

Long-term fitness consequences of early environment in a long-lived ungulate Supplementary material

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Table S1: Statistics used to test the effect of birth environment covariates on the weaning success of bighorn ewes at Ram Mountain from 1973 to 2014. Fcst/co/t (degrees of freedom) is the statistic from the ANODEV method. P-value is its associated P-value. Adj.P-value is the P-value corrected for multiple testing using the Benjamini & Hochberg method. R² describes the proportion of the variance between cohorts explained by the covariate. Delta AICc refers to the difference between the AICc of the model including the covariate and the base model (a negative value indicates a better model than the base model). Interactions with density are noted as “ * density”, quadratic effects of variables are noted as “(quad)” and models with interactions between early and current environment are noted as “Int”.

Environmental Covariate	Fcst/co/t	P-value	adj.P-value	R ²	Delta AICc
density (Int)	36.334 (1,29)	0.000	0	0.556	-32.297
density (quad)	8.930 (2,29)	0.001	0.015	0.381	-29.789
density	14.157 (1,30)	0.001	0.015	0.321	-26.436
temp.spring (Int)	6.258 (1,29)	0.018	0.215	0.177	-13.669
precip.fall (Int)	4.464 (1,29)	0.043	0.407	0.133	-9.482
precip.winter.aft (quad)	1.970 (2,29)	0.158	0.775	0.120	-6.580
precip.winter.bef (quad)	1.807 (2,29)	0.182	0.775	0.111	-5.800
precip.spring (quad)	1.693 (2,29)	0.202	0.775	0.105	-5.244
precip.winter.aft * density	1.628 (3,28)	0.214	0.775	0.104	-2.243
temp.spring * density	1.606 (3,28)	0.219	0.775	0.103	-2.166
precip.spring	3.396 (1,30)	0.075	0.589	0.102	-7.009
temp.winter.aft * density	1.546 (3,28)	0.231	0.775	0.099	-1.959
temp.winter.bef * density	0.901 (3,28)	0.418	0.846	0.060	0.393
temp.fall * density	0.899 (3,28)	0.418	0.846	0.060	0.401
precip.spring * density	0.835 (3,28)	0.444	0.846	0.056	0.643
precip.summer (quad)	0.828 (2,29)	0.447	0.846	0.054	-0.760
precip.summer	1.569 (1,30)	0.220	0.775	0.050	-2.397
precip.summer (Int)	1.507 (1,29)	0.229	0.775	0.049	-2.125
temp.winter.aft (quad)	0.592 (2,29)	0.560	0.846	0.039	0.549
temp.winter.aft	1.221 (1,30)	0.278	0.846	0.039	-1.457
precip.fall (quad)	0.574 (2,29)	0.570	0.846	0.038	0.656
precip.summer * density	0.517 (3,28)	0.602	0.846	0.036	1.890
PDO * density	0.503 (3,28)	0.610	0.846	0.035	1.945

Table S1 (continued):

Environmental Covariate	Fcst/co/t	P-value	adj.P-value	R²	Delta AICc
temp.winter.bef (quad)	0.518 (2,29)	0.601	0.846	0.034	0.974
temp.winter.bef	1.048 (1,30)	0.314	0.846	0.034	-0.981
precip.fall	0.980 (1,30)	0.330	0.846	0.032	-0.792
temp.summer * density	0.450 (3,28)	0.642	0.846	0.031	2.161
precip.winter.bef	0.958 (1,30)	0.336	0.846	0.031	-0.731
temp.summer (quad)	0.458 (2,29)	0.637	0.846	0.031	1.316
precip.fall * density	0.400 (3,28)	0.674	0.846	0.028	2.364
temp.spring (quad)	0.399 (2,29)	0.675	0.846	0.027	1.656
temp.winter.bef	0.675 (1,30)	0.418	0.846	0.023	0.075
temp.fall (quad)	0.259 (2,29)	0.774	0.866	0.018	2.477
temp.fall	0.523 (1,30)	0.475	0.846	0.017	0.495
precip.winter.bef * density	0.215 (3,28)	0.808	0.866	0.015	3.125
PDO (quad)	0.212 (2,29)	0.811	0.866	0.014	2.756
temp.winter.aft (Int)	0.403 (1,29)	0.531	0.846	0.014	0.847
temp.summer	0.361 (1,30)	0.552	0.846	0.012	0.959
PDO	0.360 (1,30)	0.553	0.846	0.012	0.963
precip.spring (Int)	0.249 (1,29)	0.622	0.846	0.009	1.333
precip.winter.aft	0.164 (1,30)	0.688	0.846	0.005	1.531
precip.winter.aft (Int)	0.149 (1,29)	0.702	0.846	0.005	1.554
PDO (Int)	0.090 (1,29)	0.766	0.866	0.003	1.741
precip.winter.bef (Int)	0.089 (1,29)	0.768	0.866	0.003	1.746
temp.spring	0.029 (1,30)	0.867	0.905	0.001	1.930
temp.summer (Int)	0.018 (1,29)	0.896	0.915	0.001	1.965
temp.fall (Int)	0.005 (1,29)	0.942	0.942	0.000	2.004

Table S2: Statistics used to test the effect of birth environment covariates on bighorn ewe survival from 1973 to 2014 using logistic mixed models. Fcst/co/t (degrees of freedom) is the statistic from the ANODEV method. Adj.P-value is the P-value corrected for multiple testing using the Benjamini & Hochberg method. R² is the proportion of the variance between cohorts explained by the covariate. Delta AICc refers to the difference between the AICc of the model including the covariate and the base model (a negative value indicates a better model than the base model). Interactions with density are noted as “ * density”, quadratic effects of variables are noted as “(quad)” and models with interactions between early and current environment are noted as “Int”.

Environmental Covariate	Fcst/co/t	P-value	adj.P-value	R²	Delta AICc
birth.precip.winter.aft (quad)	2.858 (2,29)	0.074	0.825	0.165	-2.803
birth.temp.winter.aft * density	2.182 (3,28)	0.132	0.825	0.135	-1.040
birth.temp.summer (quad)	2.144 (2,29)	0.135	0.825	0.129	-1.316
birth.precip.spring (quad)	1.660 (2,29)	0.208	0.825	0.103	-0.232
density (quad)	1.632 (2,29)	0.213	0.825	0.101	-0.167
birth.temp.winter.aft (quad)	1.552 (2,29)	0.229	0.825	0.097	0.020
density	3.073 (1,30)	0.090	0.825	0.093	-1.842
precip.winter.aft (Int)	2.807 (1,29)	0.105	0.825	0.088	-1.534
birth.temp.winter.aft	2.705 (1,30)	0.110	0.825	0.083	-1.419
birth.precip.winter.bef (quad)	0.994 (2,29)	0.382	0.968	0.064	1.370
birth.precip.spring	1.957 (1,30)	0.172	0.825	0.061	-0.527
birth.temp.summer * density	0.837 (3,28)	0.444	0.968	0.056	1.915
birth.precip.summer * density	0.777 (3,28)	0.470	0.968	0.053	2.059
birth.temp.summer	1.636 (1,30)	0.211	0.825	0.052	-0.132
birth.precip.winter.aft * density	0.738 (3,28)	0.487	0.968	0.050	2.153
birth.precip.winter.bef	1.571 (1,30)	0.220	0.825	0.050	-0.051
temp.fall (Int)	1.420 (1,29)	0.243	0.825	0.047	0.072
precip.winter.bef (Int)	1.403 (1,29)	0.246	0.825	0.046	0.175
birth.temp.fall * density	0.652 (3,28)	0.529	0.968	0.044	2.363
birth.pdo.annual * density	0.588 (3,28)	0.562	0.968	0.040	2.520
birth.precip.winter.bef * density	0.536 (3,28)	0.591	0.968	0.037	2.649
birth.precip.spring * density	0.513 (3,28)	0.604	0.968	0.035	2.707

Table S2 (continued):

Environmental Covariate	Fcst/co/t	P-value	adj.P-value	R²	Delta AICc
temp.winter.bef (Int)	0.860 (1,29)	0.361	0.968	0.029	0.821
birth.precip.summer (quad)	0.376 (2,29)	0.690	0.968	0.025	2.985
birth.precip.winter.aft	0.613 (1,30)	0.440	0.968	0.020	1.183
precip.summer (Int)	0.564 (1,29)	0.459	0.968	0.019	1.230
birth.precip.fall * density	0.249 (3,28)	0.781	0.968	0.017	3.379
birth.precip.summer	0.490 (1,30)	0.489	0.968	0.016	1.348
precip.fall (Int)	0.436 (1,29)	0.514	0.968	0.015	1.421
birth.precip.fall (quad)	0.184 (2,29)	0.833	0.968	0.013	3.513
birth.precip.fall	0.365 (1,30)	0.550	0.968	0.012	1.516
birth.temp.spring * density	0.162 (3,28)	0.851	0.968	0.011	3.607
birth.temp.fall (quad)	0.137 (2,29)	0.872	0.968	0.009	3.643
fem (Int)	0.254 (1,29)	0.618	0.968	0.009	1.697
birth.temp.spring (quad)	0.111 (2,29)	0.895	0.968	0.008	3.717
birth.pdo.annual (quad)	0.102 (2,29)	0.903	0.968	0.007	3.743
birth.pdo.annual	0.184 (1,30)	0.671	0.968	0.006	1.763
temp.summer (Int)	0.169 (1,29)	0.684	0.968	0.006	1.799
birth.temp.winter.bef * density	0.068 (3,28)	0.934	0.968	0.005	3.856
temp.spring (Int)	0.086 (1,29)	0.772	0.968	0.003	1.898
precip.spring (Int)	0.073(1,29)	0.788	0.968	0.003	1.923
birth.temp.winter.bef (quad)	0.035 (2,29)	0.966	0.968	0.002	3.934
temp.winter.aft (Int)	0.048 (1,29)	0.828	0.968	0.002	1.957
birth.temp.fall	0.046 (1,30)	0.831	0.968	0.002	1.951
birth.temp.spring	0.017 (1,30)	0.899	0.968	0.001	1.992
birth.temp.winter.bef	0.010 (1,30)	0.923	0.968	0.000	2.002
pdo.annual (Int)	0.002 (1,29)	0.968	0.968	0.000	2.018

Table S3: Statistics used to test the effect of birth environment covariates on bighorn ewe survival from 1973 to 2014 using time-dependent cox proportional models. Fcst/co/t (degrees of freedom) is the statistic from the ANODEV method. R² is the proportion of the variance between cohorts explained by the covariate. Delta AICc refers to the difference between the AICc of the model including the covariate and the base model (a negative value indicates a better model than the base model). Interactions with density are noted as “ * density”, quadratic effects of variables are noted as “(quad)” and models with interactions between early and current environment are noted as “Int”.

Environmental Covariate	Fcst/co/t	P-value	adj.P-value	R²	Delta AICc
density	11.157 (1,30)	0.002	0.106	0.271	-14.188
density (quad)	5.585 (2,29)	0.009	0.209	0.278	-12.600
precip.spring	4.774 (1,30)	0.037	0.577	0.137	-6.197
precip.spring (quad)	2.638 (2,29)	0.089	0.862	0.154	-5.185
precip.winter.aft (quad)	2.303 (2,29)	0.118	0.862	0.137	-4.178
temp.winter.aft	2.420 (1,30)	0.130	0.862	0.075	-2.456
temp.winter.aft *density	2.122 (3,28)	0.139	0.862	0.132	-1.717
precip.winter.aft (Int)	2.223 (1,29)	0.147	0.862	0.071	-2.179
precip.winter.bef	2.007 (1,30)	0.167	0.871	0.063	-1.743
temp.winter.aft (quad)	1.306 (2,29)	0.286	0.962	0.083	-0.928
precip.winter.bef (Int)	1.144 (1,29)	0.294	0.962	0.038	-0.166
precip.spring (Int)	0.892 (1,29)	0.353	0.962	0.030	0.468
precip.summer *density	1.076 (3,28)	0.355	0.962	0.071	0.906
precip.winter.bef (quad)	1.040 (2,29)	0.366	0.962	0.067	0.011
temp.fall (Int)	0.708 (1,29)	0.407	0.962	0.024	0.641
temp.winter.bef (Int)	0.677 (1,29)	0.417	0.962	0.023	0.633
temp.fall *density	0.663 (3,28)	0.523	0.962	0.045	2.043
precip.summer (Int)	0.406 (1,29)	0.529	0.962	0.014	1.180
precip.winter.aft *density	0.645 (3,28)	0.532	0.962	0.044	2.096
temp.summer (quad)	0.626 (3,28)	0.542	0.962	0.041	1.535
precip.fall	0.368 (1,30)	0.549	0.962	0.012	1.280
precip.summer (quad)	0.602 (2,29)	0.554	0.962	0.040	1.626
precip.winter.bef *density	0.579 (3,28)	0.567	0.962	0.040	2.285

Table S3 (continued):

Environmental Covariate	Fcst/co/t	P-value	adj.P-value	R²	Delta AICc
precip.spring *density	0.576 (3,28)	0.568	0.962	0.040	2.291
density (Int)	0.259 (1,29)	0.614	0.962	0.009	1.632
precip.fall (Int)	0.237 (1,29)	0.630	0.962	0.008	1.554
temp.summer	0.237 (1,30)	0.630	0.962	0.008	1.535
temp.summer *density	0.466 (3,28)	0.632	0.962	0.032	2.610
pdo.annual	0.196 (1,30)	0.661	0.962	0.006	1.615
temp.winter.bef	0.195 (1,30)	0.662	0.962	0.006	1.617
pdo.annual *density	0.415 (3,28)	0.664	0.962	0.029	2.758
precip.summer	0.132 (1,30)	0.719	0.962	0.004	1.741
pdo.annual (Int)	0.124 (1,29)	0.727	0.962	0.004	1.754
precip.fall *density	0.303 (3,28)	0.741	0.962	0.021	3.090
temp.winter.bef (quad)	0.253 (2,29)	0.778	0.962	0.017	2.983
temp.fall	0.068 (1,30)	0.796	0.962	0.002	1.868
precip.fall (quad)	0.190 (2,29)	0.828	0.962	0.013	3.234
temp.spring (quad)	0.174 (2,29)	0.841	0.962	0.012	3.301
precip.winter.aft	0.041 (1,30)	0.842	0.962	0.001	1.922
temp.summer (Int)	0.036 (1,29)	0.852	0.962	0.001	1.939
temp.winter.bef *density	0.130 (3,28)	0.878	0.962	0.009	3.610
temp.spring *density	0.130 (3,28)	0.879	0.962	0.009	3.612
pdo.annual (quad)	0.120 (2,29)	0.887	0.962	0.008	3.516
temp.winter.aft (Int)	0.012 (1,29)	0.914	0.962	0.000	1.985
temp.spring (Int)	0.010 (1,29)	0.921	0.962	0.000	1.987
temp.spring	0.005 (1,30)	0.944	0.962	0.000	1.993
temp.fall (quad)	0.035 (2,29)	0.966	0.962	0.002	3.864

Figure S1: Predicted reproduction of bighorn ewes by a) cohort and b) individual according to current density. Birth density is represented by the color of the curves. All density values were standardized.

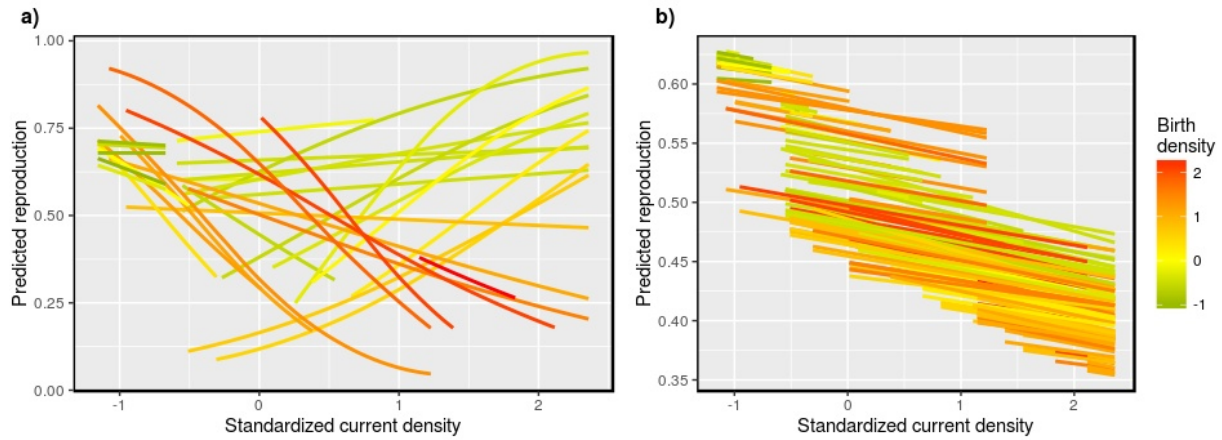


Figure S2: Number of ewes at Ram Mountain according to current and birth density. Dot size is proportional to sample size.

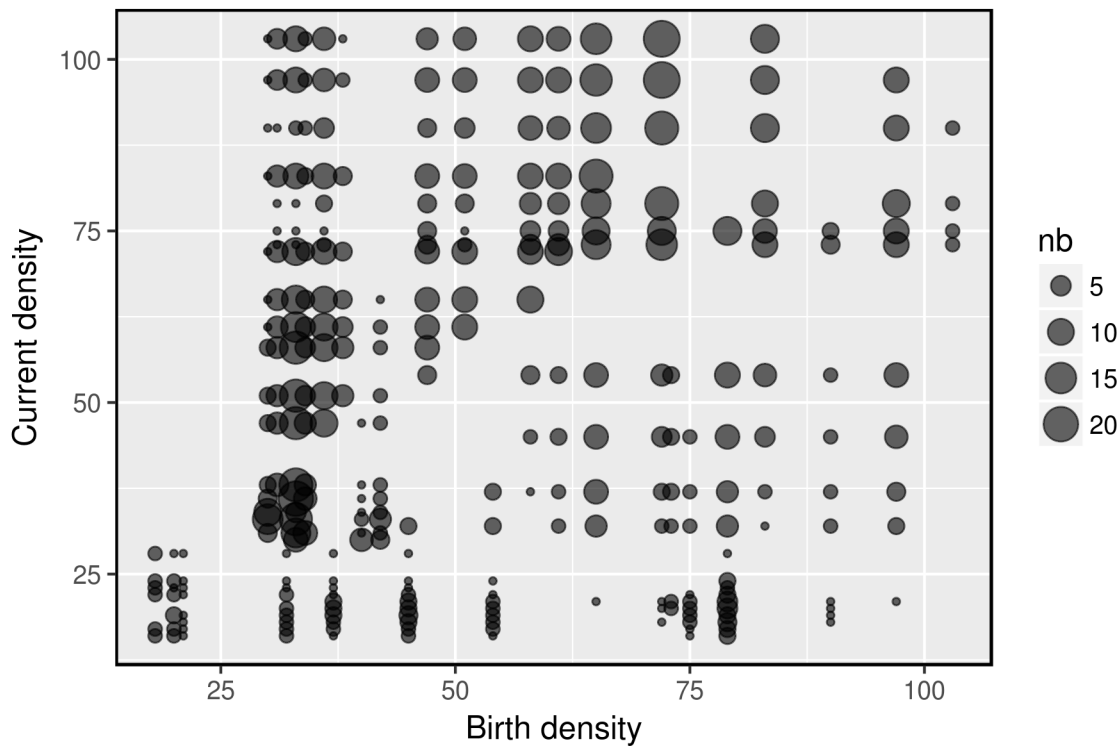


Table S4: Additional information about cohorts of bighorn ewes at Ram Mountain. Number of individual per cohort (N); length of time the cohort was present in the population in years (Present for); mean number of years a ewe was observed (Mean(obs/id); standard deviation of the number of observation per individual (Mean(obs/id)).

Cohort	N	Present for	Mean(obs/id)	Sd(obs/id)
1973	6	15	10.47	4.88
1974	7	10	5.17	3.23
1975	8	17	11.61	6.11
1976	12	10	4.35	2.84
1977	6	17	10.5	5.99
1978	11	19	12.23	4.4
1979	8	15	10.54	3.78
1980	7	13	8.75	2.53
1981	7	16	11.09	2.58
1982	11	15	10.4	2.8
1983	6	10	6.52	2.08
1984	8	14	10.85	3.08
1985	9	12	8.39	2.03
1986	10	14	9.92	2.56
1987	11	14	9.59	3.28
1988	18	14	10.05	2.83
1989	22	15	7.89	2.89
1990	12	11	7.26	1.98
1991	9	11	7.61	2.17
1992	2	5	4	0
1993	3	6	4.64	1.21
1994	4	11	7.42	3.15
1995	12	17	10.59	4.93
1996	3	7	5.4	1.24
1997	2	11	8.76	1.52
1998	3	11	8.05	2.57
1999	4	13	9	3.22
2000	6	12	7.21	4.6
2001	2	13	10	2.91
2002	1	10	9	0
2003	3	11	7.88	2.99
2004	2	10	8.12	1.02