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SHORT COMMUNICATION

Short communication articles are short scientific entities often dealing with methodological problems or with byproducts of larger research projects. The style should be the same as in original articles

Reindeer *Rangifer tarandus* fences as a mortality factor for ptarmigan *Lagopus* spp.

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To assess how important reindeer *Rangifer tarandus* fences are as a mortality factor for ptarmigan *Lagopus* spp. we collected data during 1991-1994. Our fieldwork covered 12 different sections of reindeer fence (totalling 71.1 km) in the county of Finnmark, northern Norway. The sections consisted of steel wire, steel netting or a combination of these, and ranged in height from 100 to 250 cm. The fieldwork took the form of spring patrols during which dead birds and their remains were searched for along the fences immediately after snow melt. We covered a total of 179.9 km and found 253 collision victims belonging to at least 20 species. Of the 253 victims found, 215 were willow ptarmigan *Lagopus lagopus* and rock ptarmigan *L. mutus*; thus these two species comprised 85% of the victims. During the winters of 1992/93 and 1993/94, we carried out experiments with dummy willow ptarmigan which were placed along fence sections and monitored serving as artificial fence-strike victims. Our experiments showed that approximately 64% of the total number of ptarmigan killed by the fences during winter would be detected during spring patrols along the fences. The type and height of the fence had no effect on the ptarmigan collision rate. In contrast, both the fence section and year factor contributed significantly to the observed variation in collision rate. We estimate that on average 1.4 ± 0.5 (SE) ptarmigan are being killed per kilometre of reindeer fence in Finnmark annually, with a greater variation between fence sections than between years.

Key words: bird collision, Lagopus spp., management, netting fence, Norway, wire fence

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Man-made obstacles are known to kill birds of numerous species (see Avery, Springer & Dailey 1980, Hebert, Reese, Mark, Anderson & Brownell 1995, Trapp 1998 and references therein), and fences are no exception, particularly those with barbed wire (Allen & Ramirez 1990). Most fences serve either to keep wanted

Figure 1. Location of the 12 reindeer fence sections in the county of Finnmark, northern Norway, which were patrolled during 1991-1994 to assess the extent of bird collisions.

organisms (mainly mammals) within a specific area, or to prevent unwanted organisms from getting into areas where, for some reason, they are undesired. Extensive use of fences is known from most parts of the world, particularly in connection with farming (Bevanger & Henriksen 1996), either as a means to keep wild animal populations separated from husbanded animals (Fitzwater 1972, Williamson & Williamson 1985) or as a means to control pest species (McKnight 1969). Until recently there has been no systematic mapping of fences as a mortality factor for birds (Catt, Dugan, Green, Monrieff, Moss, Picozzi, Summers & Tyler 1994, Bevanger 1995a, Baines & Summers 1997, Summers 1998).

Several authors have reported losses of gallinaceous species due to their flying into overhead wires and other obstacles (Leopold 1931, Borell 1939, Paludan 1963, Krapu 1974, Miquet 1990, Rose & Baillie 1992). Studies in Norway have revealed that tetraonids have a particular tendency to fly into power lines (Bevanger 1990, 1995b,c, 1998, Bevanger, Brøseth & Sandaker 1998), and recent research in Scotland has shown that these species also frequently collide with fences (Catt et al. 1994, Baines & Summers 1997).

In Scandinavia, frequent reports of feather remains from ptarmigan found along reindeer fences have given wildlife management authorities cause for concern. In this paper, we present the results of our study quantifying the collision hazards posed by reindeer fences for the potentially most frequent collision victims in these areas - willow ptarmigan *Lagopus lagopus* and rock ptarmigan *L. mutus*.

Material and methods

Study area

Twelve sections of reindeer fences were selected in eight municipalities in the county of Finnmark, northern Norway (69-71°N, 22-29°E, Fig. 1). The fences were of three different types and consisted of steel wire, steel netting or a combination of these, and their height varied within 100-250 cm (Table 1, Fig. 2). The fence sections were of two different categories, barrier fence and guiding fence, distinguished by their function. The criteria applied when selecting a fence section was

Table 1. Technical data on the 12 reindeer fence sections in Finnmark patrolled immediately after snow melt to find birds that were killed when colliding with the fences during 1991-1994. The fence types were: A) netting fence, B) steel wire fence, C) combined netting and steel wire fence (see Fig. 2). The fence categories were: 1) barrier fence, 2) guiding fence. For additional information, see Bevanger (1995a).

Fence	Name of	Fence distance patrolled (km)				Fence		
section	section	1991	1992	1993	1994	Type	Category	Height (cm)
1	Sennalandet	-	4.4	4.4	4.4	A	1	150
2	Masi	-	4.0	5.6	5.5	A	2	150
3	Stuorajavre	3.9	4.6	4.6	4.6	C	2	150
4	Kivilompolo	-	-	5.0	5.0	B	1	250
5	Stabbursdalen	-	7.0	7.0	7.0	B	1	130-160
6	Vieksa	5.0	5.0	5.0	5.0	B	1	130-160
7	Sørøya	-	6.0	-	-	A	1	100
8	Nordkyn	-	3.6	-	-	C	2	130-160
9	Polmak	7.5	7.8	9.8	7.5	C	1	200-250
10	Levsi	-	-	10.6	10.6	C	2	170-240
11	Pasvik	-	5.0	5.0	5.0	B	1	190
12	Seidafjell	-	-	4.5	-	C	2	150

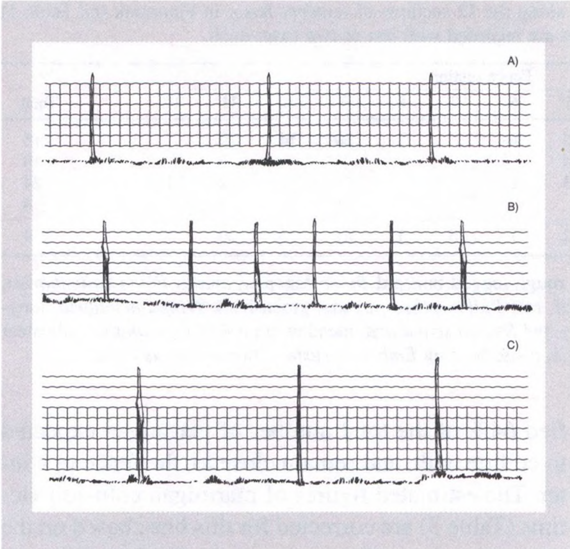

Figure 2. The three most frequently used types of reindeer fence in Norway are: A) steel netting fence; B) steel wire fence; C) combination fence.

that it should be representative of a Finnmark reindeer fence (in fence design, geography, topography and habitat) and that it should be easily accessible. The 12 sections selected covered a total of 71.1 km, and were mainly located in northern boreal birch *Betula* spp. woodland interspersed with small bogs and alpine heaths. Sections 5 and 11 passed through areas dominated by pine *Pinus sylvestris* woodland (see Bevanger 1995a for details).

Fence patrols and collision victims

Due to financial and practical constraints, killed birds were searched for along fence sections (1-12) immediately after snow melt in May-June, before the vegetation started growing. We attempted to patrol each section once a year during 1991-1994. Because the time of snow melt varied locally and annually, the patrol dates differed. Practical constraints meant that sections 7, 8 and 12 were patrolled only once and sections 4 and 10 only twice during 1991-1994 (see Table 1). One person walked along the fences and noted the number of casualties, mainly revealed by clusters of feathers. Only clusters where wing, tail and numerous body feathers were present were assessed as a collision victim. All remains were systematically collected for documentation, and effort was made to distinguish collision victims from raptor kills by visual clues at the collision site and characteristic signs on the corpse.

Removal experiment

To determine the recovery rate and the rate at which scavengers removed remains, dummy willow ptarmigan (dead birds) in winter plumage were placed along three fence sections during the winters of 1992-1994. The experiment was carried out in the areas where sections 2, 5 and 9 were located. Each spot in which a bird was placed was marked with a stick in the snow and a piece of red plastic tape attached to the fence. Skies or snowshoes were used to travel between the snow scooter and the fence where the bird was left lying on the snow. The birds were set out in a stratified systematic design, with a random start. During each of the five months with snow cover, five birds were left along the fence sections, making a total of 25 birds per fence section per year.

Statistical analyses

All statistics were performed using SPSS for Windows (Release 10.0.5, © 1999 SPSS Inc., Chicago, Illinois), or G-test. To test for effects of different factors on the collision rate of ptarmigan against reindeer fences, we applied the GLM-Univar procedure in SPSS with fence section and fence type as fixed factors, year as a random factor and fence height as a covariate (see Table 1). We tested both for main effects and interaction effects. However, because of the relatively low sample size in relation to the number of parameters, we performed the analysis in two steps. First, we tested for differences between fence sections and where this proved significant, we standardised (zero mean and unit standard deviation) the collision rate within fence section. We subsequently tested if the standardised values were affected by variation in year, fence type, fence height or the interacting effects of these parameters. To find the best model, we applied model building strategy of stepwise forward inclusion or alternate exclusion of independent variables. Only variables significant at $P < 0.05$ were accepted in the model.

Results

Harsh weather and poor light conditions in Finnmark during the winter months impose significant constraints on fieldwork performance. Consequently, a spring patrol method was adopted. However, an attempt was made to look for collision victims during the winter months as well. Section 2 was patrolled once a week (during December 1991 - May 1992), and section 9 twice a

Table 2. Bird species and their numbers recorded as collision victims along the 12 sections of reindeer fence in Finnmark (*cf.* Table 1) patrolled immediately after snow melt during 1991-1994. Other species are recorded with one or two cases each.

Species	Fence section												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
Ptarmigan *Lagopus lagopus* + *L. mutus*	6	50	18	3	15	6		1	80	14	22		215
Capercaillie *Tetrao urogallus*					4						6		10
Other species*	7	4	5		3	1				1	2	1	24
Indeterminated			3						1				4
Total number of victims	13	54	26	3	22	7	0	1	81	15	30	1	253

* Other species include: Mallard *Anas platyrhynchos*, teal *A. crecca*, rough-legged buzzard *Buteo lagopus*, merlin *Falco columbarius*, golden plover *Pluvialis apricaria*, Temmink's stint *Calidris temminckii*, ruff *Philomachus pugnax*, greenshank *Tringa nebularia*, long-tailed skua *Stercorarius longicaudus*, common gull *Larus canus*, snowy owl *Nyctea scandiaca*, meadow pipit *Anthus pratensis*, wheatear *Oenanthe oenanthe*, bluethroat *Luscinia svecica*, fieldfare *Turdus pilaris*, rustic bunting *Emberiza rustica*, raven *Corvus corax*.

week (during February - June 1993). Only five collision victims were recorded during the months with full snow cover (December-April). In three cases, owing to excellent snow tracking conditions, the course of the collision event could be reconstructed. However, in none of these cases was the ptarmigan proved to be mortally injured. In two cases, ptarmigan had flown through the netting fence and 'landed' 35-45 cm from the fence. The birds had managed to fly away approximately from the landing spot. Only some body feathers were found in the snow close to the fence. The third collision left numerous feathers in the snow at the fence. At the landing spot, about 2 m from the fence, some drops of blood were visible in the snow, but the bird had walked about 40 m from the landing spot. When the observer came within a few metres, the bird, which had been roosting in a snow burrow, was flushed and flew away. The observer saw that its feet were hanging down, an obvious sign of injury.

A total of 253 collision victims belonging to at least 20 species were identified along the 12 fence sections (Table 2). Ptarmigan were found among the victims in all but one of the sections where birds had collided with the fence. There were 215 ptarmigan among the victims, comprising about 85% of the total number of victims. Although willow ptarmigan and rock ptarmigan were not systematically differentiated, both species were recorded and most were willow ptarmigan. Ten capercaillies *Tetrao urogallus* were recorded along the two sections passing through pine woodland (sections 5 and 11), bringing the total proportion of tetraonids among the victims to 89%.

Our removal experiment indicated a mean recovery rate of 64% (range: 55-68%) for dummy ptarmigans, with no difference between fence sections (G-test with correction, G = 0.26, df = 2, P = 0.88). We therefore assumed that the method used (patrols along fences immediately after snow melt in spring) identified 64% of the total number of ptarmigan expected to collide with, and remain close to, the fence in winter. The estimated figures of ptarmigan collision victims (Table 3) are corrected for this bias, based on the assumption that collisions are evenly distributed through the study period.

To test for the combined effects of the different independent variables, we first tested for the effect of fence section to see if this factor contributed to the variation in collision frequency. There was a large effect of different fence sections on the variation in collision frequency (F = 2.65, df = 11, P = 0.03). To reduce the number of parameters in the model, we therefore standardised the effect of collision frequency within fence sections in the subsequent analysis. We found no effect of neither fence type, fence height nor their interaction on the collision frequency (P > 0.10). In contrast, year contributed significantly to the observed variation in collision frequency (F = 4.35, df = 3, P = 0.014). Accordingly, only fence section and year explained significant proportions of the variation in collision frequency. On average, the num-

Table 3. Collision rate expressed as number of ptarmigan collisions per kilometre fence per year recorded along 12 sections of reindeer fences in Finnmark patrolled immediately after snow melt during 1991-1994 (*cf.* Table 1). The figures are corrected for bias caused by scavengers removing kill remains.

Fence section	Year 1991	1992	1993	1994	Mean ± SD
1	-	1.4	0	0.7	0.7 ± 0.7
2	-	5.1	6.7	3.7	5.2 ± 1.5
3	2.0	4.1	0.3	0	1.6 ± 1.9
4	-	-	0.3	0.6	0.5 ± 0.2
5	-	2.0	1.1	0.2	1.1 ± 0.9
6	0.6	0.6	0.6	0	0.5 ± 0.3
7	-	0	-	-	0
8	-	0.4	-	-	0.4
9	8.1	2.4	2.2	3.1	4.0 ± 2.8
10	-	-	0.1	1.9	1.0 ± 1.3
11	-	4.8	2.2	0.3	2.3 ± 2.0
12	-	0	-	-	0

ber of ptarmigan per kilometre fence per year estimated to be killed along the fence sections patrolled in spring was 1.4 ± 0.5 (SE; see Table 3). The mean variation (CV) of recorded ptarmigan victims were 80% and 116% between years and fence sections, respectively.

Discussion

Several biasing factors should be considered when estimating the number of bird collisions with fences. Some remains will not be noticed during the patrol, particularly if they are hidden in dense thickets, or are placed some distance from the fence. The winter patrols indicated that some ptarmigan that fly into the fence are not mortally wounded and manage to move quite a long distance from the fence. It is not known how many of these birds actually die, but it seems clear that they would never be found using the present method. This means that the detection rates we found are absolute minimums (*cf.* Bevanger, Bakke & Engen 1994, Bevanger et al. 1998, Bevanger 1999).

As we only corrected for the removal bias by scavengers, our results indicate that an annual average of 1.4 ptarmigan per kilometre of reindeer fence in Finnmark is a conservative estimate representing an absolute minimum. However, it is close to the estimate made by Baines & Summers (1997) for red grouse *Lagopus l. scoticus* collisions in Scotland (1.1 ± 1.3 (SD) birds per kilometre per year). The fact that the variation between years was lower than between fence sections probably reflects variation in ptarmigan densities and/or the diversity of reindeer fences as regards design, local snow conditions, topography and routing. Although most of the casualties were found in spring, the majority were in winter plumage, indicating that the accidents had taken place during the winter months. However, ptarmigan in spring plumage were also recorded.

In isolation, the ptarmigan mortality caused by fences in Finnmark is probably of minor significance for the ptarmigan populations. However, reindeer fences are only one of several causes of mortality, and it is the cumulative and synergetic effect of factors with negative population effects that should be of prime ecological interest. The effect of hunting on tetraonid populations is another such mortality factor which has been given increased attention (Bergerud 1985, Ellison 1991); in this matter the essential question is whether hunting mortality is compensated for or is additive. Resent research on willow ptarmigan in Scandinavia indicate limited support for compensation of hunting mortality under the densities studied (Smith & Willebrand 1999, Frilund 2000, H.C. Pedersen, unpubl. data), and there is little reason to believe that mortality caused by man-made obstacles should have a different effect on this species given the same conditions. Local situations where the 'fence load' is high enough to create negative population consequences cannot be ruled out. No data are available on the total length of reindeer fences in Finnmark, but estimates exceeding 1,000 km are likely to be correct (County Governor of Finnmark, pers. comm.). It would be difficult to determine the effect of fence mortality on the population, because of the diversity of reindeer fence constructions and locations, short- and long-term fluctuations in ptarmigan populations and the diversity of other factors affecting ptarmigan populations. However, studies focusing on whether the mortality caused by interaction with man-made obstacles is compensated for or is additive to natural mortality are most needed and should be encouraged.

Research carried out in connection with birds and power lines has pointed to several factors that probably make tetraonids particularly vulnerable to colliding with artificial obstacles in the air (Bevanger 1994, 1998). Their poor manoeuvrability combined with a lack of acute vision and a high level of activity in periods with poor light conditions may increase the probability of collisions. It has also been pointed out that gallinaceous birds seem to suffer a particularly high mortality rate in connection with specific, local topographical elements such as, for instance, depressions, elevations (e.g. ridges) and openings in the woodland due to strips of mire (Bevanger 1990, 1994). When potential collision obstacles like fences cross these types of leading lines or flight lanes, the probability of collisions will increase.

It is difficult to pinpoint and identify which specific factors connected to fence construction affect the collision hazard. However, consideration should be given to means of minimising the collision hazard. Firstly, old fences that are no longer in use should be removed. Secondly, when planning and deciding the routes of new fences, knowledge about local bird movements and topographical conditions affecting these movements should be taken into consideration. Thirdly, several fences have a seasonal function and consideration should be given to removing high-hazard fence sections when they are not in use.

Based on existing knowledge, it cannot be ruled out that the technical design and visibility of a fence may affect the collision hazard for different bird species. Although we have found no published studies focusing on fence marking to mitigate the collision hazard, experiments have been carried out in connection to power lines. However, impact assessment of marking devices is difficult. The majority of marking experiments using different varieties of marking devices have hardly produced empirical support for any unambiguously positive effect, although the observed mortality has been reduced in several cases. Unfortunately, most studies have used methods, which did not take factors such as flight intensity, type of habitat, time of day/year into consideration. Thus, the possibilities of making reliable comparisons of pre- and post-marking collision rates are severely reduced. Some experiments have, however, shown statistically significant post-marking reduction in collision frequency (Alonso, Alonso & Munoz-Pulido 1994, Brown & Drewien 1995). Consequently, further studies, preferably experimental, on these aspects should be encouraged.

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References

Allen, G.T. & Ramirez, P. 1990: A review of bird deaths on barbed-wire fences. - Wilson Bulletin 102: 553-558.

Alonso, J.C., Alonso, J.A. & Munoz-Pulido, R. 1994: Mitigation of bird collisions with transmission lines through groundwire marking. - Biological Conservation 67: 129-134.

Avery, M.L., Springer, P.F. & Dailey, N.S. 1980: Avian mortality at man-made structures: an annotated bibliography (revised). - U.S. Fish and Wildlife Service, Biological Services Program, Plant Team FWS/OBS-80/54, U.S. Department of the Interior, 152 pp.

Baines, D. & Summers, R.W. 1997: Assessment of bird collisions with deer fences in Scottish forests. - Journal of Applied Ecology 34: 941-948.

Bergerud, A.T. 1985: The additive effect of hunting mortality on the natural mortality rates of grouse. - In: Beasom, S.L. & Robertson, S.F. (Eds.); Game harvest management. Caesar Kleberg Wildlife Research Institute, Kingsville, Texas, pp. 345-366.

Bevanger, K. 1990: Topographic aspects of transmission wire collision hazards to game birds in central Norwegian coniferous forest. - Fauna norvegica Serie C 13: 11-18.

Bevanger, K. 1994: Bird interactions with utility structures, collision and electrocution, causes and mitigating measures. - Ibis 136: 412-425.

Bevanger, K. 1995a: Reingjerder som dødelighetsfaktor for fugl i Finnmark. (In Norwegian with English summary: Reindeer fences as a mortality factor for birds in Finnmark, Norway.) - Norwegian Institute for Nature Research, Fagrapport 4: 1-32.

Bevanger, K. 1995b: Estimates and population consequences of tetraonid mortality caused by collisions with high tension power lines in Norway. - Journal of Applied Ecology 32: 745-753.

Bevanger, K. 1995c: Tetraonid mortality caused by collisions with power lines in boreal forest habitats in central Norway. - Fauna norvegica Serie C 18: 41-51.

Bevanger, K. 1998: Biological and conservation aspects of bird mortality caused by electricity power lines: a review. - Biological Conservation 86: 67-76.

Bevanger, K. 1999: Estimating bird mortality caused by collision with power lines and electrocution, a review of methodology. - In: Ferrer, M. & Janss, G.F.E. (Eds.); Birds and power lines. Collision, electrocution and breeding. Quercus, Madrid, pp. 29-56.

Bevanger, K., Bakke, Ø. & Engen, S. 1994: Corpse removal experiments with willow ptarmigan (Lagopus lagopus) in power-line corridors. - Ökolgie der Vögel (Ecology of Birds) 16: 597-607.

Bevanger, K., Brøseth, H. & Sandaker, O. 1998: Dødelighet hos fugl som følge av kollisjoner mot kraftledninger i Mørkedalen, Hemsedalsfjellet. (In Norwegian with English summary: Bird mortality due to collisions with power lines in Mørkedalen, Hemsedalsfjellet, Norway.) - Norwegian Institute for Nature Research, Oppdragsmelding 531: 1-41.

Bevanger, K. & Henriksen, G. 1996: Faunistiske effekter av gjerder og andre menneskeskapte barrierer. (In Norwegian with English summary: Faunistic consequences of fences and other man-made barriers.) - Norwegian Institute for Nature Research, Oppdragsmelding 393: 1-26.

Borell, A.E. 1939: Telephone wires fatal to sage grouse. - Condor 41: 85-86.

Brown, W.M. & Drewien, R.C. 1995: Evaluation of two power line markers to reduce crane and waterfowl collision mortality. - Wildlife Society Bulletin 23: 217-227.

Catt, D.C., Dugan, D., Green, R.E., Monrieff, R., Moss, R., Picozzi, N., Summers, R.W. & Tyler, G.A. 1994: Collisions against fences by woodland grouse in Scotland. - Forestry 67: 105-118.

Ellison, L.N. 1991: Shooting and compensatory mortality in tetraonids. - Ornis Scandinavica 22: 229-240.
Fitzwater, W.D. 1972: Barrier fencing in wildlife management. - In: Marsh, R.E. (Ed.); Proceedings V Vertebrate Pest Control Conference. Fresno, California, pp. 49-55.
Frilund, G.E. 2000: The effect of hunting on survival in willow ptarmigan Lagopus l. lagopus. - Norwegian University of Science and Technology, Department of Zoology, M.Sc. thesis, unpubl., 39 pp.
Hebert, E., Reese, E., Mark, L., Anderson, R. & Brownell, J.A. 1995: Avian collision and electrocution: An annotated bibliography. - California Energy Commission, Sacramento, CA. Publication No. P700-95-001, 125 pp.
Krapu, G.L. 1974: Avian mortality from collisions with overhead wires in North Dakota. - Prairie Naturalist 6: 1-6.
Leopold, A. 1931: Report on a game survey of the North Central States. - Sporting Arms and Ammunition Manufactures' Institute, Madison, Wisconsin, 299 pp.
McKnight, T.L. 1969: Barrier fencing for vermin control in Australia. - Geographical Review 59: 330-347.
Miquet, A. 1990: Mortality in black grouse due to elevated cables. - Biological Conservation 54: 349-355.
Paludan, K. 1963: Partridge markings in Denmark. - Danish Review of Game Biology 4: 25-58.
Rose, P. & Baillie, S. 1992: The effects of collisions with overhead wires on British birds: an analysis of ringing recoveries. - British Trust of Ornithology. Research Report 42: 1-227.
Smith, A. & Willebrand, T. 1999: Mortality causes and survival rates of hunted and unhunted willow grouse. - Journal of Wildlife Management 63: 722-730.
Summers, R.W. 1998: The lengths of fences in Highland woods: the measure of a collision hazard to woodland birds. - Forestry 71: 73-76.
Trapp, J.L. 1998: Bird kills at towers and other man-made structures: an annotated partial bibliography (1960-1998). - U.S. Fish and Wildlife Service, Office of Migratory Bird Management, Arlington, Virginia, 43 pp.
Williamson, D.T. & Williamson, J. 1985: Botswana's fences and the depletion of Kalahari wildlife. - Parks 10: 5-7.