

**Supporting Information.** Aikens, E.O., S.P.H. Dwinell, T.N. LaSharr, R.P. Jakopak, G.L. Fralick, J. Randall, R. Kaiser, M. Thonhoff, M.J. Kauffman, and K.L. Monteith. 2021. Migration distance and maternal resource allocation determine timing of birth in a large herbivore. *Ecology*.

#### **Appendix S4** – Examining the impact of repeated measures on inference

Repeated measures, where the same adult female was included in our analysis in multiple years, accounted for 20-28% of the datapoints in our analysis (Table S1). The maximum number of years an individual was included in our analysis was two, but most adult females had complete data for only one year of the study (Table S1). We investigated how repeated measures impacted our analysis by, 1) randomly subsampling our data to remove repeated measures and 2) accounting for repeated measures by including a random intercept for maternal ID. We considered if the original coefficient estimates fell within the 95% CI of the coefficient estimates derived from the subsampled model or the model including a random intercept for maternal ID. Additionally, we investigated if the significance of any effect changed as a result of removing or accounting for repeated measures, by assessing if the 95% CI of the estimated coefficients overlapped with zero. In all cases, we found that the original coefficient estimate always fell within the 95% CI of the models that removed or accounted for pseudoreplication and that the significance of estimated coefficients was consistent irrespective of model choice (Table S2). Furthermore, including a random intercept for ID, when most IDs only had one data point often resulted in estimated variance for the random term to be zero or close to zero, indicating very little effect of including a random term.

**Table S1.** A summary of the number of birth events used in various stages of analyses.

Analysis	Sample size	Unique individuals	Number of individuals measured once	Number of individuals measured twice	Proportion of repeated measures in data
Plasticity in birth	78	56	34	22	0.28
Fetal development	50	40	30	10	0.20
Birth Timing & birth date	77	56	35	21	0.27
Green-wave surfing and migration timing	78	56	34	22	0.28

**Table S2.** Summary of model output from original models and models that removed repeated measures or accounted for repeated measures with a random term.

Approach	Coefficient	Estimate	Standard error	Lower CI (2.5%)	Upper CI (97.5%)	CIs overlap with original?
<b>(a) Fetal development in March (Fetal eye diameter ~ migration distance + December fat)</b>						
Original	Intercept*	15.86	1.04	13.76	17.96	NA
	Migration distance*	-0.02	0.01	-0.04	-0.01	NA
	December fat*	0.17	0.07	0.03	0.30	NA
Subsampled	Intercept*	16.02	1.14	13.70	18.34	Yes
	Migration distance*	-0.02	0.01	-0.04	-0.01	Yes
	December fat*	0.17	0.07	0.02	0.31	Yes
Random effect + (1   ID)†	Intercept *	15.86	1.04	13.84	17.88	Yes
	Migration distance*	-0.02	0.01	-0.04	-0.01	Yes
	December fat*	0.17	0.07	0.03	0.30	Yes
Outliers removed	Intercept*	16.52	0.79	14.93	18.11	Yes
	Migration distance*	-0.02	0.01	-0.03	-0.01	Yes
	December fat*	0.11	0.05	0.01	0.22	Yes
<b>(b) Plasticity in birth (Days to birth ~ eye diameter + fetal number + Year)</b>						
Original	Intercept*	133.94	7.38	119.23	148.65	NA
	Eye Diameter*	-2.74	0.42	-3.58	-1.90	NA
	Fetal Number	-2.73	1.46	-5.64	0.18	NA
Subsampled	Intercept*	126.41	11.00	104.30	148.52	Yes
	Eye Diameter*	-2.30	0.65	-3.60	-1.00	Yes
	Fetal Number	-2.80	1.90	-6.27	1.02	Yes
Random effect + (1   ID)	Intercept*	135.02	7.06	121.64	148.54	Yes
	Eye Diameter*	-2.79	0.42	-3.59	-2.01	Yes
	Fetal Number *	-3.15	1.32	-5.65	-0.63	Yes

<b>(c) Birth Timing (Days to birth ~eye diameter + date peak green-up on winter range + date peak green-up on summer range + exposure to green-up + date peak green-up + March fat)</b>						
Original	Intercept*	90.97	12.56	65.92	116.03	NA
	Eye Diameter*	-2.69	0.42	-3.52	-1.85	NA
	Fetal Number	-1.30	1.76	-4.80	2.20	NA
	Date peak green-up winter range*	0.38	0.09	0.21	0.56	NA
	Exposure to green-up (IRG)*	-25.26	5.61	-36.45	-14.07	NA
	Date peak green-up at birth site*	0.17	0.06	0.05	0.29	NA
	March fat	-0.63	0.40	-1.42	0.15	NA
Subsampled	Intercept*	89.51	15.18	58.99	120.03	Yes
	Eye Diameter*	-2.26	0.52	-3.31	-1.21	Yes
	Fetal Number	-0.13	2.31	-4.78	4.52	Yes
	Date peak green-up winter range*	0.31	0.11	0.10	0.52	Yes
	Exposure to green-up (IRG)*	-26.00	6.81	-39.69	-12.32	Yes
	Date peak green-up at birth site*	0.19	0.08	0.03	0.34	Yes
	March fat	-0.81	0.45	-1.72	0.11	Yes
Random effect + (1 ID)†	Intercept*	90.97	12.56	67.20	114.75	Yes
	Eye Diameter*	-2.69	0.42	-3.47	-1.90	Yes
	Fetal Number	-1.30	1.76	-4.63	2.02	Yes
	Date peak green-up winter range*	0.38	0.09	0.22	0.55	Yes
	Exposure to green-up (IRG)*	-25.26	5.61	-35.88	-14.64	Yes
	Date peak green-up at birth site*	0.17	0.06	0.06	0.28	Yes
	March fat	-0.63	0.40	-1.38	0.11	Yes
<b>(d) Birth mass ~ plasticity in birth date + fetal number + exposure to green-up + March fat</b>						
Original	Intercept*	2.62	0.42	1.78	3.45	NA
	Plasticity in birth date	0.001	0.02	-0.03	0.03	NA
	Fetal number	0.14	0.18	-0.22	0.50	NA
	Exposure to green-up (IRG)	0.89	0.58	-0.27	2.04	NA
	March fat	0.02	0.04	-0.06	0.10	NA
Subsampled	Intercept*	2.39	0.53	1.32	3.45	Yes
	Plasticity in birth date	0.01	0.02	-0.03	0.05	Yes

	Fetal number	0.13	0.23	-0.33	0.58	Yes
	Exposure to green-up (IRG)	1.38	0.74	-0.10	2.86	Yes
	March fat	0.01	0.04	-0.08	0.10	Yes
Random effect + (1 ID)	Intercept*	2.73	0.41	1.89	3.54	Yes
	Plasticity in birth date	-0.007	0.02	-0.05	0.04	Yes
	Fetal number	0.09	0.18	-0.26	0.46	Yes
	Exposure to green-up (IRG)	0.79	0.59	-0.37	1.92	Yes
	March fat	0.02	0.04	-0.05	0.10	Yes
<b>(e) Date of birth ~ end of spring migration</b>						
Original	Intercept*	137.66	7.18	123.36	151.97	NA
	End of spring migration*	0.19	0.05	0.09	0.29	NA
Subsampled	Intercept*	138.16	7.99	122.15	154.17	Yes
	End of spring migration*	0.18	0.06	0.07	0.30	Yes
Random effect + (1 ID) <sup>†</sup>	Intercept*	137.66	7.18	123.60	151.73	Yes
	End of spring migration*	0.19	0.05	0.09	0.29	Yes
<b>(f) End of spring migration ~ date of peak green-up at birth site</b>						
Original	Intercept*	38.28	14.28	9.84	66.71	NA
	Date peak green-up at birth site*	0.77	0.11	0.56	0.98	NA
Subsampled	Intercept*	46.41	17.86	10.60	82.22	Yes
	Date peak green-up at birth site*	0.70	0.13	0.44	0.97	Yes
Random effect + (1 ID)	Intercept*	46.48	14.92	15.89	76.85	Yes
	Date peak green-up at birth site*	0.71	0.11	0.48	0.93	Yes
<b>(g) Birth date ~ date of peak green-up at birth site</b>						
Original	Intercept*	136.86	8.31	120.32	153.41	NA
	Date peak green-up at birth site*	0.20	0.06	0.08	0.32	NA
Subsampled	Intercept*	139.60	9.40	120.75	158.45	Yes
	Date peak green-up at birth site*	0.18	0.07	0.04	0.32	Yes
Random effect + (1 ID)	Intercept*	136.73	8.33	120.60	153.13	Yes
	Date peak green-up at birth site*	0.20	0.06	0.08	0.32	Yes

<b>(h) Birth mismatch with green-up ~ green-wave surfing (Days-From-Peak)</b>						
Original	Intercept	0.05	4.55	-9.01	9.10	NA
	Days-From-Peak*	-1.92	0.29	-2.50	-1.34	NA
Subsampled	Intercept	2.49	5.05	-7.63	12.61	Yes
	Days-From-Peak*	-2.13	0.32	-2.78	-1.49	Yes
Random effect + (1 ID)	Intercept	-5.31	4.42	-15.01	4.46	Yes
	Days-From-Peak*	-1.60	0.28	-2.22	-0.99	Yes

\* Indicates a significant effect which was quantified as 95% confidence intervals for the coefficient estimate that does not overlap with zero.

†Indicates a singular fit, where variance estimates of random effects are equal or very close to zero.