

# **Food, family and female age affect reproduction and pup survival of African wild dogs**

**David G. Marneweck<sup>1</sup>, Dave J. Druce<sup>2,3</sup>, & Michael J. Somers<sup>1,4</sup>**

<sup>1</sup>Eugène Marais Chair of Wildlife Management, Mammal Research Institute, University of Pretoria

<sup>2</sup>Ezemvelo KwaZulu-Natal Wildlife, Hluhluwe-iMfolozi Park, South Africa

<sup>3</sup>School of Biological and Conservation Sciences, College of Agriculture, Engineering and Science, University of KwaZulu-Natal

<sup>4</sup>Centre for Invasion Biology, University of Pretoria, South Africa

**Corresponding author:** David G. Marneweck, [davidmarneweck@gmail.com](mailto:davidmarneweck@gmail.com), +2712 420 6091

**Journal:** Behavioral Ecology and Sociobiology

## Supplementary material

**Supplementary Table 1** The seven *a priori* candidate regression models used to investigate factors predicting the age (years) at which female wild dogs will produce their first litter of pups in Hluhluwe-iMfolozi Park, South Africa. Models were ranked according to the Akaike Information Criterion corrected for small sample sizes (AICc). Models used in the model averaging procedure were those with a cumulative Akaike weight  $\leq 0.95$  and top models were selected (bold) where  $\Delta\text{AICc} \leq 2$  following Burnham and Anderson (1998)

Rank	Form of regression	<i>df</i>	loglikelihood	AICc	$\Delta\text{AICc}$	$w_i$	R <sup>2</sup>
1	<b>Pack density</b>	<b>3</b>	<b>-48.46</b>	<b>103.88</b>	<b>0.00</b>	<b>0.36</b>	<b>0.10</b>
2	<b>Biomass</b>	<b>3</b>	<b>-48.75</b>	<b>104.46</b>	<b>0.57</b>	<b>0.27</b>	<b>0.10</b>
3	<b>Pack size</b>	<b>3</b>	<b>-49.16</b>	<b>105.28</b>	<b>1.40</b>	<b>0.18</b>	<b>0.08</b>
4	Rainfall	3	-50.15	107.25	3.37	0.07	0.01
5	Temperature	3	-50.20	107.36	3.48	0.06	0.00
6	Biomass: Pack size	5	-48.10	108.82	4.93	0.03	0.13
7	Biomass: Pack density	5	-48.11	108.83	4.94	0.03	0.13

R<sup>2</sup> uses the “delta R<sup>2</sup>” from the function *r.squaredGLMM* in the package *rsq* in R for family of Poisson distribution

**Supplementary Table 2** The ten *a priori* candidate regression models used to investigate factors predicting litter size of wild dogs in Hluhluwe-iMfolozi Park, South Africa. Models were ranked according to the Akaike Information Criterion corrected for small sample sizes ( $AIC_c$ ). Models used in the model averaging procedure were those with a cumulative Akaike weight  $\leq 0.95$  and top models were selected (bold) where  $\Delta AIC_c \leq 2$  following Burnham and Anderson (1998)

Rank	Form of regression	<i>df</i>	loglikelihood	$AIC_c$	$\Delta AIC_c$	$w_i$	$R^2$
<b>1</b>	<b>Pack size</b>	<b>4</b>	<b>-164.93</b>	<b>338.51</b>	<b>0.00</b>	<b>0.78</b>	<b>0.19</b>
2	Biomass: Pack size	6	-164.50	342.41	3.89	0.11	0.19
3	Female age: Pack size	6	-164.92	343.24	4.73	0.07	0.19
4	Temperature	4	-169.33	347.31	8.79	0.01	0.20
5	Female age	4	-169.68	348.00	9.48	0.01	0.20
6	Lion density	4	-169.91	348.47	9.96	0.01	0.20
7	Pack density	4	-170.26	349.16	10.65	0.00	0.20
8	Rainfall	4	-170.30	349.24	10.72	0.00	0.20
9	Biomass	4	-170.30	349.25	10.73	0.00	0.20
10	Biomass: Pack density	6	-170.20	353.80	15.29	0.00	0.20

$R^2$  uses the “delta  $R^2$ ” from the function *r.squaredGLMM* in the package *rsq* in R for family of Poisson distribution

**Supplementary Table 3** The 13 *a priori* candidate regression models used to investigate factors predicting the proportion of wild dog pups raised to six months old in Hluhluwe-iMfolozi Park, South Africa. Models were ranked according to the Akaike Information Criterion corrected for small sample sizes ( $AIC_c$ ). Models used in the model averaging procedure were those with a cumulative Akaike weight  $\leq 0.95$  and top models were selected (bold) where  $\Delta AIC_c \leq 2$  following Burnham and Anderson (1998)

Rank	Form of regression	<i>df</i>	loglikelihood	$AIC_c$	$\Delta AIC_c$	$w_i$	$R^2$
<b>1</b>	<b>Female age: Pack size</b>	<b>5</b>	<b>-90.79</b>	<b>192.63</b>	<b>0.00</b>	<b>&gt; 0.99</b>	<b>0.31</b>
2	Biomass: Pack size	5	-97.88	206.81	14.18	0.00	0.31
3	Rainfall: Pack size	5	-98.65	208.35	15.72	0.00	0.35
4	Lion density: Pack size	5	-100.99	213.03	20.40	0.00	0.23
5	Litter size: Pack size	5	-103.42	217.89	25.26	0.00	0.26
6	Pack size	3	-107.25	220.91	28.28	0.00	0.22
7	Temperature	3	-109.33	225.08	32.45	0.00	0.24
8	Temperature: Rainfall	5	-107.03	225.12	32.49	0.00	0.26
9	Female age	3	-112.92	232.25	39.63	0.00	0.19
10	Lion density	3	-114.51	235.44	42.81	0.00	0.19
11	Biomass	3	-114.65	235.71	43.08	0.00	0.19
12	Litter size	3	-114.69	235.78	43.16	0.00	0.17
13	Rainfall	3	-115.21	236.82	44.19	0.00	0.19

$R^2$  uses the “theoretical  $R^2$ ” from the function *r.squaredGLMM* in the package *rsq* in R for family of binomial distribution and logit link

**Supplementary Table 4** The 13 *a priori* candidate regression models used to investigate factors predicting the proportion of wild dog pups raised to one year old in Hluhluwe-iMfolozi Park, South Africa. Models were ranked according to the Akaike Information Criterion corrected for small sample sizes (AICc). Models used in the model averaging procedure were those with a cumulative Akaike weight  $\leq 0.95$  and top models were selected (bold) where  $\Delta AICc \leq 2$  following Burnham and Anderson (1998)

Rank	Form of regression	df	loglikelihood	AICc	$\Delta AICc$	$w_i$	R <sup>2</sup>
<b>1</b>	<b>Female age: Pack size</b>	5	-114.97	241.06	0.00	0.88	0.21
2	Biomass: Pack size	5	-118.13	247.38	6.32	0.04	0.20
3	Rainfall: Pack size	5	-118.17	247.45	6.39	0.04	0.18
4	Lion density: Pack size	5	-118.58	248.28	7.22	0.02	0.20
5	Pack size	3	-121.22	248.87	7.81	0.02	0.16
6	Litter size: Pack size	5	-120.67	252.44	11.39	0.00	0.16
7	Temperature	3	-127.43	261.29	20.23	0.00	0.21
8	Temperature: Rainfall	5	-125.34	261.79	20.74	0.00	0.21
9	Female age	3	-127.96	262.36	21.30	0.00	0.19
10	Litter size	3	-128.21	262.84	21.79	0.00	0.14
11	Rainfall	3	-129.54	265.52	24.46	0.00	0.17
12	Lion density	3	-129.60	265.63	24.58	0.00	0.18
13	Biomass	3	-129.68	265.80	24.74	0.00	0.17

R<sup>2</sup> uses the “theoretical R<sup>2</sup>” from the function *r.squaredGLMM* in the package *rsq* in R for family of binomial distribution and logit link

**Supplementary Table 5** The 13 *a priori* candidate regression models used to investigate factors predicting the number of wild dog pups raised to six months old in Hluhluwe-iMfolozi Park, South Africa. Models were ranked according to the Akaike Information Criterion corrected for small sample sizes (AICc). Models used in the model averaging procedure were those with a cumulative Akaike weight  $\leq 0.95$  and top models were selected (bold) where  $\Delta AICc \leq 2$  following Burnham and Anderson (1998)

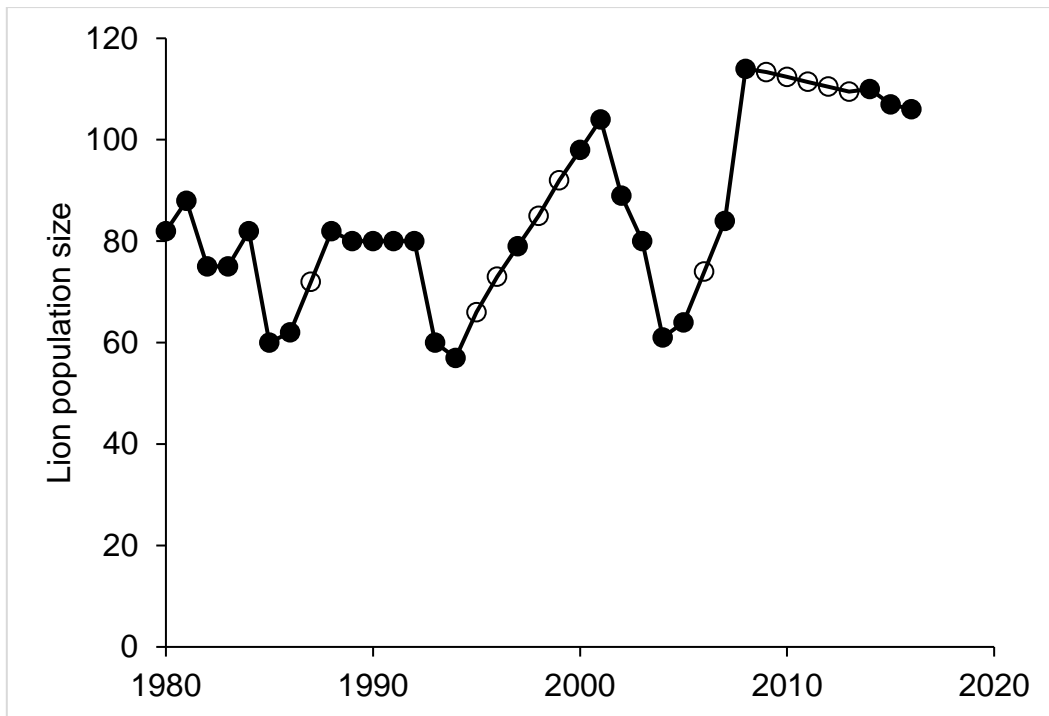
Rank	Form of regression	df	loglikelihood	AICc	$\Delta AICc$	$w_i$	$R^2$
<b>1</b>	<b>Litter size</b>	<b>3</b>	<b>-132.55</b>	<b>271.51</b>	<b>0.00</b>	<b>0.76</b>	<b>0.54</b>
2	Litter size: Pack size	5	-131.38	273.81	2.31	0.24	0.54
3	Female age: Pack size	5	-152.21	315.47	43.96	0.00	0.45
4	Lion density: Pack size	5	-155.41	321.87	50.36	0.00	0.34
5	Pack size	3	-159.08	324.56	53.06	0.00	0.29
6	Biomass: Pack size	5	-157.25	325.56	54.05	0.00	0.30
7	Rainfall: Pack size	5	-159.02	329.09	57.59	0.00	0.29
8	Temperature	3	-166.96	340.32	68.82	0.00	0.32
9	Rainfall	3	-167.12	340.65	69.14	0.00	0.31
10	Biomass	3	-167.35	341.11	69.60	0.00	0.31
11	Female age	3	-167.37	341.14	69.64	0.00	0.31
12	Lion density	3	-167.38	341.16	69.66	0.00	0.31
13	Temperature: Rainfall	5	-166.39	343.84	72.33	0.00	0.33

$R^2$  uses the “delta  $R^2$ ” from the function *r.squaredGLMM* in the package *rsq* in R for family of Poisson distribution

**Supplementary Table 6** The 13 *a priori* candidate regression models used to investigate factors predicting the number of wild dog pups raised to one year old in Hluhluwe-iMfolozi Park, South Africa. Models were ranked according to the Akaike Information Criterion corrected for small sample sizes (AICc). Models used in the model averaging procedure were those with a cumulative Akaike weight  $\leq 0.95$  and top models were selected (bold) where  $\Delta AICc \leq 2$  following Burnham and Anderson (1998)

Rank	Form of regression	df	loglikelihood	AICc	$\Delta AICc$	$w_i$	R <sup>2</sup>
<b>1</b>	<b>Litter size: Pack size</b>	<b>5</b>	<b>-125.88</b>	<b>262.88</b>	<b>0.00</b>	<b>0.54</b>	<b>0.54</b>
<b>2</b>	<b>Litter size</b>	<b>3</b>	<b>-128.39</b>	<b>263.22</b>	<b>0.34</b>	<b>0.46</b>	<b>0.51</b>
3	Female age: Pack size	5	-148.19	307.50	44.62	0.00	0.42
4	Lion density: Pack size	5	-149.37	309.85	46.97	0.00	0.40
5	Pack size	3	-152.41	311.25	48.37	0.00	0.33
6	Rainfall: Pack size	5	-151.88	314.87	51.99	0.00	0.34
7	Biomass: Pack size	5	-151.98	315.07	52.19	0.00	0.34
8	Rainfall	3	-156.94	320.32	57.44	0.00	0.41
9	Biomass	3	-157.73	321.88	59.00	0.00	0.41
10	Temperature	3	-157.73	321.89	59.01	0.00	0.42
11	Female age	3	-158.02	322.48	59.60	0.00	0.41
12	Lion Density	3	-158.03	322.48	59.60	0.00	0.41
13	Temperature: Rainfall	5	-156.19	323.50	60.62	0.00	0.41

R<sup>2</sup> uses the “delta R<sup>2</sup>” from the function *r.squaredGLMM* in the package *rsq* in R for family of Poisson distribution



**Supplementary Fig. 1** Time series showing the change in the estimated lion population size from 1980 to 2016 in Hluhluwe-iMfolozi Park. Solid points (●) show actual counts of lions estimated from various methods (see Grange et al. 2012) while open points (○) show estimated data counts reconstructed from mean and linear regression analyses (see *Methods – Lions*)