Evaluation of a conflict-related brown hyaena translocation in central Namibia

Florian J. Weise[1,2], Ingrid Wiesel[3,4*], Joseph Lemeris Jr[5] & Rudie J. van Vuuren[1]

[1]*N/a'an ku sê Research Programme, P.O. Box 99292, Windhoek, Namibia*

[2]*Division of Biology and Conservation Ecology, School of Science and the Environment, Manchester Metropolitan University, Chester Street, Manchester, M1 5GD, U.K.*

[3]*Brown Hyena Research Project, P.O. Box 739, Lüderitz, 9000 Namibia*

[4]*Centre for Wildlife Management, University of Pretoria, Pretoria, 0002 South Africa*

[5]*Duke University – Nicholas School of the Environment, and National Geographic Society – Big Cats Initiative, Box 90328, Durham, NC 27708, U.S.A.*

Received 13 May 2014. To authors for revision 24 July 2014. Accepted 21 August 2014

The distribution of the brown hyaena (*Hyaena brunnea*) in southern Africa overlaps widely with commercial livestock ranching. As a direct result, both perceived and confirmed conflict with farmers occurs and hyaenas are trapped for lethal control or translocation. We studied the outcomes of a conflict-related brown hyaena translocation in Central Namibia involving a subadult female – the first reported GPS-monitored translocation of this species. The animal was moved 63 km from the conflict site and after exploratory movements settled into a new home range incorporating resident conspecifics. The hyaena caused no further conflict and did not return home to its original capture site where livestock depredation ceased. The hyaena was killed in a road accident five months after release. We assess and review our results (and brown hyaena translocations in general) with respect to species ecology, previous translocations as well as monitoring data from resident conspecifics. We provide supporting information that individual hyaenas can be translocated successfully but emphasize that decisions need to be made case-specifically considering the age, sex and social status of the animals. We highlight the importance of brown hyaena sociality when considering translocation as a management tool.

Key words: brown hyaena, *Hyaena brunnea*, management, conflict, relocation, social carnivore, monitoring.

INTRODUCTION

Across southern Africa, large carnivores continue to be translocated in considerable numbers in efforts to restore ecosystem functioning and safeguard endangered species (Gusset, Graf & Somers, 2006a; Hayward *et al.*, 2007a; Hayward & Somers, 2009; Trinkel *et al.*, 2008) and in response to conflict with livestock farmers (*e.g.* Stander, //au, |ui, Dabe & Dabe, 1997; van der Meulen, 1977; Weilenmann, Gusset, Mills, Gabanapelo & Schiess-Meier, 2010). Although only few structured studies have been carried out to document the outcomes of these actions, translocation of conflict predators is generally viewed with scepticism because it is largely unsuccessful (Fontúrbel & Simonetti, 2011; Linnell, Aanes, Swenson, Odden & Smith, 1997; Massei, Roger, Quy, Gurney & Cowan, 2010). The necessity and value of rigorous post-release monitoring to improve conservation management and elucidate translocation biology have been emphasized (*e.g.* Fischer & Lindenmayer, 2000; Houser, Gusset, Bragg, Boast & Somers, 2011; Gusset *et al.*, 2008). The controversy around conflict-translocations is further complicated when individuals from social species are moved solitarily (Mills & Hofer, 1998).

Whilst post-translocation information is accumulating for some African carnivores including leopards (*Panthera pardus*) (Hayward, Adendorff, Moolman, Hayward & Kerley, 2006; Stander *et al.*, 1997; Weilenmann *et al.*, 2010), African wild dogs (*Lycaon pictus*) (Gusset, Slotow & Somers, 2006b; Somers, Graf, Szykman, Slotow & Gusset, 2008) and lions (*Panthera leo*) (Hunter, 1998; Stander, 1990; Trinkel *et al.*, 2008; van der Meulen, 1977), very little is understood about hyaena translocations (Mills & Hofer, 1998). Skinner & van Aarde (1987) recorded first range data for three translocated brown hyaenas (*Hyaena brunnea*) in South Africa. Their work suggested that individuals are capable of adjusting to unfamiliar environments and establishing themselves for prolonged periods without

*To whom correspondence should be addressed
E-mail: strandwolf@iway.na

ISSN 2410-7220 [Print], ISSN 2410-8200 [Online] — DOI: http://dx.doi.org/10.3957/056.045.0178

causing conflict (despite visiting human habitation), thus fulfilling some of the criteria regarded as important to achieve translocation success (Linnell *et al.*, 1997; Massei *et al.*, 2010). In addition, Hayward *et al.* (2007b) report mixed results for reintroductions of the species into the Eastern Cape of South Africa and our current understanding of brown hyaena translocations is limited to these studies. Mills & Hofer (1998) generally caution that translocation of individual female hyaenas (referring to the spotted hyaena (*Crocuta crocuta*)) without matrilineal kin support may not be a suitable management approach and thus prone to failure. They further express concern over intraspecific competition resulting from hyaena translocations into extant range areas.

Our study evaluates the outcomes of a conflict-related translocation of a single subadult female brown hyaena in central Namibia. To our knowledge, this represents the first GPS-monitored translocation for the species and provides relevant information for future management. We interpret our findings with regard to species ecology, the limited data available from previous brown hyaena translocations (Skinner & van Aarde, 1987) and compare information from resident conspecifics. Therefore, we also document range use data for Namibia's inland brown hyaenas. The objectives of this translocation were: a) to mitigate opportunistic calf-attack events in a non-lethal manner and without causing further conflict, b) to test and assess the release of a brown hyaena into known conspecifics' range, and c) to facilitate the hyaena's contribution to the free-ranging gene pool.

STUDY ANIMALS AND RESEARCH PROTOCOLS

Translocated female N055

The translocated female hyaena (N055) was trapped on a commercial livestock farm in Central Namibia in January 2012, following four incidents of bite injuries inflicted on newborn cattle (*Bos primigenius*) calves that were less than seven days old. The predatory capacity of brown hyaenas (in areas with largely immobile prey) has been documented in detail (*e.g.* Wiesel, 2010) suggesting a strongly developed instinct for hunting live prey. In this case, examination of bite wounds provided evidence (subcutaneous haemorrhaging on hind quarters and hind legs coupled with only mild skin perforations and signs of tearing, dragging and pulling) that these were indeed atypical of other indigenous large predators, *i.e.* cheetahs (*Acinonyx jubatus*) and leopards, and most likely inflicted by a brown hyaena. Bite marks and injuries were consistent across all attacked calves and exceeded the dimensions that would potentially be caused by black-backed jackals (*Canis mesomelas*) or caracals (*Caracal caracal*). Attacks were restricted to a small, fenced cattle area in which fresh hyaena spoor and fence burrowing activities had been observed, without obvious signs of other predators. The hyaena was captured in a baited live trap with collapsible cage doors at either end a few hours after the last bite incident. The affected landowner requested the live removal of the animal, but refrained from lethal control.

With permission from the state wildlife authorities, N055 was translocated at a linear distance of 63 km and released onto a private wildlife reserve (with game-proof but not predator-proof fencing) within 48 h of capture. Before release, a licensed veterinarian immobilized the hyaena. Whilst immobilized, the animal was measured, examined, fitted with a GPS iridium satellite transponder (Africa Wildlife Tracking, Pretoria, South Africa) and biological samples, *i.e.* hair, saliva and blood, were collected. The animal was approximately 12 months old (estimated by I. Wiesel assessing tooth eruption and wear), weighed 27 kg and measured 48 cm around the neck, 68 cm at the shoulder and 112 cm in length (naso-anal). After complete recovery from anaesthesia, N055 was released into an area known to support resident conspecifics. Habitat conditions at source and recipient sites were generally consistent – both localities are part of the mountainous, semi-arid, bush-encroached highland Savanna Biome in Namibia's Khomas Highlands. The GPS unit was programmed to record and transmit three locations every 24 h, *i.e.* 19:00, 00:00 and 05:00 (local time) resembling expected times of emerging, peak and declining activity (Owens & Owens, 1978). We shared location data with private landowners on a daily basis in order to determine details of post-release conflict and ecology.

Resident brown hyaenas

In October 2013, a subadult male brown hyaena (N075) was accidentally captured in a live trap placed at a leopard kill which was only 9.0 km from N055's release location (Fig. 1). Because data on Namibia's inland brown hyaenas are scarce, the male was also fitted with a GPS iridium satellite transponder (Africa Wildlife Tracking, Pretoria,

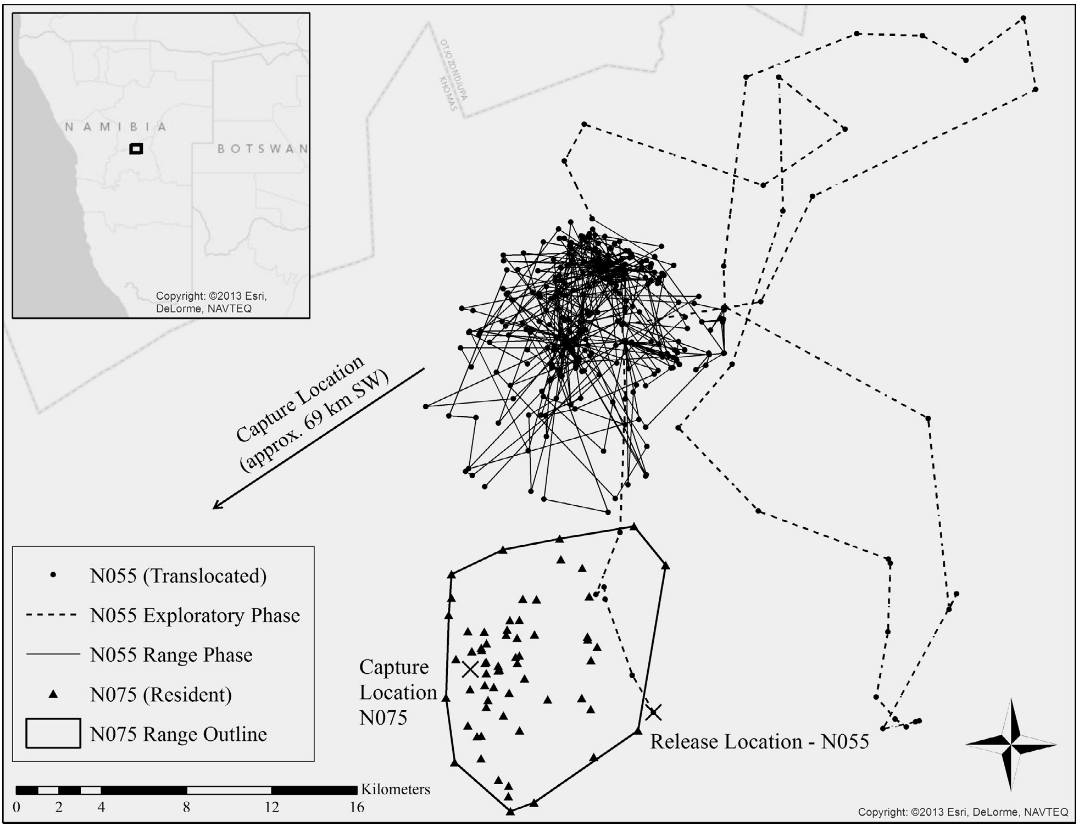

Fig. 1. Movements of two subadult brown hyaenas (translocated female N055 and resident male N075) in the same bio-geographic region of central Namibia.

South Africa) and released at the capture site immediately (Ministry of Environment and Tourism permit number: 1782/2013). All capture and handling protocols were in agreement with ethics and welfare considerations gazetted in the national guidelines for the research and keeping of large carnivores (MET, 2012) and ethical clearance for the research was granted by Manchester Metropolitan University (clearance number: RD1-06979 434-20130923). N075 was approximately 24 months old, weighed 33 kg and measured 52 cm around the neck, 69 cm at the shoulder and 109 cm in length (naso-anal). Similar to N055, the male's collar was programmed to record and relay at least three locations every night (19:00, 00:00, 05:00). When N075's GPS unit failed less than two weeks into the monitoring, we continued to record his movements opportunistically through standard VHF telemetry using triangulation to determine his positions. N075's anaesthesia and data sharing protocols were identical to those of N055.

Moreover, to interpret N055's post-release activities in more detail we also evaluated them against data from resident Namib Desert brown hyaenas, including one adult male, two breeding females and two subadult females (see Table 1 and Fig. 2). These hyaenas belonged to different clans and were GPS-monitored between 2005 and 2011 as part of a long term ecological study (Brown Hyena Research Project – www.strandwolf.org).

RESULTS

Upon release, translocated female N055 displayed large-scale exploratory movements for 16 days (Fig. 1), roaming over an area of approximately 582.2 km^2 (100% Minimum Convex Polygon (MCP)). During this time, the hyaena travelled a minimum total distance of 133 km (median = 10.1 km/day; S.E. = 2.0 km; n = 11, range = 1.5–21.9 km/day) and moved through 15 private farms managed for livestock and/or game production, hunting and recreational and non-consumptive wildlife tourism. N055 did not show any release site fidelity and left the reserve during the night follow-

Table 1. Comparison of home ranges and movement details for translocated and resident brown hyaenas in South Africa and Namibia.

Individual	Sex	Age class	Treatment	Total no. of locations (days)	Monitoring duration	100% Minimum Convex Polygon range size in km^2 (50% core area)	Mean movement per night ± S.D. in km	Source
A – Transvaal, S.A.	M	Adult	Translocated	43	91	8.8	12.5 ± 4.9 (n = 81) pooled value for hyaenas A, B and C	Skinner & van Aarde (1987)
B – Transvaal, S.A.	F	Adult	Translocated	52	107	5.5		Skinner & van Aarde (1987)
C – Transvaal, S.A.	M	Adult	Translocated	187	461	48.9		Skinner & van Aarde (1987)
N055 – inland, Nam.	F	Subadult	Translocated	364	137	133.5 (21.4)*	8.6 ± 4.0 (n = 94)*	This study
N075 – inland, Nam.	M	Subadult	Resident	66	191	103.2 (12.9)*	10.4 ± 2.5 (n = 12)*	This study
Alaika – coastal, Nam.	F	Subadult	Resident	225	78	217.9 (46.7)*	11.1 ± 6.0 (n = 67)*	Brown Hyena Research

*Ranges and movements were calculated with ArcGIS v. 10.1 (ESRI, 2013) using the ArcMET extension (Wall, 2014) and R (R Core Team, 2013).

ing translocation, but did not return to her capture site. The resident hyaena N075 showed no exploratory movements of such scale (Fig. 1).

Following initial explorations, N055 established a stable range which she maintained until her death four months later. The range's geographic centroid was located 19 km northwest of the release site and 69 km from the original capture location (Fig. 1). Local habitat was mainly characterized by undulating mountain terrain, large areas of black-thorn (*Acacia mellifera*) encroachment, semi-open grassland glades, seasonal river courses and swamps as well as large permanent water dams. Road density was higher in N055's release area with 1.39 km/km^2 compared to 0.85 km/km^2 in her capture area (measured in 100 km^2 quadrates around trap and release sites, respectively). N055's range measured 133.5 km^2 (100% MCP) and daily movements decreased to a median of 8.3 km/day (S.E. = 0.4 km; n = 94, range = 1.6–19.4 km/day) which were significantly different from those during the exploration phase (comparing ranked means with a Mann-Whitney U-test: W = 688, P = 0.037). In comparison with resident subadults (see also Table 1), her distances were similar to those of inland male N075 (Mann-Whitney U-test: W = 380, P = 0.067) but differed significantly from coastal female Alaika (Mann-Whitney U-test: W = 2360, P = 0.007).

N055 settled into an area in which landowners regularly observed resident brown hyaenas on wildlife cameras and where the species was known to reproduce successfully (C. Kruger, pers. comm., 12 June 2012). Within the range, N055 displayed distinct oriented movements towards one specific location for 28 days, closely resembling those of resident hyaenas during cub-provisioning and social interaction at active dens (Fig. 2.). During the same period, N055 was once observed in company of an adult brown hyaena and both animals fled in the same direction when approached. N055's movements hence suggest that she found and visited an active den site of the resident hyaenas and possibly assimilated into the local clan. We did not detect den-oriented activity in N075's location data (Fig. 2).

N055's post-release range encompassed livestock and game production properties, hunting and other tourism enterprises as well as a sand-mining concession. Through regular consultation with these landowners and sharing of positional data we established that N055 caused no conflict

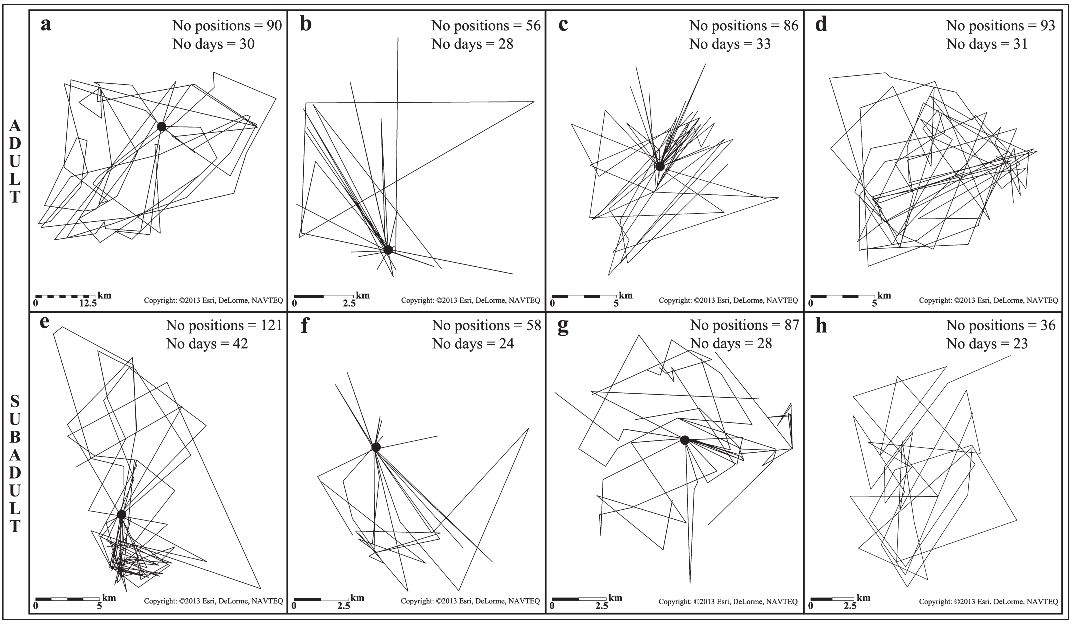

Fig. 2. Brown hyaena movements as influenced by denning activity – showing oriented movements of resident individuals in the direction of their clan's known active den site for cub provisioning and social interaction (male Alfie (**a**), breeding females Obelixa (**b**) and Tosca (**c**), young females Helene (**e**) and Alaika (**f**)), non-oriented movements of Tosca outside the breeding period (**d**), oriented movements of translocated female N055 to a suspected active den site (**g**) and non-oriented movements of male N075 suggesting his clan was not denning (**h**). Den locations are indicated by black dots. Panels display selected movements standardized for consistent data and time periods.

throughout her range. Moreover, no further bite incidents occurred at the original conflict site for at least 10 weeks after the hyaena was removed (W. Teubner, pers. comm., 8 April 2012). No conflict was reported for subadult male N075.

N055 died in a vehicle accident in her new range 137 days after release. The total cost of this translocation including relocation, examination and GPS-monitoring was US$1672 (see cost structure and detail in Weise, Stratford & van Vuuren, 2014). Resident male N075 was alive when the study was concluded.

DISCUSSION

Namibia's brown hyaena population appears stable, if not increasing (Stein, Aschenborn, Kastern, Andreas & Thompson, 2012) and the species is widespread across commercial livestock farmlands (Lindsey *et al.*, 2013; Stein *et al.*, 2012). The importance of landscape-scale pastoralist systems as a mainstay habitat for brown hyaenas has already been identified across southern Africa (Kent & Hill, 2013; Lindsey *et al.*, 2013; Wiesel, Maude, Scott & Mills, 2008). Extensive range overlap with pastoralism compounds the species' opportunity to predate on small domestic animals (Mills & Mills, 1978; van As, 2012) or to feed on livestock carcasses killed by other carnivores (*e.g.* Maude & Mills, 2005; Stein, Fuller & Marker, 2013). This will inevitably result in regular conflict with commercial farmers. Similar to livestock depredation studies elsewhere in southern Africa (Schiess-Meier, Ramsauer, Gabanapelo & König, 2007; van As, 2012), 16% of Namibian land managers (n = 221) report brown hyaenas as conflict carnivores – especially during peak calving/lambing seasons, and 3.8% of all respondents state that they are the primary cause of livestock depredation (F.J. Weise, unpubl. data, 2008–2014). Where lethal control of confirmed or perceived livestock raiders is not considered acceptable, translocation of offending individuals may offer one avenue for conflict mitigation. However, more detailed information is needed to formulate suitable protocols for such interventions.

The outcomes of N055's translocation confirm several aspects of post-release behaviour observed in other translocated brown hyaenas (Skinner & van Aarde, 1987). First, the animal displayed no true site fidelity but settled into a definable range in the vicinity of the release area (Fig. 1). Secondly, despite living close to human habitation and crossing through cattle ranches, no conflict was reported as a consequence of this translocation. Thirdly, the new range incorporated large tracts of mountainous habitat supporting the notion that post-release movements may be influenced by this type of topography (Skinner & van Aarde, 1987). Moreover, N055's adapted to an unfamiliar environment and her new range was in agreement with those of resident subadults in Namibia (Skinner, van Aarde & Goss, 1995 and Table 1).

This translocation was successful in alleviating livestock attacks at the capture location without moving conflict elsewhere. The hyaena did not return to her capture site and settled into a stable range overlapping with conspecifics in the vicinity of the release reserve. Movement data also suggest successful clan assimilation (Fig. 2). Dens are the social meeting point for resident brown hyaenas, and social cohesion is maintained through the greeting ceremony and other interactions, such as food provisioning for cubs (Mills, 1982; Mills, 1983a). N055's premature age probably contributed to this success, as young brown hyaenas usually display submissive behaviours during intraspecific encounters (Mills, 1981; Mills, 1983b), immigrate or become nomadic (Mills, 1982). The animal's extensive and immediate exploratory movements are consistent with post-release behaviour of other large carnivores (see Bradley *et al.*, 2005; Houser *et al.*, 2011; Priatna, Santosal, Prasetyo & Kartono, 2012; Riley, Aune, Mace & Madel, 1994; Ruth, Logan, Sweanor, Hornocker & Temple, 1998; Weilenmann *et al.*, 2010). The hyaena left the target release area and died less than six months post-release, therefore failing to achieve true translocation success. Road accidents are a common mortality cause for Namibian brown hyaenas (I. Wiesel and F.J. Weise, pers. obs.) and in this case, it is possible that N055's road death was an effect of translocation because the hyaena was moved into an area where road density was considerably higher than in her capture area.

Although preliminary, and in part anecdotal, we provide supporting information that individual brown hyaenas may be translocated successfully. However, we strongly caution that this strategy should not be undertaken lightly or as a standard management approach. Due to the low hunting success of brown hyaenas (Mills, 1984) compensation for livestock damage may also be an economically feasible conflict mitigation strategy and encourage landowners to tolerate offending individuals. Here, the financial cost of N055's translocation was approximately equivalent to the value of three to four cattle calves, the number attacked by the hyaena.

Where translocation is considered necessary, the recipient population should be studied prior to releases so as to determine its social structure in detail. The importance of sociality and group integration during translocations has already been demonstrated for other social carnivores (*e.g.* Gusset *et al.*, 2006; Gusset, Stewart, Bowler & Pullin, 2010; Somers & Gusset, 2009; Trinkel *et al.*, 2008). In the case of brown hyaenas, subadults of both sexes as well as adult males often disperse from natal clans and are usually tolerated by other resident groups (Mills, 1983b; Mills, 1984; Owens & Owens, 1978). Skinner & van Aarde (1987) report variable outcomes for adult females including the successful translocation of one animal into uninhabited range whilst another female left the area and travelled several hundred kilometres from the release site. Because brown hyaenas mainly forage solitarily (Mills, 1983b; Owens & Owens, 1978), it would appear to be very difficult to trap integral family sub-groups for translocation and also bear the risk of compromising remaining clan members such as dependent offspring at the source site. Moreover, it would be very resource-consuming to accurately determine information required to conduct group translocations responsibly – namely recipient potential and social status of resident populations in release areas. Due to the *ad hoc* nature of translocations, managers simply cannot anticipate the age, sex or social status (all of which probably influence an individual's translocation suitability) of candidate hyaenas. Therefore, wildlife authorities may consider temporarily admitting individuals into registered rehabilitation facilities allowing for artificial group establishment and/or case-specific identification of adequate release sites – rather than experimentally translocating hyaenas. Release site selection should always be assessed in consultation with local and regional species experts – vast mountainous habitats have proven ideal for translocation purposes (Skinner & van Aarde, 1987 and this study).

Translocation should only be considered to facilitate range expansion (Skinner & van Aarde, 1987; Hayward *et al.*, 2007b) or to prevent lethal removal of offending individuals when other conflict mitigation strategies such as improved livestock protection have failed. Nonetheless, the strategy should be available to managers and be further tested as part of a larger conflict mitigation repertoire – although never as a first choice. Translocated hyaenas (except juveniles) should always be equipped with GPS satellite transponders to permit intensive monitoring and subsequent evaluation of case studies. The biological and technical considerations that should precede any translocation have already been described in detail (see Miller, Ralls, Reading, Scott & Estes, 1999). Where conflict is doubtful or can be managed on-site, the immediate release of trapped hyaenas should be promoted instead – through joint research or compensation of damage. Including landowners in monitoring activities was beneficial to our studies and improved local perception of the species – neither of the study hyaenas was persecuted and collaborative efforts are under way to collar more free-ranging specimens for scientific and conflict mitigation purposes.

ACKNOWLEDGEMENTS

We thank the Ministry of Environment and Tourism in Namibia for granting permission to conduct this experimental study. We further thank Chester Zoo, U.K., and Colchester Zoo, U.K., for funding the GPS satellite transponders used in this study and associated data fees. The Brown Hyena Research Project acknowledges support from Namdeb Diamond Corporation and Nedbank's Go Green Fund. We thank all landowners for active support of this research. M. Hayward, R. van Aarde, K. Stratford, S. Munro, A. Bowden and two anonymous reviewers provided helpful comments on earlier drafts of this manuscript and improved its clarity and content.

REFERENCES

Bradley, E.H., Pletscher, D.H., Bangs, E.E., Kunkel, K.E., Smith, D.W., Mack, C.M., Meier, T.J., Fontaine, J.A., Niemeyer, C.C. & Jimenez, M.D. (2005). Evaluating wolf translocation as a nonlethal method to reduce livestock conflicts in the northwestern United States. *Conservation Biology*, 9, 1498–1508.

ESRI (2013). ArcGIS Desktop: Release 10.1. Redlands, California, U.S.A.: Environmental Systems Research Institute.

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

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

Gusset, M., Graf J.A. & Somers, M.J. (2006a). The re-introduction of endangered wild dogs into Hluhluwe-iMfolozi Park, South Africa: a update on the first 25 years. *Re-introduction NEWS*, 25, 31–33.

Gusset, M., Slotow, R. & Somers, M.J. (2006b). Divided we fail: the importance of social integration for the re-introduction of endangered African wild dogs (*Lycaon pictus*). *Journal of Zoology*, 270, 502–511.

Gusset, M., Ryan, S.J., Hofmeyr, M., Van Dyk, G., Davies-Mostert, H.T., Graf, J.A., Owen, C., Szykman, M., Macdonald, D.W., Monfort, S.L., Wildt, D.E., Maddock, A.H., Mills, M.G.L., Slotow, R. & Somers, M.J. (2008). Efforts going to the dogs? Evaluating attempts to re-introduce endangered wild dogs in South Africa. *Journal of Applied Ecology*, 45, 100–108.

Gusset, M., Stewart, G.B., Bowler, D.E. & Pullin, A.S. (2010). Wild dog reintroductions in South Africa: a systematic review and cross-validation of an endangered species recovery programme. *Journal for Nature Conservation*, 18, 230–234.

Hayward, M.W., Adendorff, J., Moolman, L., Hayward, G.J. & Kerley, G.I.H. (2006). The successful reintroduction of leopard *Panthera pardus* to the Addo Elephant National Park. *African Journal of Ecology*, 45, 103–104.

Hayward, M.W., Adendorff, J., O'brien, J., Sholto-Douglas, A., Bissett, C., Moolman, L.C., Bean, P., Fogarty, A., Howarth, D., Slater, R. & Kerley, G.I.H. (2007a). Practical considerations for the reintroduction of large, terrestrial, mammalian predators based on reintroductions to South Africa's Eastern Cape Province. *The Open Conservation Biology Journal*, 1, 1–11.

Hayward, M.W., Adendorff, J., O'brien, J., Sholto-Douglas, A., Bissett, C., Moolman, L.C., Bean, P., Fogarty, A., Howarth, D., Slater, R. & Kerley, G.I.H. (2007b). The reintroduction of large carnivores to the Eastern Cape Province, South Africa: an assessment. *Oryx*, 41, 205–214.

Hayward, M.W. & Somers, M.J. (Eds) (2009). *Reintroduction of top-order predators*. Oxford, U.K.: Wiley-Blackwell.

Houser, A., Gusset, M., Bragg, C.J., Boast, L.K. & Somers, M.J. (2011). Pre-release hunting training and post-release monitoring are key components in the rehabilitation of orphaned large felids. South African. *Journal of Wildlife Research*, 41, 11–20.

Hunter, L.T.B. (1998). *The behavioural ecology of reintroduced lions and cheetahs in the Phinda Resource Reserve, Kwazulu-Natal, South Africa.* (Ph.D. thesis). University of Pretoria, Pretoria, South Africa.

Kent, V.T. & Hill, R.A. (2013). The importance of farmland for the conservation of the brown hyaena *Parahyaena brunnea*. *Oryx*, 47; 431–440.

Lindsey, P.A., Havemann, C.P., Lines, R., Palazy, L., Price, A.E., Retief, T.A., Rhebergen, T. & Van Der Waal, C. (2013). Determinants of persistence and tolerance of carnivores on Namibian ranches: implications for conservation on southern African private lands. *PLOS ONE*, 8, e52458.

Linnell, J.D.C., Aanes, R., Swenson, J.E., Odden, J. & Smith, M.E. (1997). Translocation of carnivores as a method for managing problem animals: a review. *Biodiversity and Conservation*, 6, 1245–1257.

Massei, G., Roger, J., Quy, A., Gurney, J. & Cowan, D.P. (2010). Can translocations be used to mitigate human–wildlife conflicts? *Wildlife Research,* 37, 428–439.

Maude, M. & Mills, M.G.L. (2005). The comparative feeding ecology of the brown hyaena in a cattle area and a national park in Botswana. South African *Journal of Wildlife Research*, 35, 201–214.

MET (2012). Regulations for large carnivores in captivity: Nature Conservation Ordinance, 1975. Government Gazette of the Republic of Namibia No. 4911. Ministry of Environment and Tourism, Windhoek, Namibia.

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.

Mills, M.G.L. (1981). *The socio-ecology and social behaviour of the brown hyaena,* Hyaena brunnea *Thunberg, 1820 in the southern Kalahari.* (D.Sc. thesis). University of Pretoria, Pretoria, South Africa.

Mills, M.G.L. (1982). The mating system of the brown hyaena, *Hyaena brunnea* in the southern Kalahari. *Behavioral Ecology and Sociobiology*, 10, 131–136.

Mills, M.G.L. (1983a). Mating and denning behaviour of the brown hyaena *Hyaena brunnea* and comparisons with other hyaenidae. *Zeitschrift für Tierpsychologie*, 63, 331–342.

Mills, M.G.L. (1983b). Behavioural mechanisms in territory and group maintenance of the brown hyaena, *Hyaena brunnea*, in the southern Kalahari. *Animal Behavior,* 31, 503–510.

Mills, M.G.L. (1984). The comparative behavioural ecology of the brown hyaena *Hyaena brunnea* and the spotted hyaena *Crocuta crocuta* in the southern Kalahari. Supplement to *Koedoe*, 27, 237–247.

Mills, M.G.L. & Hofer, H. (compilers) (1998). *Hyaenas. status survey and conservation action plan.* IUCN/SSC Hyaena Specialist Group. IUCN, Gland, Switzerland, and Cambridge, U.K.

Mills, M.G.L. & Mills, M.E.J. (1978). The diet of the brown hyaena *Hyaena brunnea* in the southern Kalahari. *Koedoe*, 21, 125–149.

Owens, M.J. & Owens, D.D. (1978). Feeding ecology and its influence on social organization in brown hyenas (*Hyaena brunnea*, Thunberg) of the central Kalahari Desert. *East African Wildlife Journal*, 16, 113–135.

Priatna, D., Santosal, Y., Prasetyo, L.B. & Kartono, A.P. (2012). Home range and movements of male translocated problem tigers in Sumatra. *Asian Journal of Conservation Biology*, 1, 20–30.

R Core Team (2013). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

Riley, S.J., Aune, K., Mace, R.D. & Madel, M.J. (1994). Translocation of nuisance grizzly bears in northwestern Montana. *International Conference for Bear Research and Management*, 9, 567–573.

Ruth, T.K., Logan, K.A., Sweanor, L.L., Hornocker, M.G. & Temple, L.J. (1998). Evaluating cougar translocation in New Mexico. *Journal of Wildlife Management*, 62, 1264–1275.

Schiess-Meier, M., Ramsauer, S., Gabanapelo, T. & König, B. (2007). Livestock predation – Insights from problem animal control registers in Botswana. *Journal of Wildlife Management*, 71, 1267–1274.

Skinner, J.D. & Van Aarde, R.J. (1987). Range use of brown hyaenas *Hyaena brunnea* relocated in an agricultural area of the Transvaal. *Journal of Zoology*, 212, 350–352.

Skinner, J.D., Van Aarde, R.J. & Goss, R.A. (1995). Space and resource use by brown hyenas *Hyaena brunnea* in the Namib Desert. *Journal of Zoology*, 237, 123–131.

Somers, M.J., Graf, J.A., Szykman, M., Slotow, R. & Gusset, M. (2008). Dynamics of a small re-introduced population of wild dogs over 25 years: Allee effects and the implications of sociality for endangered species' recovery. *Oecologia*, 158, 239–247.

Somers, M.J. & Gusset, M. (2009). The role of social behaviour in carnivore reintroductions. In M.W. Hayward & M.J. Somers (Eds), *Reintroduction of top-order predators* (pp. 270–281). Oxford, U.K.: Wiley-Blackwell.

Stander, P.E. (1990). A suggested management strategy for stock-raiding lions in Namibia. *South African Journal of Wildlife Research*, 20, 37–43.

Stander, P.E., //au, K., |ui, N., Dabe, T. & Dabe, D. (1997). Non-consumptive utilisation of leopards: community conservation and ecotourism in practice. Proceedings of a Symposium on Lions and Leopards as Game Ranch Animals. Onderstepoort, South Africa, (pp. 50–57).

Stein, A.B., Aschenborn, O., Kastern, M., Andreas A. & Thompson, S. (2012). Namibia large carnivore atlas. Windhoek, Namibia: Report, Ministry of Environment and Tourism.

Stein, A., Fuller, T.K. & Marker, L.L. (2013). Brown hyaena feeding ecology on Namibian farmlands. *South African Journal of Wildlife Research*, 43, 27–32.

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.

Van As, M. (2012). *Livestock, leopards and brown hyaenas: conflicts of cohabitation in the Roodewalshoek Conservancy, Mpumalanga*. (M.Sc. thesis). University of the Free State, Bloemfontein, South Africa.

Van Der Meulen, J.H. (1977). Notes on the capture and translocation of stock raiding lions in north eastern and north western Rhodesia. *South African Journal of Wildlife Research*, 7, 15–17.

Wall, J. (2014). ArcMET 10.1.11. Movement Ecology Tools for ArcGIS. Downloaded 15 April 2014 from www.movementecology.net.

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(8), e105042.

Wiesel, I., Maude, G., Scott, D. & Mills, G. (2008). *Hyaena brunnea*. In IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. Retrieved from: http://www.iucnredlist.org/details/10276/0 on 12 April 2014.

Wiesel, I. (2010). Killing of Cape fur seal (*Arctocephalus pusillus pusillus*) pups by brown hyenas (*Parahyaena brunnea*) at mainland breeding colonies along the coastal Namib Desert. *Acta Ethologica*, 13, 93–100.

Responsible Editor: M.W. Hayward