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Supporting Online Material for

African Wild Ungulates Compete with or Facilitate Cattle Depending on Season

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This PDF file includes:

Supporting Online Material
www.sciencemag.org
Materials and Methods
Figs. S1, S2
Tables S1-S6

MATERIALS AND METHODS

Study site and experimental treatments
We conducted the study at Mpala Research Centre (0°17'N, 37°52'E, 1800 m a.s.l.) using a set of large mammal exclosures established by the Kenya Long-term Exclosure Experiment (KLEE) (*11, 25*). We used treatment plots cattle accessed exclusively (C), and those they shared with medium-sized wild ungulates (> 20 kg; plains zebra *Equus burchelli*, Grevy's zebra *E. grevyi*, African buffalo *Syncerus caffer*, eland *Tragelaphus oryx*, hartebeest *Acelaphus buselaphus*, oryx *Oryx gazella* and Grant's gazelle *Gazella granti*) in the absence (WC), or presence (MWC), of megaherbivores (African elephant *Loxodonta africana* and giraffe *Giraffa camelopardalis*). Each of the three herbivory treatments was replicated across three experimental blocks, resulting in a completely randomized block design comprising nine 4-ha treatment plots.

Trial periods, test animals and stocking density
We carried out two 16-week trials during 2007-2008. The first trial was conducted during February-June 2007, and the second trial during August-December 2008. Each trial comprised a wet and a dry season, with the first 6 weeks of the first trial (i.e. February-March) and the first 8 weeks of the second trial (i.e. August-October) being dry, and the remaining segments of both trials being wet.

At the start of each trial period, we obtained 36 Boran heifers (*Bos indicus*) aged 2-3.5 years and weighing 261 kg $\pm$ 43 (SD), from Mpala Ranch, and randomly grouped them into nine herds of four heifers each. We then randomly allocated the composed heifer herds to the nine experimental plots (one herd/plot), and with the help of experienced local Maasai and Turkana herdsmen, herded them within their respective treatment plots throughout the trial period. Our stocking rate of ~0.3 cattle/ha/year was slightly higher than stocking rates in most commercial ranches that accommodate wildlife in the Laikipia region (*12,13*).

Data collection
During the course of each trial, we measured live weight change bi-weekly. In addition, we estimated organic matter food intake (OMI) as faecal output/(1-digestible organic matter, DOM) once or twice during each dry period, with faecal output being measured by total faecal collection over 5-day period. Dung was generally too loose during the wet periods to make total faecal collection reliable. To estimate diet quality, we analysed faecal samples from the total collections in the dry periods and additional samples obtained twice or thrice during each wet period for prediction of dietary DOM and crude protein (CP) contents using the near infrared reflectance spectroscopy (NIRS) (*26*). Finally, to estimate the relative bites taken by cattle on different forage species, we observed individual heifers in four 5-minute focal periods bi-weekly. Contemporaneous

with these observations, we measured herbage cover as contacts/100 pins by placing a 1-m pin perpendicular to the ground at approximately1-m intervals along four 25-m transects randomly located on the grazing paths of experimental animals, and recording all pin contacts with different plant species and parts (live/dead stems/leaves). We used data on relative bites and cover of different herbage species consumed by cattle to compute their respective selection indices following Ivlev's formula (*27*). Ivlev's index varies from -1 (total avoidance) through 0 (no selection) to 1 (total selection).

Data analysis

We used treatment plots as experimental units, and individual heifers and vegetation surveys as plot sub-samples. For each year, we averaged data across animals (or vegetation surveys) in each plot per season. We then averaged seasonal data across years and analysed each season separately using ANOVA, with experimental block effects, to test for differences among the three herbivory treatments (C, WC and MWC). We performed Tukey's HSD to separate treatment means. We subjected data on all measured variables to normality tests prior to analysis, and found them to be normally distributed (one-sample Kolmogorov-Smirnov test Z = 0.387-0.81; P = 0.411-0.997).

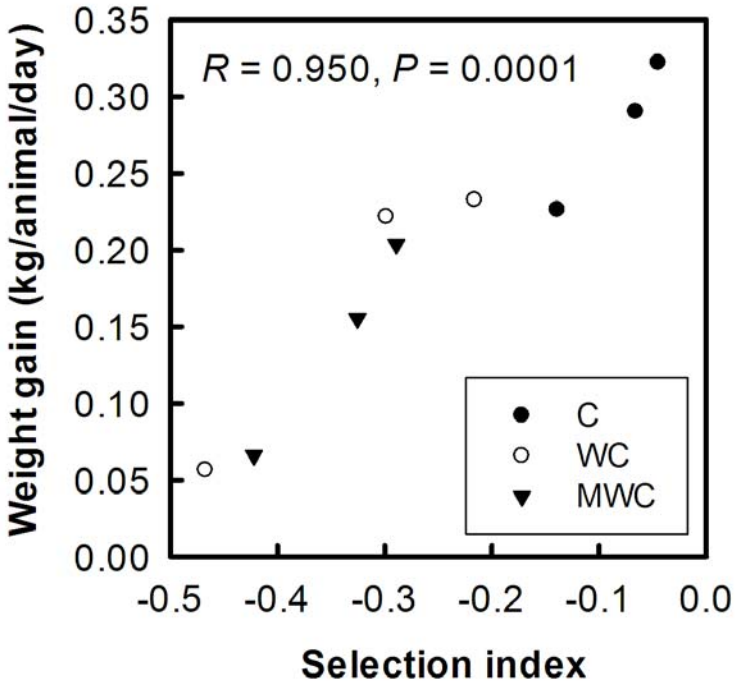

Figure S1. A scatter plot showing the relationship between selection index of *Pennisetum stramineum* and weight gain of cattle across treatments during dry season. Treatments were plots cattle accessed exclusively (C), and those they shared with wild herbivores excluding (WC), or including (MWC), megaherbivores.

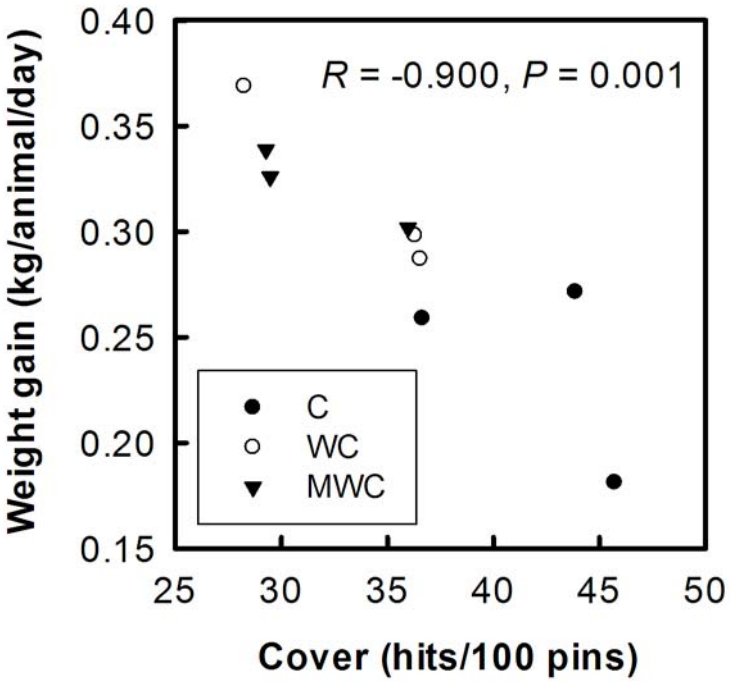

Figure S2. A scatter plot showing the relationship between the cover of dead grass stems and weight gain of cattle across treatments during wet season. Treatments were plots cattle accessed exclusively (C), and those they shared with wild herbivores excluding (WC), or including (MWC), megaherbivores.

Table S1. Cover (mean ±SEM, $N = 3$) of major grass species (excluding *Pennisetum stramineum*) in treatment plots cattle accessed exclusively (C), and those they shared with wild herbivores excluding (WC), or including (MWC), megaherbivores.

	C Hits/100 pins	WC Hits/100 pins	MWC Hits/100 pins	*F*	*P*
Dry season					
Brachiaria lachnantha	111.7 ± 7.1	110.5 ± 7.1	97.8 ± 28.5	0.2	0.8
Themeda triandra	61.9 ± 10.0	58.7 ± 9.5	76.4 ± 14.6	0.9	0.5
Pennisetum mezianum	17.4 ± 2.8	20.9 ± 3.0	24.6 ± 7.6	1.3	0.4
Lintonia nutans	9.0 ± 2.8	7.5 ± 1.2	13.4 ± 1.5	6.5	0.1
Bothriochloa insculpta	6.5 ± 5.1	17.1 ± 10.6	8.3 ± 5.5	3.0	0.2
Wet season					
Brachiaria lachnantha	112 ± 6.4	111.8 ± 10.5	97.2 ± 7.4	1.2	0.4
Themeda triandra	55.9 ± 5.5	58.6 ± 9.4	71.5 ± 12.6	1.3	0.4
Pennisetum mezianum	17.9 ± 3.2	13.9 ± 2.0	19.4 ± 4.3	1.6	0.3
Lintonia nutans	12.9 ± 2.5	11.1 ± 0.3	17.0 ± 1.9	4.5	0.1
Bothriochloa insculpta	4.0 ± 1.00	15.9 ± 6.8	5.5 ± 1.7	4.0	0.1

Table S2. Relative bites (mean ±SEM, $N = 3$) by cattle on major grass species (excluding *Pennisetum stramineum*) in treatment plots cattle accessed exclusively (C), and those they shared with wild herbivores excluding (WC), or including (MWC), megaherbivores.

	C Bites (%)	WC Bites (%)	MWC Bites (%)	*F*	*P*
Dry season					
Brachiaria lachnantha	45 ± 3.4	51.9 ± 3.3	46.4 ± 4.7	0.7	0.5
Themeda triandra	19.8 ± 0.9	25.1 ± 4.1	30.5 ± 4.1	3.0	0.2
Pennisetum mezianum	1.0 ± 0.4	1.8 ± 0.6	1.6 ± 0.5	4.1	0.1
Lintonia nutans	3.0 ± 0.8	2.3 ± 0.4	5.3 ± 1.5	6.0	0.1
Bothriochloa insculpta	1.5 ± 0.7	4 ± 2.0	3.3 ± 2.7	0.9	0.5
Wet season					
Brachiaria lachnantha	57.7 ± 1.8	59.5 ± 1.0	58.3 ± 3.2	0.3	0.8
Themeda triandra	**17.1^{a} ± 0.3**	**19.8^{ab} ± 1.9**	**23.0^{b} ± 2.0**	**6.6**	**0.05**
Pennisetum mezianum	1.2 ± 0.2	1.0 ± 0.2	1.3 ± 0.5	0.5	0.6
Lintonia nutans	1.6 ± 0.3	1.6 ± 0.1	2.2 ± 0.4	1.9	0.3
Bothriochloa insculpta	0.5 ± 0.3	2.6 ± 1.6	1.4 ± 0.7	2.6	0.2

Means listed in bold and bearing different superscripts differ within rows ($P < 0.05$; Tukey's HSD).

Table S3. Selection indices (mean ±SEM, $N = 3$) of major grass species (excluding *Pennisetum stramineum*) consumed by cattle in treatment plots they accessed exclusively (C), and those they shared with wild herbivores excluding (WC), or including (MWC), megaherbivores.

	C Selection index	WC Selection index	MWC Selection index	*F*	*P*
Dry season					
Brachiaria lachnantha	0.18 ± 0.04	0.22 ± 0.04	0.22 ± 0.06	0.2	0.8
Themeda triandra	0.08 ± 0.13	0.18 ± 0.04	0.12 ± 0.02	0.7	0.6
Pennisetum mezianum	-0.66 ± 0.08	-0.57 ± 0.11	-0.66 ± 0.04	1.0	0.4
Lintonia nutans	0.09 ± 0.11	0.02 ± 0.02	0.08 ± 0.09	0.3	0.7
Bothriochloa insculpta	0.12 ± 0.24	-0.22 ± 0.24	-0.08 ± 0.32	0.4	0.7
Wet season					
Brachiaria lachnantha	0.30 ± 0.03	0.29 ± 0.05	0.30 ± 0.03	0.2	0.8
Themeda triandra	0.07 ± 0.03	0.07 ± 0.02	0.01 ± 0.06	1.4	0.4
Pennisetum mezianum	-0.59 ± 0.02	-0.60 ± 0.06	-0.66 ± 0.06	0.6	0.6
Lintonia nutans	-0.36 ± 0.08	-0.35 ± 0.03	-0.44 ± 0.07	0.4	0.7
Bothriochloa insculpta	-0.41 ± 1.00	-0.36 ± 1.00	-0.24 ± 0.12	4.9	0.1

Table S4. Data on the measured performance, food intake and diet quality variables in each of the nine experimental plots during dry and wet seasons. Treatment plots were those cattle accessed exclusively (C), and those they shared with wild herbivores excluding (WC), or including (MWC), megaherbivores.

	Weight gain (kg/day)	OMI (kg/day)	DOM (%)	CP(%)
Dry season				
Central block				
C	0.290	4.57	56.79	8.19
WC	0.233	4.19	56.76	7.92
MWC	0.204	4.36	56.17	8.21
North block				
C	0.226	4.54	56.90	7.50
WC	0.057	4.36	56.86	7.94
MWC	0.066	4.22	57.50	8.06
South block				
C	0.322	4.64	57.49	8.62
WC	0.222	4.20	55.98	7.88
MWC	0.156	4.34	56.95	7.83
Wet season				
Central block				
C	0.271	_	58.67	10.59
WC	0.298	_	58.92	11.11
MWC	0.326	_	57.83	11.06
North block				
C	0.259	_	59.38	10.53
WC	0.369	_	58.10	10.61
MWC	0.339	_	58.75	10.83
South block				
C	0.181	_	58.97	10.76
WC	0.287	_	58.04	11.10
MWC	0.302	_	59.23	11.36

Table S5. Data on cover, relative bites and selection index of *Pennisetum stramineum* in each of the nine experimental plots used in the study during dry and wet seasons. Treatment plots were those cattle accessed exclusively (C), and those they shared with wild herbivores excluding (WC), or including (MWC), megaherbivores.

	Cover (hits/100 pins)	Bites (%)	Selection index
Dry season			
Central block			
C	145.0	33.7	-0.07
WC	127.7	23.9	-0.22
MWC	107.4	13.3	-0.29
North block			
C	135.2	25.8	-0.14
WC	91.7	9.2	-0.47
MWC	77.3	11.3	-0.42
South block			
C	82.6	24.2	-0.04
WC	42.0	7.5	-0.30
MWC	44.5	9.2	-0.33
Wet season			
Central block			
C	131.4	23.0	-0.15
WC	71.8	15.2	-0.20
MWC	59.2	16.3	-0.12
North block			
C	108.7	16.8	-0.29
WC	98.3	17.2	-0.26
MWC	70.6	8.6	-0.42
South block			
C	114.9	20.6	-0.25
WC	74.5	9.3	-0.38
MWC	65.7	13.1	-0.23

Table S6. Data on different grass parts in each of the nine experimental plots used in the study during dry and wet seasons. Treatment plots were those cattle accessed exclusively (C), and those they shared with wild herbivores excluding (WC), or including (MWC), megaherbivores.

	Live leaves (hits/100pins)	Dead leaves (hits/100pins)	Live stems (hits/100pins)	Dead stems (hits/100pins)
Dry season				
Central block				
C	104.6	147.7	16.0	73.7
WC	69.4	141.9	18.4	85.5
MWC	110.5	202.3	8.2	84.0
North block				
C	73.1	159.7	20.1	92.9
WC	78.2	131.9	14.4	76.8
MWC	55.2	116.1	14.3	61.4
South block				
C	88.5	135.6	10.1	63.1
WC	80.2	120.6	21.9	66.1
MWC	76.4	99.8	10.4	41.8
Wet season				
Central block				
C	197.8	71.6	43.3	43.9
WC	171.3	58.5	21.2	36.3
MWC	147.7	53.4	25.9	29.5
North block				
C	157.0	70.3	31.1	36.7
WC	170.6	55.9	25.8	28.3
MWC	166.2	79.7	13.0	29.3
South block				
C	188.6	52.6	24.5	45.7
WC	184.9	60.3	36.6	36.6
MWC	168.6	52.4	25.4	36.0

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