Table S1. Ambient climate models: Outputs of linear mixed models for fledging mass with ambient climate measures (mean temperature/ mean rainfall) during specific developmental stages (hatchling/nestling) as explanatory variables along with laydate, and clutch size as fixed effects. Year of birth, brood identity, mother identity and natal nest box are included as random effects. All fixed effects are scaled to a mean of zero and standard deviation of one. Significant terms (*p <0.05)* are in bold.

Variable	Estimate	Std. Error	df	t	p
Average temperature (hatchling stage)					
Mean temperature	0.1202	0.01994	10010	6.03	**< 0.001**
(Mean temperature)^2	**-0.0763**	0.01099	10090	-6.94	**< 0.001**
Lay date	-0.3343	0.02021	10430	-16.54	**< 0.001**
Clutch size	-0.2474	0.01409	10010	-17.55	**< 0.001**
Average temperature (hatchling stage) – using splines (df=5)					
Mean temperature.1	**0.8245**	0.1548	9863	5.33	**< 0.001**
Mean temperature.2	**0.6015**	0.1795	9878	3.35	**0.0008**
Mean temperature.3	**0.7902**	0.1262	10060	6.26	**< 0.001**
Mean temperature.4	**0.7237**	0.3826	9912	1.89	**0.0586**
Mean temperature.5	0.03598	0.2200	10150	0.16	0.8701
Lay date	-0.3317	0.02026	10400	-16.37	**< 0.001**
Clutch size	-0.2477	0.01410	10020	-17.57	**< 0.001**
Average temperature (nestling stage)					
Mean temperature	0.1344	0.01812	10340	7.42	**< 0.001**
(Mean temperature)^2	**-0.04692**	0.01009	10130	-4.65	**< 0.001**

Lay date	-0.3515	0.02039	10510	-17.24	**< 0.001**
Clutch size	-0.2485	0.01412	10030	-17.61	**< 0.001**
Average temperature (nestling stage) – using splines (df=5)					
Mean temperature.1	**0.5032**	0.1848	9981	2.72	**0.0064**
Mean temperature.2	**0.3726**	0.2049	9983	1.82	**0.0690**
Mean temperature.3	**0.8374**	0.1546	10220	5.42	**< 0.001**
Mean temperature.4	0.09307	0.4643	9937	0.20	0.84114
Mean temperature.5	-0.3220	0.4166	10070	-0.77	0.43955
Lay date	-0.3516	0.02047	10490	-17.17	**< 0.001**
Clutch size	-0.2488	0.01412	10030	-17.63	**< 0.001**
Average rainfall (hatchling stage)					
Mean rainfall	**-0.06288**	0.01813	10260	-3.47	**0.000526**
Lay date	-0.2918	0.01871	10500	-15.59	**< 0.001**
Clutch size	-0.2387	0.01408	9981	-16.96	**< 0.001**
Average rainfall (nestling stage)					
Mean rainfall	**-0.1439**	0.01580	10250	-9.11	**< 0.001**
Lay date	-0.2857	0.01867	10480	-15.30	**< 0.001**
Clutch size	-0.2349	0.01404	10000	-16.72	**< 0.001**

Table S1.1 Model selection for ambient temperature effects on fledging mass (based on AICc)

Model (developmental stage)	K	AICc	ΔAICc	AICcWt	Cum.Wt	Res.LL
Spline (hatchling)	13	249655.4	0.0	0.99	0.99	-124814.7
Quadratic (hatchling)	10	249664.1	8.7	0.01	1.00	-124822.1
Spline (nestling)	13	249656.0	0.0	0.99	0.99	-124815.0
Quadratic (nestling)	10	249665.2	9.2	0.01	1.00	-124822.6

Table S2. Extreme climate events (frequency) models: Outputs of linear mixed models for fledging mass with number of ECEs during specific developmental stages (hatchling/nestling) as explanatory variables along with mean temperature during the relevant stage, laydate, and clutch size as fixed effects. Year of birth, brood identity, mother identity and natal nest box are included as random effects. All fixed effects are scaled to a mean of zero and standard deviation of one. Significant terms (*p <0.05)* are in bold. Here, ECEs are calculated with a 5% threshold.

Variable	Estimate	Std. Error	df	t	p
Number of hot ECEs (hatchling stage)					
Mean temperature	0.1051	0.02749	9941	3.83	**< 0.001**
Lay date	-0.3332	0.02144	10350	-15.54	**< 0.001**
Clutch size	-0.2445	0.01416	10010	-17.27	**< 0.001**
Number of hot ECEs	-0.02235	0.02258	10170	-0.99	0.3222
Number of hot ECEs (nestling stage)					
Mean temperature	0.0614	0.0237	10320	2.59	**0.009**
Lay date	-0.3202	0.0216	10500	-14.82	**< 0.001**
Clutch size	-0.2444	0.0142	10060	-17.25	**< 0.001**
Number of hot ECEs	**0.0914**	0.0240	10180	3.81	**0.00014**

Number of hot ECEs (nestling stage) – using splines					
Number of hot ECEs.1	0.08188	0.07484	10030	1.09	0.274
Number of hot ECEs.2	**-0.8576**	0.2392	10130	-3.59	**< 0.001**
Number of hot ECEs.3	**1.883**	0.4019	10220	4.68	**< 0.001**
Mean temperature	0.07136	0.02424	10330	2.94	**0.003**
Lay date	-0.3236	0.02176	10510	-14.87	**< 0.001**
Clutch size	-0.2447	0.01417	10050	-17.27	**< 0.001**
Number of cold ECEs (hatchling stage)					
Mean temperature	0.05067	0.02205	10170	2.30	**0.0216**
Lay date	-0.3224	0.02024	10400	-15.93	**< 0.001**
Clutch size	-0.2428	0.01411	10010	-17.22	**< 0.001**
Number of cold ECEs	**-0.06948**	0.02089	10160	-3.33	**0.00089**
Number of cold ECEs (nestling stage)					
Mean temperature	0.1734	0.02080	10210	8.34	**< 0.001**
Lay date	-0.3705	0.02088	10500	-17.74	**< 0.001**
Clutch size	-0.2524	0.01414	10050	-17.85	**< 0.001**
Number of cold ECEs	0.09059	0.01833	9961	4.97	**< 0.001**
Number of rain ECEs (hatchling stage)					
Mean temperature	0.08192	0.01954	10070	4.19	**< 0.001**
Lay date	-0.3243	0.02026	10400	-16.01	**< 0.001**
Clutch size	-0.2431	0.01411	10010	-17.23	**< 0.001**

Number of rain ECEs	-0.02431	0.01637	10320	-1.49	0.137
Number of rain ECEs (nestling stage)					
Mean temperature	0.1095	0.01805	10270	6.06	**< 0.001**
Lay date	-0.3367	0.02051	10400	-16.42	**< 0.001**
Clutch size	-0.2451	0.01414	10030	-17.33	**< 0.001**
Number of rain ECEs	**-0.07346**	0.01619	10270	-4.54	**< 0.001**

Table S3. Extreme climate events (binary) models: Outputs of linear mixed models for fledging mass with presence of at least 1 ECE (1% or 5%) during specific developmental stages (hatchling/nestling) as explanatory variables along with mean temperature during the relevant stage, laydate, and clutch size as fixed effects. Year of birth, brood identity, mother identity and natal nest box are included as random effects. All fixed effects are scaled to a mean of zero and standard deviation of one. Significant terms (*p <0.05)* are in bold.

Variable	**β**	**Std. Error**	**df**	**t**	**p**	**β**	**Std. Error**	**df**	**t**	**p**
Presence of at least 1 hot (1%) ECE (hatchling)						*Presence of at least 1 hot (5%) ECE (hatchling)*				
Presence of hot ECE	-0.014	0.018	10220	-0.797	0.425	0.047	0.02	10270	2.319	0.0204
Mean temperature	0.095	0.023	9981	4.221	**< 0.001**	0.048	0.025	10120	1.866	0.0621
Clutch size	-0.244	0.014	10010	-17.26	**< 0.001**	-0.241	0.014	10010	-17.089	**< 0.001**
Lay date	-0.329	0.02	10370	-16.054	**< 0.001**	-0.314	0.021	10420	-14.98	**< 0.001**
Presence of at least 1 hot (1%) ECE (nestling)						*Presence of at least 1 hot (5%) ECE (nestling)*				
Presence of hot ECE	0.023	0.02	10210	1.138	0.255	0.012	0.02	10170	0.597	0.551
Mean temperature	0.11	0.02	10340	5.479	**< 0.001**	0.113	0.022	10370	5.18	**< 0.001**
Clutch size	-0.248	0.014	10040	-17.533	**< 0.001**	-0.248	0.014	10040	-17.547	**< 0.001**
Lay date	-0.343	0.021	10480	-16.539	**< 0.001**	-0.344	0.021	10520	-16.164	**< 0.001**
Presence of at least 1 cold (1%) ECE (hatchling)						*Presence of at least 1 cold (5%) ECE (hatchling)*				

Presence of cold ECE	0.013	0.013	10240	1.004	0.315	-0.031	0.02	10270	-1.582	0.113785
Mean temperature	0.088	0.019	10070	4.504	**< 0.001**	0.071	0.021	10100	3.339	**< 0.001**
Clutch size	-0.244	0.014	10010	-17.259	**< 0.001**	-0.243	0.014	10010	-17.239	**< 0.001**
Lay date	-0.328	0.02	10400	-16.158	**< 0.001**	-0.324	0.02	10400	-15.982	**< 0.001**
Presence of at least 1 cold (1%) ECE (nestling)						*Presence of at least 1 cold (5%) ECE (nestling)*				
Presence of cold ECE	0.087	0.017	9390	4.983	**< 0.001**	0.096	0.017	10280	5.667	**< 0.001**
Mean temperature	0.132	0.018	10330	7.333	**< 0.001**	0.174	0.02	10310	8.614	**< 0.001**
Clutch size	-0.249	0.014	10030	-17.662	**< 0.001**	-0.251	0.014	10050	-17.776	**< 0.001**
Lay date	-0.356	0.02	10500	-17.416	**< 0.001**	-0.369	0.021	10520	-17.817	**< 0.001**
Presence of at least 1 rain (1%) ECE (hatchling)						*Presence of at least 1 rain (5%) ECE (hatchling)*				
Presence of rain ECE	-0.041	0.016	10160	-2.578	**0.00995**	-0.012	0.016	10240	-0.751	0.453
Mean temperature	0.084	0.019	10070	4.324	**< 0.001**	0.084	0.02	10080	4.293	**< 0.001**
Clutch size	-0.243	0.014	10000	-17.235	**< 0.001**	-0.243	0.014	10000	-17.242	**< 0.001**
Lay date	-0.325	0.02	10410	-16.065	**< 0.001**	-0.325	0.02	10400	-16.058	**< 0.001**
Presence of at least 1 rain (1%) ECE (nestling)						*Presence of at least 1 rain (5%) ECE (nestling)*				
Presence of rain ECE	-0.042	0.017	10200	-2.488	0.0129	-0.077	0.016	10270	-4.86	**< 0.001**
Mean temperature	0.115	0.018	10300	6.364	**< 0.001**	0.105	0.018	10270	5.786	**< 0.001**
Clutch size	-0.248	0.014	10040	-17.554	**< 0.001**	-0.246	0.014	10030	-17.39	**< 0.001**
Lay date	-0.343	0.02	10450	-16.773	**< 0.001**	-0.341	0.02	10450	-16.7	**< 0.001**

Table S4. Interaction models (ambient climate x ECE frequency): Outputs of linear mixed models for fledging mass with number of ECEs during specific developmental stages (hatchling/nestling) interacting with relevant ambient climate measures as predictors, along with laydate and clutch size as fixed effects. Year of birth, brood identity, mother identity and natal nest box are included as random effects. All fixed effects are scaled to a mean of zero and standard deviation of one. Significant terms ($p < 0.05$) are in bold. Here, ECEs are calculated with a 5% threshold.

Variable	Estimate	Std. Error	df	t	p
Average temperature x number of rain ECEs (hatchling stage)					
Mean temperature	0.10280	0.02055	10040	5.000	**< 0.001**
(Mean temperature)^2	-0.08914	0.01140	10160	-7.816	**< 0.001**
Number of rain ECEs	-0.008569	0.01932	10200	-0.443	0.657
Number of rain ECEs x mean temp	**-0.08596**	0.01729	10580	-4.973	**< 0.001**
Number of rain ECEs x (mean temp)^2	-0.01853	0.01240	10370	-1.494	0.135
Lay date	-0.32330	0.02031	10360	-15.915	**< 0.001**
Clutch size	-0.24490	0.01408	10020	-17.391	**< 0.001**
Average temperature x number of rain ECEs (nestling stage)					
Mean temperature	0.12780	0.01871	10300	6.831	**< 0.001**
(Mean temperature)^2	-0.04408	0.01047	10160	-4.210	**< 0.001**
Number of rain ECEs	**-0.09363**	**0.01879**	10290	-4.983	**< 0.001**
Number of rain ECEs x mean temp	-0.01330	0.01887	10240	-0.705	0.4808
Number of rain ECEs x (mean temp)^2	0.02973	0.01329	10150	2.236	0.0253
Lay date	-0.33750	0.02056	10410	-16.418	**< 0.001**
Clutch size	-0.24470	0.01413	10020	-17.317	**< 0.001**
Average rainfall x number of hot ECEs (hatchling stage)					

Mean rainfall	-0.08781	0.01867	10280	-4.703	**< 0.001**
Number of hot ECEs	**-0.06939**	0.02115	10340	-3.282	**0.00104**
Number of hot ECEs x mean rainfall	**-0.16190**	0.02197	10230	-7.367	**< 0.001**
Lay date	-0.28250	0.01872	10490	-15.088	**< 0.001**
Clutch size	0.23510	0.01405	9984	-16.729	**< 0.001**
Average rainfall x number of hot ECEs (nestling stage)					
Mean rainfall	-0.11430	0.01682	10170	-6.795	**< 0.001**
Number of hot ECEs	**0.12860**	0.02045	9950	6.288	**< 0.001**
Number of hot ECEs x mean rainfall	0.05163	0.02041	10120	2.530	0.0114
Lay date	-0.28690	0.01864	10500	-15.389	**< 0.001**
Clutch size	-0.23560	0.01403	10010	-16.800	**< 0.001**
Average rainfall x number of cold ECEs (hatchling stage)					
Mean rainfall	-0.05072	0.01831	10240	-2.770	**0.00561**
Number of cold ECEs	**-0.08035**	0.01874	10080	-4.287	**< 0.001**
Number of cold ECEs x mean rainfall	0.03919	0.01985	10170	1.974	0.04838
Lay date	-0.30360	0.01890	10510	-16.070	**< 0.001**
Clutch size	-0.24000	0.01407	9986	-17.059	**< 0.001**
Average rainfall x number of cold ECEs (nestling stage)					
Mean rainfall	-0.14640	0.01593	10200	-9.190	**< 0.001**
Number of cold ECEs	0.03267	0.01587	9979	2.059	0.03952

Number of cold ECEs x mean rainfall	0.05829	0.01624	10040	3.589	**0.000334**
Lay date	-0.28960	0.01870	10470	-15.488	**< 0.001**
Clutch size	-0.23540	0.01404	10010	-16.767	**< 0.001**

Table S5. Interaction models (relative laydate x ECE frequency): Outputs of linear mixed models for fledging mass with number of ECEs during specific developmental stages (hatchling/nestling) interacting with relative lay date as predictors, along with mean temperature and clutch size as fixed effects. Year of birth, brood identity, mother identity and natal nest box are included as random effects. All fixed effects are scaled to a mean of zero and standard deviation of one. Significant terms (*p <0.05)* are in bold. Here, ECEs are calculated with a 5% threshold.

Variable	Estimate	Std. Error	df	t	p
Base model for relative laydate					
Relative laydate	-0.13960	0.01443	10010	-9.676	**< 0.001**
(Relative laydate)^2	**-0.04080**	0.00464	10890	-8.791	**< 0.001**
Clutch size	-0.23560	0.01404	9973	-16.787	**< 0.001**
Relative laydate x number of hot ECEs (hatchling stage)					
Relative laydate	-0.16190	0.01596	10250	-10.144	**< 0.001**
(Relative laydate)^2	-0.04306	0.00465	10860	-9.268	**< 0.001**
Mean temperature	0.11280	0.02724	9227	4.142	**< 0.001**
Number of hot ECEs	-0.02641	0.02388	9812	-1.106	0.269
Number of hot ECEs x relative laydate	**-0.06710**	0.01295	10070	-5.181	**< 0.001**

Number of hot ECEs x (relative laydate)^2	0.006421	0.00493	9379	1.304	0.192
Clutch size	-0.23970	0.01409	9983	-17.008	**< 0.001**
Relative laydate x number of hot ECEs (nestling stage)					
Relative laydate	-0.15770	0.01646	10420	-9.586	**< 0.001**
(Relative laydate)^2	-0.03956	0.00467	10900	-8.480	**< 0.001**
Mean temperature	0.05694	0.02365	10070	2.407	0.01609
Number of hot ECEs	0.07277	0.02432	9859	2.992	**0.00278**
Number of hot ECEs x relative laydate	0.01174	0.01738	10020	0.676	0.49926
Number of hot ECEs x (relative laydate)^2	0.00822	0.00490	9755	1.677	0.09364
Clutch size	-0.24110	0.01414	10030	-17.049	**< 0.001**
Relative laydate x number of cold ECEs (hatchling stage)					
Relative laydate	-0.1575	0.01522	10170	-10.349	**< 0.001**
(Relative laydate)^2	-0.04095	0.00501	10930	-8.173	**< 0.001**
Mean temperature	0.07051	0.02191	9871	3.218	**0.0013**
Number of cold ECEs	-0.01598	0.02347	9912	-0.681	0.4960
Number of cold ECEs x relative laydate	**0.1000**	0.01585	10420	6.313	**< 0.001**
Number of cold ECEs x (relative laydate)^2	-0.01439	0.00772	10770	-1.864	0.0623
Clutch size	-0.2368	0.01404	9998	-16.861	**< 0.001**
Relative laydate x number of cold ECEs (nestling stage)					

Relative laydate	-0.1964	0.01594	10410	-12.321	**< 0.001**
(Relative laydate)^2	-0.0441	0.00497	10890	-8.881	**< 0.001**
Mean temperature	0.1621	0.02069	9708	7.834	**< 0.001**
Number of cold ECEs	0.1432	0.02270	9561	6.305	**< 0.001**
Number of cold ECEs x relative laydate	**0.0377**	0.01279	10040	2.945	**0.00324**
Number of cold ECEs x (relative laydate)^2	**-0.0394**	0.00885	10680	-4.449	**< 0.001**
Clutch size	-0.2491	0.01409	10040	-17.682	**< 0.001**
Relative laydate x number of rain ECEs (hatchling stage)					
Relative laydate	-0.1643	0.01522	10170	-10.796	**< 0.001**
(Relative laydate)^2	-0.04215	0.00464	10900	-9.076	**< 0.001**
Mean temperature	0.09277	0.01939	9775	4.784	**< 0.001**
Number of rain ECEs	0.00335	0.01818	10270	0.184	0.854
Number of rain ECEs x relative laydate	0.06374	0.01318	10360	4.835	**< 0.001**
Number of rain ECEs x (relative laydate)^2	-0.01935	0.00481	10600	-4.020	**< 0.001**
Clutch size	-0.2414	0.01404	9990	-17.193	**< 0.001**
Relative laydate x number of rain ECEs (nestling stage)					
Relative laydate	-0.1650	0.01582	10350	-10.433	**< 0.001**
(Relative laydate)^2	-0.04319	0.00479	10930	-9.024	**< 0.001**
Mean temperature	0.09695	0.01805	10060	5.372	**< 0.001**
Number of rain ECEs	**-0.05820**	0.01751	10160	-3.323	**0.000893**

Number of rain ECEs x relative laydate	-0.01501	0.01628	10190	-0.922	0.356464
Number of rain ECEs x (relative laydate)^2	**-0.01414**	0.00606	10550	-2.334	**0.019614**
Clutch size	-0.2411	0.01410	10010	-17.100	**< 0.001**

Table S6. Local recruitment models: Outputs of generalised linear mixed models for recruitment probability with number of ECEs during specific developmental stages (hatchling/nestling) as predictors, along with clutch size as fixed effect. Outputs of additional models with laydate as fixed effect have also been detailed below. ECEs are treated here as categorical variables. Year of birth, brood identity, mother identity and natal nest box are included as random effects. All fixed effects are scaled to a mean of zero and standard deviation of one. Significant terms (*p <0.05)* are in bold. Here, ECEs are calculated with a 5% threshold.

Variable	β	Std. Error	z	p	β	Std. Error	z	p
Number of Cold ECEs (hatchling stage)					*with laydate*			
1 Cold ECE	**-0.2418**	0.07388	-3.273	**0.00106**	-0.14016	0.07507	-1.867	0.0619
2 Cold ECEs	-0.02525	0.08889	-0.284	0.77642	-0.03618	0.08958	-0.404	0.6863
3 Cold ECEs	**-0.26187**	0.10499	-2.494	**0.01262**	**-0.22566**	0.10568	-2.135	**0.0327**
4+ Cold ECEs	**-0.30369**	0.12826	-2.368	**0.01789**	-0.20996	0.13088	-1.604	0.1087
Mean temperature	-0.14797	0.02337	-6.332	**< 0.001**	-0.03616	0.02486	-1.454	0.1459
Clutch size	-0.04323	0.01513	-2.858	**0.00427**	-0.1079	0.01591	-6.783	**< 0.001**
Lay date	–	–	–	**–**	-0.33045	0.02486	-13.295	**< 0.001**
Number of Cold ECEs (nestling stage)					*with laydate*			
1 Cold ECE	**-0.15801**	0.06662	-2.372	**0.017695**	-0.02927	0.0683	-0.429	0.6683
2 Cold ECEs	0.041865	0.13519	0.31	0.756821	0.1619	0.13507	1.199	0.2307

3 Cold ECEs	0.004844	0.12191	0.04	0.968308	0.19524	0.12305	1.587	0.1126
4+ Cold ECEs	**-0.56687**	0.15759	-3.597	**0.000322**	-0.16141	0.16179	-0.998	0.3184
Mean temperature	-0.17697	0.02122	-8.337	**< 0.001**	-0.04842	0.02408	-2.011	**0.0444**
Clutch size	-0.04353	0.01513	-2.878	**0.004008**	-0.10503	0.01599	-6.569	**< 0.001**
Lay date	–	–	–	–	-0.31035	0.0259	-11.984	**< 0.001**
Number of Rain ECEs (hatchling stage)					*with laydate*			
1 Rain ECE	-0.04466	0.04182	-1.068	0.2856	-0.005418	0.042032	-0.129	0.897
2 Rain ECEs	-0.07559	0.06781	-1.115	0.2649	-0.035606	0.068786	-0.518	0.605
3+ Rain ECEs	0.13694	0.19798	0.692	0.4891	0.120993	0.205366	0.589	0.556
Mean temperature	-0.12121	0.02063	-5.874	**< 0.001**	-0.011484	0.022206	-0.517	0.605
Clutch size	-0.04333	0.01513	-2.863	**0.0042**	-0.110118	0.015911	-6.921	**< 0.001**
Lay date	–	–	–	–	-0.33384	0.024779	-13.473	**< 0.001**
Number of Rain ECEs (nestling stage)					*with laydate*			
1 Rain ECE	-0.002987	0.042626	-0.07	0.9441	-0.016176	0.042829	-0.378	0.7057
2 Rain ECEs	-0.079729	0.062284	-1.28	0.2005	-0.001325	0.063122	-0.021	0.9833
3+ Rain ECEs	**-0.275035**	0.128208	-2.145	**0.0319**	-0.114075	0.129947	-0.878	0.38
Mean temperature	-0.149838	0.01889	-7.932	**< 0.001**	-0.051995	0.020788	-2.501	**0.0124**
Clutch size	-0.040311	0.015127	-2.665	**0.0077**	-0.105978	0.015981	-6.632	**< 0.001**
Lay date	–	–	–	–	-0.313345	0.025328	-12.371	**< 0.001**
Number of Hot ECEs (hatchling stage)					*with laydate*			
1 Hot ECE	**0.12491**	0.0626	1.995	**0.046018**	-0.022391	0.064208	-0.349	0.727

2 Hot ECEs	**0.34596**	0.0948	3.649	**0.000263**	0.031739	0.098806	0.321	0.748
3 Hot ECEs	**0.24191**	0.10574	2.288	**0.022148**	-0.164768	0.111179	-1.482	0.138
4 Hot ECEs	**0.46152**	0.1761	2.621	**0.008771**	0.088114	0.180568	0.488	0.626
5+ Hot ECEs	**0.52201**	0.15026	3.474	**0.000513**	0.029637	0.156089	0.19	0.849
Mean temperature	-0.19485	0.02826	-6.895	**< 0.001**	-0.001021	0.032092	-0.032	0.975
Clutch size	-0.04543	0.01514	-3.002	**0.002686**	-0.111208	0.015944	-6.975	**< 0.001**
Lay date	–	–	–	**–**	-0.338837	0.025942	-13.061	**< 0.001**
Number of Hot ECEs (nestling stage)					*with laydate*			
1 Hot ECE	**0.23385**	0.05376	4.35	**< 0.001**	0.08144	0.05566	1.463	0.143399
2 Hot ECEs	**0.34338**	0.08938	3.842	**0.000122**	0.1952	0.09084	2.149	**0.031642**
3 Hot ECEs	**0.52889**	0.10655	4.964	**< 0.001**	0.23387	0.11032	2.12	**0.034011**
4 Hot ECEs	**0.55928**	0.11811	4.735	**< 0.001**	0.23986	0.12172	1.971	**0.048772**
5+ Hot ECEs	**0.7122**	0.12106	5.883	**< 0.001**	0.27359	0.12834	2.132	**0.033026**
Mean temperature	-0.25472	0.02409	-10.572	**< 0.001**	-0.09981	0.02776	-3.595	**0.000324**
Clutch size	-0.04643	0.01515	-3.065	**0.002174**	-0.10275	0.01602	-6.416	**< 0.001**
Lay date	–	–	–	**–**	-0.29293	0.02654	-11.037	**< 0.001**

Table S7. Higher frequencies of ECEs were grouped into a single categorical level, due to the reduced number of individuals experiencing high frequencies of ECEs. Local recruitment models from Table 6 used categorical ECE variables for analysis. Blue shaded areas indicate the values that were combined for each type of ECE in each developmental period.

ECE type	**Frequency**							
	0	1	2	3	4	5	6	7
Hatchling								

Hot	68167	8084	2568	3262	595	633	565	61
Cold	70622	5036	4015	2382	1443	424	13	0
Rain	59522	17499	6432	459	23	0	0	0
Nestling								
Hot	60344	12561	3821	2537	2055	1594	934	84
Cold	74884	5902	994	1153	440	463	99	0
Rain	59181	16132	6890	1495	237	0	0	0

Table S8. Sensitivity of key fledging mass and recruitment models to inclusion of father identity as a random effect. Shown are fixed-effect estimates (on the standardised scale or logit scale, with standard errors) and random-effect standard deviations for models fitted with and without father identity. Across all model types, including father ID modestly reallocated variance among random effects but did not materially alter the magnitude, direction, or statistical significance of climatic, ECE, clutch-size, or lay-date effects.

Average temperature (hatchling stage) - FLEDGING MASS		
Fixed effects	Estimate (SE) – no father ID	Estimate (SE) – with father ID
Mean temperature	0.120 (0.019)	0.0127 (0.019)
(Mean temperature)^2	-0.076 (0.01)	-0.071 (0.01)
Lay date	-0.334 (0.02)	-0.321 (0.02)
Clutch size	-0.247 (0.01)	-0.258 (0.01)
Random effects	Variance (SD)	Variance (SD)
Brood ID	1.180 (1.08)	0.869 (0.93)
nestbox	0.072 (0.27)	0.064 (0.25)
birthyear	0.724 (0.85)	0.663 (0.81)
Mother ID	0.252 (0.5)	0.210 (0.45)
Father ID	–	0.131 (0.36)
Residual	0.975 (0.98)	0.947 (0.97)

Average temperature (hatchling stage) – splines - FLEDGING MASS		
Fixed effects	Estimate (SE) – no father ID	Estimate (SE) – with father ID
Mean temperature.1	0.824 (0.15)	0.814 (0.14)
Mean temperature.2	0.601 (0.17)	0.571 (0.17)
Mean temperature.3	0.790 (0.12)	0.732 (0.12)
Mean temperature.4	0.723 (0.38)	0.680 (0.36)
Mean temperature.5	0.0359 (0.22)	0.284 (0.21)
Lay date	-0.331 (0.02)	-0.319 (0.02)
Clutch size	-0.247 (0.01)	-0.259 (0.01)
Random effects	Variance (SD)	Variance (SD)
Brood ID	1.178 (1.08)	0.865 (0.93)
nestbox	0.072 (0.27)	0.063 (0.25)
birthyear	0.717 (0.84)	0.657 (0.81)
Mother ID	0.253 (0.5)	0.212 (0.46)
Father ID	–	0.131 (0.36)
Residual	0.975 (0.98)	0.947 (0.97)

Average rainfall (nestling stage) - FLEDGING MASS		
Fixed effects	Estimate (SE) – no father ID	Estimate (SE) – with father ID
Mean rainfall	-0.143 (0.015)	-0.149 (0.015)
Lay date	-0.285 (0.018)	-0.271 (0.018)
Clutch size	-0.234 (0.014)	-0.245 (0.014)
Random effects	Variance (SD)	Variance (SD)
Brood ID	1.178 (1.08)	0.869 (0.93)
nestbox	0.072 (0.27)	0.064 (0.25)

birthyear	0.684 (0.82)	0.624 (0.79)
Mother ID	0.252 (0.5)	0.212 (0.46)
Father ID	–	0.127 (0.36)
Residual	0.975 (0.98)	0.947 (0.97)

Number of hot ECEs (nestling stage) - FLEDGING MASS

Fixed effects	Estimate (SE) – no father ID	Estimate (SE) – with father ID
No. of hot ECEs	0.091 (0.02)	0.07 (0.02)
Mean temperature	0.061 (0.02)	0.08 (0.02)
Lay date	-0.32 (0.02)	-0.31 (0.02)
Clutch size	-0.24 (0.01)	-0.25 (0.01)
Random effects	Variance (SD)	Variance (SD)
Brood ID	1.181 (1.08)	0.87 (0.93)
nestbox	0.072 (0.27)	0.065 (0.25)
birthyear	0.744 (0.86)	0.68 (0.82)
Mother ID	0.252 (0.5)	0.210 (0.45)
Father ID	–	0.129 (0.36)
Residual	0.975 (0.98)	0.947 (0.97)

Number of cold ECEs (hatchling stage) - FLEDGING MASS

Fixed effects	Estimate (SE) – no father ID	Estimate (SE) – with father ID
No. of cold ECEs	-0.07 (0.02)	-0.06 (0.02)
Mean temperature	0.05 (0.02)	0.063 (0.02)
Lay date	-0.32 (0.02)	-0.31 (0.02)
Clutch size	-0.24 (0.01)	-0.25 (0.01)
Random effects	Variance (SD)	Variance (SD)

Brood ID	1.184 (1.08)	0.87 (0.93)
nestbox	0.072 (0.27)	0.063 (0.25)
birthyear	0.717 (0.86)	0.65 (0.82)
Mother ID	0.255 (0.5)	0.211 (0.45)
Father ID	–	0.131 (0.36)
Residual	0.975 (0.98)	0.947 (0.97)

Average temperature x number of rain ECEs (hatchling stage) - FLEDGING MASS

Fixed effects	Estimate (SE) – no father ID	Estimate (SE) – with father ID
Mean temp	0.103 (0.021)	0.105 (0.020)
Mean temp²	–0.089 (0.011)	–0.086 (0.011)
No of Rain ECEs	–0.009 (0.019)	–0.014 (0.019)
Temp × rain ECE	–0.086 (0.017)	–0.081 (0.017)
Temp² × rain ECE	–0.019 (0.012)	–0.026 (0.012)
Lay date	–0.323 (0.020)	–0.310 (0.020)
Clutch size	–0.245 (0.014)	–0.256 (0.014)
Random effects	Variance (SD)	Variance (SD)
Brood ID	1.177 (1.08)	0.87 (0.93)
nestbox	0.072 (0.27)	0.063 (0.25)
birthyear	0.701 (0.83)	0.64 (0.79)
Mother ID	0.252 (0.5)	0.209 (0.45)
Father ID	–	0.134 (0.36)
Residual	0.975 (0.98)	0.947 (0.97)

Number of cold ECEs (hatchling stage) - LOCAL RECRUITMENT		
Fixed effects	Estimate (SE) – no father ID	Estimate (SE) – with father ID
Mean temperature	–0.036 (0.025)	–0.032 (0.026)
1 cold day	–0.140 (0.075)	–0.132 (0.078)
2 cold days	–0.036 (0.090)	–0.012 (0.093)
3 cold days	–0.226 (0.106)	–0.214 (0.108)
4+ cold days	–0.210 (0.131)	–0.197 (0.134)
Clutch size	–0.108 (0.016)	–0.118 (0.017)
Lay date	–0.330 (0.025)	–0.319 (0.026)
Random effects	Variance (SD)	Variance (SD)
Brood ID	0.208 (0.45)	0.138 (0.37)
nestbox	0.023 (0.15)	0.025 (0.16)
birthyear	0.431 (0.65)	0.414 (0.64)
Mother ID	0.06 (0.24)	0.036 (0.19)
Father ID	–	0.083 (0.28)

Table S9. Robustness of nestling-stage ECE effects to potential carry-over from hatchling exposure. All effects are standardized (SD units). Positive interactions indicate greater nestling-stage effects for chicks with prior hatchling exposure; negative interactions indicate reduced effects.

ECE Type	**Analysis**	**N**	**Estimate (SE)**	**df**	**t-value**	**p-value**
Cold	Full dataset	83,935	0.091 (0.018)	9961	4.94	<0.001
	No hatchling ECEs	70,622	0.086 (0.022)	7527	3.88	<0.001
	Hatchling ECE x Nestling ECE	83,935	-0.024 (0.015)	10140	-1.62	0.106

Rain	Full dataset	83,935	-0.074 (0.016)	10270	-4.54	<0.001
	No hatchling ECEs	59,522	-0.089 (0.022)	7009	-4.09	<0.001
	Hatchling ECE x Nestling ECE	83,935	-0.039 (0.016)	10300	-2.38	0.017
Hot	Full dataset	83,935	0.091 (0.024)	10180	3.81	<0.001
	No hatchling ECEs	68,167	0.062 (0.028)	8091	2.22	0.027
	Hatchling ECE x Nestling ECE	83,935	0.043 (0.015)	9984	2.86	0.004

Path analysis for disentangling the effects of laydate on fledging mass

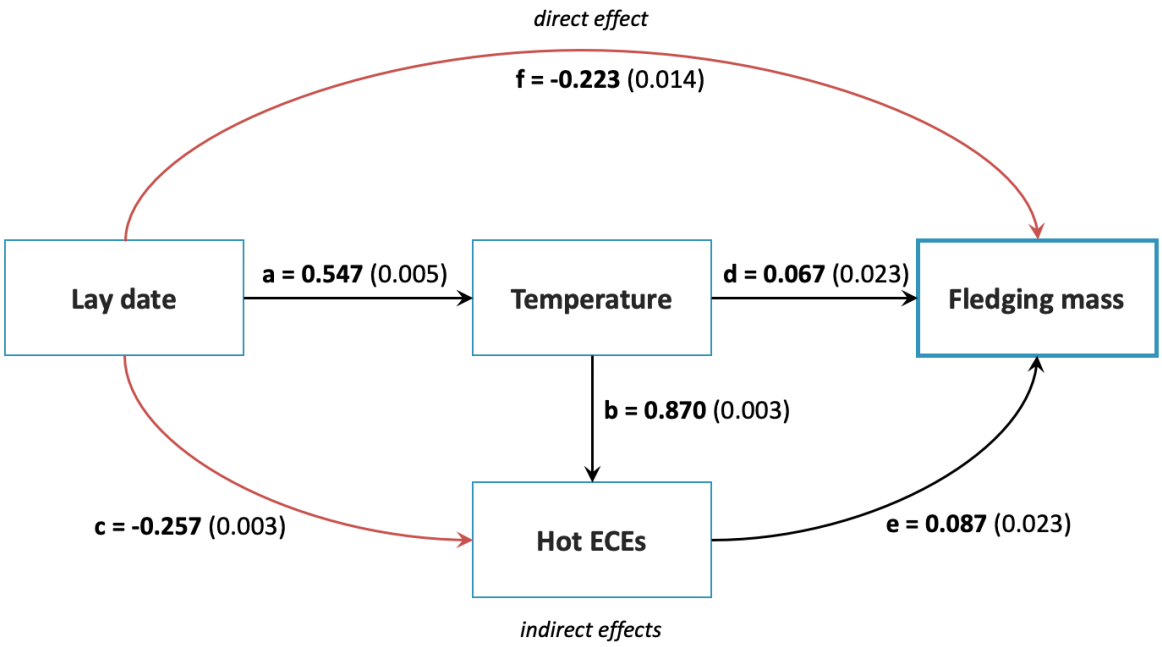

Figure S1. Path diagram showing standardized regression coefficients (β) for lay date, temperature, ECEs, and chickweight relationships. Positive relationships are shown in black, negative relationships in red.

Methodology: We constructed 3 linear mixed models (using lme4) with random effects (RE) of year of birth, brood identity, mother identity and natal nest box. Clutch size was included as a covariate to account for its well-established effect on fledging weight. Indirect effects calculated as products of constituent paths.

Model 1: **Average temperature ~ relative laydate** + RE
Model 2: **Number of hot ECEs ~ relative laydate + average temperature**
Model 3: **Fledging mass ~ relative laydate + average temperature + number of hot ECEs** + clutch size + RE

Paths were constructed as follows:

Path a: laydate → temp (model 1) = +0.547
Path b: temp → ECE (model 2) = +0.870
Path c: laydate → ECE (model 2) = -0.257
Path d: temp → chickweight (model 3) = +0.0677
Path e: ECE → chickweight (model 3) = +0.0870
Path f: laydate → chickweight (model 3) = -0.2232

Direct effect of laydate on mass = f = -0.2232
Indirect effects of laydate on mass via temperature and ECEs =

(a * d) + (a * b * e) + (c * e) = (0.547 × 0.0677) + (0.547 x 0.870 x 0.087) + (-0.257 × 0.0870)

Here, (a*d) are laydate effects via temperature only,
(a*b*e) are laydate effects via indirect temperature effects via ECEs,
And (c*e) are laydate effects on mass via ECEs only.

Thus, overall indirect effects of laydate are = 0.0371 - 0.0223 + 0.0414 = 0.0562

Total laydate effects = f + 0.0562 = **-0.167**
And thus, weather-mediated indirect effects are 33.6% of the total laydate effects on fledging mass

Table S10. Path analysis coefficients, standard errors, and t-values

Variable	Estimate	Std. Error	df	t	p	vif
Model 1: average temp ~ relative laydate						
Relative laydate	0.5475	0.005	6181	97.41	**< 0.001**	–
Model 2: Hot ECEs ~ relative laydate + average temperature						
Relative laydate	-0.257	0.003	–	-75.83	**< 0.001**	1.094851

Average temperature	0.870	0.003	–	255.39	**< 0.001**	1.094851
Model 3: Fledging mass ~ relative laydate + average temperature + hot ECEs						
Relative laydate	-0.223	0.014	10840	-15.397	**< 0.001**	1.446125
Average temperature	0.067	0.023	10104	2.864	**0.004**	2.086233
Number of hot ECEs	0.087	0.023	9887	3.646	**< 0.001**	1.753853
Clutch size	-0.246	0.014	10060	-17.36	**< 0.001**	1.103718

Table S11. Average temperatures during Hot ECE exposure comparing very early broods (≤15th percentile relative laydate within each cohort year) and very late (≥85th percentile). Hot ECEs defined as daily mean temperature ≥+4.52°C above monthly mean temperature.

Brood Timing	ECE Count	Mean Temperature (°C)	Number of Broods (n)	Mean Temperature (°C)	Number of Broods (n)
		HATCHLING STAGE		*NESTLING STAGE*	
Early	0	10.8	1,413	11.4	1,386
Early	1	12.5	127	13.7	188
Early	2	13.6	88	13.6	40
Early	3	14.5	48	15.6	67
Early	4	15.6	7	14.6	17
Early	5	16.5	12	15.5	8
Early	6	16.5	30	16.5	17
Late	0	12.5	1,332	13.3	1,446
Late	1	13.9	210	15.2	118

Late	2	13.9	80	15.8	60
Late	3	16.3	34	17.2	30
Late	4	16.2	25	16.7	29
Late	5	15.8	22	16.8	23
Late	6	16.8	17	17.6	11

Table S12. Average temperatures during Cold ECE exposure comparing very early broods (≤15th percentile relative laydate within each cohort year) and very late (≥85th percentile). Cold ECEs defined as daily mean temperature ≤ -4.49°C below monthly mean temperature.

Brood Timing	ECE Count	Mean Temperature (°C)	Number of Broods (n)	Mean Temperature (°C)	Number of Broods (n)
		HATCHLING STAGE		*NESTLING STAGE*	
Early	0	11.8	1366	12.3	1517
Early	1	10.7	108	10.4	101
Early	2	9.2	115	8.8	45
Early	3	8.3	93	9.7	43
Early	4	7.6	42	7.9	10
Early	5	7.3	1	7.2	9
Late	0	13.1	1521	14	1527
Late	1	11.9	164	12.1	124
Late	2	10.9	15	11.3	7
Late	3	11.3	8	11.6	30
Late	4	9.4	4	9.9	12
Late	5	9.6	8	9.7	8

Late	6	9.3	1	9.3	13

Table S13. Average rainfall during Rain ECE exposure comparing very early broods (≤15th percentile relative laydate within each cohort year) and very late (≥85th percentile). Rain ECEs defined as total rainfall in 24 hours ≥ 6.20 mm above the monthly mean.

Brood Timing	ECE Count	Mean Rainfall (mm)	Number of Broods (n)	Mean Rainfall (mm)	Number of Broods (n)
		HATCHLING STAGE		*NESTLING STAGE*	
Early	0	1	1286	1.2	1225
Early	1	3.1	304	2.9	407
Early	2	4.4	107	4.6	88
Early	3	6	28	5.2	5
Late	0	1	1263	1.1	1264
Late	1	2.9	285	2.9	234
Late	2	4.4	151	4.6	173
Late	3	5.5	20	6.1	36
Late	4	8.4	2	6.7	14

Table S14a. Mean temperatures (ºC) experienced by broods during both hatchling and nestling periods, grouped by number of ECEs.

ECE type	ECE Count	Mean Temperature (ºC)	Number of Broods (n)	Mean Temperature (ºC)	Number of Broods (n)
		HATCHLING STAGE		*NESTLING STAGE*	
Hot	0	11.2	68167	12.2	60344
Hot	1	13.5	8084	13.7	12561

Hot	2	13.9	2568	14.4	3821
Hot	3	15.3	3262	15.9	2537
Hot	4	15.2	595	16.2	2055
Hot	5	15.7	633	16	1594
Hot	6	16.5	565	16.9	934
Hot	7	17	61	17.2	84
Cold	0	12.2	70622	13.1	74884
Cold	1	10.8	5036	12	5902
Cold	2	9.2	4015	10.3	994
Cold	3	9.4	2382	10.6	1153
Cold	4	7.9	1443	9.5	440
Cold	5	7.8	424	9.2	463
Cold	6	9.4	13	9.3	99

Table S14b. Mean rainfall (mm) experienced by broods during both hatchling and nestling periods, grouped by number of rain ECEs.

ECE type	ECE Count	Mean Rainfall (mm)	Number of Broods (n)	Mean Rainfall (mm)	Number of Broods (n)
		HATCHLING STAGE		*NESTLING STAGE*	
Rain	0	1.1	59522	1	59181
Rain	1	2.9	17499	2.9	16132
Rain	2	5.3	6432	4.7	6890
Rain	3	5.5	459	5.5	1495
Rain	4	7.8	23	6.8	237

Characterising ECEs using brood-specific windows

Methodology: To evaluate the robustness of our ECE metrics, we implemented an alternative, brood-specific approach to calculating temperature ECEs. In contrast to the main analyses, where daily deviations were calculated relative to monthly means across 1965–2024 to obtain fixed 5th/95th percentile thresholds (hot ECE ≥ +4.52°C, cold ECE ≤ −4.49°C), here we defined a local climatic baseline for each brood's developmental window.

For each brood, we first identified the hatch date (hd, in Julian days), and defined the two developmental periods used in the main analyses: hatchling period (P1: hd to hd+7) and nestling period (P2: hd+8 to hd+15). We then constructed a 31-day window centred on the midpoint of hd to hd+15 (i.e. ±15 days around hd+7). Using the full climate time series (1965–2024), we calculated the long-term mean temperature of this 31-day window across all years. Daily deviations in the focal brood year were then computed as the difference between the observed daily mean temperature and this brood-specific window mean. As in the main analyses, days with deviations ≥ +4.52°C were classified as hot ECEs and ≤ −4.49°C as cold ECEs.

For each brood and developmental stage (P1, P2), we summed the number of hot and cold ECE days under this brood-specific method and compared them to the original monthly-baseline ECE counts. We then re-fitted the linear mixed models for fledging mass using these alternative ECE frequencies to assess whether effect sizes and significance levels were sensitive to the choice of ECE definition.

Table S15a. Pearson correlations between original (monthly baseline) and brood-specific ECE counts across developmental stages. Bold values show within-ECE-type correlations between methods (original vs brood-specific). n = 10,892 broods.

	Hot ECE P1	**Hot ECE P2**	**Cold ECE P1**	**Cold ECE P2**
Hot ECE P1	**0.83**	0.13	-0.12	-0.03
Hot ECE P2	0.13	**0.90**	0.15	-0.08
Cold ECE P1	-0.12	0.15	**0.84**	0.09
Cold ECE P2	-0.03	-0.08	0.09	**0.70**

Table S15b. Linear mixed model parameter estimates for hot ECE effects: Original (monthly baseline) vs brood-specific window methods

NESTLING STAGE	Original method	Brood-specific method
Intercept	18.35 (SE = 0.113, t = 162.6, p < 0.001)	18.35 (SE = 0.112, t = 163.3, p < 0.001)
Mean Temperature	0.061 (SE = 0.024, t = 2.59, p = 0.010)	0.038 (SE = 0.025, t = 1.53, p = 0.126)
Laydate	-0.320 (SE = 0.022, t = -14.8, p < 0.001)	-0.309 (SE = 0.022, t = -14.2, p < 0.001)
Clutch size	-0.244 (SE = 0.014, t = -17.2, p < 0.001)	-0.244 (SE = 0.014, t = -17.2, p < 0.001)
Number of Hot ECEs	**0.091 (SE = 0.024, t = 3.81, p = 0.00014)**	**0.124 (SE = 0.025, t = 4.89, p < 0.0001)**
HATCHLING STAGE	**Original method**	**Brood-specific method**
Intercept	18.35 (SE = 0.111, t = 165.2, p < 0.001)	18.35 (SE = 0.111, t = 165.4, p < 0.001)
Mean Temperature	0.105 (SE = 0.027, t = 3.83, p = 0.00013)	0.082 (SE = 0.027, t = 3.09, p = 0.0020)
April laydate	-0.333 (SE = 0.021, t = -15.5, p < 0.001)	-0.325 (SE = 0.022, t = -14.9, p < 0.001)
Clutch size	-0.245 (SE = 0.014, t = -17.3, p < 0.001)	-0.243 (SE = 0.014, t = -17.2, p < 0.001)
Number of Hot ECEs	-0.022 (SE = 0.022, t = -0.99, p = 0.322)	0.004 (SE = 0.021, t = 0.21, p = 0.834)

Overall, the alternative brood-specific method produced highly correlated ECE counts and closely similar model estimates to the original method (see Table S15A, S15B and Fig. S2), indicating that our main conclusions are robust to the choice of climatic baseline. Distributions overlap strongly in all cases (r = 0.70–0.90), indicating close agreement between the two ECE calculation methods (Fig. S2).

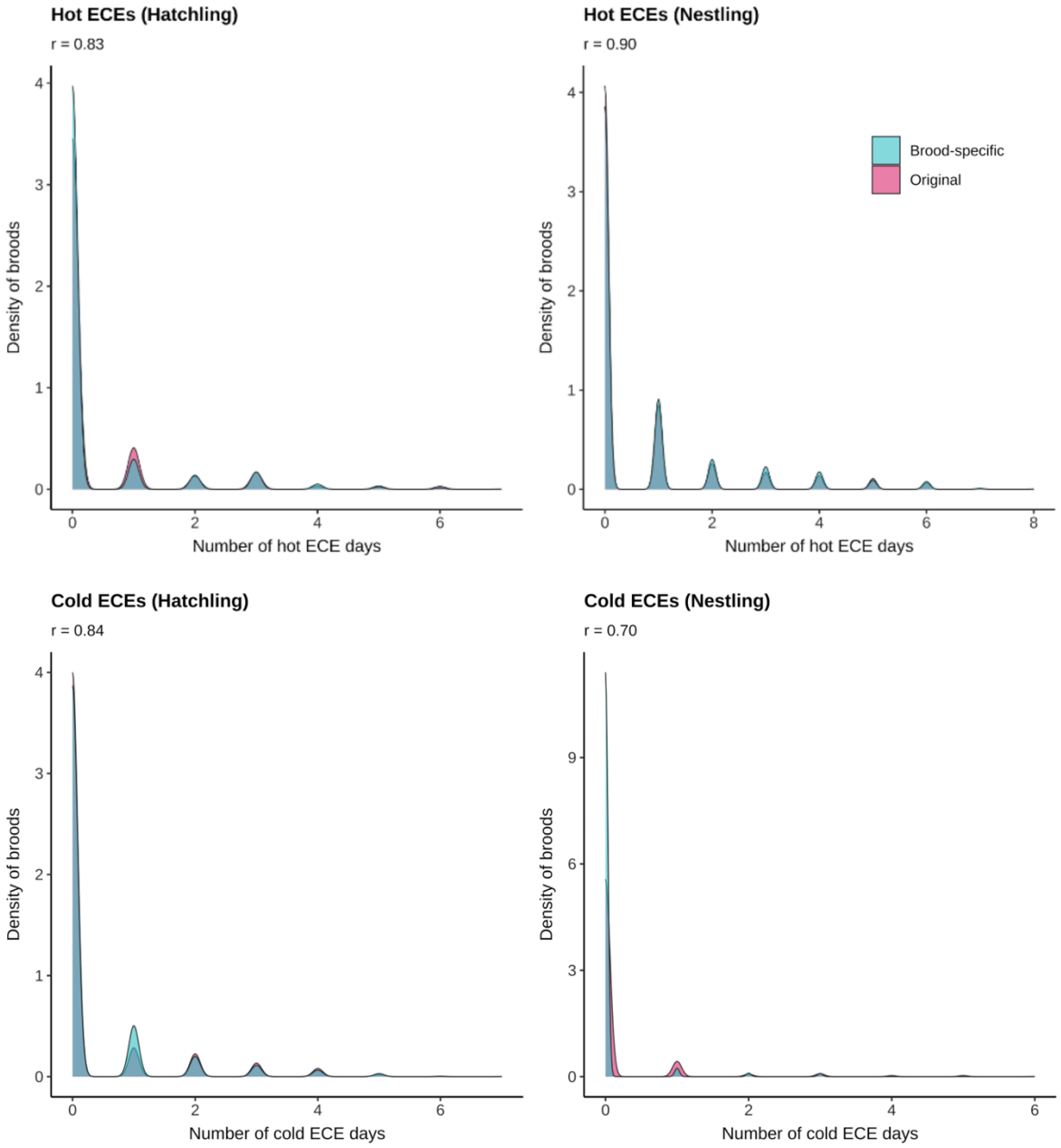

Figure S2. Comparison of ECE frequency estimates under the original (monthly baseline) and brood-specific window methods. Each plot shows distributions of the number of extreme temperature events (ECEs) per brood under the original monthly-baseline method (pink; "Original") and the brood-specific ±15-day window method (blue; "Brood-specific"). Plots show (A) hot ECEs during the hatchling stage, (B) hot ECEs during the nestling stage, (C) cold ECEs during the hatchling stage and (D) cold ECEs during the nestling stage. Reported Pearson correlation coefficients (r) indicate the strength of agreement in brood-level ECE counts between methods for each stage and ECE type.