Supplementary material to:

Body mass ageing trajectory is modulated by environmental conditions but independent of lifespan

Michael Briga[1,3], Blanca Jimeno[1,2] and Simon Verhulst[1]

[1] Groningen Institute for Evolutionary Life Sciences, University of Groningen, Groningen, the Netherlands.

[2] Max Planck Institute for Ornithology, Seewiesen, Germany.

[3] Present address: Department of Biology, University of Turku, Turku, Finland.

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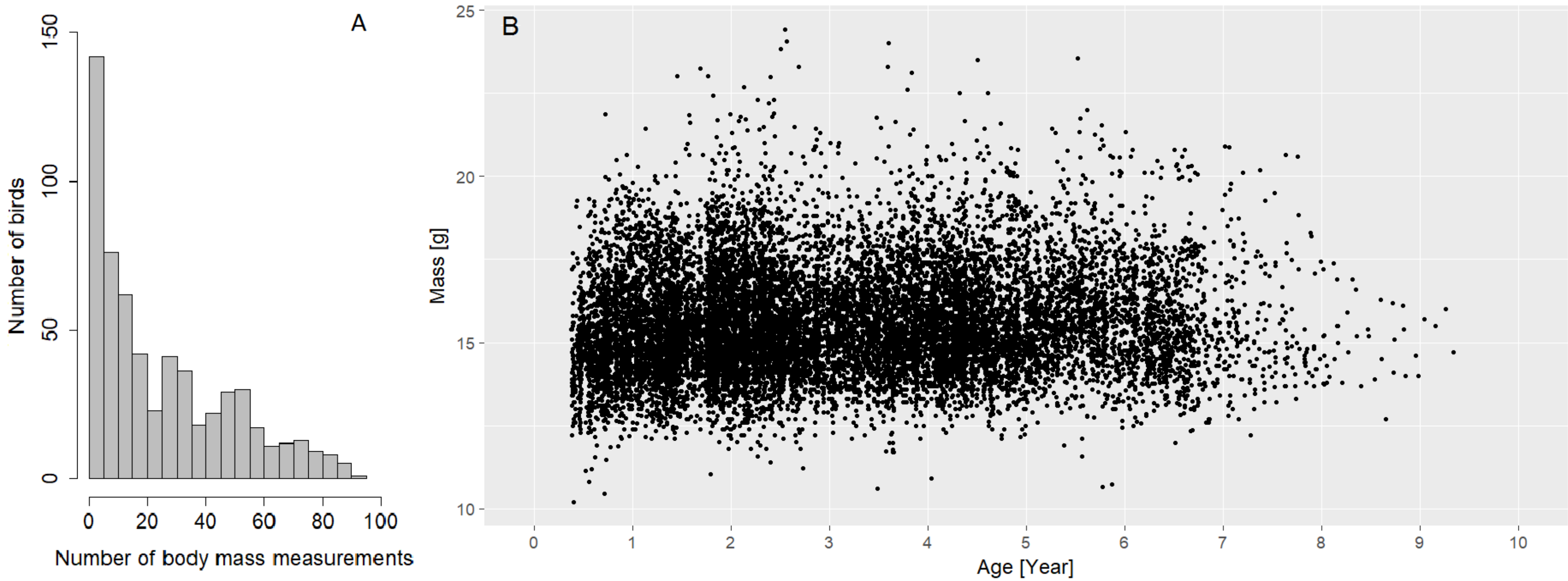
Supplementary Information 1: Data distribution

Fig. S1: (A) Number of body mass measurements per bird and (B) their distribution with respect to age.



Supplementary Information 2: Time and seasonal effects on mass

Body mass measurements were taken throughout the day at any time between 6AM and 10PM (Fig. S2A) and throughout the year (Fig. S2B). To control for daily and seasonal variation in mass when analyzing age effects, we first investigated which daily and seasonal covariates affected mass (Table S1A). We found that birds get heavier within the day (time ΔAICc=-2747.1). The rate of weight gain was faster on shorter days with birds being lighter in the morning but ending up heavier at the end of the day (time * nightlength ΔAICc=-199.9). In addition, there was a bi-seasonal effect on daily weight gain, with birds gaining weight faster over the day in the first half of the year relative to the second (time * photoperiod ΔAICc=-23.1). Both seasonal effects combined resulted birds being a little lighter in winter compared to summer, which is inconsistent with most theoretical models (reviewed in [1]) and data (e.g. [2,3]) on winter fattening strategies in wild birds. These results are however consistent with what was found earlier in captive zebra finches [4]. Thus, birds showed daily mass gain at a season specific rate. We included these daily and seasonal covariates and their interactions in all analyses.

Fig. S2: Distribution of body mass measurements through (A) time of the day and (B) month of the year.

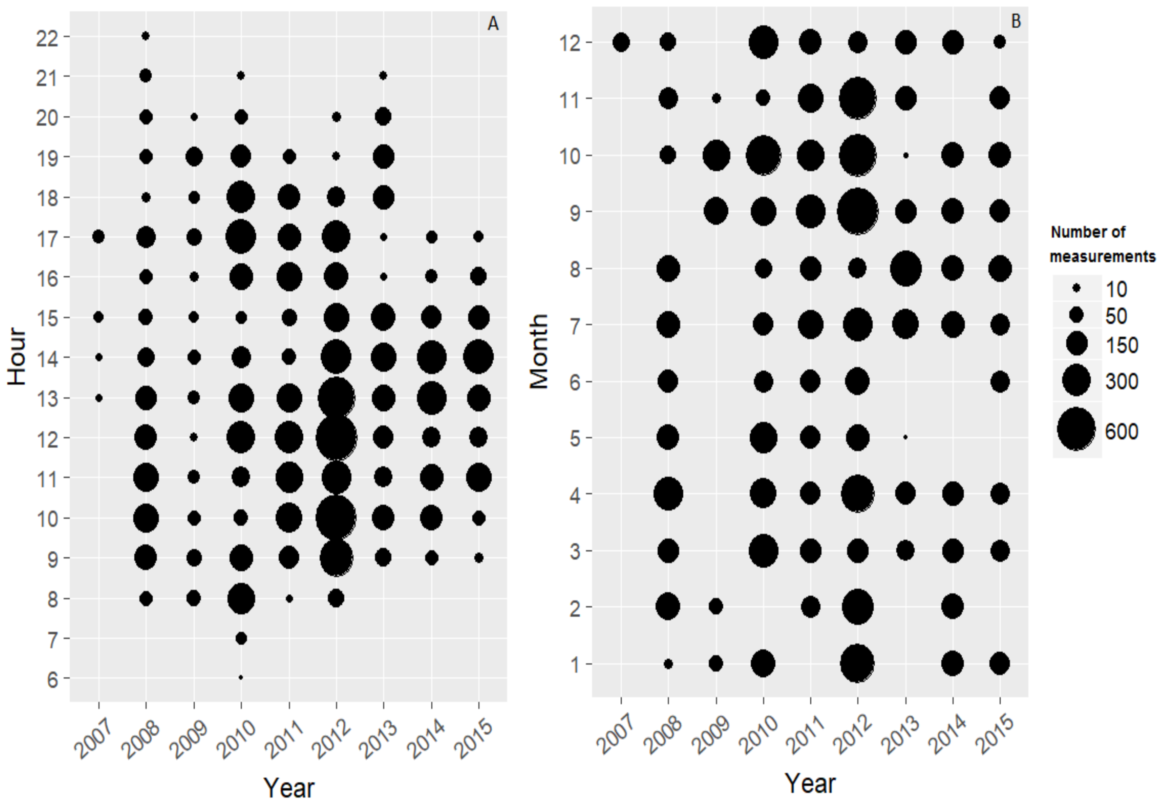


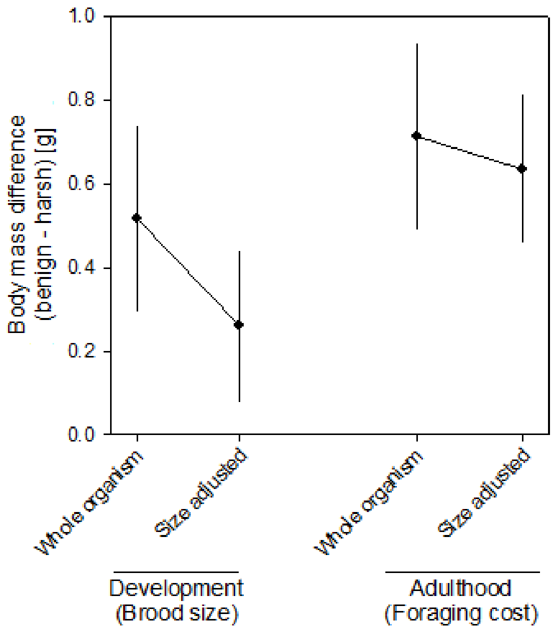
Table S1: Model selection results for time and seasonal effects on mass. Photoperiod (Photo) is a dichotomous variable coding for whether nightlength (Night) was increasing (0) or decreasing (1). Models are ordered by increasing AICc.

				Photo	Night				
Model	**Photo**	**Night**	**Time**	*** Time**	*** Time**	**df**	**AICc**	**ΔAICc**	**weight**
1	-0.38	-5.03	-1.48	0.59	7.51	8	37455.8	0	1.00
2		-4.41	-0.66		6.42	6	37478.9	23.1	0.00
3	-0.03	-4.38	-0.62		6.35	7	37483.5	27.8	0.00
4	-0.04	-0.77	2.54			6	37655.7	199.9	0.00
5		-0.75	2.53			5	37655.8	200.0	0.00
6	-0.04	-0.77	2.54	0.01		7	37660.5	204.7	0.00
7			2.58			4	37844.4	388.6	0.00
8	-0.02		2.59			5	37851.6	395.8	0.00
9	-0.04		2.57	0.04		6	37856.3	400.5	0.00
10		-0.96				4	40202.9	2747.1	0.00
11	0.01	-0.96				5	40211.4	2755.6	0.00
12						3	40466.8	3011.0	0.00
13	0.03					4	40469.3	3013.6	0.00

Supplementary Information 3: Size and size independent manipulation effects on mass

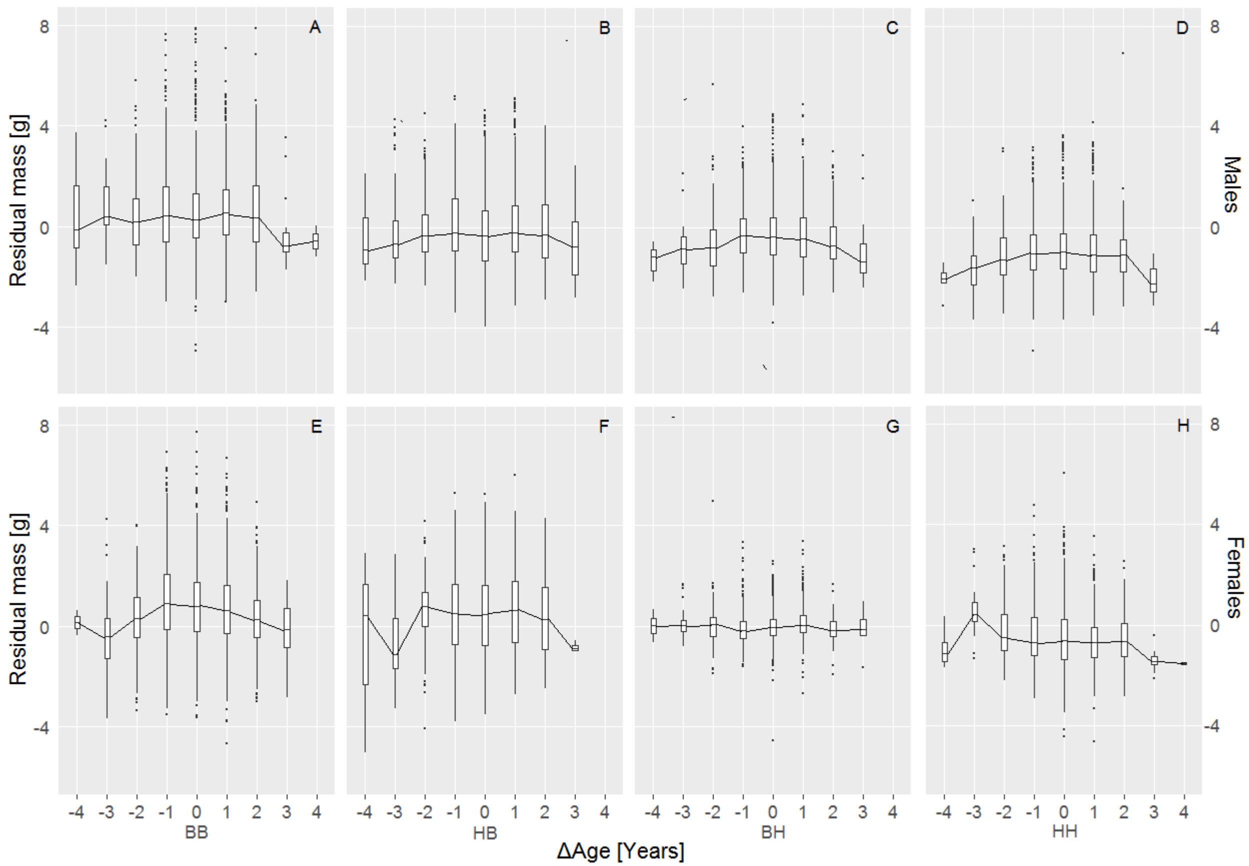
The effect of our experimental manipulations on mass can reflect a variety of organismal changes. Here we examine in further detail to what extent the effects on mass arise due to size or whether it is independent of size. In our dataset mass is to a large extent determined by an individual's size (r^2=0.31) and growing up in large broods resulted in a smaller size at adulthood (measured at the age of 120 days, N=594 individuals, t=-4.37, p=0.000014). Birds were randomly allocated to the foraging cost treatment with respect to size (N=594 individuals, t=-1.41, p=0.16) and thus, birds did not differ in size between foraging costs treatments. When analyzing the effects of the experimental manipulation on mass including structural body size as a covariate in the model, we found that both manipulations resulted in lower mass (developmental: ΔAICc=-1.7; adult: ΔAICc=-40.8). However, the effect of the brood size manipulation on size corrected mass was considerably smaller than that on whole organism mass (ΔAICc=-1.7 vs. -22.4, Fig. S4). In contrast, the effect of foraging cost manipulation became more evident (ΔAICc=-40.8 vs. -32.4, Fig. S4). The effect of both manipulations remained additive (developmental * adult environment ΔAICc=3.6). Thus, both our manipulations affected mass, but the effect of the developmental manipulation occurred mostly via body size, while the effect of the adult manipulation was size independent.

Fig. S3: Manipulation effects on mass with and without taking body size into account. Approximately half of the effect of the brood size manipulation on mass could be attributed to a size difference, while the foraging cost manipulation during adulthood affected mass irrespective of size. Shown is the mass difference between benign and harsh environment ±95CI.



Supplementary information 4: Data distribution plots over Δage

Fig. S4: Data distribution plot of mass age trajectories with Δage per experimental group. Most trajectories are quadratic, whereas, except for females in the hard treatment which are linear. Note that there is selective disappearance of light individuals in most groups around Δage=0. Boxplots show median, quartiles and 95% CI. Horizontal lines connect medians. Residuals correct for time, seasonal variation and selective disappearance of light individuals where necessary.



Supplementary information 5: Model selection tables

Table S2: Manipulation effects on mass (g). Models are ordered by increasing AICc.

	Experimental manipulations			Age covariates			Time and seasonal covariates					Model Fit			
Model	**Brood size**	**Treat**	**Brood size * Treat**	**ΔAge**	**ΔAge^2**	**Lifespan**	**Time**	**Night**	**Time * Night**	**Photo**	**Time * Photo**	**df**	**AICc**	**ΔAICc**	**weight**
1	-0.56	-0.66		0.03	-0.03	0.12	-2.00	-5.54	8.38	-0.49	0.80	16	36402.3	0.0	0.84
2	-0.56	-0.65	-0.01	0.03	-0.03	0.12	-2.00	-5.54	8.38	-0.49	0.80	17	36405.5	3.3	0.17
3		-0.66		0.03	-0.03	0.14	-2.01	-5.55	8.39	-0.49	0.80	15	36424.7	22.4	0.00
4	-0.56			0.03	-0.03	0.12	-2.00	-5.54	8.38	-0.49	0.80	15	36434.7	32.4	0.00
5				0.03	-0.03	0.14	-2.01	-5.55	8.38	-0.49	0.81	14	36455.7	53.4	0.00

*Table S3: The mass age trajectory and its response to environmental manipulations are sex-specific. Models are ordered by increasing AICc. Note that only the 35 better fitting models are shown (ΔAICc<51). Note the strong evidence for sex-specific age trajectories (ΔAge^2 * Sex ΔAICc=-46.2), with treatment specific age trajectories in females (Treat * Sex ΔAICc=-37.9) but not in males (ΔAge^2 * Treat * Sex ΔAICc=-37.9).*

All Mass	Experimental manipulations		Age and Age * Experiment interactions					Sex and Sex * Age interactions							Time and seasonal covariates					Model Fit			
Model	**Brood size**	**Treat**	**ΔAge**	**ΔAge^2**	**Treat * ΔAge**	**Treat * ΔAge^2**	**Lifespan**	**Sex**	**Brood size * Sex**	**Treat * Sex**	**ΔAge * Sex**	**ΔAge^2 * Sex**	**ΔAge * Treat * Sex**	**ΔAge^2 * Treat * Sex**	**Time**	**Night**	**Time * Night**	**Photo**	**Time *Photo**	**df**	**AICc**	**ΔAICc**	**weight**
1	-0.36	-0.88	0.02	-0.12		0.10	0.13	-0.36	-0.38	0.41		0.08		-0.10	-1.97	-5.52	8.35	-0.46	0.75	20	36556.4	0.0	0.42
2	-0.56	-0.88	0.02	-0.12		0.10	0.13	-0.55		0.41		0.08		-0.10	-1.97	-5.52	8.35	-0.46	0.75	19	36556.4	0.1	0.41
3	-0.36	-0.88	-0.01	-0.12		0.10	0.13	-0.36	-0.38	0.41	0.05	0.08		-0.10	-1.97	-5.52	8.35	-0.46	0.75	21	36559.9	3.5	0.07
4	-0.56	-0.88	-0.01	-0.12		0.10	0.13	-0.55		0.41	0.05	0.08		-0.10	-1.97	-5.52	8.35	-0.46	0.75	20	36559.9	3.5	0.07
5	-0.36	-0.88	0.02	-0.12	0.01	0.10	0.13	-0.36	-0.38	0.41		0.08		-0.10	-1.97	-5.52	8.35	-0.46	0.75	21	36563.8	7.4	0.01
6	-0.56	-0.88	0.02	-0.12	0.01	0.10	0.13	-0.55		0.41		0.08		-0.10	-1.97	-5.52	8.35	-0.46	0.75	20	36563.8	7.5	0.01
7	-0.36	-0.88	-0.01	-0.12	0.01	0.10	0.13	-0.36	-0.38	0.41	0.05	0.08		-0.10	-1.97	-5.52	8.35	-0.46	0.75	22	36567.3	10.9	0.00
8	-0.56	-0.88	-0.01	-0.12	0.01	0.10	0.13	-0.55		0.41	0.05	0.08		-0.10	-1.97	-5.52	8.35	-0.46	0.75	21	36567.3	11.0	0.00
9	-0.36	-0.88	0.00	-0.12	-0.02	0.10	0.13	-0.36	-0.38	0.41	0.03	0.08	0.04	-0.10	-1.97	-5.52	8.35	-0.46	0.75	23	36572.7	16.4	0.00
10	-0.56	-0.88	0.00	-0.12	-0.01	0.10	0.13	-0.55		0.41	0.03	0.08	0.04	-0.10	-1.97	-5.52	8.35	-0.46	0.75	22	36572.8	16.4	0.00
11	-0.36	-0.66	0.02	-0.08		0.03	0.13	-0.15	-0.38			0.03			-1.97	-5.52	8.34	-0.46	0.76	18	36594.3	37.9	0.00
12	-0.56	-0.67	0.02	-0.08		0.03	0.13	-0.34				0.03			-1.97	-5.52	8.34	-0.46	0.76	17	36594.3	37.9	0.00
13	-0.36	-0.84	0.02	-0.08		0.03	0.13	-0.32	-0.38	0.34		0.03			-1.97	-5.52	8.34	-0.46	0.76	19	36595.0	38.6	0.00
14	-0.56	-0.84	0.02	-0.08		0.03	0.13	-0.51		0.34		0.03			-1.97	-5.52	8.34	-0.46	0.76	18	36595.0	38.7	0.00
15	-0.36	-0.66	-0.01	-0.08		0.03	0.13	-0.15	-0.38		0.05	0.03			-1.97	-5.52	8.33	-0.46	0.76	19	36597.7	41.3	0.00
16	-0.56	-0.67	-0.01	-0.08		0.03	0.13	-0.34			0.05	0.03			-1.97	-5.52	8.34	-0.46	0.76	18	36597.7	41.3	0.00
17	-0.37	-0.84	-0.01	-0.08		0.03	0.13	-0.32	-0.38	0.34	0.05	0.03			-1.97	-5.52	8.33	-0.46	0.76	20	36598.4	42.0	0.00
18	-0.56	-0.84	-0.01	-0.08		0.03	0.13	-0.51		0.34	0.05	0.03			-1.97	-5.52	8.34	-0.46	0.76	19	36598.4	42.0	0.00
19	-0.36	-0.66	0.02	-0.08	0.00	0.03	0.13	-0.15	-0.38			0.03			-1.97	-5.52	8.34	-0.46	0.76	19	36601.7	45.3	0.00
20	-0.56	-0.67	0.02	-0.08	0.00	0.03	0.13	-0.34				0.03			-1.97	-5.52	8.34	-0.46	0.76	18	36601.7	45.4	0.00
21	-0.36	-0.84	0.02	-0.08	0.00	0.03	0.13	-0.32	-0.38	0.34		0.03			-1.97	-5.52	8.34	-0.46	0.76	20	36602.4	46.0	0.00
22	-0.56	-0.84	0.02	-0.08	0.00	0.03	0.13	-0.51		0.34		0.03			-1.97	-5.52	8.34	-0.46	0.76	19	36602.5	46.1	0.00
23	-0.36	-0.66	0.02	-0.06		0.03	0.13	-0.12	-0.38						-1.96	-5.51	8.32	-0.46	0.76	17	36602.6	46.2	0.00
24	-0.56	-0.67	0.02	-0.06		0.03	0.13	-0.32							-1.96	-5.51	8.32	-0.46	0.76	16	36602.6	46.3	0.00
25	-0.36	-0.83	0.02	-0.06		0.03	0.13	-0.30	-0.38	0.33					-1.96	-5.51	8.32	-0.46	0.76	18	36603.3	46.9	0.00
26	-0.56	-0.84	0.02	-0.06		0.03	0.13	-0.49		0.33					-1.96	-5.51	8.32	-0.46	0.76	17	36603.4	47.0	0.00
27	-0.36	-0.66	-0.01	-0.08	0.00	0.03	0.13	-0.15	-0.38		0.05	0.03			-1.97	-5.52	8.33	-0.46	0.76	20	36605.1	48.7	0.00
28	-0.56	-0.67	-0.01	-0.08	0.00	0.03	0.13	-0.34			0.05	0.03			-1.97	-5.52	8.34	-0.46	0.76	19	36605.1	48.7	0.00
29	-0.37	-0.83	-0.01	-0.08	0.00	0.03	0.13	-0.32	-0.38	0.34	0.05	0.03			-1.97	-5.52	8.33	-0.46	0.76	21	36605.8	49.4	0.00
30	-0.56	-0.84	-0.01	-0.08	0.00	0.03	0.13	-0.51		0.34	0.05	0.03			-1.97	-5.52	8.34	-0.46	0.76	20	36605.8	49.5	0.00
31	-0.36	-0.64	0.02	-0.06			0.13	-0.15	-0.38			0.03			-1.97	-5.52	8.35	-0.47	0.76	17	36606.6	50.2	0.00
32	-0.56	-0.64	0.02	-0.06			0.13	-0.34				0.03			-1.97	-5.52	8.35	-0.47	0.76	16	36606.6	50.2	0.00
33	-0.36	-0.66	-0.01	-0.06		0.03	0.13	-0.12	-0.38		0.05				-1.96	-5.51	8.31	-0.47	0.76	18	36606.9	50.6	0.00
34	-0.56	-0.67	-0.01	-0.06		0.03	0.13	-0.32			0.05				-1.96	-5.51	8.32	-0.47	0.76	17	36607.0	50.6	0.00
35	-0.56	-0.66	0.02	-0.06		0.03	0.12								-1.96	-5.51	8.32	-0.47	0.76	15	36607.1	50.7	0.00

Table S4: No evidence that the mass age trajectory of males varies between experimental manipulations.

Male Mass	Experimental manipulations			Age terms and interactions									Time and seasonal covariates					Model Fit			
Model	Brood size	Treat	Brood size * Treat	ΔAge	ΔAge^2	Brood size * ΔAge	Brood size * ΔAge^2	Treat * ΔAge	Treat * ΔAge^2	Brood size * Treat * ΔAge	Brood size * Treat * ΔAge^2	Lifespan	Time	Night	Time * Night	Photo	Time *Photo	df	AICc	ΔAICc	weight
1	-0.74	-0.46		0.04	-0.02							0.11	-1.43	-3.62	7.19	-0.38	0.52	16	16743.4	0.0	0.70
2	-0.79	-0.50	0.08	0.04	-0.02							0.11	-1.43	-3.62	7.19	-0.38	0.52	17	16745.9	2.5	0.21
3	-0.74	-0.46		0.04	-0.02	-0.003						0.11	-1.43	-3.62	7.19	-0.38	0.53	17	16750.5	7.1	0.02
4	-0.74	-0.46		0.04	-0.02			0.002				0.11	-1.43	-3.62	7.19	-0.38	0.53	17	16750.5	7.1	0.02
5	-0.74	-0.46		0.04	-0.02		-0.009					0.11	-1.43	-3.62	7.19	-0.38	0.53	17	16751.3	7.8	0.01
6	-0.74	-0.45		0.04	-0.02				-0.004			0.11	-1.43	-3.62	7.19	-0.38	0.52	17	16751.4	8.0	0.01
7	-0.79	-0.50	0.08	0.04	-0.02	-0.003						0.11	-1.43	-3.62	7.19	-0.38	0.53	18	16753.0	9.5	0.01
8	-0.79	-0.50	0.08	0.04	-0.02			0.002				0.11	-1.43	-3.62	7.19	-0.38	0.53	18	16753.0	9.5	0.01
9	-0.78	-0.50	0.08	0.04	-0.02		-0.009					0.11	-1.43	-3.62	7.19	-0.38	0.53	18	16753.7	10.3	0.00
10	-0.79	-0.50	0.08	0.04	-0.02				-0.004			0.11	-1.43	-3.62	7.19	-0.38	0.52	18	16753.9	10.4	0.00
11	-0.74	-0.46		0.04	-0.02	-0.003		0.002				0.11	-1.43	-3.62	7.19	-0.38	0.53	18	16757.6	14.1	0.00
12	-0.74	-0.46		0.04	-0.02	-0.005	-0.009					0.11	-1.43	-3.62	7.19	-0.39	0.53	18	16758.3	14.8	0.00
13	-0.74	-0.46		0.04	-0.02		-0.009	0.002				0.11	-1.43	-3.62	7.19	-0.39	0.53	18	16758.3	14.9	0.00
14	-0.74	-0.45		0.04	-0.02			0.001	-0.003			0.11	-1.43	-3.62	7.19	-0.38	0.53	18	16758.5	15.0	0.00
15	-0.74	-0.45		0.04	-0.02	-0.003			-0.004			0.11	-1.43	-3.62	7.19	-0.38	0.53	18	16758.5	15.0	0.00
16	-0.74	-0.45		0.04	-0.01		-0.009		-0.003			0.11	-1.43	-3.62	7.19	-0.39	0.53	18	16759.2	15.8	0.00
17	-0.79	-0.50	0.08	0.04	-0.02	-0.003		0.002				0.11	-1.43	-3.62	7.19	-0.38	0.53	19	16760.0	16.6	0.00
18	-0.78	-0.50	0.08	0.04	-0.02	-0.005	-0.009					0.11	-1.43	-3.62	7.19	-0.39	0.53	19	16760.7	17.3	0.00
19	-0.78	-0.50	0.08	0.04	-0.02		-0.009	0.002				0.11	-1.43	-3.62	7.19	-0.39	0.53	19	16760.8	17.3	0.00
20	-0.79	-0.50	0.08	0.04	-0.02			0.001	-0.003			0.11	-1.43	-3.62	7.19	-0.38	0.53	19	16760.9	17.5	0.00
21	-0.79	-0.50	0.08	0.04	-0.02	-0.003			-0.004			0.11	-1.43	-3.62	7.19	-0.38	0.53	19	16760.9	17.5	0.00
22	-0.78	-0.50	0.08	0.04	-0.01		-0.009		-0.003			0.11	-1.43	-3.62	7.19	-0.39	0.53	19	16761.7	18.2	0.00
23	-0.74	-0.46		0.04	-0.02	-0.005	-0.009	0.002				0.11	-1.43	-3.62	7.19	-0.39	0.53	19	16765.3	21.9	0.00
24	-0.79	-0.50	0.08	0.05	-0.02	-0.017		-0.011		0.03		0.11	-1.43	-3.62	7.19	-0.39	0.53	20	16765.5	22.0	0.00
25	-0.74	-0.45		0.04	-0.02	-0.003		0.001	-0.003			0.11	-1.43	-3.62	7.19	-0.39	0.53	19	16765.5	22.1	0.00
26	-0.74	-0.45		0.04	-0.01	-0.005	-0.009		-0.003			0.11	-1.43	-3.62	7.19	-0.39	0.53	19	16766.2	22.8	0.00
27	-0.74	-0.45		0.04	-0.01		-0.009	0.001	-0.003			0.11	-1.43	-3.62	7.19	-0.39	0.53	19	16766.3	22.8	0.00
28	-0.78	-0.49	0.07	0.04	-0.003		-0.035		-0.030		0.06	0.11	-1.43	-3.62	7.19	-0.39	0.53	20	16766.4	23.0	0.00
29	-0.78	-0.50	0.08	0.04	-0.02	-0.005	-0.009	0.002				0.11	-1.43	-3.62	7.19	-0.39	0.53	20	16767.8	24.3	0.00
30	-0.79	-0.50	0.08	0.04	-0.02	-0.003		0.001	-0.003			0.11	-1.43	-3.62	7.19	-0.39	0.53	20	16768.0	24.5	0.00
31	-0.78	-0.50	0.08	0.04	-0.01	-0.005	-0.009		-0.003			0.11	-1.43	-3.62	7.19	-0.39	0.53	20	16768.7	25.3	0.00
32	-0.78	-0.50	0.08	0.04	-0.01		-0.009	0.001	-0.003			0.11	-1.43	-3.62	7.19	-0.39	0.53	20	16768.7	25.3	0.00
33	-0.78	-0.50	0.08	0.05	-0.02	-0.020	-0.010	-0.012		0.03		0.11	-1.43	-3.62	7.19	-0.39	0.53	21	16773.2	29.8	0.00
34	-0.74	-0.45		0.04	-0.01	-0.005	-0.009	0.001	-0.003			0.11	-1.43	-3.62	7.19	-0.39	0.53	20	16773.3	29.8	0.00
35	-0.78	-0.49	0.07	0.04	-0.003	-0.006	-0.035		-0.030		0.06	0.11	-1.43	-3.62	7.19	-0.39	0.53	21	16773.4	30.0	0.00
36	-0.79	-0.50	0.08	0.05	-0.02	-0.017		-0.012	-0.003	0.03		0.11	-1.43	-3.62	7.19	-0.39	0.53	21	16773.4	30.0	0.00
37	-0.78	-0.49	0.07	0.04	-0.003		-0.035	0.000	-0.030		0.06	0.11	-1.43	-3.62	7.19	-0.39	0.53	21	16773.4	30.0	0.00
38	-0.78	-0.50	0.08	0.04	-0.01	-0.005	-0.009	0.001	-0.003			0.11	-1.43	-3.62	7.19	-0.39	0.53	21	16775.7	32.3	0.00
39	-0.78	-0.49	0.07	0.04	-0.003	-0.006	-0.035	0.001	-0.030		0.06	0.11	-1.43	-3.62	7.19	-0.39	0.53	22	16780.4	37.0	0.00
40	-0.78	-0.50	0.08	0.05	-0.01	-0.020	-0.009	-0.012	-0.003	0.03		0.11	-1.43	-3.62	7.19	-0.39	0.53	22	16781.2	37.8	0.00
41	-0.78	-0.49	0.07	0.05	-0.001	-0.028	-0.037	-0.020	-0.032	0.04	0.06	0.11	-1.43	-3.62	7.19	-0.39	0.53	23	16785.6	42.2	0.00

*Table S5: Mass age trajectory of females differs between benign and harsh foraging treatment (Treat * ΔAge^2 ΔAICc=-16.1).*

Female Mass	Experimental manipulations			Age terms and interactions									Time and seasonal covariates					Model Fit			
Model	Brood size	Treat	Brood size * Treat	ΔAge	ΔAge^2	Brood size * ΔAge	Brood size * ΔAge^2	Treat * ΔAge	Treat * ΔAge^2	Brood size * Treat * ΔAge	Brood size * Treat * ΔAge^2	Lifespan	Time	Night	Time * Night	Photo	Time *Photo	df	AICc	ΔAICc	weight
1	-0.37	-0.89		0.01	-0.11				0.12			0.14	-2.98	-8.12	10.45	-0.60	1.09	17	18471.2	0	0.41
2	-0.35	-0.87	-0.05	-0.02	-0.11	0.07		0.14	0.13	-0.30		0.14	-2.98	-8.11	10.43	-0.61	1.10	21	18472.9	1.7	0.18
3	-0.37	-0.89		0.06	-0.11	-0.09			0.13			0.14	-2.98	-8.11	10.43	-0.60	1.09	18	18473.1	1.9	0.16
4	-0.35	-0.87	-0.03	0.01	-0.11				0.12			0.14	-2.98	-8.12	10.45	-0.60	1.09	18	18473.9	2.6	0.11
5	-0.36	-0.87	-0.03	0.06	-0.11	-0.09			0.13			0.14	-2.98	-8.11	10.43	-0.60	1.09	19	18475.8	4.6	0.04
6	-0.38	-0.89		0.01	-0.13		0.04		0.13			0.14	-2.98	-8.12	10.45	-0.61	1.10	18	18476.0	4.8	0.04
7	-0.37	-0.89		0.01	-0.11			0.003	0.12			0.14	-2.98	-8.12	10.45	-0.60	1.09	18	18477.7	6.4	0.02
8	-0.37	-0.87	-0.03	0.01	-0.13		0.04		0.13			0.14	-2.98	-8.12	10.45	-0.61	1.10	19	18478.7	7.4	0.01
9	-0.36	-0.87	-0.05	-0.03	-0.12	0.08	0.03	0.14	0.13	-0.30		0.14	-2.98	-8.11	10.43	-0.61	1.10	22	18479.4	8.2	0.01
10	-0.37	-0.89		0.06	-0.11	-0.09		-0.002	0.12			0.14	-2.98	-8.11	10.43	-0.60	1.09	19	18479.6	8.4	0.01
11	-0.38	-0.89		0.05	-0.12	-0.07	0.03		0.13			0.14	-2.98	-8.11	10.44	-0.61	1.10	19	18479.7	8.4	0.01
12	-0.35	-0.87	-0.03	0.01	-0.11			0.003	0.12			0.14	-2.98	-8.12	10.45	-0.60	1.09	19	18480.3	9.1	0.00
13	-0.36	-0.87	-0.03	0.06	-0.11	-0.09		-0.002	0.12			0.14	-2.98	-8.11	10.43	-0.60	1.09	20	18482.2	11.0	0.00
14	-0.36	-0.87	-0.03	0.05	-0.12	-0.07	0.03		0.13			0.14	-2.98	-8.11	10.44	-0.61	1.10	20	18482.3	11.1	0.00
15	-0.38	-0.89		0.01	-0.13		0.04	0.002	0.13			0.14	-2.98	-8.12	10.45	-0.61	1.10	19	18482.5	11.2	0.00
16	-0.36	-0.87	-0.04	0.01	-0.12		0.03		0.11		0.03	0.14	-2.98	-8.12	10.45	-0.61	1.10	20	18484.6	13.4	0.00
17	-0.36	-0.87	-0.03	-0.04	-0.13	0.09	0.05	0.16	0.15	-0.33	-0.05	0.14	-2.97	-8.11	10.42	-0.61	1.10	23	18484.7	13.5	0.00
18	-0.37	-0.87	-0.03	0.01	-0.13		0.04	0.002	0.13			0.14	-2.98	-8.12	10.45	-0.61	1.10	20	18485.1	13.9	0.00
19	-0.38	-0.89		0.05	-0.12	-0.07	0.03	-0.002	0.13			0.14	-2.98	-8.11	10.44	-0.61	1.10	20	18486.1	14.9	0.00
20	-0.37	-0.85		0.01	-0.05							0.14	-2.99	-8.13	10.46	-0.62	1.11	16	18487.3	16.1	0.00
21	-0.35	-0.83	-0.05	0.01	-0.05	0.07		0.07		-0.30		0.14	-2.99	-8.12	10.44	-0.61	1.11	20	18487.7	16.5	0.00
22	-0.36	-0.87	-0.04	0.05	-0.11	-0.07	0.01		0.11		0.03	0.14	-2.98	-8.12	10.44	-0.61	1.10	21	18488.2	17.0	0.00
23	-0.36	-0.87	-0.03	0.05	-0.12	-0.07	0.03	-0.002	0.13			0.14	-2.98	-8.11	10.44	-0.61	1.10	21	18488.7	17.5	0.00
24	-0.35	-0.83	-0.03	0.01	-0.05							0.14	-2.99	-8.13	10.46	-0.62	1.11	17	18489.9	18.7	0.00
25	-0.37	-0.85		0.05	-0.05	-0.07						0.14	-2.99	-8.12	10.45	-0.62	1.12	17	18490.6	19.4	0.00
26	-0.36	-0.87	-0.04	0.01	-0.12		0.03	0.00	0.11		0.03	0.14	-2.98	-8.12	10.45	-0.61	1.10	21	18491.0	19.8	0.00
27	-0.37	-0.85		0.05	-0.05			-0.07				0.14	-2.99	-8.12	10.46	-0.61	1.11	17	18491.5	20.3	0.00
28	-0.36	-0.83	-0.03	0.05	-0.05	-0.07						0.14	-2.99	-8.12	10.45	-0.62	1.12	18	18493.2	22.0	0.00
29	-0.38	-0.85		0.01	-0.06		0.03					0.14	-2.99	-8.13	10.46	-0.62	1.12	17	18493.6	22.4	0.00
30	-0.37	-0.85		0.09	-0.05	-0.08		-0.08				0.14	-2.98	-8.12	10.44	-0.61	1.11	18	18494.0	22.8	0.00
31	-0.35	-0.84	-0.03	0.05	-0.05			-0.07				0.14	-2.99	-8.12	10.46	-0.61	1.11	18	18494.1	22.9	0.00
32	-0.36	-0.87	-0.04	0.05	-0.11	-0.07	0.01	-0.002	0.11		0.03	0.14	-2.98	-8.12	10.44	-0.61	1.10	22	18494.7	23.5	0.00
33	-0.35	-0.83	-0.05	0.01	-0.05	0.08	0.01	0.07		-0.30		0.14	-2.99	-8.12	10.44	-0.62	1.11	21	18494.7	23.5	0.00
34	-0.36	-0.83	-0.03	0.01	-0.06		0.03					0.14	-2.99	-8.13	10.46	-0.62	1.12	18	18496.2	25.0	0.00
35	-0.36	-0.84	-0.03	0.09	-0.05	-0.08		-0.08				0.14	-2.98	-8.12	10.44	-0.61	1.11	19	18496.6	25.4	0.00
36	-0.38	-0.85		0.05	-0.06		0.03	-0.08				0.14	-2.99	-8.12	10.46	-0.61	1.11	18	18497.4	26.2	0.00
37	-0.38	-0.85		0.04	-0.05	-0.07	0.01					0.14	-2.99	-8.12	10.45	-0.62	1.12	18	18497.6	26.4	0.00
38	-0.37	-0.84	-0.03	0.05	-0.06		0.03	-0.08				0.14	-2.99	-8.12	10.46	-0.61	1.11	19	18500.0	28.8	0.00
39	-0.36	-0.83	-0.03	0.04	-0.05	-0.07	0.01					0.14	-2.99	-8.12	10.45	-0.62	1.12	19	18500.2	29.0	0.00
40	-0.38	-0.85		0.09	-0.05	-0.07	0.01	-0.08				0.14	-2.98	-8.12	10.44	-0.61	1.11	19	18501.0	29.8	0.00
41	-0.36	-0.84	-0.03	0.09	-0.05	-0.07	0.01	-0.08				0.14	-2.98	-8.12	10.44	-0.61	1.11	20	18503.7	32.4	0.00

Table S6: Mass age trajectory depends on developmental conditions (brood size) for females in the harsh (B) but not in the benign foraging treatment (A).

(A) Mass females in benign treatment															
	Age terms and interactions						**Time and seasonal covariates**					**Model Fit**			
Model	**Brood size**	**ΔAge**	**ΔAge^2**	**Brood size * ΔAge**	**Brood size * ΔAge^2**	**Lifespan**	**Time**	**Night**	**Time * Night**	**Photo**	**Time *Photo**	**df**	**AICc**	**ΔAICc**	**weight**
1	-0.36	0.01	-0.11			0.15	-2.31	-8.45	8.97	-0.62	1.26	15	9854.5	0.0	0.85
2	-0.36	-0.03	-0.11	0.07		0.14	-2.32	-8.46	8.98	-0.62	1.26	16	9858.6	4.1	0.11
3	-0.37	0.01	-0.12		0.02	0.15	-2.31	-8.44	8.96	-0.62	1.26	16	9861.0	6.5	0.03
4	-0.37	-0.04	-0.13	0.10	0.05	0.15	-2.31	-8.44	8.96	-0.62	1.26	17	9863.8	9.3	0.01
5	-0.37	0.07				0.14	-2.29	-8.41	8.88	-0.65	1.31	14	9869.5	15.0	0.00
6	-0.37	0.03		0.08		0.14	-2.30	-8.41	8.89	-0.65	1.31	15	9873.4	18.9	0.00
(B) Mass females in harsh treatment															
1	-0.40	0.10		-0.24		0.14	-3.31	-7.40	11.26	-0.55	0.86	15	8175.3	0.0	0.98
2	-0.40	0.10	0.01	-0.24		0.14	-3.31	-7.39	11.24	-0.55	0.86	16	8183.4	8.2	0.02
3	-0.39	-0.01				0.14	-3.31	-7.40	11.27	-0.55	0.85	14	8186.2	10.9	0.00
4	-0.40	0.10	0.01	-0.24	-0.0005	0.14	-3.30	-7.39	11.24	-0.55	0.86	17	8190.4	15.1	0.00
5	-0.39	0.00	0.01			0.14	-3.31	-7.40	11.26	-0.55	0.85	15	8194.4	19.1	0.00
6	-0.40	0.00	-0.02		0.05	0.14	-3.32	-7.41	11.28	-0.55	0.86	16	8199.3	24.1	0.00

Supplementary Information 6: References

1. Brodin, A. 2007 Theoretical models of adaptive energy management in small wintering birds. *Philos. Trans. R. Soc. Lond. B. Biol. Sci.* **362**, 1857–1871. (doi:10.1098/rstb.2006.1812)

2. Krams, I., Cirule, D., Suraka, V., Krama, T., Rantala, M. J. & Ramey, G. 2010 Fattening strategies of wintering great tits support the optimal body mass hypothesis under conditions of extremely low ambient temperature. *Funct. Ecol.* **24**, 172–177. (doi:10.1111/j.1365-2435.2009.01628.x)

3. Rogers, C. M. 2015 Testing optimal body mass theory: Evidence for cost of fat in wintering birds. *Ecosphere* **6**, 1–12. (doi:10.1890/ES14-00317.1)

4. Meijer, T., Rozman, J. & Schulte, M. 1996 New findings in body mass regulation in zebra finches (Taeniopygia guttuta) in responseto photoperiod and temperature. *J. Zool.* **240**, 717–734.

5. Bouwhuis, S., Sheldon, B. C. & Verhulst, S. 2011 Basal metabolic rate and the rate of senescence in the great tit. *Funct. Ecol.* **25**, 829–838. (doi:10.1111/j.1365-2435.2011.01850.x)

6. van de Pol, M. & Verhulst, S. 2006 Age-dependent traits: a new statistical model to separate within- and between-individual effects. *Am. Nat.* **167**, 766–73. (doi:10.1086/503331)

7. Maklakov, A. A. et al. 2009 Sex differences in nutrient-dependent reproductive ageing. *Aging Cell* **8**, 324–330. (doi:10.1111/j.1474-9726.2009.00479.x)

8. Bouwhuis, S., Sheldon, B. C., Verhulst, S. & Charmantier, A. 2009 Great tits growing old: selective disappearance and the partitioning of senescence to stages within the breeding cycle. *Proc. R. Soc. B Biol. Sci.* **276**, 2769–77. (doi:10.1098/rspb.2009.0457)