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SUPPLEMENTARY MATERIAL

Information on population trends and biological constraints from bat counts in roost cavities: a 22-year case study of a pipistrelle bats (*Pipistrellus pipistrellus* Schreber) hibernaculum

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Supplementary material - Appendix S1

Characteristics of the hibernaculum of pipistrelle bats (*Pipistrellus pipistrellus*) located in a railway tunnel (600 meter long, Picture 1).The counting method is a direct visual count of individuals who are located in shallow notches. These notches are expansion joint vertical depth of 10 cm between concrete slabs (Picture 2), This is close to some natural cracks (Picture 3) The count procedure leads thus to very thin measurements errors, because all individuals are observable.

Fig. S1: Characteristics of the hibernaculum

railway tunnel where the hibernaculum of pipistrelle bats is located

pipistrelle in a notche between concrete slabs.

pipistrelle in a natural cracks

Supplementary material - Appendix S2:

Table S2: Table of correlations (Spearman's rank test) between the pairs of weather variables used in the modelling. $T._{day}$ is the local ambient temperature at the time of the count; $T._{January}$ is the average temperature in January; $T._{winter}$ is the average temperature in the winter (December-January-February); $T._{Anomalies}$ is the temperature anomaly observed in January relative to the average temperatures over the 1951-1989 period; *Frost day* is the number of frost days in January; $P._{June}$ is the rainfall recorded in June of the previous year; $P._{July}$ is the rainfall recorded in July of the previous year; $T._{June}$ is the average temperature in June of the previous year; $T._{July}$ is the average temperature in July of the previous year; Significance tests are indicated in bold characters (α=0.05).

	Winter variables					*Spring variables*			
	$T._{day}$	$T._{January}$	$T._{winter}$	$T._{Anomalies}$	*Frost day*	$P._{June}$	$P._{July}$	$T._{June}$	$T._{July}$
Year	p=0.63 rho=-0.12	p=-0.83 rho =-0.05	p=-0.87 rho=0.04	p=-0.63 rho=0.12	p=-0.45 rho=-0.18	p=0.54 rho=-0.14	p=0.45 rho=0.18	**P=0.004 rho=0.61**	P=0.79 rho=0.06
$T._{day}$		p=0.11 rho=0.39	P=0.52 rho=0.16	**p=-0.03 rho=0.50**	P=0.34 rho=-0.24	p=0.94 rho=-0.02	p=0.15 rho=0.35	p=0.56 rho=-0.14	p=0.55 rho=-0.14
$T._{January}$			**P<0.001 rho=0.76**	**p=0.02 rho=0.53**	**P=0.002 rho=-0.67**	p=0.37 rho=0.22	p=0.66 rho=0.11	p=0.85 rho=-0.05	p=0.73 rho=-0.08
$T._{winter}$				**P=0.01 rho=0.57**	**P<0.001 rho=-0.72**	p=0.31 rho=0.25	p=0.23 rho=0.28	p=0.45 rho=0.18	p=0.78 rho=-0.06
$T._{Anomalies}$					P=0.28 rho=-0.26	p=0.39 rho=0.21	p=0.10 rho=0.38	p=0.80 rho=-0.06	p=0.62 rho=0.12
Frost day						p=0.93 rho=-0.02	p=0.20 rho=-0.31	p=0.15 rho=-0.34	p=0.47 rho=0.18
$P._{June}$							**p=0.04 rho=-0.45**	p=0.40 rho=-0.19	p=0.84 rho=-0.05
$P._{July}$								p=0.82 rho=0.06	p=0.95 rho=-0.01
$T._{June}$									p=0.77 rho=-0.07

* Spearman's rho showed no important correlations between variables (correlation coefficient |rho| < 0.5; Freckleton 2002).

Reference

FRECKLETON, R.P. 2002. On the misuse of residuals in ecology: regression of residuals vs. multiple regression. Journal of Animal Ecology 71: 542-545.

Supplementary Material. - Appendix S3 of The adjusted scenario.

We aimed to examine an additional scenario (hereafter, adjusted scenario) as follows: (i) with the same demographic structure and properties as our median scenario (i.e., a scenario based on the most reliable demographic parameters provided by the literature) and (ii) yielding a growth rate similar to the one observed over the 1995-2010 period (0.93).

For this purpose, we kept the same transition matrix structure as the median scenario (see Figure S2.1 below, this model yields a deterministic growth λ_{median}=0.797), and we slightly modified the demographic parameters to obtain $\lambda_{adjusted}$=0.93.

This can be achieved by multiplying the transition matrix by a constant term, α= $\lambda_{adjusted}/\lambda_{median}$=1.17, or by multiplying the demographic parameters such that all of the non-zero terms of the transition matrix are multiplied by α (Caswell 2001).

Figure S2 Transition matrix corresponding to the median scenario. σ=0.5; s_0=0.53; s_{ad}=0.59; F=0.78.

$$\begin{pmatrix} \sigma s_0 F & \sigma s_0 F \\ s_{ad} & s_{ad} \end{pmatrix}$$

We obtained the following parameters for the adjusted scenario:

s0'= √α×0.53=0.57

sad'= α×0.59=0.69

F'= √α×0.78=0.84

This new set of parameters leads to a population with similar demographic properties as the median scenario (i.e., the same generation time and proportions of age classes at demographic equilibrium) but a different deterministic growth rate ($\lambda_{adjusted}$=0.93).

Supplementary material - Appendix S4: Model selection table

Model	AIC
Count ~ Year	1574
Count ~ Traffic	3154
Count ~ $T._{day}$	3083
Count ~ $T._{January}$	1574
Count ~ $T._{winter}$	2907
Count ~ $T._{Anomalies}$	2467
Count ~ Frost day	2922
Count ~ $P._{June}$	3130
Count ~ $P._{July}$	3155
Count ~ $T._{June}$	1574
Count ~ $T._{July}$	3153
Count ~ Year + Traffic	621
Count ~ Year + $T._{day}$	1532
Count ~ Year + $T._{January}$	1470
Count ~ Year + $T._{winter}$	1533
Count ~ Year + $T._{Anomalies}$	1529
Count ~ Year + Frost day	1454
Count ~ Year + $P._{June}$	1558
Count ~ Year + $P._{July}$	1560
Count ~ Year + $T._{June}$	1432
Count ~ Year + $T._{July}$	1564
Count ~ Year + Traffic	3090
Count ~ Traffic + $T._{day}$	3079
Count ~ Traffic + $T._{January}$	3090
Count ~ Traffic + $T._{winter}$	2909
Count ~ Traffic + $T._{Anomalies}$	2443
Count ~ Traffic + Frost day	2921
Count ~ Traffic + $P._{June}$	3128
Count ~ Traffic + $P._{July}$	3155
Count ~ Traffic + $T._{June}$	2688
Count ~ Traffic + $T._{July}$	3154
Count ~ Year + Traffic +$T._{day}$	597
Count ~ Year + Traffic +$T._{January}$	539
Count ~ Year + Traffic +$T._{winter}$	552
Count ~ Year + Traffic +$T._{Anomalies}$	553
Count ~ Year + Traffic +Frost day	467
Count ~ Year + Traffic +$P._{June}$	622
Count ~ Year + Traffic +$P._{July}$	606
Count ~ Year + Traffic +$T._{June}$	622
Count ~ Year + Traffic +$T._{July}$	603
Count ~ Year + Traffic +$T._{day}$ + $P._{June}$	598
Count ~ Year + Traffic +$T._{day}$ + $P._{July}$	593
Count ~ Year + Traffic +$T._{day}$ + $T._{June}$	597
Count ~ Year + Traffic +$T._{day}$ + $T._{July}$	577
Count ~ Year + Traffic + $T._{January}$ + $P._{June}$	536
Count ~ Year + Traffic + $T._{January}$ + $P._{July}$	533
Count ~ Year + Traffic + $T._{January}$ + $T._{June}$	541
Count ~ Year + Traffic + $T._{January}$ + $T._{July}$	516
Count ~ Year + Traffic + $T._{winter}$ + $P._{June}$	553
Count ~ Year + Traffic + $T._{winter}$ + $P._{July}$	539
Count ~ Year + Traffic + $T._{winter}$ + $T._{June}$	553
Count ~ Year + Traffic + $T._{winter}$ + $T._{July}$	517
Count ~ Year + Traffic + $T._{Anomalies}$ + $P._{June}$	553
Count ~ Year + Traffic + $T._{Anomalies}$ + $P._{July}$	537
Count ~ Year + Traffic + $T._{Anomalies}$ + $T._{June}$	555
Count ~ Year + Traffic + $T._{Anomalies}$ + $T._{July}$	524
Count ~ Year + Traffic + Frost day + $P._{June}$	469
Count ~ Year + Traffic + Frost day + $P._{July}$	465
Count ~ Year + Traffic + Frost day + $T._{June}$	467
Count ~ Year + Traffic + Frost day + $T._{July}$	**435**

Supplementary material - Appendix S5:

Figure S5. Identification of the most likely causal factors of temporal variations in recorded bat abundance, using hierarchical partitioning (R package *hier.part*), including (A) All variables; (B) variables adjusted to the yearly trend and (C) variables adjusted to both yearly trend and railway traffic effects.