SHORT COMMUNICATION

Outcomes of lion, *Panthera leo*, translocations to reduce conflict with farmers in Botswana

Mompoloki Morapedi[1],
Mmadi Reuben[2],
Phemelo Gadimang[2],
James Bradley[1],
William Given[1],
Richard P. Reading[1,3] (iD)[§],
Keitumetse Ngaka[1] (iD),
Moses Selebatso[1] (iD) &
Glyn Maude[1*] (iD)

[1]*Kalahari Research and Conservation, Hukuntsi, Botswana*

[2]*Department of Wildlife and National Parks, Gaborone, Botswana*

[3]*Butterfly Pavilion, 6252 East 104th Avenue, Westminster, CO 80020, U.S.A.*

Received 20 May 2020. To authors for revision 16 June 2020.
Accepted 30 January 2021

INTRODUCTION

Lions, *Panthera leo*, in sub-Saharan Africa have decreased significantly in both number and distribution during the past two decades (Bauer, Packer, Funston, Henschel & Nowell, 2016). Reasons for this include declines in wild prey species, habitat destruction, and increased conflict with farmers, especially along the borders of conservation areas (Nowell & Bauer, 2006; Karanth & Chellam, 2009; Bauer *et al.*, 2016). Farmers often harbour negative attitudes towards carnivores (Fraser-Celin, Hovorka, Hovorka & Maude, 2017) and lions pose a potential threat to human safety and livelihoods (Mbaiwa & Stronza, 2010; Linnell, Odden & Mertens, 2012). As a result, livestock farmers frequently kill carnivores, even in the absence of direct losses (Marker, Muntifering, Dickman, Mills & Macdonald, 2003; Ripple *et al.*, 2014; Loveridge *et al.*, 2016).

In an effort to reduce human wildlife conflict, the translocation of large carnivores that kill livestock commonly occurs, but the effectiveness of this practice remains debatable (Massei, Quy, Gurney & Cowan, 2010; Fontúrbel & Simonetti, 2011). In Africa, some information exists on the fate of large carnivores following translocation (Marnewick, Hayward, Cilliers & Sommers, 2009; Johnson *et al.*, 2010; Weilenmann, Gusset, Mills, Gabanapelo & Schiess-Meier, 2010); however, there are very little data available on lions. One study in northern Namibia showed that lions viewed as occasional livestock-raiders were translocated with some success, whereas there was less success with lions viewed as habitual stock raiders (Stander, 1990). A study in northern Rhodesia (now Zimbabwe) was largely inconclusive, but did have evidence that of eight livestock-raiding lions translocated, two settled into the release area for at least eight months (Van der Meulen, 1977). There was also some success in translocating 16 lions into the In the Hluhluwe-iMfolozi Park (HiP), from Pilanesberg National Park and the Madikwe Game Reserve, South Africa (Trinkel *et al.*, 2008). However, these lions were not livestock-raiders and were moved into the HiP to restore the genetic variation of the inbred lion population and HIP is also a small (900 km^2) and enclosed park.

In Botswana, communities often complain that lions around their settlements cause livestock losses (Gusset, Swarner, Mponwane, Keletile & McNutt, 2009; Valeix, Hemson, Loveridge, Mills & Macdonald, 2012; Weise *et al.*, 2018, Weise *et al.*, 2019). When feasible, the Botswana Department of Wildlife and National Parks (DWNP) translocates lions known to kill livestock from farmlands into protected areas. In order to study the outcome of this management strategy a number of lions released into the Central Kalahari Game Reserve (CKGR) and Kgalagadi Transfrontier Park (KTP) were fitted with satellite collars. In this paper, we analyse the data collected from the collars to find out how the translocated lions moved, what their survival rates were, and, where relevant and possible, their cause of death.

METHODS

We followed Fontúrbel & Simonetti (2011) in describing translocation as the deliberate and mediated movement of wild individuals from one part of their range to another location. We conducted our work in the CKGR (52 145 km^2) and Wildlife Management Areas (WMAs) adjacent to the CKGR (GH10 and GH11), as well as in the KTP (26 000 km^2) and the adjacent WMAs, including KD1, KD2, KD12 and KD15 (36 000 km^2, Fig. 1). The wider region contains open semi-arid

*To whom correspondence should be addressed.
E-mail: glyn@krcbots.org

ISSN 2410-8200 [Online only] — DOI: https://doi.org/10.3957/056.051.0006

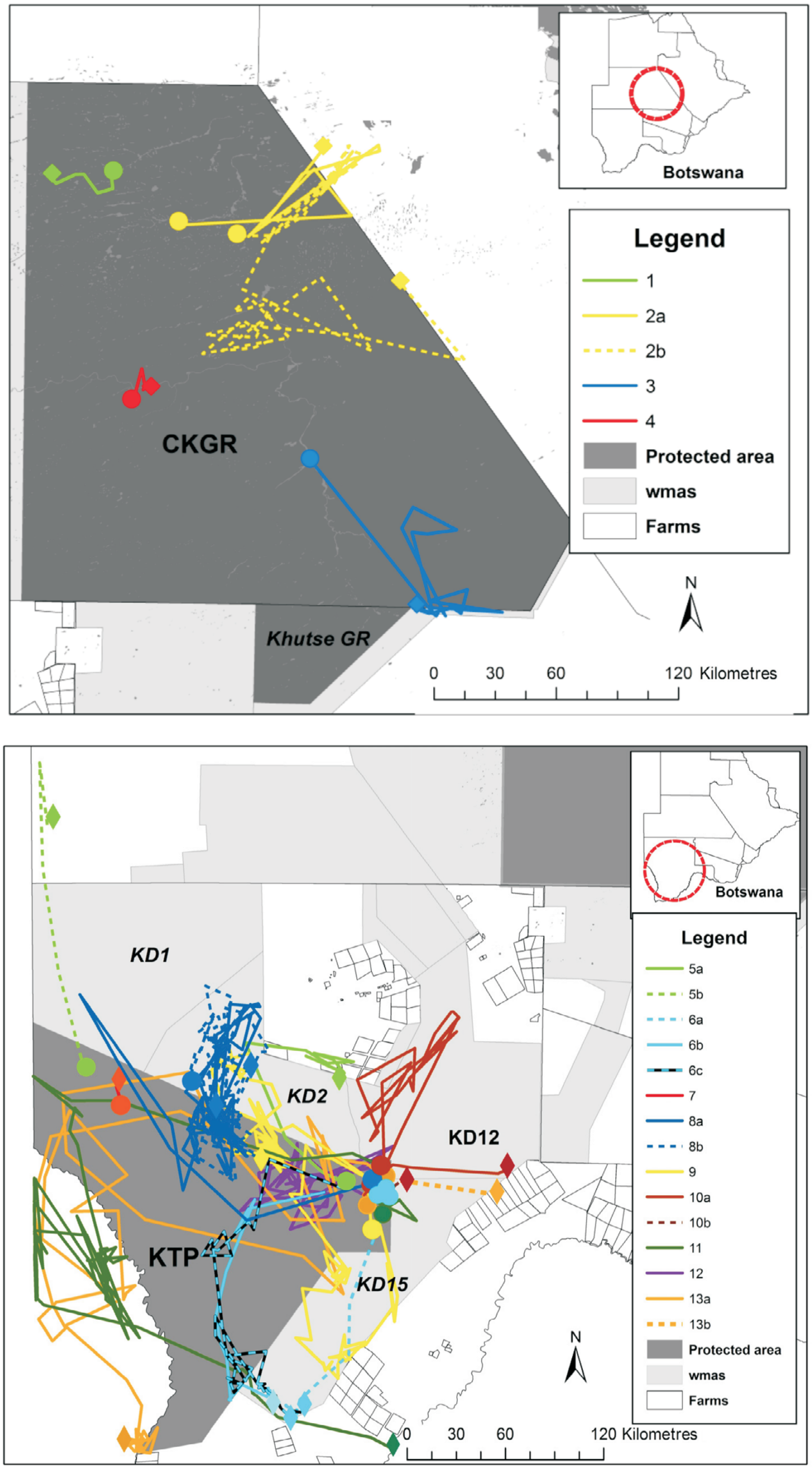

Fig. 1. The study area and the movement of the 13 lions after translocation. The ● represents the point of release and the ◆ represent the last location for each translocation. Letters after number represent multiple translocations of the same lion.

savanna with ephemeral surface water only after good rains (Skarpe, 1986; Keeping, 2014). Both the KTP's and the CKGR's adjacent WMAs and communal areas consist of livestock grazing and subsistence gathering of grass, wooden poles, and firewood within a 20 km radius of settlements (Keeping, 2014).

Between April 2013 and August 2017, we were able to collar 13 lions (7 males & 6 females) that the DWNP translocated because they reportedly attacked livestock. Prior to release, we fitted these lions with satellite telemetry collars (Vectronic Aerospace GmbH) to track and monitor their movements and fate. Most lions ($n = 9$) came from the areas around KTP, with the rest ($n = 4$) coming from the area around the CKGR. The collars recorded four GPS locations per day, but we increased the number of fixes to 13 locations per day to prepare for re-capture if a lion continually moved close to a cattle post and killed livestock. The DWNP selected release sites in the protected area closest to the lion's point of capture equal to or greater than 120 km from its point of capture. Of the initial 13 lions released, 10 were hard released straight into the reserve after having being transported there by cage, and three were soft releases straight from an electrified fenced boma area located in a protected area, after being kept in the boma for at least 10 days prior to release (Table 1). Of the other seven recaptures and releases, five were hard releases and two were soft releases (Table 1).

We used the program Jump 13.0 for all statistical analysis and we examined variables (Table 2) for normality and where necessary log-transformed non-normally distributed data to conform to normality. We used a general linear model to examine the influence of those variables on the number of days that lions survived following translocation. We used a chi-square goodness of fit test to examine lion deaths by season. Finally, we used a paired t-test to examine whether lions varied in the percentage of time they spent in protected areas during the wet season (December–April) and dry season (May–November) and unpaired t-tests to compare distances lions were translocated at first and during subsequent releases. We excluded a lion that lost its collar 15 days after translocation from analyses as we could not confirm the fate of this individual. Acknowledging that our sample size was small (and therefore the power to detect significant differences was low), we set significance at $P < 0.10$ to help avoid Type II errors. We report means ± 1 standard error (S.E.) of the mean.

RESULTS AND DISCUSSION

Lions were released a mean distance of 156 ± 12 km from capture and a mean distance of 26 ± 6 km from the boundary inside the park (Table 1). Due to repeated killing of livestock after the first release, six lions that continued to kill livestock were recaptured and released, and one lion that continued to kill livestock needed a third translocation (Table 1). Those additional translocations moved lions a mean distance of 99 ± 20 km from capture to release sites and a mean distance of 22 ± 6 km from the park boundary. These distances were shorter than the first releases (significantly so for the distance from capture site: $t = 2.52$, d.f. = 18, $P = 0.02$; but not for distance to the park boundary: $t = 0.73$, d.f. = 18, $P = 0.47$), as the lions were captured closer to the protected areas than previously. After release translocated lions spent most (58.8 ± 6.5%) of their time inside the protected areas, although the proportion of time varied greatly by individual lion (Table 1). Lion movement patterns differed significantly by season ($t = 1.94$, d.f. = 16, $P = 0.07$). Lions moved into and out of protected areas repeatedly in both seasons (Fig. 1).

Details of each translocation and the fate of each lion are shown in Table 1. Of the 13 translocated lions, ten died after a mean of 275 ± 68 days post-release, one lost its collar after just 15 days (Table 1). Another lion collar stopped transmitting after ten months and an additional collar automatically dropped off as programed. We recovered the collar without knowing the fate of the lion. Four of the ten lions died in protected areas, two in the CKGR and two in the KTP and the remaining six outside a protected area. Farmers killed five lions after they left the protected areas and five lions died of unknown causes, including the four in a protected area.

Several variables had a significant influence on the length of time the lions survived post-translocation (Table 2), including distance from capture to release point and distance from release point to the nearest park boundary. Days spent inside the park and days spent outside the park are both correlated with the number of days survived rather than having a direct influence on survival time. Sex was not significant. Lions released further from their point of capture and further from a park boundary survived fewer days post-translocation (Table 2).

Table 1. Description of 'problem' lion translocations in Botswana. Note: for animals released multiple times, the days survived equals the cumulative total number of days the animal survived.

Lion	Sex/Age	Grouping ^	Park	Capture date	Dist. (km) from capture site to:		Days (after translocation)		Release mode	Mortality date	Days survived until release or recapture
					release	park	inside park	outside park			
1	M/adult	Solitary	CKGR	24/04/13	223	45	50	–	Hard	13/06/13	50
2	F/adult[a]	With 1F	CKGR	14/06/13	129	31	27	19	Hard	30/06/14	46
3	F /adult	Solitary	CKGR	05/04/14	103	74	71	69	Hard	23/08/14	140
4	F/adult	Solitary	CKGR	13/01/15	245	60	23	–	Hard	05/02/15	23
5	M/adult[a]	Solitary	KTP	21/08/13	160	14	21	39	Hard	06/11/13	60
6	F/adult[a]	Solitary	KTP	23/08/13	136	10	12	37	Hard	09/09/14	49
7	M/sub	With 1 sub M	KTP	15/10/13	86	15	15	–	Hard	–	15[b]
8	M/adult	Solitary	KTP	16/11/13	125	17	237	109	Hard	17/10/15	346
9	M/sub	Solitary	KTP	05/04/14	130	12	264	294	Hard	–	558
10	M/adult	With 1F	KTP	12/07/15	175	18	27	139	Soft	19/01/16	166
11	F/adult[a]	With 1M & 1F	KTP	30/06/15	175	18	341	39	Soft	14/07/16	380
12	M/adult	Solitary	KTP	15/10/15	167	18	275	16	Soft	–	291[b]
13	F/adult[a]	With 1F	KTP	16/06/16	172	10	374	42	Hard	17/08/17	416
2[c]	F/adult[a]	Solitary	CKGR	01/08/13	57	50	204	131	Soft	30/06/14	335
5[c]	M/adult[a]	Solitary	KTP	20/10/13	160	10	3	14	Hard	06/11/13	17
8[c]	M/adult	Solitary	KTP	27/10/14	125	11	161	193	Hard	17/10/15	354
6[c]	F/adult[a]	Solitary	KTP	10/10/13	136	25	50	20	Hard	09/09/14	70
10[c]	M/adult	With 1F	KTP	25/12/15	80	6	6	19	Hard	19/01/16	25
6[d]	F/adult	Solitary	KTP	20/12/13	130	19	120	143	Hard	09/09/14	263
13[c]	F/adult[a]	Solitary	KTP	17/04/17	9	18	4	7	Soft	17/08/17	11

[a]Killed by farmers.
[b]Only collar found, not known if the lion was alive or dead.
[c]Recapture.
[d]Second recapture
^Grouping – at time of capture/release.

Table 2. Results of a general linear model analysing the influence of listed variables on the number of days that lions survived after translocation in Botswana.

Term	Coefficient	S.E. of coeff.	*t*-value	*P*
Constant	–23.10	92.78	0.06	0.804
Sex	–11.05	16.34	0.45	0.501
Release distance (km)	–0.84	0.35	5.22	0.022
Log of the distance to the park (km)	–188.64	57.43	9.05	0.003
Log of days spent in the park	105.65	11.23	37.82	<0.001
Log of days spent outside of the park	39.58	16.54	5.46	0.020

Our results are in line with other similar studies that concluded translocating 'problem' animals did not solve human–wildlife conflicts (Stander, 1990; Fischer & Lindenmayer, 2000; Massei *et al.*, 2010; Miller, Ralls, Reading, Scott & Estes, 1999). A study in Botswana concluded that translocation was not an effective tool for dealing with stock-raiding leopards (*Panthera pardus*) (Weilenmann *et al.*, 2010). The results showed that of four stock-raiding leopards that were translocated into the CKGR, three were shot and the fourth continued to raid stock. Another study on cheetahs (*Acinonyx jubatus*) in Botswana found that only two translocated cheetahs out of 11 survived for a year or longer (Boast, Good & Klein, 2016). Boast *et al.* (2016) concluded that the high mortality rate, significant financial cost of translocations, and the failure to reduce livestock losses meant that conflict mitigation methods should focus on co-existence between predators and humans and not translocations. Stander (1990) found that 11 out of 12 translocated lions that were classed as occasional livestock-raiders discontinued stock-raiding activities for at least one year after translocation. However, eight of 15 lions judged to be repeat livestock-raiders and thus classed as problem lions were killed, two were lured back into Etosha National Park but continued to raid livestock and were also killed, whereas the remaining five were translocated (Stander 1990). Of these, three continued to livestock-raid so were killed and the other two appeared not to kill livestock for at least one year. Most of the repeat livestock-raiders were subadult males whereas occasional raiders consisted of mostly groups with adult females and sometimes cubs. Van der Meulen (1977) found that two stock-raiding lions in northwestern Zimbabwe that were captured, ear tagged and translocated 27 km from Matetsi into the Kazuma National Park, were back killing livestock near where they were captured five months later. He also found that of six livestock-raiding lions moved from the Rukomechi Tsetse Research Station 45 km into the Chewore Controlled Hunting Area, only two appeared to settle there for at least eight months. The other four were not seen again. However, there were no reports of livestock being killed near Rukomechi for 12 months after the six lions were moved.

Most of the lions we translocated died or continued to kill livestock soon after translocation. There were two translocations of adult females that were both released with a second female where they remained for a while in a protected area. Although both were eventually shot by farmers, one remained in the KTP for almost a year before she was shot a few days after leaving the park to kill livestock (Fig. 1, lion 11). The other adult female remained in the CKGR for the majority of her time and then got shot also a year later when she left the park to kill livestock (Fig. 1, lions 2a, 2b). Accordingly, if translocations are to be conducted, targeting groups of adult females which may not yet be repeat livestock-raiders could potentially yield higher success rates. However, capturing an entire group of females together, in particular as they are likely to be evasive, may prove to be very challenging. Translocating only some group members into a new area may also reduce the chances of survival for them, as well as group members left behind.

The high rate of mortality of translocated lions, and the considerable financial cost of translocating carnivores (Weise, Stratford & van Vuuren, 2014), point to the need to explore other methods of resolving human–lion conflict. The use of a soft release may increase the chances of a successful translocation, although a study in Namibia showed little beneficial effort of using soft release methods compared to hard (Weise *et al.*, 2014). The same study also showed that using soft releases for cheetahs resulted in a cost in excess of US$ 5000 per animal. A study in Botswana estimated a cost of US$ 7330 per cheetah translocation through hard release including the significant cost of post-release monitoring (Boast *et al.*, 2016). While evaluating the financial issues concerning relocation is beyond the scope of this study, with lions being larger than cheetahs and therefore requiring higher doses of drugs to dart and more food when in captivity, the cost would be significantly higher than for cheetahs. A further issue is the lack of appropriate places to receive translocated lions, as ideally the destination should have a low lion density, reasonable wild prey availability, and low poaching levels (Stander, 1990; IUCN/SSC 2013). In addition, it is important to gather detailed information on the demography of the resident lions at the release site, as well as detailed knowledge of the social structure of the lions being captured and translocated (IUCN/SSC 2013). Important elements that were not considered in this study were the disease relocation risk, conflict mitigation, the impact caused on the recipient lion populations in protected areas and the lion population in the areas from which we moved lions, and the lack of reporting financial costs. Any future study could look at these key aspects.

To increase the chances of translocated lions surviving and not continuing to kill livestock, it is important to improve livestock husbandry in the region by, for example, improving kraal design and fortification (Ogada, Woodroffe, Oguge & Frank, 2003; Lichtenfeld, Trout & Kisimir, 2015; Weise *et al.*, 2018) and promoting livelihoods other than livestock farming in landscapes that contain lions (Woodroffe, 2001). Other methods, such as early warning systems for when lions approach livestock areas (Weise *et al.*, 2019) and incentive-based schemes for encouraging farmers to be more tolerant of lions (Hazza, Mulder & Frank, 2009), may also increase the chances of successful translocation and human/wildlife conflict mitigation. These actions described above, may also reduce the numbers of lions that are deemed necessary to be translocated. However, it is not practical to conduct these actions across all of the areas in Botswana where there is conflict between lions and people. We conclude that translocation was not an effective method for dealing with conflict between lions and farmers in this study. Available and limited resources may be more effectively used to improve livestock husbandry or for other preventative measures.

We thank the Wildlife Foundation, The Wild Source and Denver Zoological Foundation for their funding the project. We also thank Leopard Ecology which contributed two satellite collars for lions and helped with logistics. We also thank the Botswana Department of Wildlife and National Park for helping to jointly initiate the study.

§ORCID iDs

R.P. Reading: orcid.org/0000-0003-1838-472X
K. Ngaka: orcid.org/0000-0002-0989-2459
M. Selebatso: orcid.org/0000-0003-1302-2981
G. Maude: orcid.org/0000-0003-2399-3415

REFERENCES

Bauer, H., Packer, C., Funston, P.F., Henschel, P. & Nowell, K. (2016). *Panthera leo* (errata version published in 2017) The IUCN Red List of Threatened Species 2016.

Boast, L., Good, K., & Klein, R. (2016). Translocation of problem predators: is it and effective way to mitigate conflict between farmers and cheetahs *Acinonyx jubatus* in Botswana? *Oryx*, 50, 537–544.

Fischer, J. & Lindenmayer, D.B. (2000). An assessment of the published results of animal relocations. *Biological Conservation*, 96, 1 –11.

Fraser-Celin, V-L., Hovorka, A.J., Hovorka, M. & Maude, G. (2017). Farmer–African wild dog (*Lycaon pictus*) relations in the eastern Kalahari region of Botswana, *Koedoe*, 59, 2–12.

Fontúrbel, F.E. & Simonetti, J.A. (2011). Translocations and human–carnivore conflicts: problem solving or problem creating? *Wildlife Biology*, 17, 217–224.

Gusset, M., Swarner, M.J., Mponwane, L., Keletile, K. & McNutt, J.W. (2009). Human–wildlife conflict in northern Botswana: livestock predation by Endangered African wild dog *Lycaon pictus* and other carnivores. *Oryx*, 43, 67–72.

Hazza, L., Mulder. M.B. & Frank, L. (2009). Lions and warriors: social factors underlying declining African lion populations and the effect of incentive-based. management in Kenya. *Biological Conservation*, 142(11), 2428–2437.

IUCN/SSC (2013). Guidelines for Reintroductions and Other Conservation Translocations. Version 1.0. Gland, Switzerland: IUCN Species Survival Commission, vii + 57 pp.

Johnson, S., Mengersen, K., de Waal, A., Marnewick, K., Cilliers, D., Houser, A.M. & Boast, L.K. (2010). Modelling cheetah relocation success in southern Africa using Iterative Bayesian Network Development Cycle. *Ecological Modelling*, 221: 641–651.

Karanth, K.U. & Chellam, R. (2009). Carnivore conservation at the crossroads. *Oryx*, 43, 1–2.

Keeping, D. (2014). Rapid assessment of wildlife abundance: estimating animal density with track counts using body mass–day range scaling rules. *Animal Conservation*, 17, 486–497.

Linnell, J.D.C., Odden, J. & Mertens, A. (2012). Mitigation methods for conflicts associated with carnivore depredation on livestock. In L. Boitani. & R.A. Powell (Ed.), *Carnivore ecology and conservation: a hand-*

book of techniques (pp. 314–332). Oxford, U.K.: Oxford University Press.
Lichtenfeld, L.L., Trout, C. & Kisimir, E.L. (2015). Evidence-based conservation: predator proof bomas protect livestock and lions. *Biodiversity Conservation*, 24, 483–491.
Loveridge, A. J., Valeix, M., Chapron, G., Davidson, Z.,Mtare, G. & Macdonald, D. W. (2016). Conservation of large predator populations: demographic and spatial responses of African lions to the intensity of trophy hunting. *Biological Conservation*, 204, 247–254.
Marker, L.L., Muntifering, J.R., Dickman, A.J., Mills, M.G.L. & Macdonald, D.W. (2003). Quantifying prey preferences of free-ranging Namibian cheetahs. *South African Journal of Wildlife Research*, 33, 43–53.
Marnewick, K., Hayward, M.W., Cilliers, D. & Somers, M.J. (2009). Survival of cheetahs relocated from ranch land to fenced protected areas in South Africa. In N.W. Hayward. & M. Somers (Ed.), *Reintroduction of top-order predators* (pp. 282–306). London, U.K.: Wiley-Blackwell.
Massei, G., Quy, R.J., Gurney, J. & Cowan, D.P. (2010). Can translocations be used to mitigate human–wildlife conflicts? *Wildlife Research*, 37, 428–439.
Mbaiwa, J.E. & Stronza, A.L. (2010). The effects of tourism development on rural livelihoods in the Okavango Delta, Botswana. *Journal of Sustainable Tourism*, 18, 635–656.
Miller, B., Ralls, K., Reading, R.P., Scott, J.M. & Estes, J. (1999). Biological and technical considerations of carnivore translocation: a review. *Animal Conservation*, 2, 59 –68.
Nowell, K. & Bauer, H. (2006). *Conservation strategy for the lion* (Panthera leo) *in eastern and southern Africa*. IUCN/SSC Cat Specialist Group.
Ogada, O. M., Woodroffe, R., Oguge. N. & Frank, L. (2003). Limiting depredation by African carnivores: the role of livestock husbandry. *Conservation Biology*, 17, 1521–1530.
Ripple, W.J., Estes, J.A., Beschta, R.L., Wilmers, C.C., Ritchie, E.G., Hebblewhite, M., Berger, J., Elmhagen, B., Letnic, M., Nelson, M.P., Schmitz, O.J., Smith, D.W., Wallach, A.D. & Wirsing, A.J. (2014). Status and ecological effects of the world's largest carnivores. *Science*, 343, 151–162.
Skarpe, C. (1986). Plant community structure in relation to grazing and environmental changes along a north–south transect in the western Kalahari. *Vegetatio*, 68, 3–18.
Stander, P. (1990). A suggested management strategy for stock-raiding lions in Namibia. *South African Journal of Wildlife Research*, 20, 37–43.
Trinkel, M., Ferguson, N., Reid, A., Reid, C., Somers, M., Turelli, L., Graf, J., Szykman, M., Cooper, D., Haverman, P., Kastberger, G., Packer, C. & Slotow, R. (2008). Translocating lions into an inbred lion population in the Hluhluwe-iMfolozi Park, South Africa. *Animal Conservation*, 11, 138–143.
Valeix, M., Hemson, G., Loveridge, A.J., Mills, G. & Macdonald, D.W. (2012). Behavioural adjustments of a large carnivore to access secondary prey in a human-dominated landscape. *Journal of Applied Ecology*, 49, 73–81.
Van der Meulen, J.H. (1977). Notes on the capture and translocation of stock raiding lions in northeastern and northwestern Rhodesia. *South African Journal of Wildlife Research*, 7, 15–17.
Weilenmann, M., Gusset, M., Mills, D. R., Gabanapelo, T. & Schiess-Meier, M. (2010). Is translocation of stock-raiding leopards into a protected area with resident conspecifics an effective management tool? *Wildlife Research*, 37, 702–707.
Weise, F.J., Stratford, K.J. & van Vuuren, R.J. (2014). Financial costs of large carnivore translocations – Accounting for conservation. *PLOS ONE*, 9, e105042.
Weise, F.J., Hayward, M.W., Aquire, R. C., Tomeletso, M., Gadimang, P., Somers, M.J. & Stein, A.B. (2018). Size, shape and maintenance matter: a critical appraisal of a global carnivore conflict mitigation strategy – livestock protection kraals in northern Botswana. *Biological Conservation*, 225, 88–97.
Weise, F.J., Hauptmeir, H., Stratford, K.J., Hayward, M. W., Aal. K., Heur, M., Tomeletso, M., Wulf, V., Somers, M.J. & Stein, A.B. (2019). Lions at the gates: trans-disciplinary design of an early warning system to improve human–lion coexistence. *Ecology Evolution*, 6(242), 1–19.
Woodroffe, R. (2001). Carnivore conservation. In J. L. Gittleman, R. K. Wayne, D. W. Macdonald and S. M. Funk (Ed.), *Strategies for carnivore conservation: lessons from contemporary extinctions* (pp. 61–92). Cambridge, U.K.: Cambridge University Press.

Responsible Editor: B.J. Allen