

Supplementary Material

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Appendix A: Pilot Questionnaire

1. Experiences

[Start with introduction and small talk – build trust. Then move on to identification test. Then the questions]

Livestock predation:

- a) How many cattle, sheep, goats, and donkeys do you lose every year to hyenas?
 - b) How many cattle, sheep, goats, and donkeys do you lose every year to lions?
 - c) How many cattle, sheep, goats, and donkeys do you lose every year to leopards?
 - d) How many cattle, sheep, goats, and donkeys do you lose every year to cheetahs?
 - e) How many cattle, sheep, goats, and donkeys do you lose every year to wild dogs?
- 1.1. What other causes of death do you have to your livestock herds (e.g. drought, disease, accidents)? Do you lose more livestock through predators or the other causes?
 - 1.2. How much money do you lose yearly to predation on livestock, on average? (calculate ourselves based on market price)
 - 1.3. Have you directly observed hyenas, or any other predator, attack your livestock (both at the boma and while herding)?
 - 1.4. Can you tell, based on tracks or carcass evidence, which species of predator attacked your livestock?
 - 1.5. Have you or anyone in your family been attacked by a hyena or another predator?
 - 1.6. How do predators kill your livestock (e.g. approaching bomas at night, attacking livestock lost in the forest)?
 - 1.7. Have you attempted to prevent hyenas or other predators from attacking your livestock without killing them? If so, how (e.g. bells, light, banging pots and pans, dogs, throwing stones)? Does this method work?
 - 1.8. What do you do after a hyena attacks your livestock?
 - 1.9. What do the authorities provide as a reward for living with carnivores? Is this sufficient?
 - 1.9.1. If it is not sufficient, what could the authorities provide so that you can live happily together with carnivores?

2. Values

Domination

People can kill wildlife if they think it poses a threat to their life or property.

1 2 3 4 5 6 7

The needs of humans should be over wildlife protection.

1 2 3 4 5 6 7

Killing animals is cruel and inhumane to animals.

1 2 3 4 5 6 7

Killing an animal does not respect the life of the animal.

1 2 3 4 5 6 7

Mutualism

People and wildlife should live side by side without fear.

1 2 3 4 5 6 7

All living beings are part of one big family.

1 2 3 4 5 6 7

I feel a strong emotional bond with animals.

1 2 3 4 5 6 7

I care about wildlife as much as I do about other people.

1 2 3 4 5 6 7

3. Attitudes

Hyenas

Hyenas should be protected.

1 2 3 4 5 6 7

Hyenas play an important role in nature.

1 2 3 4 5 6 7

Hyenas are important in our culture.

1 2 3 4 5 6 7

Hyenas are fascinating/interesting animals.

1 2 3 4 5 6 7

Hyenas are dangerous to people.

1 2 3 4 5 6 7

Hyenas are dangerous to livestock.

1 2 3 4 5 6 7

Hyenas belong in the Ngorongoro Conservation Area and should be able to live here.

1 2 3 4 5 6 7

Losing livestock to predators is natural and acceptable.

1 2 3 4 5 6 7

The fact that hyenas scavenge on dead, diseased livestock is good for the ecosystem and/or the health of my herd.

1 2 3 4 5 6 7

Management strategies

Using guard dogs is an effective method of protecting livestock.

1 2 3 4 5 6 7

Employing two herd boys instead of just one is an effective method of protecting livestock.

1 2 3 4 5 6 7

Improving boma construction would deter attacks on my livestock.

1 2 3 4 5 6 7

A compensation scheme would make me less likely to kill predators in retaliation.

1 2 3 4 5 6 7

4. Interviewee information

Age: _____

Sex: _____

Number of cattle: _____ sheep: _____ goats: _____ donkeys: _____

Village: _____

Profession: _____

Appendix B: Human-Carnivore Coexistence Questionnaire

Date:

Translator:

Investigator:

Interview ID:

Before or After treatment (circle one)

Introduction: My name is _____ and I am a researcher with _____. I am studying the Maasai community's relationship with wildlife, especially predators (hyenas, lions, and leopards). I am particularly interested in how the predators are impacting your livelihoods due to predation on livestock and how this affects your perceptions towards predators. Over the next 20-30 minutes, I will ask you a series of questions about your experiences, values, and emotions towards predators, and what sorts of management strategies you would favor. You can take as much time as you need to answer the questions and explain your thoughts. Participation is completely voluntary and all your responses will be confidential. I will take notes on this sheet of paper to record your responses.

1. Depredation

1.1. Livestock loss:

1.1.1. How many cattle, sheep, goats, and donkeys do you lose every year to hyenas?

1.1.2. How many cattle, sheep, goats, and donkeys do you lose every year to lions?

1.1.3. How many cattle, sheep, goats, and donkeys do you lose every year to leopards?

1.1.4. How many cattle, sheep, goats, and donkeys do you lose every year to disease and drought?

1.2. Have you seen any of the predators attack your livestock mentioned above?

Which one(s): _____

1.3. Have you or anyone in your family been attacked by a predator mentioned above?

Which one(s): _____

2. Wildlife Value Orientations

Domination

2.1. Wildlife is on Earth for people to use.

1 2 3 4 5 6 7

2.2. People can kill wildlife if they think it poses a threat to their life.

1 2 3 4 5 6 7

2.3. The needs of humans are more important than wildlife protection.

1 2 3 4 5 6 7

Mutualism

2.4. I feel a strong emotional bond with wild animals.

1 2 3 4 5 6 7

2.5. I care about wildlife as much as I do about other people.

1 2 3 4 5 6 7

2.6. I take comfort in the relationships I have with wild animals.

1 2 3 4 5 6 7

3. Hyenas

3.1. To what extent do you like or dislike hyenas?

1 2 3 4 5 6 7

3.2. I fear hyenas.

1 2 3 4 5 6 7

3.3. I find hyenas disgusting.

1 2 3 4 5 6 7

3.4. I feel happy about hyenas.

1 2 3 4 5 6 7

3.5. Hyenas should be protected.

1 2 3 4 5 6 7

3.6. Hyenas play an important role in nature.

1 2 3 4 5 6 7

3.7. Hyenas are important in Maasai culture.

1 2 3 4 5 6 7

3.8. It is acceptable that the NCAA kill hyenas to reduce their numbers.

1 2 3 4 5 6 7

3.9. It is acceptable that the NCAA relocate hyenas far away from my village.

1 2 3 4 5 6 7

3.10. It is acceptable that the NCAA leave hyenas in the Ngorongoro Conservation Area.

1 2 3 4 5 6 7

4. Lions

4.1. To what extent do you like or dislike lions?

1 2 3 4 5 6 7

4.2. I fear lions.

1 2 3 4 5 6 7

4.3. I find lions disgusting.

1 2 3 4 5 6 7

4.4. I feel happy about lions.

1 2 3 4 5 6 7

4.5. Lions should be protected.

1 2 3 4 5 6 7

4.6. Lions play an important role in nature.

1 2 3 4 5 6 7

4.7. Lions are important in Maasai culture.

1 2 3 4 5 6 7

4.8. It is acceptable that the NCAA kill lions to reduce their numbers.

1 2 3 4 5 6 7

4.9. It is acceptable that the NCAA relocate lions far away from my village.

1 2 3 4 5 6 7

4.10. It is acceptable that the NCAA leave lions in the Ngorongoro Conservation Area.

1 2 3 4 5 6 7

5. Leopards

5.1. To what extent do you like or dislike leopards?

1 2 3 4 5 6 7

5.2. I fear leopards.

1 2 3 4 5 6 7

5.3. I find leopards disgusting.

1 2 3 4 5 6 7

5.4. I feel happy about leopards.

1 2 3 4 5 6 7

5.5. Leopards should be protected.

1 2 3 4 5 6 7

5.6. Leopards play an important role in nature.

1 2 3 4 5 6 7

5.7. Leopards are important in Maasai culture.

1 2 3 4 5 6 7

5.8. It is acceptable that the NCAA kill leopards to reduce their numbers.

1 2 3 4 5 6 7

5.9. It is acceptable that the NCAA relocate leopards far away from my village.

1 2 3 4 5 6 7

5.10. It is acceptable that the NCAA leave leopards in the Ngorongoro Conservation Area.

1 2 3 4 5 6 7

6. Interviewee information

Age: _____

Sex: _____

Number of cattle: _____ sheep: _____ goats: _____ donkeys: _____

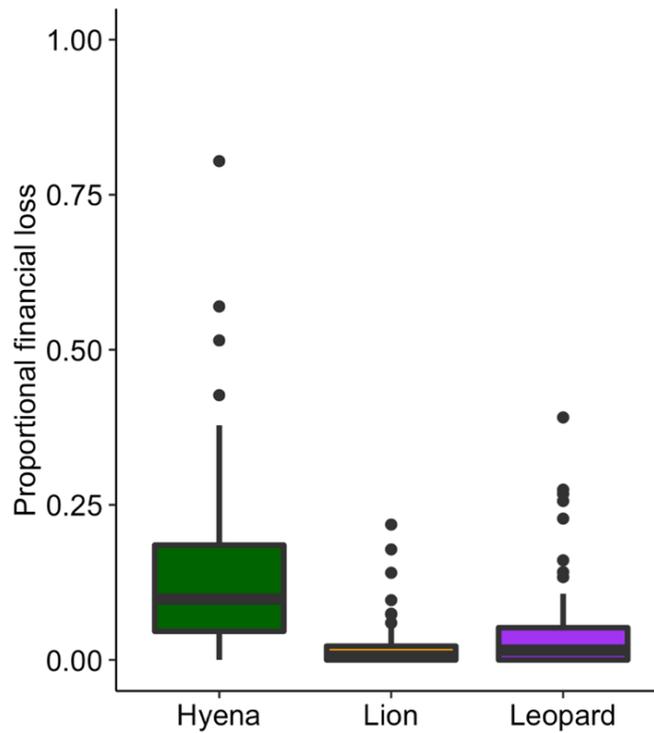
Village: _____

Profession: _____

Appendix C: Data on cause of livestock and financial loss

Supplementary Table 1: Mean (\pm standard error) number of livestock heads killed (column “Heads”) and the corresponding financial loss per interviewee caused (in USD; column “Financial”) by three species of wild carnivores and by disease/drought. The calculation of means was restricted to cases where the interviewee owned at least one head of cattle ($n = 99$ respondents), sheep ($n = 99$), goat ($n = 95$), or donkey ($n = 89$) prior to losses.

Cause of loss	Cattle		Sheep		Goat		Donkey	
	Heads	Financial	Heads	Financial	Heads	Financial	Heads	Financial
Hyena	6.9 \pm 0.8	1200.4 \pm 139.2	14.0 \pm 1.8	672.0 \pm 84.2	10.5 \pm 1.6	505.8 \pm 74.7	3.9 \pm 0.5	342.1 \pm 47.1
Lion	2.0 \pm 0.3	351.5 \pm 48.0	0.1 \pm 0.1	4.9 \pm 3.5	0.1 \pm 0.1	3.5 \pm 3.5	0.2 \pm 0.1	17.6 \pm 6.8
Leopard	1.8 \pm 0.6	309.3 \pm 97.4	4.7 \pm 1.2	225.9 \pm 55.2	6.7 \pm 1.3	319.3 \pm 63.5	0.0 \pm 0.0	2.0 \pm 2.0
Disease/drought	40.6 \pm 5.3	7067.2 \pm 926.8	31.8 \pm 4.1	1528.2 \pm 196.0	24.5 \pm 3.6	1176.8 \pm 172.8	2.3 \pm 0.7	200.4 \pm 60.6



Supplementary Figure 1: Proportional financial loss due to depredation of livestock by spotted hyenas, lions, and leopards in the Maasai community living in Ngorongoro Conservation Area, Tanzania. Livestock loss was estimated based on the total number of heads of each species of livestock owned by each interviewee ($n = 100$) and on the number of heads that reportedly died. Financial loss was then quantified by converting the number of heads into their estimated financial value on the local market (see methods). Boxes indicate the interquartile range around the median (horizontal bar), vertical bars represent financial losses that lie within 1.5 times the interquartile range. Dots represent data with a value higher than 1.5 times the interquartile range. The mean proportional financial loss due to disease and drought (not depicted) was $38.2\% \pm 2.3\%$.

Appendix D: Additional ordinal logistic regression model results

Supplementary Table 2: Variation in acceptance scores by Maasai pastoralists as a function of management strategies, carnivore species, emotions, cultural importance, and livestock depredation. Shown are the odds ratios (OR), their associated 95% confidence intervals (CI_{95%}), and p-values for each predictor, as derived from an ordinal logistic regression model (individual-level random effect variance = 0.07). OR > 1 and OR < 1 indicate a relative increase and decrease, respectively, in the acceptance score associated with a 1-unit increase or shift in the focal predictor when all other covariates are held constant at their population mean or reference level. The reference carnivore species is the hyena and the reference management strategy is relocation. Threshold coefficients refer to the cumulative probability that an acceptance score is at or below the threshold cut point, e.g. the OR for the threshold 2|3 compares the probability of the acceptance score falling within the range of 1-2 to the probability of the acceptance score falling within the range of 3-7. Data in bold were deemed significant ($p < 0.05$).

Predictor	OR	CI _{95%}	<i>p</i>
<u>Threshold coefficients</u>			
1 2	0.13	0.08 - 0.22	-
2 3	0.66	0.41 - 1.07	-
3 4	1.07	0.66 - 1.72	-
4 5	2.06	1.27 - 3.35	-
5 6	5.47	3.31 - 9.05	-
6 7	17.92	10.47 - 30.69	-
<u>Management strategies</u>			
No action	3.19	1.68 - 6.05	<0.001
Lethal control	0.30	0.15 - 0.59	<0.001
<u>Species</u>			
Lion	0.24	0.11 - 0.52	<0.001
Leopard	0.23	0.12 - 0.43	<0.001
<u>Emotions</u>			
Joy	0.87	0.73 - 1.03	0.10
Disgust	1.09	0.94 - 1.26	0.25
Fear	1.08	0.97 - 1.20	0.18
<u>Cultural importance</u>	0.83	0.72 - 0.96	0.011
<u>Livestock depredation</u>	0.01	0.00 - 0.13	<0.001
<u>Interaction terms</u>			
No action*Lion	4.86	1.75 - 13.50	0.002

Lethal control*Lion	1.61	0.53 - 4.86	0.40
No action*Leopard	7.02	2.95 - 16.71	<0.001
Lethal control*Leopard	1.26	0.07 - 0.44	0.63
No action*Joy	1.79	1.42 - 2.26	<0.001
Lethal control*Joy	0.67	0.52 - 0.85	0.001
No action*Disgust	0.85	0.70 - 1.03	0.10
Lethal control*Disgust	1.09	0.88 - 1.34	0.44
No action*Fear	1.05	0.82 - 1.10	0.53
Lethal control*Fear	0.85	0.73 - 1.00	0.057
No action*Cultural importance	1.44	1.18 - 1.75	<0.001
Lethal control*Cultural importance	0.96	0.77 - 1.20	0.70
No action*Livestock depredation	156.20	5.40 - 4515.46	0.003
Lethal control*Livestock depredation	34.93	0.97 - 1253.46	0.052

Supplementary Table 3: Variation in acceptance scores by Maasai pastoralists as a function of management strategies, carnivore species, emotions, cultural importance, and livestock depredation. Shown are the odds ratios (OR), their associated 95% confidence intervals (CI_{95%}), and p-values for each predictor, as derived from an ordinal logistic regression model (individual-level random effect variance = 0.07). OR > 1 and OR < 1 indicate a relative increase and decrease, respectively, in the acceptance score associated with a 1-unit increase or shift in the focal predictor when all other covariates are held constant at their population mean or reference level. The reference carnivore species is the hyena and the reference management strategy is lethal control. Threshold coefficients refer to the cumulative probability that an acceptance score is at or below the threshold cut point, e.g. the OR for the threshold 2|3 compares the probability of the acceptance score falling within the range of 1-2 to the probability of the acceptance score falling within the range of 3-7. Data in bold were deemed significant ($p < 0.05$).

Predictor	OR	CI _{95%}	p
<u>Threshold coefficients</u>			
1 2	0.44	0.26 - 0.74	-
2 3	2.23	1.34 - 3.73	-
3 4	3.58	2.13 - 6.02	-
4 5	6.90	4.06 - 11.74	-
5 6	18.34	10.55 - 31.89	-
6 7	60.08	33.33 - 108.26	-
<u>Management strategies</u>			
No action	10.70	5.44 - 21.03	<0.001
Relocation	3.35	1.68 - 6.65	<0.001
<u>Species</u>			
Lion	0.39	0.17 - 0.89	0.025
Leopard	0.29	0.15 - 0.57	<0.001
<u>Emotions</u>			
Joy	0.58	0.48 - 0.69	<0.001
Disgust	1.18	1.01 - 1.38	0.034
Fear	0.92	0.81 - 1.04	0.19
<u>Cultural importance</u>			
	0.79	0.67 - 0.94	0.008
<u>Livestock depredation</u>			
	0.35	0.03 - 4.63	0.43
<u>Interaction terms</u>			
No action*Lion	3.03	1.04 - 8.81	0.042
Relocation*Lion	0.62	0.21 - 1.88	0.40
No action*Leopard	5.58	2.28 - 13.63	<0.001
Relocation*Leopard	0.80	0.32 - 2.01	0.63

No action*Joy	2.69	2.10 - 3.44	<0.001
Relocation*Joy	1.50	1.17 - 1.93	0.001
No action*Disgust	0.78	0.64 - 0.96	0.017
Relocation*Disgust	0.92	0.75 - 1.14	0.44
No action*Fear	1.12	0.95 - 1.31	0.17
Relocation*Fear	1.17	1.00 - 1.38	0.057
No action*Cultural importance	1.50	1.21 - 1.87	<0.001
Relocation*Cultural importance	1.05	0.84 - 1.31	0.70
No action*Livestock depredation	4.47	0.15 - 131.76	0.39
Relocation*Livestock depredation	0.03	0.00 - 1.03	0.052

Supplementary Table 4: Variation in acceptance scores by Maasai pastoralists as a function of management strategies, carnivore species, emotions, cultural importance, and livestock depredation. Shown are the odds ratios (OR), their associated 95% confidence intervals (CI_{95%}), and p-values for each predictor, as derived from an ordinal logistic regression model (individual-level random effect variance = 0.07). OR > 1 and OR < 1 indicate a relative increase and decrease, respectively, in the acceptance score associated with a 1-unit increase or shift in the focal predictor when all other covariates are held constant at their population mean or reference level. The reference carnivore species is the lion and the reference management strategy is no action. Threshold coefficients refer to the cumulative probability that an acceptance score is at or below the threshold cut point, e.g. the OR for the threshold 2|3 compares the probability of the acceptance score falling within the range of 1-2 to the probability of the acceptance score falling within the range of 3-7. Data in bold were deemed significant ($p < 0.05$).

Predictor	OR	CI _{95%}	p
<u>Threshold coefficients</u>			
1 2	0.04	0.02 - 0.06	-
2 3	0.18	0.11 - 0.28	-
3 4	0.28	0.18 - 0.44	-
4 5	0.55	0.36 - 0.84	-
5 6	1.45	0.95 - 2.22	-
6 7	4.75	3.01 - 7.48	-
<u>Management strategies</u>			
Relocation	0.06	0.03 - 0.12	<0.001
Lethal control	0.03	0.02 - 0.06	<0.001
<u>Species</u>			
Hyena	0.85	0.42 - 1.69	0.64
Leopard	1.35	0.79 - 2.31	0.28
<u>Emotions</u>			
Joy	1.55	1.31 - 1.82	<0.001
Disgust	0.92	0.81 - 1.06	0.24
Fear	1.03	0.93 - 1.14	0.59
<u>Cultural importance</u>			
	1.19	1.04 - 1.36	0.013
<u>Livestock depredation</u>			
	1.57	0.17 - 14.97	0.70
<u>Interaction terms</u>			
Relocation*Hyena	4.86	1.75 - 13.50	0.002
Lethal control*Hyena	3.03	1.04 - 8.81	0.042
Relocation*Leopard	0.69	0.32 - 1.52	0.36
Lethal control*Leopard	0.54	0.23 - 1.28	0.16

Relocation*Joy	0.56	0.44 - 0.71	<0.001
Lethal control*Joy	0.37	0.29 - 0.48	<0.001
Relocation*Disgust	1.18	0.97 - 1.44	0.10
Lethal control*Disgust	1.28	1.05 - 1.57	0.017
Relocation*Fear	1.05	0.91 - 1.21	0.53
Lethal control*Fear	0.90	0.76 - 1.05	0.17
Relocation*Cultural importance	0.70	0.57 - 0.85	<0.001
Lethal control*Cultural importance	0.67	0.54 - 0.83	<0.001
Relocation*Livestock depredation	0.01	0.00 - 0.19	0.003
Lethal control*Livestock depredation	0.22	0.01 - 6.59	0.39
