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Supplementary material

Appendix 1

Table A1. Comparison of models of (a) clutch size and (b) recruitment probability in response to weather during various durations of (a) pre-laying and (b) post-fledging periods. For each response, the effects of daily mean temperature (ºC) and precipitation (mm) were compared for the 4, 8, 12, 14, 16 and 32 days preceding laying or following fledging, controlling for non-climatic parameters (see Table 1 of the main manuscript). Values represent the difference in AICc values of the specified weather model compared to the model comprising only non-climatic parameters. Use of different focal durations has negligible impact on model fit; a 14-day period was used in subsequent analyses.

Length of period (days)	**Temperature**		**Precipitation**		**Mean**	
	Linear	**Quadratic**	**Linear**	**Quadratic**	**Linear**	**Quadratic**
(a) Clutch size in response to pre-laying weather						
4	+0.7	+2.5	+2.0	+3.6	+1.4	+3.1
8	+1.5	+3.4	+2.0	+1.3	+1.8	+2.4
12	+1.0	+1.6	+1.2	+2.4	+1.1	+2.0
14	+1.1	+1.9	+1.4	+3.4	+1.3	+2.7
16	+1.3	+2.5	+1.9	+4.0	+1.6	+3.3
32	+1.9	+3.4	+1.9	+3.1	+1.9	+3.3
(b) Recruitment probability in response to post-fledging weather						
4	-0.7	+0.3	+1.8	+2.0	+0.6	+1.2
8	-2.6	-0.6	+1.1	-0.9	-0.8	-0.8
12	-0.6	+0.6	+0.9	+1.8	+0.2	+1.2
14	-0.7	+0.7	+1.0	+1.1	+0.2	+0.9
16	-0.5	+0.4	-0.6	-0.8	-0.6	-0.2
32	-2.3	-1.4	+2.1	+3.9	-0.1	+1.3

Table A2. Individual productivity modelled in response to three indices of extreme precipitation, i.e. the presence/absence of exceptionally wet, extremely wet, or very wet days during the focal period, as defined below. Non-climatic predictors were controlled for in all models as detailed in Table 1 of the main manuscript. Values are the difference in AICc of the specified model compared to the model comprising only non-climatic predictors. In subsequent analyses the presence/absence of very wet days was used as the predictor in subsequent analyses; the exception was for analyses of recruitment probability, for which the presence/absence of extremely wet days was used due to sample size issues.

Productivity response	**Exceptionally wet days (wettest 2.5%)**	**Extremely wet days (wettest 5%)**	**Very wet days (wettest 10%)**
Fledged brood size	+1.1	+1.3	+1.2
Hatching probability	+30.1	+29.9	+30.1
Fledging probability	+25.4	+10.1	-11.5
Nestling mass	+2.1	+1.9	+1.9
Recruitment probability	+1.8	-2.9	-2.8

The three indices of extreme precipitation were defined as follows. Exceptionally wet = precipitation exceeded the amount falling on the wettest 2.5% of days, i.e. ≥14.7, 16.7, 16.5, 15.7 mm during the egg, $nestling_{11}$, nestling and post-fledging periods, respectively. Extremely wet = precipitation exceeded the amount falling on the wettest 5% of days, i.e. ≥11.3, 11.2, 11.2, 10.4 mm during the egg, $nestling_{11}$, nestling and post-fledging periods, respectively. Very wet = precipitation exceeded the amount falling on the wettest 10% of days, i.e. ≥6.4, 6.0, 5.9, 6.0 mm during the egg, $nestling_{11}$, nestling and post-fledging periods, respectively.

Table A3. The effects of winter weather on population-level productivity in a population of long-tailed tits in the Rivelin Valley, 1995–2013. Productivity outcomes were (a) mean clutch size, (b) mean brood size of fledged nests, modelled in response to mean daily temperature (temp) and mean daily precipitation (prec) during each month of the winter (December to February) preceding breeding. Non-climatic parameters were controlled for as detailed in Table 2 of the main manuscript. Model averaged parameter estimates and unconditional standard errors are displayed together with the model averaged model R^2 and partial R^2.

Variable	Est.	SE	Partial R^2
(a) Clutch size: R^2 = 0.37; 3 models in set			
Intercept	*+8.492*	*0.533*	--
Prop 1st attempts	+1.594	0.623	0.24
Adult pop size	-0.004	0.002	0.03
Feb prec	+0.002	0.002	0.03
(b) Brood size: R^2 = 0.39; 4 models in set			
Intercept	*-2.189*	*5.241*	--
Clutch size	+1.107	0.455	0.20
Prop 1st attempts	+2.196	1.080	0.13
Dec prec	-0.005	0.003	0.01
Feb prec	+0.007	0.004	0.03

Table A4. Annual predation rate in response to weather during the breeding season and the preceding winter, in a population of long-tailed tits in the Rivelin Valley, 1995–2013. Predation was modelled in response to (a) average weather conditions, which were mean monthly temperature and precipitation during the winter (December–February) and during each month of the breeding season (March–May); (b) extreme weather conditions, which were mean temperature and total precipitation during the coldest and the wettest winter month, the number of very wet days during each month of the breeding season, and mean temperature during each month of the breeding season. Very wet days were defined as those on which precipitation exceeded 5.9 mm, which was the amount falling on the wettest 10% of days when chicks were in the nest over the course of the study. All analyses controlled for adult population size. The model-averaged parameter estimate (est.), unconditional standard error (SE) and partial R^2 of each variable retained in one of more models with delta AICc values <2 of the most parsimonious fitted model. In both analyses, four models were retained in the model average set, but note that in both cases the null model (i.e. that which lacked predictors) had a lower AICc value.

Variable	Est.	SE	Partial R^2
(a) Average weather			
Intercept	*+3.139*	*0.956*	--
March temperature	+0.205	0.137	0.10
March precipitation	-0.013	0.008	0.14
April precipitation	-0.007	0.005	0.03
(b) Extreme weather			
Intercept	*+3.118*	*0.718*	--
March temperature	+0.161	0.123	0.10
March very wet days	-0.158	0.127	0.09
May very wet days	+0.141	0.123	0.08

Table A5. Model averages of individual-level productivity outcomes in response to weather during nest-specific periods of the breeding season, in a population of long-tailed tits in the Rivelin Valley, 1995-2013. Productivity outcomes were (a) clutch size, (b) brood size of fledged nests, (c) hatching probability, (d) fledging probability, (e) nestling mass, and (f) recruitment probability of fledged males, modelled in response to mean daily temperature (temp) and mean daily precipitation (prec) during nest-specific periods. Non-climatic parameters that could influence productivity were also included as predictors, as detailed in Table 1 of the main manuscript. The model-averaged parameter estimate (est.) and unconditional standard error (SE) are presented for each variable present in at least one of the models with delta AICc values <2 relative to the most parsimonious fitted model. The D^2 of the most parsimonious model, and the partial D^2 of each predictor retained in that model are also presented, -- indicates variables not retained in the most parsimonious model.

Variable	Est.	SE	Partial D^2
(a) **Clutch size**: D^2 = 0.10, 5 models in set			
Intercept	*+9.740*	*0.237*	
Relative lay date	+0.025	0.014	0.104
Relative lay date^2	-0.002	<0.001	
Pre-laying temperature	+0.029	0.040	--
Pre-laying precipitation	-0.050	0.121	--
Laying temperature	-0.009	0.028	--
Laying precipitation	+0.029	0.087	--
(b) **Fledged brood size**: D^2 = 0.05, 8 models in set			
Intercept	*-2.385*	*1.640*	
Relative lay date	-0.013	0.015	--
Clutch size	+1.002	0.133	0.054
Number of helpers	+0.199	0.114	0.003
Nestling_{11} temperature	+0.096	0.081	--
Nestling_{11} wet days	+0.274	0.015	--
(c) **Hatching probability**: D^2 = 0.04, 2 models in set			
Intercept	*-0.781*	*0.602*	
Relative lay date	-0.052	0.009	0.029
Predation rate	-0.408	0.109	0.008
Egg temperature	+0.266	0.052	0.020
Egg wet days	+0.141	0.208	--
(d) **Fledging probability**: D^2 = 0.12, 2 models in set			
Intercept	*-4.182*	*1.080*	
Relative lay date	-0.041	0.014	0.017
Predation rate	-0.070	0.217	--
Nestling temperature	+0.366	0.089	0.038
Nestling wet days	+1.720	0.291	0.071
(e) **Nestling mass**: D^2 = 0.50, 7 models in set			
Intercept	*-1.060*	*0.524*	
Relative lay date	+0.004	0.002	0.008
Number of helpers	+0.057	0.021	0.024
Number of helpers^2	-0.004	0.008	
Tarsus length	+0.462	0.029	0.482
Brood size	-0.011	0.006	0.007
Nestling_{11} temperature	-0.013	0.015	--
(f) **Recruitment probability**: D^2 = 0.07, 8 models in set			
Intercept	*-2.565*	*2.487*	--
Relative lay date	-0.052	0.014	0.035
Population size	-0.003	0.002	0.006
Mass:tarsus ratio	+7.726	5.029	0.005
Post-fledging temp	+0.128	0.085	--
Post-fledging wet days	-0.541	0.205	0.012

Table A6. The effects of weather on population-level productivity outcomes in a population of long-tailed tits in the Rivelin Valley, 1995–2013. Productivity outcomes were (a) mean clutch size, (b) mean brood size of fledged nests, (c) number of fledglings per breeding female, (d) number of recruits per breeding female, and (e) recruitment probability of fledged males, modelled in response to mean daily temperature (temp) and mean daily precipitation (prec) during each month of the breeding season, March–May (models a – d), or the year from hatching to recruiting, i.e. March to February (model e). Non-climatic parameters were controlled for as detailed in Table 2 of the main manuscript. The most parsimonious models (assessed by AICc values) are presented with their model R^2 (models a-d) or D^2 (for the logistic model e) and the parameter estimate (est.), unconditional standard error (SE) and partial R^2/D^2 of each variable retained in the most parsimonious model.

Variable	**Est.**	**SE**	**Partial D/R^2**
(a) Clutch size: $R^2 = 0.30$			
Intercept	*+8.365*	*0.479*	--
Proportion 1st nests	+1.672	0.633	0.30
(b) Brood size: $R^2 = 0.57$			
Intercept	*-4.350*	*3.815*	--
Clutch size	+1.080	0.399	0.23
Proportion 1st nests	+1.838	0.936	0.12
March prec	+0.009	0.004	0.14
(c) Fledglings per ♀: $R^2 = 0.53$			
Intercept	*+3.585*	*0.955*	--
Predation rate	-0.805	0.199	0.52
Season length	+0.072	0.038	0.11
(d) Recruits per ♀: $R^2 = 0.67$			
Intercept	*-6.505*	*1.733*	--
Population size	-0.009	0.003	0.28
March temp	-0.473	0.119	0.44
May temp	+0.820	0.186	0.54
(e) Recruitment probability: $D^2 = 0.77$			
Intercept	*-4.370*	*1.359*	--
Population size	-0.009	0.002	0.64
March temp	-0.298	0.089	0.27
May temp	+0.575	0.141	0.42