Long-term fitness effects of the early-life environment in a wild bird population

Supplemental methods: unusual individuals

The senescence curves were potentially skewed by two extreme individuals, displayed in Figure 2 (the two oldest individuals) and Figure 3 (the only female and male that had data at Δage = -4, -3, 3 and 4). They are a female and a male that both lived for nine years, which is a rare long lifespan for wild house sparrows. Therefore, the analyses were rerun excluding these two individuals from the dataset. For the annual adult survival model, the interaction between age^2 and number of fledglings was no longer significant. Instead, the interaction between age and number of fledglings and the interaction between age^2 and natal environment became significant (Table S2).

For the reproduction models, the negative effect of noise in the natal environment on female annual genetic recruits remained significant (Table S3, Figure S1), but the effect of noise in the rearing environment on male annual genetic recruits disappeared (Table S3). Because we are confident that they are true data points, we kept these two individuals in the dataset and interpreted the models accordingly, but we highlight that the negative effect of the noise in the natal environment on female reproduction is the most robust effect and not driven by extreme long-lived individuals.

Table S1. Estimates from the full GLMM (before removing insignificant interactions) explaining annual adult survival by age in Lundy house sparrows. Levels and corresponding sample sizes for categorical effects: natal environment: noisy = 351, quiet = 1,336; rearing environment: noisy = 359, quiet = 1,328; sex: female = 797, male = 890. Significant highest-order fixed effects are in bold.

Fixed effects	**Level**	**Estimate**	**Std. Error**	**p**
(Intercept)		0.441	0.857	0.607
Age		-0.585	0.640	0.361
Age^2		0.121	0.101	0.229
Natal environment	Quiet	-0.538	0.584	0.357
Rearing environment	Quiet	-0.281	0.540	0.603
Number of hatchlings		0.031	0.070	0.660
Number of fledglings		-0.601	0.226	0.008
Sex	Male	-0.022	0.546	0.968
Natal brood order		-0.102	0.103	0.325
Foster brood order		-0.077	0102	0.449
Age × Natal environment	Quiet	0.596	0.479	0.214
Age × Rearing environment	Quiet	0.398	0.418	0.341
Age × Number of fledglings		0.440	0.197	0.341
Age × Sex	Male	-0.083	0.299	0.782
Age^2 × Natal environment	Quiet	-0.082	0.082	0.322
Age^2 × Rearing environment	Quiet	-0.102	0.072	0.158
Age^2 × Number of fledglings		-0.065	0.035	0.061
Age^2 × Sex	Male	-0.006	0.360	0.909
Natal environment × Rearing environment	Quiet × Quiet	-0.155	0.360	0.666
Natal environment × Sex	Quiet × Male	0.210	0.301	0.485
Rearing environment × Sex	Quiet × Male	0.360	0.302	0.232
Number of fledglings × Sex	Male	0.004	0.128	0.975

Random effects	**1,687 observations**	**Variance**
Bird ID	1,057 individuals	<0.001
Year	22 years	0.549
Natal brood ID	459 natal broods	0.181
Foster brood ID	449 foster broods	<0.001

Table S2 Estimates from the GLMM post-peak analysis for annual adult survival by age in Lundy house sparrows. Only data points after the peak (age = 3.4) and only linear effects were included. Levels and corresponding sample sizes for categorical effects: natal environment: noisy = 21, quiet = 141; rearing environment: noisy = 36, quiet = 126; sex: female = 68, male = 94.

Fixed effects	**Level**	**Estimate**	**Std. Error**	**p**
(Intercept)		1.802	1.865	0.334
Age		-0.255	0.403	0.375
Natal environment	Quiet	-0.274	0.568	0.629
Rearing environment	Quiet	-0.741	0.497	0.136
Number of hatchlings		0.073	0.207	0.725
Number of fledglings		-0.056	0.212	0.793
Sex	Male	0.011	0.362	0.977
Natal brood order		0.145	0.389	0.709
Foster brood order		-0.052	0.354	0.883
Random effects	**162 observations**	**Variance**		
Bird ID	84 individuals	<0.001		
Year	19 years	0.471		
Natal brood ID	71 natal broods	0.018		
Foster brood ID	71 foster broods	0.018		

Table S3 Estimates from the full GLMM (before removing insignificant interactions) explaining the number of annual genetic recruits by age in adult Lundy house sparrows. Levels and corresponding sample sizes for categorical effects: natal environment: noisy = 53 (female) and 58 (male), quiet = 221 (female) and 298 (male); rearing environment: noisy = 69 (female) and 58 (male), quiet = 205 (female) and 298 (male); last reproduction: no = 159 (female) and 222 (male), yes = 115 (female) and 134 (male). Significant highest-order fixed effects are in bold. Δage: within-individual-centered age.

Fixed effects	**Level**	**Estimate**	**Std. Error**	**P**	**Estimate**	**Std. Error**	**P**
			Female			**Male**	
(Intercept)		-3.634	0.855	<0.001	-2.000	0.851	0.019
Number of hatchlings		0.254	0.119	0.033	0.016	0.113	0.887
Number of fledglings		-0.080	0.122	0.512	0.058	0.125	0.643
Natal environment	Quiet	0.244	0.527	0.644	-0.660	0.616	0.284
Rearing environment	Quiet	0.188	0.598	0.754	0.318	0.580	0.583
Δage		-0.468	0.336	0.164	-0.531	0.392	0.175
Δage^2		-0.358	0.227	0.115	-0.544	0.293	0.063
Natal brood order		0.048	0.178	0.789	-0.043	0.190	0.821
Foster brood order		0.113	0.169	0.503	-0.160	0.174	0.355
Last reproduction	Yes	0.355	0.227	0.117	0.331	0.249	0.184
Mean age		**0.756**	**0.146**	**<0.001**	**0.787**	**0.166**	**<0.001**
Number of fledglings × Δage		0.074	0.090	0.411	-0.033	0.097	0.731

Natal environment × Δage	Quiet	-0.035	0.309	0.909	0.092	0.333	0.783
Rearing environment × Δage	Quiet	0.189	0.207	0.360	0.709	0.313	0.024
Number of fledglings × Δage^2		0.023	0.073	0.748	0.012	0.075	0.874
Natal environment × Δage^2	Quiet	0.219	0.203	0.279	0.391	0.297	0.188
Rearing environment × Δage^2	Quiet	-0.165	0.131	0.209	-0.129	0.224	0.563
Natal environment × Rearing environment	Quiet × Quiet	0.624	0.667	0.350	0.358	0.681	0.600
Random effects		**274 observations**		**Variance**	**356 observations**		**Variance**
Bird ID		133 individuals		<0.001	165 individuals		0.186
Year		20 years		0.296	21 years		0.563
Natal brood ID		108 natal broods		<0.001	148 natal broods		<0.001
Foster brood ID		111 foster broods		0.115	148 foster broods		<0.001

Table S4 Estimates from the GLMM explaining the number of annual genetic recruits by age in female house sparrows, with only one bird randomly sampled from each natal brood. Levels and corresponding sample sizes for categorical effects: natal environment: noisy = 48, quiet = 184; rearing environment: noisy = 60, quiet = 172; last reproduction (LR): no = 137, yes = 95. Significant highest-order fixed effects are in bold. Δage: within-individual-centered age.

Fixed effects	**Level**	**Estimate**	**Std. Error**	**P**
			Female	
(Intercept)		-3.659	0.790	<0.001
Number of hatchlings		**0.250**	**0.114**	**0.028**
Number of fledglings		-0.081	0.107	0.449
Natal environment	Quiet	**0.813**	**0.318**	**0.011**
Rearing environment	Quiet	0.426	0.250	0.088
Δage		-0.198	0.106	0.062
Δage^2		**-0.117**	**0.057**	**0.040**
Natal brood order		0.024	0.169	0.886
Foster brood order		0.117	0.159	0.463
Last reproduction	Yes	0.499	0.236	0.035
Mean age		**0.639**	**0.140**	**<0.001**
Random effects		**232 observations**		**Variance**
Bird ID		108 individuals		0.008
Year		20 years		0.338
Foster brood ID		108 foster broods		0.008

Table S5 Estimates from the GLMM explaining annual adult survival by age in Lundy house sparrows, with two extraordinarily long-lived individuals excluded (one male and one female). Levels and corresponding sample sizes for categorical effects: natal environment: noisy = 351, quiet = 1,316; rearing environment: noisy = 339, quiet = 1,328; sex: female = 787, male = 880. Significant highest-order fixed effects are in bold. Natal brood ID was removed from the random effects because it caused a convergence problem.

Fixed effects	**Level**	**Estimate**	**Std. Error**	**p**
(Intercept)		-0.496	0.679	0.465
Age		0.247	0.477	0.606
Age^2		-0.078	0.075	0.301
Natal environment	Quiet	-1.054	0.520	0.042
Rearing environment	Quiet	0.132	0.157	0.400
Number of hatchlings		0.034	0.069	0.618
Number of fledglings		-0.348	0.122	0.004
Sex	**Male**	**0.267**	**0.118**	**0.024**
Natal brood order		-0.094	0.101	0.351
Foster brood order		-0.077	0.100	0.446
Age × Natal environment		1.217	0.497	0.014
Age × Number of fledglings		**0.155**	**0.059**	**0.009**
Age^2 × Natal environment		**-0.236**	**0.088**	**0.008**
Random effects	**1,667 observations**	**Variance**		
Bird ID	**1,055 individuals**	**<0.001**		
Year	19 years	0.539		
Foster brood ID	448 foster broods	0.140		

Table S6 Estimates from the GLMM explaining the number of annual genetic recruits by age in female and then male Lundy house sparrows, with two extraordinarily long-lived individuals excluded (one male and one female). Levels and corresponding sample sizes for categorical effects: natal environment: noisy = 53 (female) and 58 (male), quiet = 212 (female) and 289 (male); rearing environment: noisy = 60 (female) and 49 (male), quiet = 205 (female) and 298 (male); last reproduction (LR): no = 151 (female) and 214 (male), yes = 114 (female) and 133 (male). Significant highest-order fixed effects are in bold. Natal Brood ID was removed from the random effects in the female model because it caused a convergence problem. Δage: within-individual-centered age.

Fixed effects	**Level**	**Estimate**	**Std. Error**	**P**	**Estimate**	**Std. Error**	**P**
			Female			**Male**	
(Intercept)		-3.967	0.823	<0.001	-2.335	0.709	0.001
Number of hatchlings		0.226	0.117	0.053	0.015	0.105	0.885
Number of fledglings		-0.088	0.110	0.423	0.003	0.107	0.978
Natal environment	Quiet	**0.895**	**0.360**	**0.013**	-0.011	0.267	0.966
Rearing environment	Quiet	0.327	0.267	0.220	0.036	0.296	0.904
Δage		-0.131	0.119	0.273	0.041	0.125	0.743
Δage^2		**-0.287**	**0.087**	**0.001**	**-0.400**	**0.090**	**<0.001**
Natal brood order		0.008	0.176	0.964	0.005	0.179	0.978
Foster brood order		0.087	0.169	0.608	-0.160	0.160	0.318
Last reproduction	Yes	**0.478**	**0.233**	**0.040**	**0.489**	**0.248**	**0.049**

Mean age	**0.949**	**0.175**	**<0.001**	**1.084**	**0.175**	**<0.001**
Random effects	**274 observations**		**Variance**	**347 observations**		**Variance**
Bird ID	133 individuals		<0.001	164 individuals		0.094
Year	18 years		0.351	16 years		0.493
Natal brood ID				147 natal broods		<0.001
Foster brood ID	111 foster broods		0.111	147 foster broods		<0.001

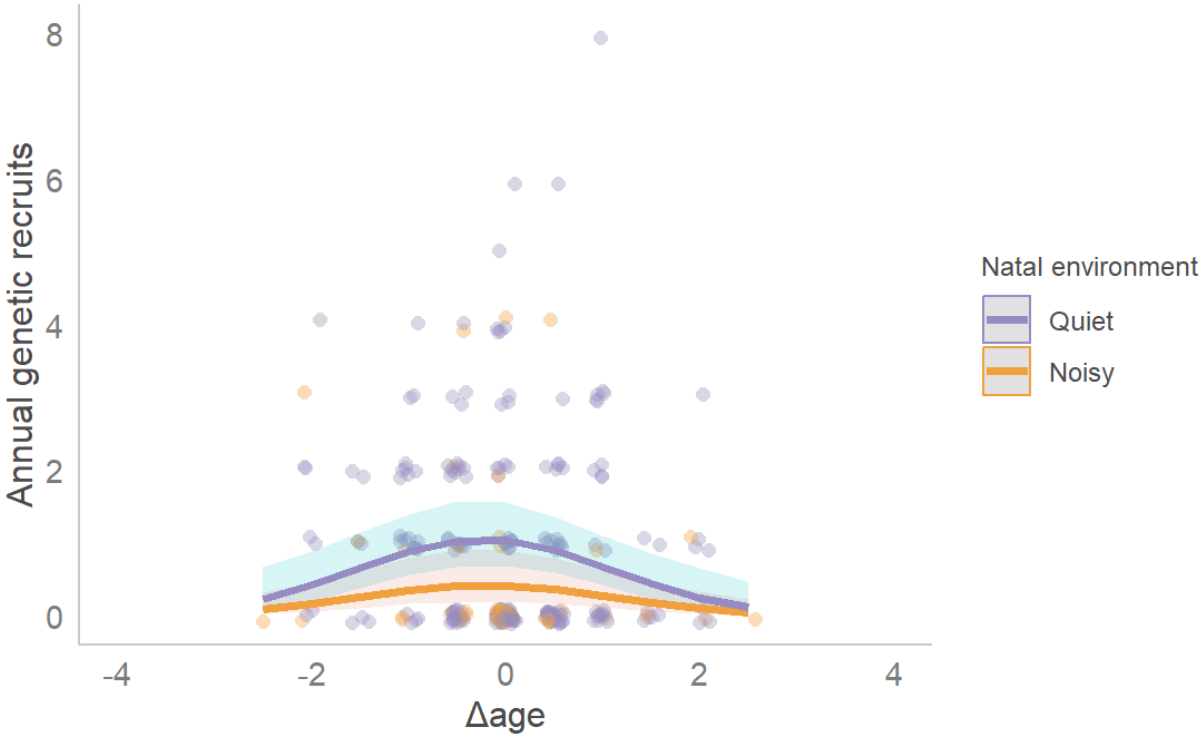

Figure S1 The number of annual genetic recruits in relationship to within-individual-centered age of adult female Lundy house sparrows, excluding the one exceptionally long-lived female. The mean ages of birds hatched in a noisy (orange) and quiet (purple) environment were: 1.8 y and 1.9 y. Each dot represents an observation; lines are predicted number of annual genetic recruits; shades represent 95% confidence intervals.