given)	not reported	- seasonal changes not reported; - no consistent habitat difference in dates of peak caterpillar abundance
Glądalski et al. 2015	1 parkland, 1 woodland	2003-2012	frassfall traps: 14 (5 in parkland, 9 in woodland)	every 5 days (length of study period not given)	U < F	not reported
Pollock et al. 2017	1 parkland, 1 forest	2015	tree beating (5 trees per site)	twice per week (ca. 7 weeks)	U < F	not reported
Seress et al. (this study)	2 urban, 2 forest sites	2013-2016	frassfall traps: 58-60 (36 in urban, 22-24 in forest)	every 3-4 days for ca. 14 weeks	U < F	- multiple small peaks in U, a single large peak in F; - no consistent habitat difference in dates of peak caterpillar abundance

Table S2. Frass sampling intensity at each study site in the four study years. Note that the number of sampled tree species and individuals changed somewhat after the first study year (2013) as in Vilma-puszta (forest), starting from 2014, we included 6 individuals of flowering ash *Fraxinus ornus* and excluded 4 individuals of downy oak *Quercus cerris* from the sampled trees because a second census of trees conducted after the 2013 field work indicated a higher relative frequency of flowering ash than estimated by the first survey. Sampled trees remained the same in 2014, 2015 and 2016; we provided the range of the yearly number of frass samples for the 2014-2016 period.

Year/Site	Sampled tree species	Number of sampled trees	Number of frass samples collected
2013			
Veszprém (urban)	Silver lime (*Tilia argentea*)	6	122
	Norway maple (*Acer platanoides*)	6	125
	Horse-chestnut (*Aesculus hippocastanum*)	6	125
Balatonfüred (urban)	Small-leaved lime (*Tilia cordata*)	6	124
	Norway maple (*Acer platanoides*)	6	133
	Sessile oak (*Quercus petraea*)	6	122
Szentgál (forest)	Common hornbeam (*Carpinus betulus*)	6	113
	Common beech (*Fagus sylvatica*)	6	116
Vilma-puszta (forest)	Downy oak (*Quercus pubescens*)	10	105
2014-2016			
Veszprém (urban)	Silver lime (*Tilia argentea*)	6	117-137
	Norway maple (*Acer platanoides*)	6	137-148
	Horse-chestnut (*Aesculus hippocastanum*)	6	130-144
Balatonfüred (urban)	Small-leaved lime (*Tilia cordata*)	6	124-143
	Norway maple (*Acer platanoides*)	6	141-161
	Sessile oak (*Quercus petraea*)	6	118-143

Szentgál (forest)	Common hornbeam (*Carpinus betulus*)	6	106-142
	Common beech (*Fagus sylvatica*)	6	107-117
Vilma-puszta (forest)	Downy oak (*Quercus pubescens*)	6	77-117
	South European flowering ash (*Fraxinus ornus*)	6	80-119

Table S3. Sample sizes (number of nests), and mean ± SE values of great tits' breeding phenology and breeding success in urban and forest sites in the four study years. Only first breeding attempts were included for each pair in each year. Laying dates are given as number of days since 1st of January. Fledgling number and fledgling body mass were recorded at ringing on day 14-16 post-hatch.

Study sites and years	Veszprém (urban)	Balatonfüred (urban)	Szentgál (forest)	Vilma-puszta (forest)
2013				
number of nests	29	7	20	7
first egg date	106.3 ± 0.66	106 ± 1.3	112.2 ± 0.53	111.1 ± 0.77
clutch size	8.97 ± 0.26	8.57 ± 0.43	11.9 ± 0.29	11.86 ± 0.59
fledgling number	7.22 ± 0.42	6 ± 0.87	11.5 ± 0.27	10.43 ± 0.64
fledgling body mass (g)	14.5 ± 0.17	15.7 ± 0.35	18.1 ± 0.08	17.6 ± 0.14
2014				
number of nests	34	17	45	24
laying date (1st egg)	83.3 ± 0.79	85.7 ± 2.05	84.8 ± 0.54	88.7 ± 0.53
clutch size	11.06 ± 0.3	11.21 ± 0.3	12.24 ± 0.19	11.96 ± 0.27
fledgling number	9.07 ± 0.45	9.79 ± 0.35	10.83 ± 0.36	10.46 ± 0.55
fledgling body mass (g)	16.2 ± 0.11	16.7 ± 0.14	17.4 ±0.05	18.0 ± 0.05
2015				
number of nests	42	20	39	21
laying date (1st egg)	102.1 ± 0.88	101.6 ± 1.41	110.2 ± 1.41	105.3 ± 0.57
clutch size	8 ± 0.26	8.85 ± 0.17	11.58 ± 0.25	10.95 ± 0.32
fledgling number	6.09 ± 0.39	6.11 ± 0.84	10.06 ± 0.52	10.11 ± 0.39
fledgling body mass (g)	14.9 ± 0.14	14.8 ± 0.20	17.5 ± 0.06	17.6 ± 0.09
2016				
number of nests	44	19	30	19
laying date (1st egg)	94.93 ± 0.72	92 ± 1.07	101.4 ± 0.7	100.3 ± 0.6
clutch size	7.98 ± 0.26	9.32 ± 0.36	11.23 ± 0.32	11.5 ± 0.24
fledgling number	5.36 ± 0.42	5.71 ± 0.66	9.56 ± 0.59	10.31 ± 0.73
fledgling body mass (g)	14.6 ± 0.14	13.9 ± 0.21	17.9 ± 0.05	17.6 ± 0.07

Table S4. Relationship between fledglings' body mass (measured at ringing on day 14-16 post-hatch) and starvation-related mortality before (a) and after (b) chick-ringing. (a) Differences in fledglings' mean body mass between broods with and without nestling mortality due to starvation; (b) differences in body mass between chicks that successfully left the nest and chicks that died in the nest (after ringing but before fledging). Results are from linear mixed models. Statistically significant ($P < 0.05$) differences are highlighted in boldface type.

Model parameters	b ± SE	t	p
(a) Mean body mass (broods)[1]			
Intercept	14.96 ± 2.17	6.89	0.666
Habitat (forest – urban)	2.25 ± 0.18	12.47	**0.006**
Laying date	-0.12 ± 0.01	-1.18	0.237
Fledglings' age	0.15 ± 0.09	1.63	0.104
Year (2014)[2]	0.19 ± 0.41	0.45	0.650
Year (2015)[2]	-0.17 ± 0.22	-0.78	0.437
Year (2016)[2]	-0.28 ± 0.29	-0.99	0.320
Pre-ringing mortality (occurred – did not occur)	-1.12 ± 0.19	-6.01	**<0.001**
(b) Body mass of chicks[3]			
Intercept	15.15 ± 1.39	10.86	<0.001
Habitat (forest – urban)	2.37 ± 0.15	15.81	**0.004**
Laying date	0.00 ± 0.01	0.11	0.909
Year (2014)[4]	0.44 ± 0.33	1.35	0.179
Year (2015)[4]	-0.21 ± 0.22	-0.97	0.335
Year (2016)[4]	-0.32 ± 0.25	-1.35	0.179
Post-ringing mortality (died in the nest – fledged)	-2.46 ± 0.15	-16.71	**<0.001**

[1] Number of broods: 360 (total), 171 (urban), 189 (forest); 96 (with mortality), 264 (no mortality)

[2] Year compared to 2013; overall year effect: ANOVA $F_{3,336} = 1.653$, $P = 0.177$

[3] Number of chicks: 3318 (total), 1287 (urban), 2031 (forest); 87 (died), 3231 (fledged)

[4] Year compared to 2013; overall year effect: ANOVA $F_{3,362} = 5.171$, $P = 0.002$

Table S5. The best linear mixed models fitted for seasonal changes of caterpillar biomass (log_{10}[mg/h]) in each year and study site. The quadratic and cubic terms of sampling date are indicated by $date^2$ and $date^3$, respectively.

Year/Site		b ± SE	DF	t	*P*
2013					
Veszprém	intercept	-3.01 ± 2.02	351	-1.48	0.139
	date	0.06 ± 0.03	351	2.16	0.032
	$date^2$	-0.00 ± 0.00	351	-2.74	0.007
Balatonfüred	intercept	-92.37 ± 19.90	358	-4.64	<0.001
	date	1.95 ± 0.41	358	4.78	<0.001
	$date^2$	-0.01 ± 0.00	358	-4.85	<0.001
	$date^3$	0.00 ± 0.00	358	4.87	<0.001
Szentgál	intercept	8.48 ± 1.72	215	4.93	<0.001
	date	-0.07 ± 0.02	215	-3.12	0.002
	$date^2$	0.00 ± 0.00	215	2.04	0.042
Vilma-puszta	intercept	39.86 ± 11.54	94	3.46	<0.001
	date	-0.51 ± 0.16	94	-3.18	0.002
	$date^2$	0.00 ± 0.00	215	3.01	0.003
2014					
Veszprém	intercept	-0.89 ± 0.62	364	-1.43	0.153
	date	0.02 ± 0.00	364	2.32	0.021
	$date^2$	-0.00 ± 0.00	364	-2.72	0.006
Balatonfüred	intercept	-24.04 ± 2.67	371	-9.01	<0.001
	date	0.57 ± 0.06	371	9.09	<0.001
	$date^2$	-0.00 ± 0.00	371	-8.91	<0.001
	$date^3$	0.00 ± 0.00	371	8.63	<0.001
Szentgál	intercept	-57.95 ± 4.03	244	-14.36	<0.001
	date	1.34 ± 0.09	244	14.40	<0.001
	$date^2$	-0.00 ± 0.00	244	-14.00	<0.001
	$date^3$	0.00 ± 0.00	244	13.41	<0.001
Vilma-puszta	intercept	-71.10 ± 6.96	221	-10.22	<0.001
	date	1.54 ± 0.15	221	10.21	<0.001
	$date^2$	-0.01 ± 0.00	221	-9.93	<0.001
	$date^3$	0.00 ± 0.00	221	9.49	<0.001
2015					
Veszprém	intercept	-19.68 ± 5.56	408	-3.54	0.001
	date	0.39 ± 0.11	408	3.44	0.001
	$date^2$	-0.00 ± 0.00	408	-3.22	0.001
	$date^3$	0.00 ± 0.00	408	2.89	0.004
Balatonfüred	intercept	-29.07 ± 3.69	426	-7.88	<0.001
	date	0.61 ± 0.07	426	-7.89	<0.001
	$date^2$	-0.00 ± 0.00	426	-7.63	<0.001
	$date^3$	0.00 ± 0.00	426	7.26	<0.001

Szentgál	intercept	-115.84 ± 8.26	198	-14.02	<0.001
	date	2.41 ± 0.17	198	14.14	<0.001
	$date^2$	-0.01 ± 0.00	198	-14.01	<0.001
	$date^3$	0.00 ± 0.00	198	13.78	<0.001
Vilma-puszta	intercept	-294.01 ± 19.78	142	-14.86	<0.001
	date	6.03 ± 0.41	142	14.71	<0.001
	$date^2$	-0.04 ± 0.00	142	-14.40	<0.01
	$date^3$	0.00 ± 0.00	142	13.99	<0.001
2016					
Veszprém	intercept	-22.34 ± 3.87	383	-5.77	<0.001
	date	0.48 ± 0.08	383	5.81	<0.001
	$date^2$	-0.00 ± 0.00	383	-5.81	<0.001
	$date^3$	0.00 ± 0.00	383	5.73	<0.001
Balatonfüred	intercept	-19.35 ± 3.43	369	-5.64	<0.001
	date	0.43 ± 0.08	369	5.63	<0.001
	$date^2$	-0.00 ± 0.00	369	-5.51	<0.001
	$date^3$	0.00 ± 0.00	383	5.30	<0.001
Szentgál	intercept	-73.19 ± 6.58	222	-11.13	<0.001
	date	1.60 ± 0.14	222	11.10	<0.001
	$date^2$	-0.01 ± 0.00	222	-10.82	<0.001
	$date^3$	0.00 ± 0.00	222	10.46	<0.001
Vilma-puszta	intercept	-154.00 ± 16.30	158	-9.45	<0.001
	date	3.24 ± 0.35	158	9.34	<0.001
	$date^2$	-0.02 ± 0.00	158	-9.10	<0.001
	$date^3$	0.00 ± 0.00	158	8.80	<0.001

Table S6. Pairwise differences in caterpillar biomass ($\log_{10}$[mg/h]) between tree species in each year of the study. Abbreviations for sites: VP: Veszprém (urban), B: Balatonfüred (urban), S: Szentgál (forest), VI: Vilma-puszta (forest); tree species: A: ash, B: beech, H: hornbeam, Hc: horse-chestnut, Ls: lime (silver), Lsl: lime (small-leaved), M: maple, Od: oak (downy), Os: oak (sessile). Shaded cells indicate pairwise comparisons between a forest and an urban site. Statistically significant (*P*< 0.05) results are highlighted by boldface type. In 2013 NA values refer to the missing pairwise comparisons with the flowering ash (A), as this species was not sampled in that year (see Appendix S1: Table S2).

	2013 b ± SE *P*	**2014** b ± SE *P*	**2015** b ± SE *P*	**2016** b ± SE *P*
VP_Hc – B_Os	-0.41 ± 0.19 0.414	-0.27 ± 0.16 0.803	-0.45 ± 0.18 0.295	-0.39 ± 0.14 0.123
VP_Ls – B_Os	-0.24 ± 0.19 0.918	-0.12 ± 0.16 0.998	-0.20 ± 0.18 0.979	-0.27 ± 0.14 0.601
VP_M – B_Os	-0.31 ± 0.19 0.773	-0.40 ± 0.16 0.234	-0.53 ± 0.18 0.097	-0.34 ± 0.14 0.223
B_Lsl – B_Os	-0.54 ± 0.12 **0.001**	-0.29 ± 0.12 0.293	-0.23 ± 0.15 0.857	-0.31 ± 0.09 **0.017**
B_M – B_Os	-0.30 ± 0.12 0.207	-0.36 ± 0.11 0.065	-0.17 ± 0.15 0.976	-0.42 ± 0.09 **0.001**
S_B – B_Os	0.59 ± 0.19 0.053	-0.00 ± 0.16 1.000	0.25 ± 0.19 0.949	0.58 ± 0.14 **0.001**
S_H – B_Os	0.79 ± 0.20 **0.002**	0.33 ± 0.17 0.636	0.79 ± 0.20 **0.003**	0.79 ± 0.15 **0.001**
VI_Od – B_Os	1.03 ± 0.19 **0.001**	0.29 ± 0.16 0.680	0.86 ± 0.18 **0.001**	0.84 ± 0.14 **0.001**
VI_A – B_Os	*NA*	0.10 ± 0.16 0.998	0.96 ± 0.18 **0.001**	0.85 ± 0.14 **0.001**
VP_Ls – VP_Hc	0.16 ± 0.11 0.851	0.14 ± 0.11 0.945	0.24 ± 0.13 0.671	0.12 ± 0.08 0.877
VP_M – VP_Hc	0.10 ± 0.12 0.993	-0.13 ± 0.11 0.972	-0.07 ± 0.14 0.999	0.05 ± 0.08 1.000
B_Lsl – VP_Hc	-0.13 ± 0.19 0.998	-0.01 ± 0.16 1.000	0.22 ± 0.18 0.962	0.08 ± 0.14 1.000
B_M – VP_Hc	0.11 ± 0.18 0.999	-0.08 ± 0.15 0.999	0.28 ± 0.18 0.844	-0.03 ± 0.13 1.000
S_B – VP_Hc	1.01 ± 0.19 **0.001**	0.27 ± 0.16 0.778	0.70 ± 0.18 **0.004**	0.97 ± 0.13 **0.001**
S_H – VP_Hc	1.21 ± 0.19 **0.001**	0.60 ± 0.16 **0.010**	1.25 ± 0.18 **0.001**	1.18 ± 0.14 **0.001**
VI_Od – VP_Hc	1.45 ± 0.20 **0.001**	0.57 ± 0.16 **0.020**	1.32 ± 0.19 **0.001**	1.23 ± 0.14 **0.001**
VI_A – VP_Hc	*NA*	0.37 ± 0.16 0.399	1.41 ± 0.19 **0.001**	1.24 ± 1.14 **0.001**
VP_M – VP_Ls	-0.06 ± 0.11 0.999	-0.27 ± 0.11 0.238	-0.32 ± 0.13 0.337	-0.08 ± 0.08 0.994
B_Lsl – VP_Ls	-0.30 ± 0.19 0.794	-0.16 ± 0.16 0.990	-0.02 ± 0.18 1.000	-0.04 ± 0.14 1.000

B_M – VP_Ls	-0.05 ± 0.19 1.000	-0.23 ± 0.16 0.901	0.03 ± 0.18 1.000	-0.15 ± 0.14 0.977
S_B – VP_Ls	0.84 ± 0.19 **0.001**	0.12 ± 0.16 0.998	0.45 ± 0.18 0.269	0.85 ± 0.14 **0.001**
S_H – VP_Ls	1.04 ± 0.19 **0.001**	0.45 ± 0.16 0.137	1.00 ± 0.19 **0.001**	1.06 ± 0.14 **0.001**
VI_Od – VP_Ls	1.28 ± 0.19 **0.001**	0.42 ± 0.16 0.199	1.07 ± 0.19 **0.001**	1.11 ± 0.14 **0.001**
VI_A – VP_Ls	*NA*	0.22 ± 0.16 0.917	1.17 ± 0.19 **0.001**	1.11 ± 0.14 **0.001**
B_Lsl – VP_M	-0.23 ± 0.19 0.943	0.11 ± 0.16 0.999	0.30 ± 0.18 0.833	0.03 ± 0.14 1.000
B_M – VP_M	0.01 ± 0.19 1.000	0.04 ± 0.16 1.000	0.36 ± 0.18 0.619	-0.08 ± 0.14 1.000
S_B – VP_M	0.90 ± 0.19 **0.001**	0.40 ± 0.16 0.257	0.78 ± 0.18 **0.001**	0.92 ± 0.14 **0.001**
S_H – VP_M	1.10 ± 0.20 **0.001**	0.73 ± 0.16 **0.010**	1.33 ± 0.19 **0.001**	1.14 ± 0.14 **0.001**
VI_Od – VP_M	1.34 ± 0.20 **0.001**	0.70 ± 0.16 **0.010**	1.39 ± 0.18 **0.001**	1.18 ± 0.14 **0.001**
VI_A – VP_M	*NA*	0.50 ± 0.16 **0.048**	1.49 ± 0.18 **0.001**	1.19 ± 0.14 **0.001**
B_M – B_Lsl	0.24 ± 0.11 0.359	-0.06 ± 0.10 0.999	0.06 ± 0.13 0.999	-0.11 ± 0.08 0.912
S_B – B_Lsl	1.14 ± 0.19 **0.001**	0.28 ± 0.16 0.717	0.48 ± 0.18 0.198	0.89 ± 0.14 **0.001**
S_H – B_Lsl	1.34 ± 0.19 **0.001**	0.62 ± 0.16 **0.010**	1.03 ± 0.18 **0.001**	1.10 ± 0.14 **0.001**
VI_Od – B_Lsl	1.58 ± 0.20 **0.001**	0.59 ± 0.16 **0.015**	1.09 ± 0.19 **0.001**	1.15 ± 0.14 **0.001**
VI_A – B_Lsl	*NA*	0.39 ± 0.16 0.342	1.19 ± 0.19 **0.001**	1.16 ± 0.14 **0.001**
S_B – B_M	0.89 ± 0.19 **0.001**	0.35 ± 0.16 0.404	0.42 ± 0.18 0.378	1.00 ± 0.14 **0.001**
S_H – B_M	1.09 ± 0.19 **0.001**	0.69 ± 0.16 **0.010**	0.96 ± 0.18 **0.001**	0.22 ± 0.14 **0.001**
VI_Od – B_M	1.34 ± 0.20 **0.001**	0.65 ± 0.16 **0.010**	1.03 ± 0.19 **0.001**	1.26 ± 0.14 **0.001**
VI_A – B_M	*NA*	0.46 ± 0.16 0.135	1.13 ± 0.19 **0.001**	0.13 ± 0.14 **0.001**
S_H – S_B	0.20 ± 0.11 0.702	0.33 ± 0.11 0.081	0.54 ± 0.14 **0.007**	0.21 ± 0.09 0.234
VI_Od – S_B	0.44 ± 0.20 0.381	0.30 ± 0.16 0.715	0.61 ± 0.19 0.059	0.26 ± 0.14 0.699
VI_A – S_B	*NA*	0.10 ± 0.16 0.999	0.71 ± 0.19 **0.011**	0.27 ± 0.14 0.661
VI_Od – S_H	0.24 ± 0.21 0.957	-0.03 ± 0.17 1.000	0.06 ± 0.20 1.000	0.05 ± 0.15 1.000
VI_A – S_H	*NA*	-0.22 ± 0.17 0.939	0.16 ± 0.20 0.998	0.05 ± 0.15 1.000
VI_A – VI_Od	*NA*	-0.19 ± 0.11 0.732	0.09 ± 0.15 0.999	0.01 ± 0.09 1.000

Table S7. Differences in occurrence of nestling mortality between urban and forest habitats in each year of the study (Fisher's exact tests). Statistically significant ($P < 0.05$) differences are highligted in boldface type.

	Occurrence of starvation-related nestling mortality			
	in 2013 urban / forest	in 2014 urban / forest	in 2015 urban / forest	in 2016 urban / forest
total number of broods	34 / 27	43 / 65	49 / 54	45 / 43
broods with no mortality (0)	18 / 26	31 / 58	30 / 49	11 / 41
broods with mortality (1)	16 / 1	12 / 7	19 / 5	34 / 2
P-value	**< 0.001**	**0.0369**	**0.001**	**< 0.001**

Fig. S1. The location of the four study sites. Urban sites are Veszprém (47°05'17.29"N, 17°54'29.66"E; altitude: 260 m) and Balatonfüred (46°57'30.82"N, 17°53'34.47"E, altitude: 131 m), forest sites are Szentgál (47°06'39.75"N, 17°41'17.94"E; altitude: 500 m) and Vilma-puszta (47°05'06.7"N, 17°51'51.4"E; altitude: 300 m). The four study sites indeed differ in their degree of urbanization as reflected by their 'urbanization scores' provided by the 'UrbanizationScore' software (Seress et al. 2014). Using Google Maps images this program quantifies the degree of urbanization in 1 km x 1 km areas, based on the densities of buildings, roads and vegetation. The 'urbanization scores' of the four study sites (ranging from the least to the most urbanized area): Szentgál (-2.26442), Vilma-puszta (-2.17992), Balatonfüred (1.88815) and Veszprém (2.55618).

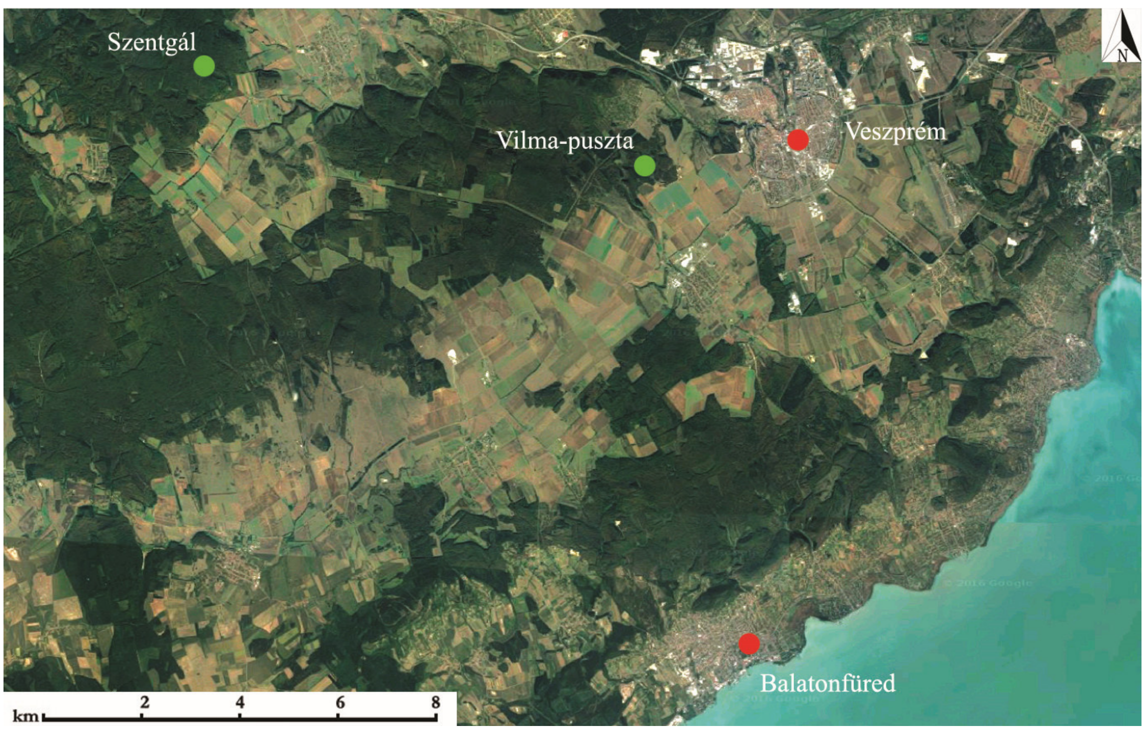


Fig. S2. Mean ± SE of daily mean temperatures between January and June in the study region for the four study years (2013-2016) and mean monthly temperatures for the preceding three decades (1988-2012). All temperature data were recorded at a meteorological station (Szentkirályszabadja, 47°03’21.07"N, 17°58'11.80"E) located 6 km from Veszprém.

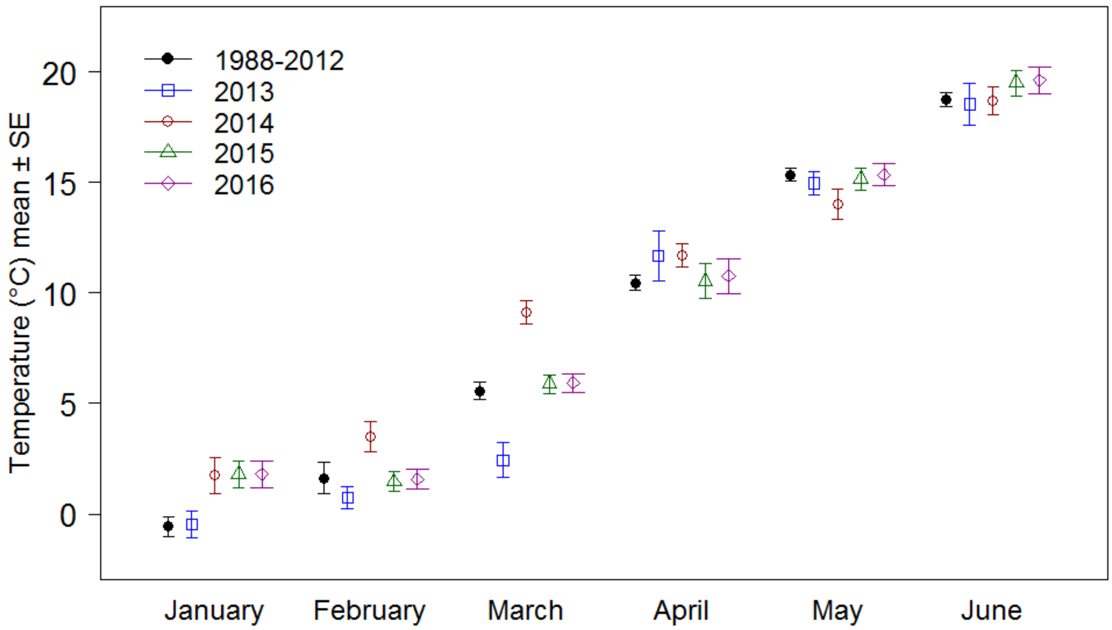


Fig. S3. Seasonal changes in caterpillar biomass as inferred by fitting Weibull-functions in the two urban sites (a-h) and two forest sites (g-n). Different numbers within a panel mark different caterpillar biomass peaks during the sampling period, as identified by the models (e.g. in panel "a" there are 4 peaks, and each sampling date marked by "2" belongs to the second peak). Note that the scale of the y axis is different for urban (Veszprém and Balatonfüred) and forest (Szentgál and Vilma-puszta) sites.

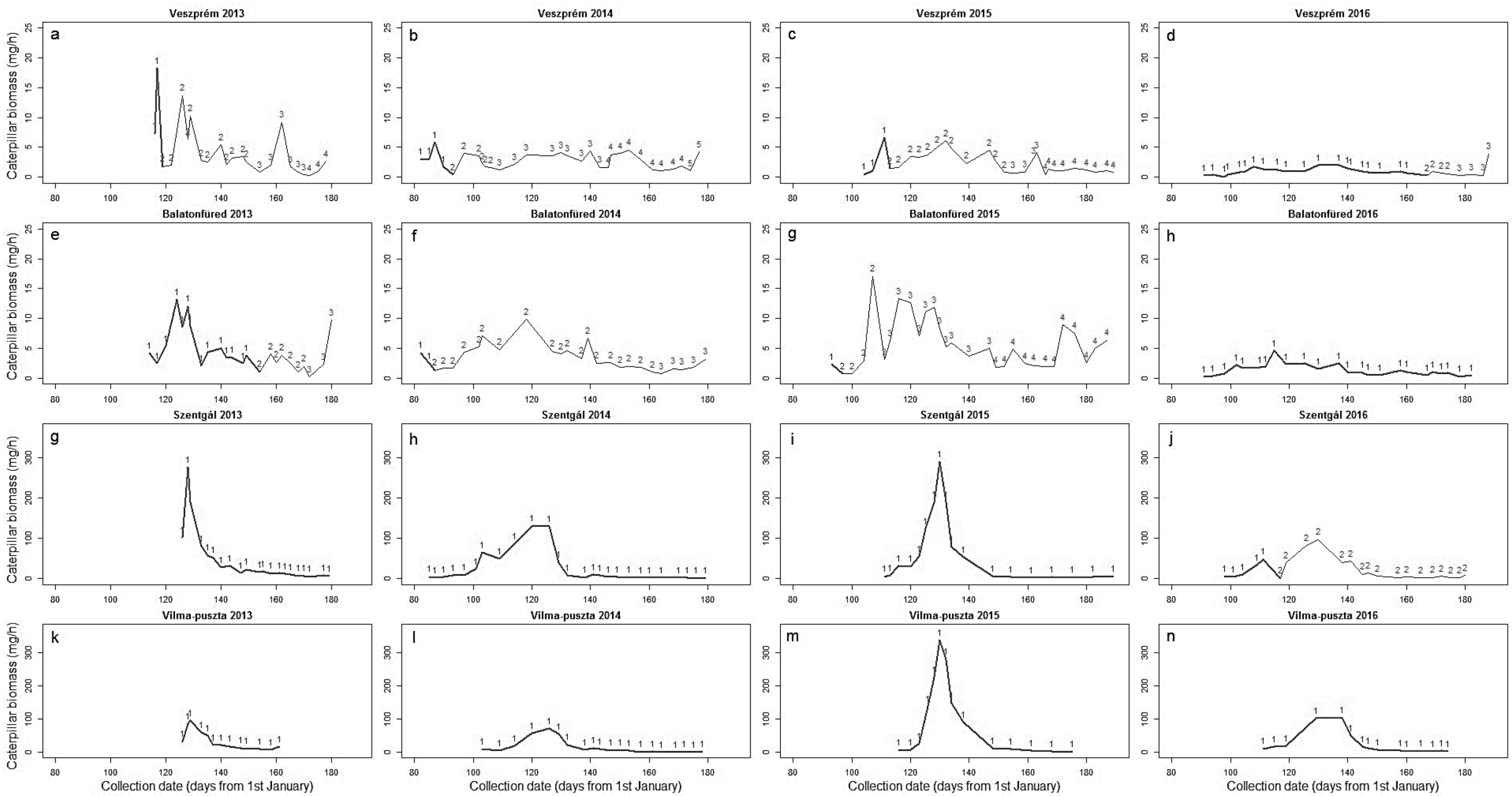


Fig. S4. Differences in maximum caterpillar biomass ($\log_{10}$[mg/h]) of individual trees between urban (grey) and forest (white) habitats in the four study years (2013-2016). Medians and interquartile ranges are indicated by the thick middle lines and the boxes, respectively. See Table 2c in the main manuscript for results of statistical analysis.

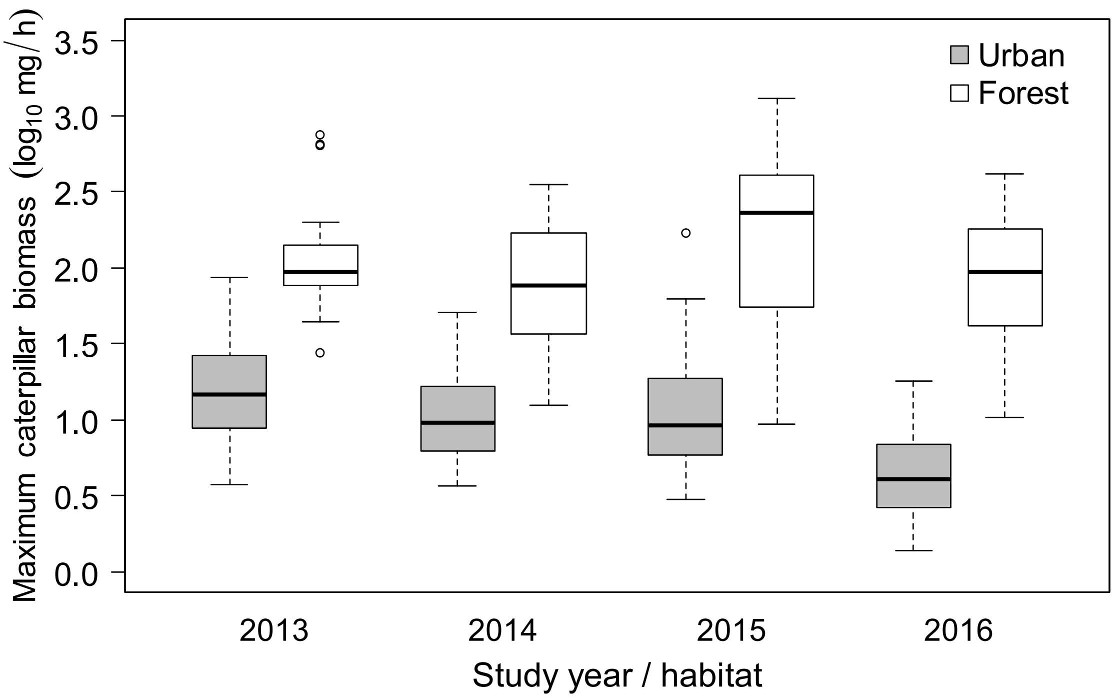


Fig. S5. Differences in hourly caterpillar biomass (log_{10}[mg/h]) between tree species in 2013-2016. Urban habitats are Veszprém (red) and Balatonfüred (purple), while forest habitats are Szentgál (blue) and Vilma-puszta (green). Medians and interquartile ranges are indicated by the thick middle lines and the boxes, respectively; see Appendix S1: Table S3 for pairwise comparisons between tree species.

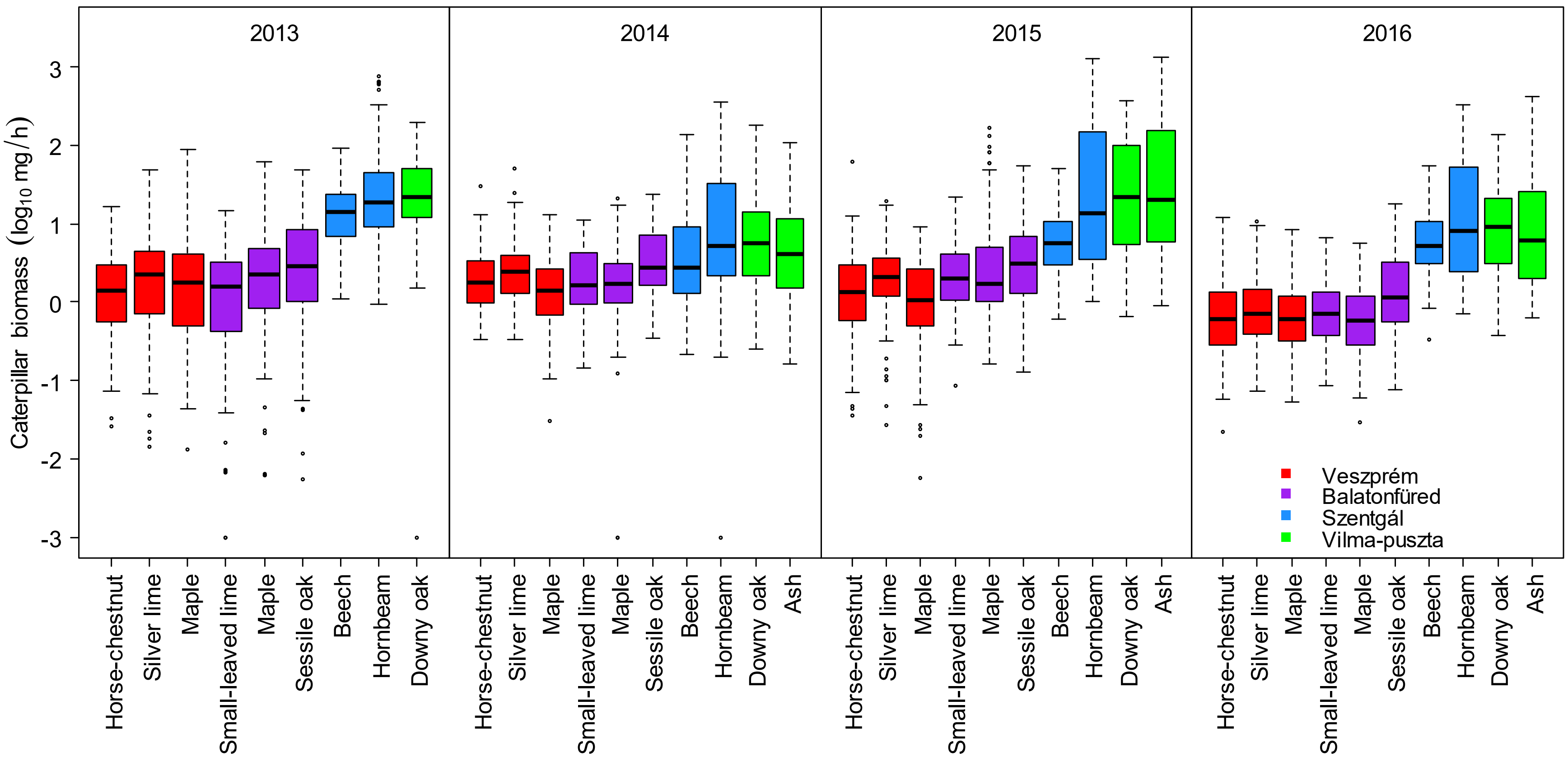
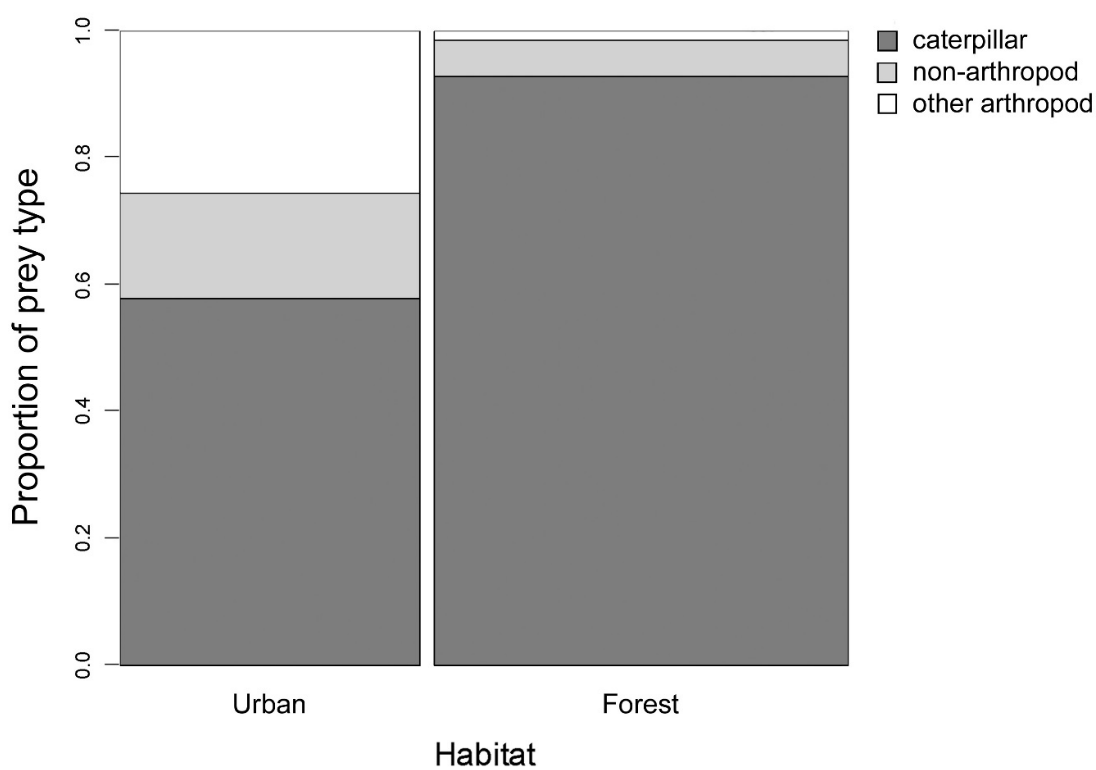


Fig. S6. Differences in the distribution of three main types of prey delivered to great tit nestlings in an urban (Veszprém) and a forest (Vilma-puszta) study site in 2012 (modified after Sinkovics 2014). Prey type was identified from 30-min long video-recordings collected by small, concealed video cameras attached to the nest box (n=36 video-recordings, in 12 urban and 11 forest broods). Delivered prey items (n=243; 102 urban and 141 forest) were categorized as 'caterpillar', 'other arthropod' (mainly spiders) and 'non-arthropod' (seeds, anthropogenic food and unidentified items). For the analysis the categories 'other arthropod' and 'non-arthropod' were pooled in a single category ('non-caterpillar'). To compare the proportion of caterpillar prey between the two sites, a generalized linear mixed-effects model was used with quasi-binomial error and logit link function, in which habitat type (urban or forest) was the predictor and brood ID was the random factor. Caterpillars made up a higher proportion of food items in the forest (0.93, CI 95% = 0.87-0.96) than in the urban site (0.58, CI 95% = 0.47-0.67; t_{34} = 5.82, *P* <0.001).



LITERATURE CITED

Glądalski, M., M. Bańbura, A. Kaliński, M. Markowski, J. Skwarska, J. Wawrzyniak, P. Zieliński, I. Cyzewska, and J. Bańbura. 2015. Inter-annual and inter-habitat variation in breeding performance of Blue tits (*Cyanistes caeruleus*) in central Poland. Ornis Fennica 92:34–42.

Isaksson, C., and S. Andersson. 2007. Carotenoid diet and nestling provisioning in urban and rural Great tits Parus major. Journal of Avian Biology 38:564–572.

Marciniak, B., J. Nadolski, M. Nowakowska, B. Loga, and J. Bańbura. 2007. Habitat and annual variation in arthropod abundance affects Blue tit Cyanistes caeruleus reproduction. Acta Ornithologica 42:53–62.

Pollock, C. J., P. Capilla-Lasheras, R. A. R. McGill, B. Helm, and D. M. Dominoni. 2017. Integrated behavioural and stable isotope data reveal altered diet linked to low breeding success in urban-dwelling blue tits (*Cyanistes caeruleus*). Scientific Reports 7:5014.

Seress, G., Á. Lipovits, V. Bókony, and L. Czúni. 2014. Quantifying the urban gradient: A practical method for broad measurements. Landscape and Urban Planning 131:42–50.

Sinkovics, C. 2014. A fiókatáplálék mennyisége, minősége és szezonalitása városi és erdei széncinege (Parus major) populációkban. Szent István University, Institute for Biology.

Solonen, T. 2001. Breeding of the Great Tit and Blue Tit in urban and rural habitats in southern Finland. Ornis Fennica 78:49–60.

Wawrzyniak, J., A. Kaliński, M. Glądalski, M. Bańbura, M. Markowski, J. Skwarska, P. Zieliński, I. Cyzewska, and J. Bańbura. 2015. Long-term variation in laying date and clutch size of the Great tit *Parus major* in central Poland: A comparison between urban parkland and deciduous forest. Ardeola 62:311–322.