Assessing the use of swing gates in game fences as a potential non-lethal predator exclusion technique

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Many Namibian farmers are diversifying from exclusive livestock farming to mixed farming, resulting in a sharp increase in the number of game-fenced areas. However, animals such as warthog (*Phacochoerus aethiopicus*), porcupine (*Hystrix africaeaustralis*) and aardvark (*Orycteropus afer*) dig holes under game fences, allowing access to predators such as cheetah (*Acinonyx jubatus*). Swing gates were installed along a 4800 m section of game fencing in the Otjiwarongo district of Namibia. The fence was monitored before and after gate installation and trip cameras were used to identify species that used the gates. Warthog, aardvark and porcupines commonly used the gates and the number of holes under the fencing was significantly reduced following gate installation. No predators were observed using the swing gates and the cost was substantially lower than fence electrification This initial research suggests that swing gates could be an important non-lethal predator exclusion technique, although further studies will be needed to confirm their long-term effectiveness. Using techniques such as swing gates, which effectively and economically reduce the frequency with which animals dig holes under fences may not only benefit farmers, but also reduce the unnecessary destruction of non-target wildlife species resulting from unselective trapping.

Key words: cheetah, electric fencing, game-fenced areas, swing gates.

INTRODUCTION

Although Namibia is home to the world's largest population of free-ranging cheetah, 90% of this population does not occur in protected areas, but on cattle-producing farmlands in the north-central part of the country (Morsbach 1987; Marker-Kraus *et al.* 1996). A long history of conflict exists between Namibian farmers and free-ranging cheetah, and the Ministry of Environment and Tourism indicated that 1624 cheetah were reported as being shot for the protection of livestock between 1986 and 1991 (Marker-Kraus *et al.* 1996). These figures are incomplete and indicate, at best, minimal removals (Marker-Kraus *et al.* 1996).

As is the trend in South Africa (Anon. 2002), many Namibian farmers are diversifying from exclusive livestock farming to mixed farming for economic reasons (Van Der Waal & Dekker 2000; Saltz *et al.* 2004), resulting in a sharp increase in the number of game farms. These are typically fenced with game fencing to control the movement of game animals, but animals such as warthog, porcupine and aardvark dig holes under game fences (Van Rooyen *et al.* 1996). These holes not only allow valuable game to escape but also allow predators, such as cheetah, to access the game-fenced areas (Du Toit 1996). These holes therefore make game fences ineffective for excluding predators and also increase maintenance costs (Heard & Stephenson 1987). This leads to trapping and shooting of predators and extensive extermination campaigns against hole-digging animals, which can be non-selective and therefore have a serious impact on target and non-target species (Heard & Stephenson 1987; Berger 1999; Marker *et al.* 2003; Woodroffe & Frank 2005).

One solution to reducing conflict is to exclude predators from the areas where valuable game is confined (Linnell *et al.* 1999). Exclusion techniques that have been tested against predators include the use of fladry (Musiani & Visalberghi 2001; Musiani *et al.* 2003) [tested against wolves (*Canis lupus*) but, as yet, not attempted with African predators], disruptive stimuli such as sound and light, electronic training collars (Beckoff 2001;

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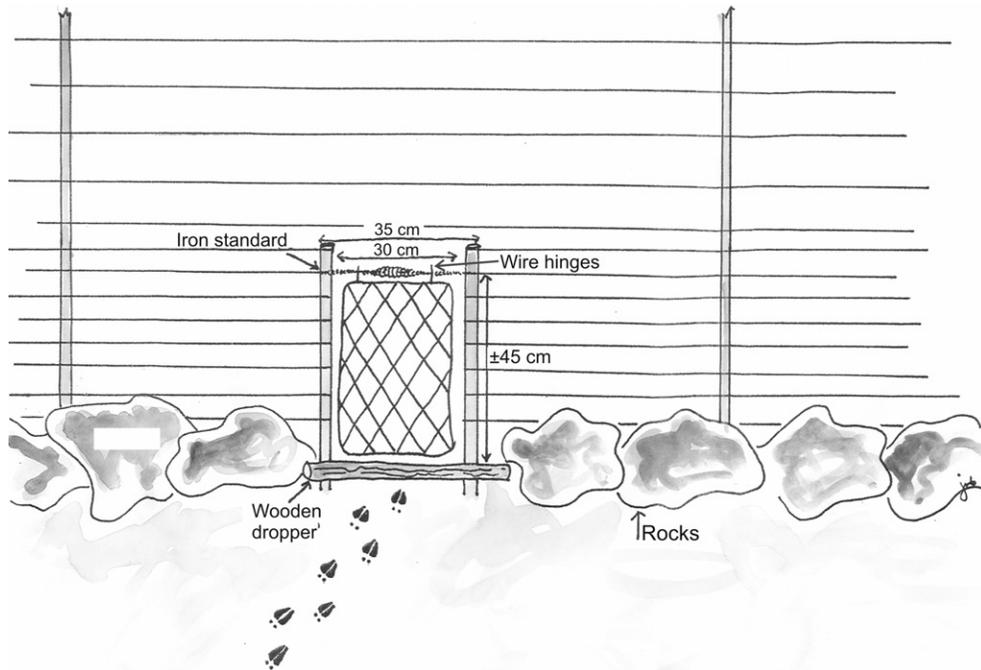
Fig. 1. Swing gate design: the gate swings freely on the wire hinges when an animal passes through.

Shivik *et al.* 2003) and electric fences (Mertens & Promberger 2000), as well as techniques where individual problem-causing animals are targeted through methods such as the use of toxic collars (Linnell *et al.* 1999). In America, electric fencing sharply reduced sheep losses to coyote (*Canis latrans*) (Linhart *et al.* 1982) and excluded red foxes (*Vulpes vulpes*) (Poole & McKillop 2002). In many instances where electric fencing was less effective, it was found that farmers were not inspecting and maintaining their fences and that the fences were poorly constructed (Linhart *et al.* 1982). Electric fencing has been successfully used in Australia to exclude dingo (*Canis dingo*) and in England, electric fencing was 99% effective against badgers (*Meles meles*) (Poole & McKillop 1999). In South Africa, electric fencing has been extensively used to exclude predators (Van Rooyen *et al.* 1996) and in some cases to confine predators such as lion (*Panthera leo*) to game-fenced areas as tourist attractions (Peel & Montagu 1999). In another instance in South Africa, the electrification of a 1.3 m high standard mesh wire fence, led to a 93% decrease in the number of holes dug by black-backed jackals (*Canis mesomelas*) under the fences and sharply decreased the cost of fence maintenance (Du Toit 1996).

In attempts to exclude predators, Namibian game farmers have resorted to electrifying game fences (Marker-Kraus *et al.* 1996). Although these farmers considered electrification to be 70–80% effective, the cost of installation is often cited as prohibitive (Marker-Kraus *et al.* 1996). Installing 'swing gates' in existing fences may be an alternative to electric fencing (Fig. 1) as they may allow hole-digging species to traverse fences, thereby reducing the number of holes that digging species make in the fence. Also, when closed, swing gates leave no visible openings in the fence for predators such as the cheetah to use and therefore may exclude these predators.

Although excluding predators from large parts of their natural habitat through fencing is not a desirable long-term objective, human–cheetah conflict in Namibia has increased to levels where game farmers are responsible for more cheetah removals than livestock farmers (Marker & Schumann 1998). This study investigated whether installing swing gates along a fence-line reduced the number of holes dug along the fence, and assessed its potential as a method for excluding predators from game-fenced areas. The study had several aims, which included determining which species passed through holes under game fences, and which species used swing gates once installed. Additionally, we examined whether it was more

effective to place swing gates at set distances along the fence-line, compared to placing them at the most well-used holes. Most importantly, however, we wanted to determine whether the installation of swing-gates significantly reduced the number of holes dug along game fences by wildlife, and to compare the cost of swing gates and electric fencing in order to examine whether these gates could potentially be used as an effective and cost-efficient method of predator exclusion.

STUDY AREA

This study was conducted on the Klein Hamakari farm in the Otjiwarongo district of Namibia. The 5138 ha farm forms part of the Waterberg Conservancy and lies 14 km southwest of the town of Okakarara and 11 km south-east of the Waterberg Plateau Park, in the north-central region of Namibia. The Waterberg Conservancy falls in the Thornbush Savanna vegetation zone as described by Geiss (1997). Dominant woody plants are *Acacia mellifera, A. tortilis, Dichrostachys cinerea, Grewia* spp., *Terminalia sericea* and *Boscia albitrunca.* The dominant grass species are *Eragrostis cylindriflora, E. porosa, Stipagrostis uniplumis, Tragus berteronianus, Cenchrus ciliaris* and *Aristida* spp. (Marker 2002).

The soil in the conservancy is of the Karoo sequence laid down 290–120 million years ago. It consists of the Omingonde Formation, which is a mix of sandstone, conglomerate, mudstones and siltstones (Schneider-Waterberg 1993). A 100-m thick layer of dune sandstone was deposited over earlier sediments and is known as the Etjo formation (Schneider-Waterberg 1993). The soils on Klein Hamakari include ferralic Arenosols, eutric Cambisols and eutric Fluvisols (Anon. 2004).

The mean annual rainfall for the area is 467 mm and temperatures in the area vary from below 0°C in winter to over 50°C in summer (Marker 2002).

Klein Hamakari is used for livestock and game farming and includes a 3000 ha game-fenced (21 strands) area where the study was conducted. The topography of the farm is generally flat with few undulations. Water is found in the form of man-made semi-permanent water reservoirs and cattle troughs. A number of game species were present in the camp, including warthog, springbok (*Damaliscus dorcas dorcas*)*,* impala (*Aepyceros melampus*) and blesbok (*Damaliscus dorcas phillipsi*). Cheetah have been removed from the game-fenced area in the past and leopard (*Panthera pardus*), caracal (*Felis caracal*) and

jackal have also been observed in the game-fenced area (W. Diekman, pers. comm., 2001).

METHODS

The use of holes and swing gates by digging species and predators

The study commenced in August 2001 with the selection of a 4800 m section of game fencing, a known access route for cheetah into the game-fenced area (W. Diekman, pers. comm., 2001). This section was chosen as we were particularly interested in whether or not cheetahs and other large predators, which tend to cause conflict in game-fenced areas, would be likely to cross the fence using swing-gates. The fence was surveyed and all existing holes under the fence were identified and numbered using plastic livestock ear tags. Holes that had been closed prior to the study were also identified and labelled as old closed holes. The study was divided into the following phases and during each phase the fence was monitored at intervals of 3–15 days:

1) Pre-gates (seven weeks) – this phase was a monitoring phase used to establish: (a) the animals using holes under the fence by identifying spoor passing through such holes; (b) the number of holes on each monitoring visit, and (c) the most commonly used routes as determined by the frequency of hole reopening. This monitoring continued throughout the study.

2) Open gates (10 weeks) – swing gates were installed along two sections of the fence and tied open with string. The swing gates consisted of a metal frame (length 45 cm, width 30 cm) covered with galvanised fencing (mesh size = 75 mm). Each swing gate was installed in the fence on a framework of iron standards and fence droppers (Fig. 1). When the gates were tied open, soil as well as thorn branches were used to close the other holes. The thorn branches were used to make it more difficult for digging animals to reopen their old holes, encouraging them to find the open gates. Two heat-sensitive cameras were installed along the fence when this phase commenced. One camera was installed at an identified aardvark burrow which was located approximately 6 m from a swing gate and the second camera was located 800 m further along the section. The cameras were installed approximately 5 m from the fence. In addition, tracks were noted going through the swing gates to determine if

they were being used.

3) Closed gates (16 weeks) – the string was removed and the gates were closed and allowed to operate freely. When the dry season commenced in April 2002, spoor became difficult as a means of identifying if the gates were being used. A single thread of sewing cotton was then used to tie the gates closed. When this was broken, the gate was recorded as being active. The heat-sensitive cameras were also used in this phase.

At the beginning of the first phase (pre-gates) the fence was divided into three equal distances and each subsequently used for one of the following treatments:

1) Gates on routes – gates were installed on the most commonly used routes, as determined during the pre-gates phase (number of gates = 6).

2) Gates evenly spaced – gates were installed every 200 m (number of gates = 8). This distance was chosen as the pre-gates phase indicated this to be the mean distance between holes along the entire fence.

3) No gates – control section.

Although there was a danger of pseudoreplication by using the same fence-line for all three treatments (Hurlbert 1984), we felt that this was a better study design than using three different fences, as other habitat variables, such as the presence of permanent water sources nearby, or differences in vegetation, would be likely to vary more between fences than if we used one long stretch of a single fence. During the surveying of the fence, we looked for evident differences between the three sections, in terms of the proximity of permanent water sources or human habitation, and no differences were noted which we felt would be likely to substantially bias the results.

During each phase, all treatments were monitored on the same day. New holes were included in the numbering and all the holes found along the three treatments were filled. For each hole, we recorded the depth (measured from the deepest part of the hole to the first strand of fencing wire above the ground) and assigned this to one of four classes (0–9 cm, 10–19 cm, 20–29 cm, >30 cm), and also noted any animal tracks passing through the hole.

Installation and maintenance costs

In addition to the quantitative data on wildlife use of swing-gates, two game farmers (both neighbours of the study farm) were asked to complete a questionnaire about their use of electric fencing, so that the installation and maintenance costs of swing gates and electric fencing could be compared.

Data analysis

To test for differences in the number of holes made by digging species across the phases and treatments, the two-factor ANOVA and the Student–Newman–Keuls tests were used (Zar 1984). The intervals between fence checks (n = 19) were irregular due to vehicle availability and volunteer assistance and varied between three and 15 days. Owing to these circumstances, the average number of days between checks was not equal for all phases, with a mean of three days for the pre-gate phase, seven days for the open gates and nine days for when the gates were closed. The data could therefore not be analysed as number of holes per section per day, but was analysed instead as the number of holes per section per sampling interval. However, the number of holes per section levelled off sharply after three days, indicating that new holes were made and old holes were reopened very soon after being closed, i.e. the number of holes dug per section was similar regardless if the interval between checks was three or 15 days, suggesting that this was not a very important source of bias. The chi-square goodness of fit test was used to test for difference in the number of holes in the various depth classes (Zar 1984).

RESULTS

The use of holes and swing gates by digging species and predators

From track identification in all sections throughout the study, several species were detected using holes to pass under the game fence (Table 1). Warthogs were the most commonly recorded species using holes (58% of species recorded), followed by jackal (22%), aardvark (17%) and porcupine (2%). Cheetah (0.5%) and leopard (0.5%) were identified using holes to pass through fences once (Table 1).

After gate installation, several species were photographed passing through the fence via the open gates, including, warthog (85%), steenbok (*Raphicerus campestris*) (5%), baboon (*Papio ursinus*) (5%), jackal (2.5%) and aardwolf (*Proteles cristatus*) (2.5%). Once the gates were closed, only warthog (73%), porcupine (18%) and aardvark (9%) were photographed using the gates

Table 1. The number of animals identified from tracks going through holes, and those photographed using and passing the gates during the study (percentage in brackets).

Species	Tracks identified going through holes	Animals photographed at gates			
		Open gates		Closed gates	
		Going through gates	Passing gates	Going through gates	Passing gates
Warthog	109 (58)	34 (85)	5 (38)	24 (73)	8 (15)
Aardvark	33 (17)	0	1 (8)	3 (9)	0
Porcupine	3 (2)	0	0	6 (18)	12 (23)
Jackal	42 (22)	1 (2.5)	2 (15)	0	1 (2)
Cheetah	1 (0.5)	0	0	0	1 (2)
Leopard	1 (0.5)	0	0	0	1 (2)
Caracal	0	0	0	0	1 (2)
Wild cat	0	0	1 (8)	0	0
Aardwolf	0	1 (2.5)	0	0	1 (2)
Baboon	0	2 (5)	0	0	0
Steenbok	0	2 (5)	4 (31)	0	13 (24)
Duiker	0	0	0	0	15 (28)
Total	189	40	13	33	53

(Table 1). No predators were recorded using swing-gates to cross the fence, despite being photographed passing close to them [jackal, cheetah, leopard, caracal and African wildcat (*Felis nigripes*)]. Aardwolf and duiker (*Silvicapra grimmia*) were also photographed passing the closed gates (Table 1).

Both treatment and phase had a significant effect on the mean number of holes dug under the fence (Table 2). At the beginning of the experiment (pre-gates), the mean number of holes in each treatment did not differ significantly and each section contained approximately 20 holes (Table 2). However, as the experiment progressed, the mean number of holes in the treatment with gates on routes decreased and differed significantly from the mean number of holes in the other treatments and phases (Table 2). By contrast, the mean number of holes in the gates evenly spaced and no gates treatments did not differ significantly as the experiment progressed (Table 2).

There was a significant difference in the frequency of holes in the different depth classes (Table 3). Most holes were recorded in the depth class 20 – 29 cm (61%) followed by holes greater than 30 cm in depth (28%; Table 3).

Installation and maintenance costs of swing gates and electric fencing

The two farmers surveyed indicated that the cost of installing electric fencing (materials only) was a minimum of US$752/km. The estimated cost of constructing and installing the swing gates (materials only) was $6.72/gate or $40.32/km using six gates (the number of gates installed on the gates on routes treatment). For the swing gates one worker (at a daily minimum wage of $4.32) was able to install six gates along 1 km in a day ($4.32/km), while for the electric fencing 12 workers were needed to install 1 km of fencing in a day ($51.84/km) (Table 4).

The two farmers both maintained approximately 38 km of electric fencing and indicated that the fences were checked twice a week entailing an annual transport cost which ranged between $560–$1280 (mean $944 per year). The swing gates need to be checked at most once a week and the transport cost is therefore taken as half of $944, i.e. $472 (Table 4).

Plants growing against the electric fences short-circuit the fencing so herbicides are used to limit this problem. The estimated cost of one commercially available herbicide (Roundup) was approximately $56.80/ha, calculated using 5 l of herbicide/ha. At least 0.5 m either side of the fence would need to be sprayed. For 1 km or 0.1 ha, this represents $5.60/km. Two sprays would be needed per rainy season at a cost of $11.20/km ($5.60 × 2 = $11.20). If herbicide is applied at the same time as the maintenance inspections using a motorized sprayer, additional fuel or labour costs could be prevented. No herbicide or related labour

Table 2. Number of holes (mean ± S.D.) counted along the section of fence line for each treatment during each phase. Diff. indicates the *P*-value for the difference between treatments and phases as determined by the Student–Newman–Keuls test.

Phase	Treatments					
	Gates on routes	Diff. between gates on routes *vs* gates evenly spaced	Gates evenly spaced	Diff. between gates evenly spaced *vs* no gates	No gates	Diff. between gates on routes *vs* no gates
Pre-gates	20.0 ± 1.7	0.302	25.7 ± 1.5	0.454	21.7 ± 1.1	0.810
Diff. between pre gates *vs* open gates	0.006		0.686		0.437	
Open gates	10.6 ± 6.2	0.0005	23.4 ± 4.7	0.562	25.0 ± 5.7	0.0002
Diff. between open gates *vs* closed gates	0.542		0.464		0.263	
Closed gates	12.2 ± 2.8	0.023	20.2 ± 4.3	0.911	19.1 ± 3.6	0.014
Diff. between pre-gates *vs* closed gates	0.016		0.271		0.779	

Two-factor ANOVA: treatment; $F = 19.07$, d.f. = 2,48, $P < 0.0001$; phase; $F = 5.53$, d.f. = 2,48
$P = 0.007$; treatment × phase; $F = 2.79$, d.f. = 4,48, $P = 0.37$

costs would be incurred for maintaining the swing gates (Table 4).

DISCUSSION

The use of holes and swing gates by digging species and predators

Prior to our study, only one other incidence could be sourced on the use of swing gates. W. Piepmeyer (pers. comm., 1999) installed swing gates on a fence in the Daan Viljoen Game Reserve (Namibia) to reduce fence maintenance caused by warthog activity. He concluded that warthog would readily use swing gates but that the other digging species such as aardvark and porcupine did not. Photographic evidence obtained during our study indicated that warthog readily used the gates and that piglets were quickly taught by adults to use the gates. However, our study also revealed that aardvark and porcupine used the gates. This difference is probably due to the fact that Piepmeyer was relying on spoor tracking on what was mostly hard rocky terrain, whereas our study combined spoor tracking with the use of trip cameras, making the detection of these species more likely.

Piepmeyer found that the number of holes along the fence was reduced by 70% within the first three months of installation. During our study the maximum decrease in hole frequency was not

Table 3. Frequency of holes (percentage in brackets) recorded in the different depth classes during the study.

	Depth class (cm)			
	0–9	10–19	20–29	>30
Frequency	6(1)	88(10)	509 (61)	236(28)

$\chi^2 = 698.82$, d.f. = 3, $P < 0.0001$.

as high (40%). This discrepancy can probably be explained by differences in the terrain between the two sites, as Daan Viljoen Game Reserve is rocky while Klein Hamakari is sandy. The rocky terrain would make it difficult to dig new holes under fences and encourage the use of existing routes and access points such as the swing gates. In sandy terrain however, creating new holes is relatively easy and additional measures, such as closing holes between the gates with rocks and or thorn branches, should to be taken to encourage the use of the gates. During this study it was noted that warthogs are very efficient at displacing thorn branches in their way, and a concerted effort may be needed to pack enough large branches and rocks to deter them. The gates in Daan Viljoen were inspected in 2003 and many were still active, suggesting that they continue to be used by wildlife in the long term. Unfortunately, current staff at the Reserve did not know the function of the gates and

Table 4. Cost analysis (in US$) of swing gates *versus* electric fencing.

Variable	Swing gates	Electric fence
Installation costs		
Materials ($/km)	39.19[a]	731
Labour costs ($/km)[b]	4.20	50.39
Total	43.39	781.39
Maintenance costs		
Transport ($/km/year)	458.79[c]	917.57
Labour ($/km/year)	11.50[c]	23.02[d]
Herbicide ($/km/year)[e]	0	11.04
Total	470.29	951.63

[a]At six gates/km.
[b]At a daily minimum wage of $27/worker/day.
[c]Taken as half of electric fence, because of half the inspection time.
[d]38 km covered by two workers twice a week for 52 weeks.
[e]Using two applications and spraying 0.5 m either side of the fence.

some of these had been packed closed with rocks, decreasing the effectiveness of the scheme.

Our study revealed that warthog used and probably caused most of the holes in the fence. Warthog movements are seasonal in Namibia in response to the distribution of water (Mason 1982; Skinner & Smithers 1990; Somers 1992) and warthogs may be most abundant near water, especially during the dry season (Mason 1982; Somers 1992). Therefore, the location of water points such as man-made dams, livestock water troughs and natural water points should be considered when deciding where to install gates. As warthogs usually return to the same burrow every evening and therefore do not have very extensive home ranges (Somers 1992), active warthog burrows near fences should also be considered when installing swing gates. A factor not taken into account during our study was seasonal trends in warthog activity and movements, and the subsequent effect on the number of holes along fences. Hole depth may also be an indicator of gate positioning as our study indicated that deeper holes (>20 cm) were most likely to be reopened.

Although our study recorded that leopard, cheetah and jackal used the holes made by digging species, these predators were only photographed walking past the closed gates, suggesting that swing gates may be effective in excluding predators from game camps. However, as our sample size was small, extensive long-term monitoring needs to be conducted to determine the effectiveness of the gates in reducing losses to predators as some predators may, over time, learn to use the gates. Nevertheless, at least in the short term, the gates are effec-

tive in reducing the number of holes along fences and should reduce fence maintenance costs and extermination campaigns against hole-digging species.

Installation and maintenance costs of swing gates and electric fencing

Although the questioning of farmers was not a quantitative, experimental part of the study, we felt that it was a very important component, as farmers are unlikely to use methods which they perceive to be expensive or difficult, regardless of any data available. Discussions with farmers here indicated that the cost of installing swing gates per kilometre is approximately 6% of the cost of electric fencing, and although this will vary slightly for individual farmers, it seems that swing gates are an economically attractive option for farmers. Although maintenance costs of swing gates per kilometre per year are high, this cost is half that of electric fencing and no herbicide is needed along the swing gates. Swing gates therefore offer a viable economic alternative to electric fencing.

CONCLUSION

Although the initial installation cost of electrification is expensive, when considered in relation to the degree of effectiveness that is achieved with well maintained electric fencing, the long-term benefits make the installation costs viable. However, due to the cost-related reluctance of farmers to install and maintain electrified fencing, our study indicates that swing gates may offer an economic alternative to farmers. Swing gates are non-lethal to wildlife and significantly reduce the number of holes along

a fence by allowing diggers such as warthogs, porcupines and aardvark through the fence and may exclude predators such as cheetah. Further long-term studies will be required to assess the effectiveness of swing gates in terms of reducing predator access to game farms, but this initial research suggests that they could be an important non-lethal predator exclusion tool. While electrification and swing gates can be useful for protecting valuable game in smaller breeding camps from predation, the long-term effect of fragmenting habitats with game fencing needs to be considered. Although the ideal aim, in terms of human–carnivore coexistence, would be to promote measures that do not restrict carnivore movement or fragment their available habitat, this is currently unrealistic in many areas and the establishment of alternative wildlife management initiatives such as conservancies, which allow free-ranging game, should be investigated. Meanwhile, this research suggests that swing-gates could be used to assist game farmers in reducing wildlife access through game fences, and therefore has potential for alleviating human–carnivore conflict in the short term while other, longer-term coexistence strategies can be developed and implemented.

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REFERENCES

ANON. 2002. Game ranch profitability in southern Africa. ABSA Group Economic Research, South Africa Financial Sector Forum, Rivonia.

ANON. 2004. Namibia CON INFO GIS. The Ministry of Agriculture, Water and Forestry – Soil Mapping Division, Windhoek.

BEKOFF, M. 2001. Human–carnivore interactions: Adopting proactive strategies for complex problems. In: J.L. Gittleman, S.M. Funk, D.W. Macdonald & R.K. Wayne (Eds), Carnivore conservation, (pp. 170–195). Cambridge University Press, Cambridge.

BERGER, J. 1999. Anthropogenic extinction of top carnivores and inter-specific animal behaviour: implications of the rapid decoupling of a web involving wolves, bears, moose and ravens. *Proc. Royal Soc. London* 266: 2261–2267.

DU TOIT, J.G. 1996. Game fences–electric fences. In: J. du P. Bothma (Ed.), Game ranch management, (pp. 91–94). Van Schaik, Pretoria.

GEISS, W. 1997. A preliminary vegetation map of South West Africa. *Dinteria* 4: 1–114.

HEARD, H.W. & STEPHENSON, A. 1987. Electrification of a fence to control the movements of black-backed jackals. *S. Afr. J. Wildl. Res.* 17: 20–24.

HURLBERT, S.H. 1984. Pseudoreplication and the design of ecological field experiments. *Ecol. Monogr.* 54(2): 187–211.

LINHART, S.B., ROBERTS, J.D. & DASCH, G.J. 1982. Electric fencing reduces coyote predation on pastured sheep. *J. Range Manage.* 35: 276–281.

LINNELL, J.D.C., ODDEN, J., SMITH, M.E., AANES, R. & SWENSON, J.E. 1999. Large carnivores that kill livestock: Do 'problem individuals' really exist? *Wildl. Soc. Bul.* 27(3): 698–705.

MARKER, L. 2002. Aspects of cheetah (*Acinonyx jubatus*) biology, ecology and conservation strategies on Namibian farmlands. Ph.D. thesis. University of Oxford, Oxford.

MARKER, L. & SCHUMANN, B.D. 1998. Cheetahs as problem animals: management of cheetahs on private land in Namibia. In: B.L. Penzhorn (Ed.), Proceedings of a symposium on cheetahs as game ranch animals (pp. 90–99). Wildlife Group of the South African Veterinary Association, Onderstepoort

MARKER, L., MILLS, M.G. L & MACDONALD, D.W. 2003. Factors influencing perceptions and tolerance toward cheetahs (*Acinonyx jubatus*) on Namibian farmlands. *Cons. Biol.* 17: 1–9.

MARKER-KRAUS, L., KRAUS, D., BARNETT, D. & HURLBUTT, S. 1996. Cheetah survival on Namibian farmlands. Solitaire Press, Windhoek.

MASON, D.R. 1982. Studies on the biology and ecology of the warthog (*Phacochoerus aethiopicus sundevalli*) in Zululand. D.Sc. thesis. University of Pretoria, Pretoria.

MERTENS, A. & PROMBERGER, C. 2000. Electric fences and fladry in Romania. *Carn. Dam. Prev. News* 1: 4.

MORSBACH, D. 1987. Cheetah in Namibia. *Cat News* 6: 25–26.

MUSIANI, M & VISALBERGHI, E. 2001. Effectiveness of fladry on captive wolves. *Wildl. Soc. Bul.* 29: 91–98.

MUSIANI, M., MAMO, C., BOITANI, L., CALLAGHAN, C., GATES, C.C., MATTEI, L., VISALBERGHI, E., BRECK, S. & VOLPI, G. 2003. Wolf depredation trends and the use of fladry barriers to protect livestock in western North America. *Cons. Biol.* 17(6): 1938–1947.

PEEL, M.J.S. & MONTAGU, G.P. 1999. Modelling predator–prey interactions on a Northern Province game ranch. *S. Afr. J. Wildl. Res.* 29(2): 31–34.

POOLE, D.W & McKILLOP, I.G. 1999. Comparison of the effectiveness of two types of electric fences to exclude badgers. *Crop Protection* 18: 61–66.

POOLE, D.W. & McKILLOP, I.G. 2002. Effectiveness of

two types of electric fence for excluding the red fox (*Vulpes vulpes*). *Mammal Rev.* 32: 52–57.

SALTZ, D., WARD, D., KAPOFI, I, & KARAMATA, J. 2004. Population estimation and harvesting potential for game in arid Namibia. *S. Afr. J. Wildl. Res.* 34(2): 153–161.

SCHNEIDER-WATERBERG, I. 1993. Waterberg Plateau Park Namibia: a Shell guide. Shell, Windhoek.

SHIVIK, J.A., TREVES, A. & CALLAHAN, P. 2003. Non-lethal techniques for managing predation: primary and secondary repellents. *Cons. Biol.* 17(6): 1531–1537.

SKINNER, J.D. & SMITHERS R.H.N, 1990. The mammals of the southern African sub-region. University of Pretoria, Pretoria.

SOMERS, M.J. 1992. The implications of social structure for the conservation and control of a warthog (*Phacochoerus aethiopicus*) population in the Andries Vosloo Kudu Reserve, Eastern Cape Province. M.Sc. thesis, University of Pretoria, Pretoria.

VAN DER WAAL, C. & DEKKER, B. 2000. Game ranching in the Northern Province of South Africa. *S. Afr. J. Wildl. Res.* 30(4): 151–156.

VAN ROOYEN, N., DU TOIT, J.G. & VAN ROOYEN, J. 1996. Game fences: wire fences. In. J. du P. Bothma (Ed.), Game ranch management (pp. 78–90). Van Schaik, Pretoria.

WOODROFFE, R. & FRANK, L.G. 2005. Lethal control of African lions (*Panthera leo*): local and regional population impacts. *Animal Cons.* 8: 91–98.

ZAR, J.H. 1984. Bio-statistical analysis. Prentice Hall, New Jersey.

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