Using artificial passageways to facilitate the movement of wildlife on Namibian farmland

Florian J. Weise[1*], Quenton Wessels[2], Stuart Munro[1] & Matthew Solberg[1]

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

[2]*Department of Anatomy, School of Medicine, University of Namibia, 340 Mandume Ndemufayo Avenue, Windhoek, Namibia*

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Wildlife-proof fencing is increasing in extent as a result of the growing wildlife industry on private lands in southern Africa. In environments where such fences hinder the movements of free-ranging wildlife, the provision of artificial passageways can restore connectivity for some species. We tested the use of 49 discarded car tyres as wildlife passageways along the border of a Namibian wildlife farm. Tyres were installed into a wildlife-proof fence to reduce regular warthog (*Phacochoerus africanus*) damage to the fence and to provide connectivity and dispersal opportunities for selected indigenous wildlife species between adjacent farmland properties. The total cost for all 49 tyre installations was USD 252, which is significantly cheaper than daily fence patrols and maintenance. In addition, one tyre was monitored specifically for large carnivore activity with a motion-triggered camera trap (*n* = 96 trap days between August and December 2010). Eleven mammalian species used the tyre as a passageway and both cheetahs (*Acinonyx jubatus*) and leopards (*Panthera pardus*) made regular and repeated use of the tyre. Nine independent recordings of cheetahs, representing seven individuals, were made. One leopard was photographed four times. The suitability of discarded tyres as cost-effective artificial wildlife passageways for a range of mammalian species is stressed.

Key words: wildlife passageway, car tyre, wildlife-proof fence, predator management, Namibian farmland, trail camera.

INTRODUCTION

Approximately 43% of Namibia's landscape is currently used as private commercial farmland for livestock production of cattle (*Bos taurus*), sheep (*Ovis aries*) and goats (*Capra aegagrus hircus*) (Barnes & de Jager 1995) but also increasingly for the farming of wildlife (Erb 2004). There are more than 3500 commercial farms in Namibia (Lindsey 2011), many of which have free-ranging leopards (*Panthera pardus*) and cheetahs (*Acinonyx jubatus*). These species have become dominant on commercial farms due, in part, to the extirpation of lions (*Panthera leo*) and spotted hyaenas (*Crocuta crocuta*) (Marker-Kraus & Kraus 1994; Marker & Dickman 2005).

At present, at least one third of these previously exclusive livestock farms are organized into 25 commercial wildlife conservancies which aim to improve the management of their wildlife (Erb 2004). The accelerating conversion of traditional livestock farms into tourism, hunting and/or wildlife production units has materialized since a legislative change in the late 1960s which gave landowners first option to derive economic benefits from various forms of wildlife utilization on their properties (Barnes & de Jager 1995; Owen-Smith 1996).

Commercial management of herbivores, whether livestock or wildlife, in the presence of free-ranging predators often necessitates the use of deterrence, removal, exclusion and/or coexistence tactics (Gusset & Lagendijk 2008; Gusset *et al.* 2009; Schumann *et al.* 2006; Woodroffe *et al.* 2005). In Namibia, one conventional approach for the safeguarding of wildlife is the erection of 'wildlife-proof' fences. Whilst domestic herbivores are usually contained within stock fences consisting of five horizontal wires that do not inhibit wildlife movements, impermeable or electrified fences are required for the containment of attractive, endangered and/or valuable wildlife.

However, wildlife fences can negatively affect large predators and their prey as they hinder or obstruct essential ecological processes such as dispersal, emigration and immigration (Beck 2010;

*To whom correspondence should be addressed.
E-mail: florian.weise@gmail.com

Fig. 1. Car tyre passageway with trail camera monitoring setup.

Gibson 2010; Williamson & Williamson 1984). Moreover, the negative impacts of wildlife-proof fences can manifest at the individual, population, species, community and ecosystem level (Gadd 2012).

In addition to the biological costs of impermeable fences, fences also require substantial maintenance in Namibia's farmland complex where digging and burrowing animals such as warthog (*Phacochoerus africanus*), porcupine (*Hystrix africaeaustralis*) and aardvark (*Orycteropus afer*) are common (Schumann *et al.* 2006). To mitigate fence damage, some land managers have started testing different passageway techniques. For example, one unpublished trial demonstrated that swing gates had the potential to significantly reduce the damage of burrowing species to a wildlife-proof fence (W. Piepmeyer, pers. comm). Another study established that swing gates may also be an effective tool for the non-lethal exclusion of unwanted large predators, such as cheetahs, from wildlife and/or livestock production properties (Schumann *et al.* 2006). Nonetheless, very few effective techniques have been developed in Namibia to either facilitate or prevent the movements of selected wildlife species. This is despite continuing habitat and population fragmentation as a direct consequence of increasing use of wildlife-proof fences. The need for and potential value of wildlife passageways within the Namibian landscape context is thus evident.

Here we report on the use of discarded car tyres which were installed into a wildlife-proof fence in order to reduce regular warthog damage and to facilitate the movements of selected indigenous wildlife between adjacent properties. We also provide data on the success and cost-effectiveness of the use of these tyres as artificial passageways for small- and large-bodied mammalian species, and evidence of thoroughfare of both cheetahs and leopards.

METHODS

Forty-nine discarded car tyres (40 cm radius) were installed at ground level into a 19.1 km long, 2.4 m high, Bonnox-combination, non-electrified fence (Fig. 1). With the exception of baboons (*Papio hamadryas*), the fence served as an effective barrier to all medium- and large-bodied free-ranging mammals, unless it was breached by burrowing animals (F.J. Weise, pers. obs.). Tyre locations were chosen according where warthog activity, resulting in repeat fence maintenance, was highest. Most tyres ($n = 41$) were installed in areas with sandy soils, whilst the remainder were placed in locations with gravel substrate. Tyres offered an

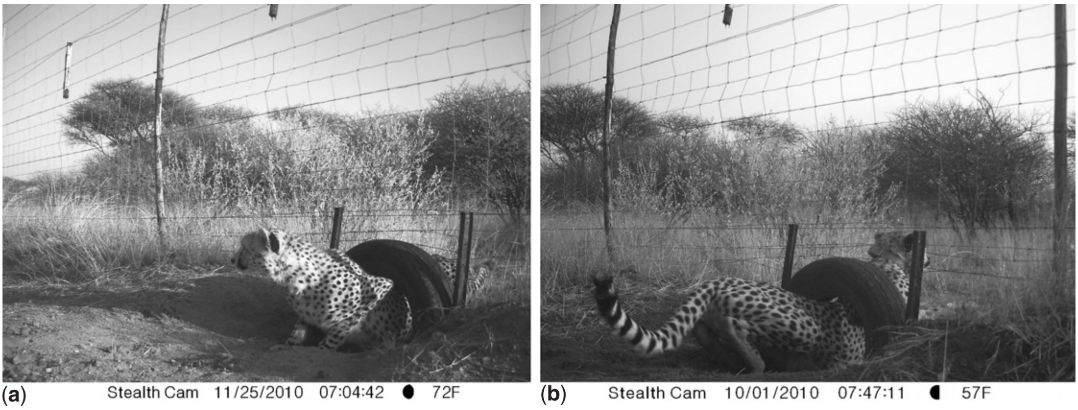

Fig. 2. Free-ranging cheetahs using the tyre passageway to enter (**a**) and leave (**b**) the wildlife reserve.

effective opening of 37 cm for wildlife to pass through the fence. There was no fixed distance between individual tyres (mean = 277 m, range = 35–907 m). Tyres were anchored into the substrate with short metal poles on either side and were wired to the fence for stability (Fig. 1).

Prior to the study, the fence was patrolled and repaired between 4 and 5 h daily. The fence had been built to contain several resident ungulates, *i.e.* greater kudu (*Tragelaphus strepsiceros*), gemsbok (*Oryx gazella*), red hartebeest (*Alcelaphus buselaphus*) and springbok (*Antidorcas marsupialis*), and several valuable wildlife species, which were reintroduced for both tourism and breeding purposes, including giraffe (*Giraffa camelopardalis*), eland (*Tragelaphus oryx*), Burchell's zebra (*Equus burchelli*) and waterbuck (*Kobus ellipsiprymnus*).

One of the tyres (22 22.450′S, 17 24.633′E) was monitored with a single, infrared, motion-triggered trail camera (STEALTH CAM ROGUE® 5.0 model) for 96 trap days between August and December 2010 (Fig. 1). The tyre connected the wildlife reserve with an adjacent cattle farm. During fence patrols, spoor of cheetah, leopard and brown hyaena (*Hyaena brunnea*) had been repeatedly seen at this site. The camera location was 15 m away from the edge of a 12 ha electrified captive cheetah holding facility that housed nine semi-wild cheetahs (five males and four females) in separate sub-sections. No bait was placed at the camera site.

The camera was mounted onto a wooden pole with the camera lens 48 cm above ground and facing the tyre at an angle of between 15 and 25 degrees to record both flank and face of wildlife passing through the tyre (Fig. 2). The distance between the fence and the camera lens was 2.8 m. The camera recorded pictures every four seconds when motion was detected. The camera was set to the minimum time-out interval of 1 min between successive bouts before it could be triggered again by movement. Camera sensitivity for motion detection was set to approximately 5 m.

The camera was re-visited every four to six days to check and, if necessary, replace batteries and to download the pictures. The camera was functional during the entire study. All spoor assessments during the study were carried out by an experienced San tracker working for the carnivore research programme. Wildlife spoor at the tyre were erased after every visit.

RESULTS

The camera recorded 311 detections (considering all wildlife events at 1 min intervals) of which 100 observations were classed as independent records (Table 1). These 100 observations comprised 11 mammalian species passing through the tyre. Six of the recorded species were carnivores which also contributed the majority of the total photographic records. Records of avian species, *i.e.* Red-crested Korhaan (*Eupodotis ruficrista*) and Crimson-breasted Shrike (*Laniarius atrococcineus*), as well as of the striped mouse (*Rhabdomys pumilio*) were excluded as they did not have to rely on the tyre to cross the fence. Black-backed jackals (*Canis mesomelas*) and porcupines used the tyre most frequently, followed by cheetahs and warthogs (Table 1).

Cheetahs were recorded on nine independent occasions, representing at least seven known individuals; and one male leopard was photographed four times. Spot patterns and tracking

Table 1. Detections of target mammalian species crossing through an artificial wildlife passageway in the form of a car tyre, as recorded with a trail camera (n = 96 trap days).

Species	% Capture of independent records[a]	Total number of recording events (at 1 min intervals)
Carnivores		
Black-backed jackal, *Canis mesomelas*	44	81
Cheetah, *Acinonyx jubatus*	9	12
Leopard, *Panthera pardus*	4	4
Cape fox, *Vulpes chama*	3	3
Caracal, *Caracal caracal*	1	1
Small-spotted genet, *Genetta genetta*	1	1
Subtotal	62	102
Others		
Porcupine, *Hystrix africaeaustralis*	21	36
Warthog, *Phacochoerus africanus*	7	9
Scrub hare, *Lepus saxatilis*	6	11
Baboon, *Papio hamadryas*	3	3
Common duiker, *Sylvicapra grimmia*	1	3
Subtotal	38	62
Total	100	164

[a]Independent recording events were defined as image records of the same species with a minimum inter-recording interval of 12 h. Repeat recordings of the same species within 12 h were ignored.

collars were used to identify individuals of these species (Fig. 2). A collared coalition of three male cheetahs was recorded four times; another coalition of two un-collared male cheetahs passed through the tyre three times, whilst an adult female cheetah with one subadult cub was photographed once. One set of cheetah pictures could not be identified with confidence due to over-exposure. All identified cheetahs and the leopard were known to be resident in the area (F.J. Weise, unpubl. data). On three separate occasions, the spoor of large carnivores (cheetah: n = 1, leopard: n = 2) was recorded passing through the tyre without matching photographs. It was assumed that the animals passed through the tyre during the camera's 1 min time-out.

The cheetahs and the leopard passed through the tyre to enter and leave the wildlife reserve. The male leopard was recorded at night and in the morning, whilst the cheetahs were only documented during evening hours (19:00–21:00), around midnight (23:00–00:00) and with a distinct activity peak (seven records) in the morning (07:00–09:00). There were no records of large predators passing through the tyre between 09:00 and 19:00 or between 01:00 and 06:00. Black-backed jackals were recorded using the tyre throughout the day and night.

We directly observed one adult springbok and one juvenile red hartebeest passing through the tyres which were not monitored by the camera. Warthogs were seen using all 49 tyres during the study. Although only recorded opportunistically, spoor of aardvark, black-backed jackal, caracal (*Caracal caracal*), baboon, common duiker (*Sylvicapra grimmia*), Helmeted Guineafowl (*Numida meleagris*), porcupine, honey badger (*Mellivora capensis*), scrub hare (*Lepus saxatilis*), springhare (*Pedetes capensis*) and steenbok (*Raphicerus campestris*) were identified as crossing through unmonitored tyres by the San tracker. Spoor of cheetahs and leopards were observed at six of the 49 tyres. There was no spoor or photographic evidence of brown hyaenas at any of the tyres. Considering all available data from the camera, spoor and direct observations, the tyres were used as passageways by at least 18 mammalian species and three avian species.

Prior to tyre installations, a mean of 31.3 holes per day (n = 10 days) had to be fixed along the fence. After the installation of the tyre passages, this number decreased to a mean of 13.6 holes per day (n = 10 days) resulting in a significant (Mann-Whitney U-test: W = 3.5, P < 0.001) reduction in maintenance. The total investment was USD 5.13 per tyre passageway or USD 252 for the entire programme. Labour time (at the minimum local salary of USD 0.7 per h) contributed 79% to the total cost. After preparations, the installation of a single tyre into the fence required approximately 1 h to complete. Fuel (at USD 1.0 per litre diesel) contributed the remaining 21% of the total cost. All conversions from Namibian dollars to USD were made at the time of the tyre installations at a rate of USD 1.00 : 7.6549 Nam$ (16 June 2010). There was no additional material cost pertaining to this experiment because tyres, metal rods and wiring were sourced entirely from scrap materials.

DISCUSSION

Landowners across the globe come into conflict with predators. However, extensive research on predator passages has only been carried out in North America for cougars (*Puma concolor*) (*e.g.* Beier 1995; Gloyne & Clevenger 2001). The species serves as a model for the management of ecosystems through the placement of artificial passageways in fragmented habitats (Harris & Scheck 1991; Beier & Loe 1992; Royte 1992). Cougars select home ranges based on the availability of prey and integrate these artificial passageways into their habitat (Clevenger & Waltho 1999; Clevenger *et al.* 2001). The lack of complementary applied research in Africa is surprising, especially when considering that Namibia, for example, harbours six species of large carnivores in coexistence with valuable wildlife and livestock.

Our study showed that medium- to large-bodied carnivores passed through the tyre more frequently than other taxa, thus maintaining unrestricted and regular movements between different farm properties. Black-backed jackals contributed nearly half of all mammal records and represented the most abundant carnivore on the wildlife reserve. Although not quantified, it appeared that one pair of black-backed jackals was photographed 27 times out of the total 44 recordings. Similarly, repeat recordings of identifiable cheetahs as well as one leopard suggests that use of the tyre as a passageway was not isolated or coincidental but rather habitual. High capture rates at the monitoring site, however, were likely influenced by the presence of the nearby cheetah holding facility inside the fence acting as an attractant. It is plausible that resident free-ranging male cheetahs were attracted to the site by the presence of captive females. Conversely, captive male cheetahs were perhaps perceived as intruders in resident male territories and therefore as competition.

In the cases of known (GPS collared) individuals, the tyres enabled the maintenance of previously established home ranges even in the presence of a new artificial obstruction (F.J. Weise, unpubl. data). In support of this notion, both cheetahs and leopards used six of the available 49 tyres during the study. The passageway offered resident predators an opportunity for natural movements and thus access to alternative prey sources on other properties. Therefore, tyre passageways may have the potential to mitigate localized predation pressure on fenced-in wildlife populations.

In agreement with Little *et al.* (2002), our study produced no evidence that predators may utilize artificial passageways as prey traps. There is the risk, however, that tyres facilitate carnivore movements into areas with highly valuable game, such as sable antelope (*Hippotragus niger*). In situations where the safeguarding of rare or expensive wildlife or stock animals becomes the primary objective, swing gates may be more appropriate (Schumann *et al.* 2006).

Although preliminary, our data indicate that the tyres offered an effective passageway for the movements of several wildlife species. The setup remedied one of the common negative effects of impermeable wildlife fencing (*i.e.* habitat segregation) at least for the species observed at our study site. We suggest that different sizes of tyres will enable a higher degree of selectivity towards the species of wildlife that can pass through them.

From a management perspective, the tyres provided a cost-effective alternative to the routine of fence repairs. In addition to minimal installation costs, the tyres required little maintenance, *i.e.* occasional removal of soil and debris to maintain an effective opening. Schumann *et al.* (2006) reported a similarly low investment cost of USD 6.72 per swing gate and showed that this was substantially less than installation and maintenance costs for an electrified wildlife-proof fence. Following the installation of all 49 tyres and a habituation period for wildlife to identify them as suitable passageways, our study resulted in a considerable reduction in holes under the fence. Consequently, time allocated for fence patrols and repairs could be reduced by over 50% to less than 2 h per day. The resulting reduction in fence maintenance cost (approximately USD 1.4 per day) clearly justifies the investment, considering that the installation costs were recovered in about 180 days.

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