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Marking of deer fences to reduce frequency of collisions by woodland grouse

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Abstract

Recent studies of the effects of deer fences on tetraonids have concluded that fences are an important cause of mortality in woodland grouse. This 2-year study involving 16 sections of fences in the Scottish Highlands evaluates the effectiveness of making fences highly visible by using orange netting to reduce bird collisions with fences. A total of 437 collisions involving 13 bird species were recorded. Red grouse (*Lagopus lagopus scoticus)* formed 42% of all collisions, with black grouse (*Tetrao tetrix)* 29% and capercaillie (*T. urogallus*) 20%. Allowing for corpse removal by scavengers, an estimated 70% of red grouse and 29% of black grouse collisions were fatal. Black grouse and capercaillie both collided with 11 of the 16 fences at mean rates of 1.3 and 0.9 collisions km^{-1} $year^{-1}$, red grouse collisions occurred at 13 fences, with a mean rate of 1.6 collisions km^{-1} $year^{-1}$. Fewer grouse collisions occurred in the summer. Three quarters of black grouse collisions were by males. Collision rates were positively correlated with indices of black grouse and capercaillie abundance. Fence marking reduced capercaillie collisions by 64%, black grouse by 91% and red grouse by 49%. Although marked fences reduced capercaillie collision rates, they still remained an important cause of mortality. To conserve capercaillie, fences need to be removed altogether pending increased deer culls that would allow woodland regeneration without fences, or "grouse friendly" fences designed.

Keywords: Capercaillie; Black grouse; Red grouse; Fence-marking; Collisions; Pinewoods

1. Introduction

Losses of black grouse (*Tetrao tetrix)*, capercaillie (*T. urogallus)* and willow ptarmigan (*Lagopus lagopus)* are associated with collisions against electricity transmission wires in Norway (Bevanger, 1994, 1995, 1998), losses of black grouse with cables at Alpine ski resorts (Miquet, 1990; Novoa et al., 1990) and ptarmigan (*Lagopus mutus)* with cables at Scottish ski resorts (Watson, 1982). In Scotland, reinforced wire mesh fences have been erected to exclude domestic stock and deer, particularly red deer (*Cervus elaphus)*, from young conifer plantations and regenerating native woodlands. These have been shown recently to kill both black grouse and capercaillie (woodland grouse) in Scotland (Catt et al., 1994; Baines and Summers, 1997). The study by Catt et al. (1994) reported mean collision rates for capercaillie and black grouse of 3.0 and 0.4 km^{-1} $annum^{-1}$ respectively, whilst Baines and Summers (1997), from a more extensive sample of forests, recorded 1.8 and 0.6 collisions km^{-1} $annum^{-1}$. Given the abundance of deer fences in the Scottish Highlands, estimated at 1925 km (±312 SE) for the Moray and Dee region alone (Summers, 1998), these data would strongly support the suggestion that fences are a serious problem, at least to capercaillie. This impact on capercaillie has been estimated from radio-tagged birds to be 24% juvenile mortality in the period September to May and 8% annual adult mortality (Moss et al., 2000).

The capercaillie is in serious decline and a survey in 1992–1994 estimated only 2200 birds [95% confidence limits (C.L.)1500–3200] in Scotland (Catt et al., 1998). This figure has now been revised to only 1000 birds in the winter 1998/1999 (N. Wilkinson, pers. comm.), and an annual decline rate of 18% (±5% S.E.) per annum has been calculated for hens (Moss, 2001). Capercaillie

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are listed under Annex 1 of the EC Birds Directive (79/409/EEC). This Directive affords protection to all wild birds and their habitats within the European Community and gives member states the power and responsibility to designate Special Protection Areas (SPAs) to protect birds that are considered rare or vulnerable within the European Community (listed in Annex 1 of the Birds Directive).

Native pinewoods are considered within Scotland to be a core habitat for capercaillie, whose future may depend on the expansion of this habitat (Picozzi et al., 1992; Catt et al., 1998). Scots pine forest of *Pinus sylvestris* var. scotica is listed as a priority habitat in the EC Habitats Directive (92/43/EEC). Areas may be designated as Special Areas of Conservation (SAC) where they support rare, endangered or vulnerable natural habitats and species of plant or animals (other than birds). Some important pinewoods inhabited by capercaillie are scheduled to become both SAC and SPA (Table 1). Expansion and regeneration of native pinewoods is generally achievable only when grazing pressure by deer is <5 animals km^{-2} (Holloway, 1967). This can be accomplished either through increasing deer culls (e.g. Beaumont et al., 1995), or by fencing to exclude deer. Although the former method may be preferable, many land-owners consider that in some forests successful regeneration and retention of sufficient deer for sporting purposes can only simultaneously occur through fencing. Reduced grazing pressure may have beneficial effects for both capercaillie and black grouse in the short-term through increasing ericaceous food plants and insects important to chicks (Baines et al., 1994), leading to higher breeding success, at least in black grouse (Baines, 1996). However, any such benefits either in the short-term by providing better habitat, or in the longer term by providing more habitat, may be outweighed by increased mortality from fence collisions.

Making deer fences highly visible in an attempt to reduce collision rates by woodland grouse, whilst at the same time permitting forest habitats to regenerate, may form a solution to this dilemma. This experimental study aims to test the effectiveness of a marking technique to reduce the collision rates of grouse and other forest birds.

2. Methods

2.1. Selection of fences

Given the declines and threatened status of capercaillie (Catt et al., 1998; Moss et al., 2000) and black grouse (Baines and Hudson, 1995; Hancock et al., 1999) and the known high impact of fences on these birds (Moss, 1987; Catt et al., 1994; Baines and Summers, 1997), fences were selected that maximised collision rates in order to adequately test the marking method. Fences for this study were identified through consultation with landowners, foresters and conservationists. Over a 2-year period from April 1995 to May 1997, 16 fences, each of standard 1.8 m height and of a combined length of 80 km, were monitored in 13 different forests for signs of bird collisions. Twelve of the 13 forests containing the study fences occurred within the Cairngorms Partnership Area (Cairngorms Working Party, 1992) in

Table 1
Location, status and characteristics of the forests in which the sixteen study fences are located in the Scottish Highlands

Fence	Exclosure area (ha)	Wood type	Status	Fence date	Fence length (km)
Strathspey A	598	NP	SSSI/pSPA/pSAC	1993	13.5
Strathspey B	82	NP	SSSI/pSPA/pSAC	1991	4.2
Strathspey C	–	NP	NNR/pSPA/pSAC	1985	2.3
Strathspey D	35	NP/B	NNR/pSPA/pSAC	1987	1.9
Strathspey E	25	Dec. Plant	None	1994	1.8
Strathspey F	–	NP	SSSI/pSPA/pSAC	1969	3.1
Strathspey G	–	NP	NNR/SPA/pSAC	1972	4.2
Strathspey H	–	NP	SSSI/pSAC	1988	2.0
Perthshire I	354	Con. Plant	None	1983	10.8
Deeside J	334	NP/B	NNR/pSPA/pSAC	1994	3.8
Deeside K	90	NP	None	1977	4.1
Deeside L	65	NB	NNR/pSAC	1995	3.4
Deeside M	332[a]	NP	None	1992	10.6
Deeside N	298	Con. Plant	None	1995	5.3
Deeside O	–	NP	NNR/SPA/pSAC	1969	6.5
Deeside P	49[b]	NP	NNR/SPA/pSAC	1993	2.9

Wood type: NP = native pine, NB = native birch, Dec. Plant = deciduous plantation, Con. Plant = coniferous plantation. Status: SSSI = Site of Special Scientific Interest, NNR = National Nature Reserve, SPA = Special Protection Area, SAC = Special Area of Conservation, p = proposed. Fence date = date when fence was erected. Fence length is the length of fence walked to the nearest 0.1 km. For location of fences see Fig. 1.

[a] Includes 20 ha fenced for regeneration in 1979.

[b] Two exclosures totalling 49 ha, one erected in 1992, the other 1994.

the Highlands of Scotland. Of these, six were in Deeside and six in Strathspey. The 13th forest was in North Perthshire (Fig. 1).

Ten of the 16 fences had been erected specifically for the purpose of native woodland regeneration, particularly native pinewoods (Table 1). The exclosures, mostly funded by the UK Government's Woodland Grant Scheme, varied considerably in size, with five schemes <100 ha and five almost 300 ha or more, the largest being nearly 600 ha. Six of the 13 selected forests were designated as National Nature Reserves, whilst another two were Sites of Special Scientific Interest and potential SACs. Of the other study fences, three were in plantation woodlands, where deer were excluded either at initial planting, or at the restocking stage following harvesting. Of these, one fence enclosed a series of deciduous plantations and two were boundary fences between different estates. The oldest fence dated back to 1969; 12 were erected within the last 5 years.

2.2. Fence searches

Thirteen fences in 11 forests were monitored monthly from April or May 1995 throughout the first year, a further three fences in two additional forests were identified as suitable for inclusion during the first year (August 1995 and January 1996) and were monitored monthly thereafter. Visits were not made on 12% of occasions when snow covered the ground and obscured signs of collisions. Under such circumstances, the accumulated remains found on the next visit were equally divided between the consecutive months when no visits were made. When bird remains were found, a sample of feathers was collected and the species identified against a known reference collection of feathers. The collision site was marked by attaching a numbered plastic tag to the fence 0.5 m above the ground and its position marked on a 1:25000 O.S. map. Collision rates (the number of collisions per km of fence per annum) were calculated for each fence, but data from the first visit (the clearance round) were excluded as feathers and corpses had accumulated over an unknown period of time.

The timing of collisions was compared by dividing the year into seasons; spring (April–June visits, i.e. collisions occurring in March, April or May), summer (July–September rounds), autumn (October–December rounds) and winter (January–March rounds). Seasonal differences were tested by Chi-squared goodness of fit tests.

2.3. Corpse removal experiment

Scavengers are known to patrol power lines and fences and remove corpses (Bevanger et al., 1994; Bevanger, 1995). The proportion of grouse corpses removed by scavengers prior to detection during the monthly visits was unknown. To estimate this potential source of bias, a total of 37 grouse corpses, either collected from shoots (red grouse 16 corpses), or corpses stored from previous fresh fence collisions (black grouse 20 and capercaillie one) were vigorously thrown at the fence to simulate flight collisions. This was done at known locations along each of 10 experimental fences in November 1996 at randomised distances both along and on either side of the fence. Four corpses were used along each of eight fences and three and two corpses respectively at one site each, the latter a shorter section of fence only 1 km in length. The number of corpses per fence was chosen to reflect the observed natural collision rates. Fences were subsequently searched an average of 22 days later (range 20–27 days) by two observers. The first observer was unaware of the corpse locations and was used to assess observer efficiency in detecting collisions. The second observer, who initially placed the corpses, checked whether the remains were still present, and, if so, whether they had been detected by the first observer. The roles of the two observers were reversed at four of the 10 fences. Effects of "species" and "fence-line" on whether corpses were removed, and effects of "species", "observer" and "fence-line" on whether a collision was detected, were analysed by logistic regression analysis with corpse present (1) or absent (0) and strike detected (1) or undetected (0) as the dependent variables. For the analyses involving "species", the one capercaillie corpse was combined with the black grouse corpses.

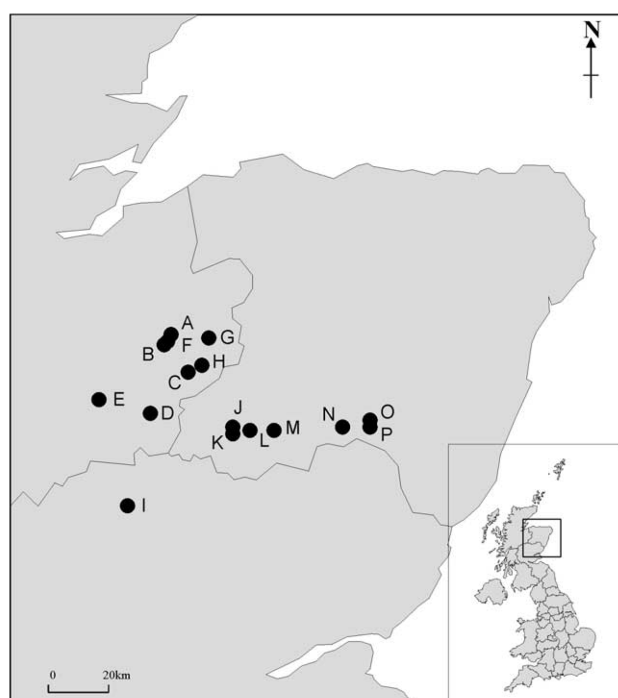

Fig. 1. Location of the 16 study fences in the Scottish Highlands.

2.4. Bird counts

Repeated annual counts of displaying male black grouse were made at dawn in forests containing 10 and 14 fences respectively in the springs of 1995 and 1996 prior to the start of the experiment (Cayford and Walker, 1991; Baines, 1996). These counts provided an approximation of the number of birds that were present in each area and hence potentially at risk from the fences. Where repeat counts were made within the same year, the highest number of males was used. Where counts were made in more than 1 year, the mean of the annual counts was used as the index. A second index of bird abundance in the vicinity of fences was obtained by recording the number and sex of black grouse and capercaillie flushed whilst monitoring 14 of the 16 fences each month between April 1995 and March 1996 for signs of collisions.

2.5. Experimental marking

Collision sites were mapped in year 1. They tended to be aggregated along certain sections of fence or "hot spots". The 10 fences with the highest overall collision rates were selected for the experimental marking. Two such aggregations, each 1 km in length and containing most collisions, were identified on each of the 10 fences. One section on each fence was randomly assigned as a control and the other section was "highlighted" with orange, plastic netting called barrier netting of 0.7 cm gauge and mesh size 9×3.5 cm, manufactured by Netlon. Two strips, each of depth 25 cm, were attached to the fence, one at the top and the second halfway down. Both treatment and control sections were walked monthly for 1 year to search for evidence of bird collisions. Three forest fences were marked as described above in April 1995 following a year of monitoring from April 1994. A further seven fences were marked in April or May 1996 after a year of monitoring.

To avoid potential biases caused by birds seeing the marked sections and diverting their flight path and colliding with the adjacent unmarked control section, six of the 10 matched pairs of sections were separated by distances >100 m. On four fences, this was not possible due to the short lengths of fence involved and the matched pairs of sections were immediately adjacent. However, fewer collisions (5.0) were observed on the first 50 m of the control section than expected (5.7) calculated from the total number of collisions on the control section. This suggested that, if birds took avoiding action on seeing the treated sections, they did not collide with adjacent control sections.

For the three grouse species individually, the two woodland grouse and all grouse combined, the distribution of number of collisions per fence section was skewed and frequently included a high proportion of zero values. Thus analyses were performed using generalised linear models with a Poisson error distribution and a logarithmic link function (McCullagh and Nelder, 1989). The models were fitted to each of the grouse collision variables, and included the following terms: constant, fence, fence section (two sections per fence), fence year (either 2 or 3 years per fence) and fence treatment (marked or control). Each fence section was assumed to have the same inherent collision rate each year if unmarked. The logarithm of section length (km) was included as an offset in the models to standardise all data to collisions per km. In this way, the analysis made full use of all available data, and the treatment effect was estimated by comparing differences in collision rates between sections within a fence before and after treatments were applied. In all cases, the model fitted satisfactorily ($P<0.05$) based on approximation of the residual deviates to chi-square with 12 degrees of freedom, providing no evidence of overdispersion in the data.

3. Results

3.1. Corpse removal experiment

Bird remains could not be found by either of the observers at two of the 37 places where simulated collisions had been made. This could either have been because their location had been recorded incorrectly, or because all signs had disappeared. However, these data points did not affect the results whether they were omitted altogether or classed as undetected collisions and only the former are quoted. Of the remaining 35, all but two were located by the independent observer. All collisions were identified to the correct species. There was no difference in detection rate between species ($X_1^2=0.04$, $P=0.83$), observer ($X_1^2=0.69$, $P=0.71$) or site ($X_9^2=7.01$, $P=0.64$). Ten (29%) of the 35 corpses had been removed by the time of the second visit. Significantly more red grouse corpses were removed (seven out of 15) than black grouse (three out of 20) ($X_1^2=4.24$, $P=0.04$). Corpse removal also differed significantly between fence sites ($X_9^2=21.42$, $P=0.01$). Assuming that removal rates were constant over the period and that the average interval between fence search visits was 30.5 days, then for black grouse the proportion of corpses taken by scavengers between successive visits was 21% and for red grouse 65%.

3.2. Bird collision rates and species composition

A total of 437 bird collisions involving 13 species was recorded on the 16 fences monitored during the period May 1995 to April 1997 (Table 2). All four species of British grouse collided with fences and they formed 400

Table 2
Total numbers of bird collisions, including those where a corpse was found at 16 fences in the Scottish Highlands monitored between May 1995 and April 1997[a]

Species	Collisions	Corpse present
Red grouse (*Lagopus lagopus scoticus)*	183	45
Black grouse (*Tetrao tetrix)*	127	26
Capercaillie (*Tetrao urogallus)*	89	14
Wood pigeon (*Calumba palumbus*)	20	3
Mallard (*Anas platyrhynchos*)	4	0
Song thrush (*Turdus philomelos*)	3	1
Blackbird (*Turdus merula*)	3	1
Carrion crow (*Corvus corone*)	2	1
Bullfinch *(Pyrrhula pyrrhula)*	1	1
Teal (*Anas crecca*)	1	1
Ptarmigan (*Lagopus mutus)*	1	1
Goose (*Anser* sp.)	1	0
Tawny owl (*Strix aluco*)	1	0
"Woodland grouse" (*Tetrao* sp.)	1	0

[a] The totals do not include collisions from the clearance round.

or 92% of all collisions. Red grouse formed 42% of all collisions, with black grouse 29% and capercaillie 20%. Fences were, by and large, not in ptarmigan habitat and consequently there was only one record of a ptarmigan colliding with a fence. Wood pigeon (*Columba palumbus)* was the only other species frequently colliding with fences (20 records).

Capercaillie and black grouse collisions were each recorded from 11 of the 16 fences (69%), where the mean collision rates, excluding the clearance round, were 0.9 (95% CL 0.3–1.5) and 1.3 (95% CL 0.1–2.4) collisions km^{-1} $year^{-1}$ respectively. Either capercaillie or black grouse collisions were found from 15 of the 16 fences (94%), with a mean collision rate of 1.5 (95% CL 0.6–2.5). Red grouse collided with 13 fences (81%) at a mean collision rate of 1.6 collisions km^{-1} $year^{-1}$ (95% CL 0.5–2.8). Pooling collision rates for all grouse species gave a mean collision rate of 2.7 (95% CL 1.4–4.0). The proportion of collisions resulting in a carcass being found was relatively constant between grouse species, varying only from 0.16 in capercaillie to 0.20 and 0.25 in black and red grouse respectively. By correcting for corpses removed by scavengers and assuming that this rate was constant throughout the year, the proportion of fatal collisions was estimated as 0.70 in red grouse [0.25/(1–0.65)] and 0.26 in black grouse [0.20/(1–0.21)].

The monthly distribution of collisions of the three species is given in Table 3. Grouping the months into the four seasons, the timing of collisions also differed between grouse species ($X^2_6 = 13.30$, $P < 0.05$). Red grouse collisions peaked in the spring (comparison with uniform distribution $X^2_3 = 25.00$, $P < 0.001$), when almost half of all collisions occurred. Capercaillie collisions were fewer in summer ($X^2_3 = 11.14$, $P < 0.05$), a trend repeated for black grouse, but not significantly ($X^2_3 = 5.39$, $P > 0.1$).

3.3. Differences between sexes

Prior to marking the 16 fences, the mean collision rates by black grouse were positively correlated with the mean number of displaying males in spring within 2 km ($r_S = 0.60$, $n = 16$, $P < 0.02$; Fig. 2). Similarly, numbers of both black grouse and capercaillie seen when visiting the fences were both positively correlated with the numbers of collisions found ($r_s = 0.76$, $n = 14$, $P = 0.001$ and $r_s = 0.58$, $n = 14$, $P < 0.05$ respectively).

Of the 163 black grouse collisions, including those from the clear-up round, 124 (76%) were by males, an overall ratio of 3.2 males per female and a highly significant deviation from unity ($X^2_1 = 44.3$, $P < 0.001$). This highly skewed sex ratio from collisions reflected the ratio of birds observed while walking fences. Of 136 birds seen, 107 (79%) were males, a ratio of 3.7 males per female. The ratio of male to female collisions was the same as that of male to female observations whilst walking the fence ($X^2_1 = 0.00$, $P > 0.99$). Of the 95 capercaillie collisions, 41% were by males, a ratio of 0.7 males per female which did not differ significantly from unity ($X^2_1 = 3.04$, $P = 0.09$). This ratio did not differ from that of birds (14 males, eight females) observed along the fences ($X^2_1 = 3.68$, $P = 0.06$).

3.4. Experimental marking

The 10 fences with the highest woodland grouse collision rates from monitoring in year one were selected as experimental fences in year two. Fewer bird collisions

Table 3
The monthly breakdown of capercaillie, black grouse and red grouse collisions with deer fences in the Scottish Highlands between May 1995 and April 1996[a]

	May	June	July	August	September	October	November	December	January	February	March	April
Capercaillie	1	1	0	0	2	9	3	5	5	3	3	4
Black grouse	3	1	2	0	4	4	2	11	9	2	4	10
Red grouse	11	14	6	0	4	6	2	6	7	6	8	15

[a] The month denotes the timing of the walk and gives the number of collisions accumulated in the previous month.

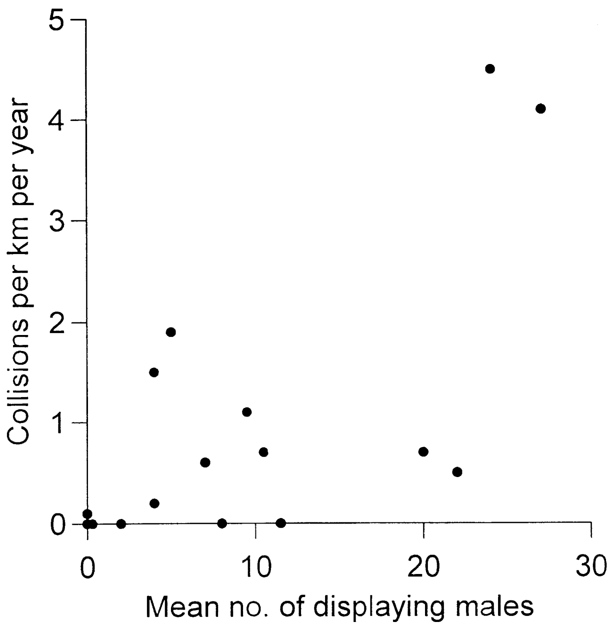

Fig. 2. The relationship between the mean number of black grouse displaying within 2 km of the fence and the black grouse collision rates (mean collisions km^{-1} $annum^{-1}$) at 16 fences in the Scottish Highlands between May 1995 and April 1996.

were found on the marked "treatment" sections than on the unmarked "controls" on nine of the 10 fences, the number of collisions on each section being equal on the tenth fence. Overall, 71% (95% CL 52–82%) fewer collisions were found on the treatment sections (a mean of 0.35 collisions km^{-1} $month^{-1}$) than on the control sections (1.13 collisions km^{-1} $month^{-1}$) ($P<0.001$) (Table 4). Considering only woodland grouse, 84% (95% CL 66–92%) fewer collisions occurred on the treatment sections than on the controls, with rates of 0.14 and 0.67 collisions km^{-1} $month^{-1}$ respectively. The marking treatment significantly reduced collision rates for capercaillie and black grouse by 64% (95% CL 8–86%; $P<0.05$) and 91% (95% CL 67–98%; $P<0.001$) respectively. There was no significant effect of marking fences on collision rates by red grouse, although the mean collision rate on treated sections was half of that on controls.

4. Discussion

Grouse species formed 92% of the 437 collisions between May 1995 and April 1997, the same value as reported by Baines and Summers (1997) for a different set of fences over a wider geographic distribution within the Scottish Highlands. Capercaillie and black grouse collectively formed almost half of the collisions, as opposed to only a quarter of the collisions in the study by Baines and Summers (1997). This difference reflected the deliberate decision to target fences within key woodland grouse areas in or around the Cairngorms area.

Both this study and that of Baines and Summers (1997) showed similar seasonal trends in collisions, with fewer in summer and a spring peak in red grouse collisions. Earlier, Catt et al. (1994) found an autumn peak in capercaillie collisions, which they attributed to young birds dispersing from their natal areas. This study found no such peak probably reflecting the presence of few juveniles in the population following years of below average breeding success (Moss et al., 2000).

Indices of bird abundance were correlated with collision frequency for both lekking black grouse and capercaillie, but were not strong predictors of collision rates. It is likely that other factors such as habitat composition and structure (Baines and Summers, 1997) and topography (Bevanger, 1990) in relation to the fence-line may be at least as important in determining the number of birds that collide. Three-quarters of black grouse collisions were by males. This correlated with four times more males than females were seen whilst visiting the fences. Female black grouse may be less susceptible to fence collisions than males through spending more time on moorland (Baines, 1994) and thus away from the forest edge along which most fences are routed. The sex ratio of capercaillie involved in collisions was in broad agreement with the 1.5 hens per cock estimated for the Scottish population in native woodlands between 1992 and 1994 (Catt et al., 1998).

Reliable estimates of annual mortality from fence collisions were not possible. This was because of an inadequate knowledge of the number of birds at risk

Table 4
The effects of fence marking on bird collision rates[a]

Variable	Treated/control	95% CL	Chi-squared	Probability
All birds	29%	18–48%	25.67	$P<0.001$
Woodland grouse	16%	8–34%	27.40	$P<0.001$
Capercaillie	36%	14–92%	4.82	$P<0.05$
Black grouse	9%	2–33%	17.17	$P<0.001$
Red grouse	51%	23–114%	2.72	NS

[a] Treated/control is the collision rate on the treated section as a proportion of that on the control section, with 95% Confidence Limits (CL). All Chi-squared tests have one degree of freedom, NS = not significant.

during the course of the study and of their movements in relation to fence proximity. There were also considerable difficulties in determining the proportion of collisions that were fatal. Corpse removal rates by scavengers differed between sites, probably in relation to predator abundance and prey availability. Hence a general correction factor that does not take either this or seasonal differences in removal rates into account must be treated with caution (Bevanger et al., 1994; Bevanger, 1995). Despite the crudeness, it is clear from the estimated 65% of corpses removed by scavengers in this study and 90% in a similar trial by Baines and Summers (1997) that mortality, particularly of red grouse, may be severely underestimated by these methods. This is despite high (95%) collision detection rates. Birds may hit fences and die without shedding any feathers (R. Moss, pers. comm.) If the corpse is then removed by a fox, no trace is left. Furthermore, birds that suffered crippling injuries in hitting the fence may have moved and died at some distance from the fence and thus remain undetected, thus leading to further underestimation of true mortality.

This study adds to the increasing awareness of the impact of obstacles such as power lines and fences on birds (reviewed by Bevanger, 1998). It has identified that marking fences significantly reduces bird collisions, particularly those by woodland grouse, and hence is a useful conservation technique. Marking with this orange plastic netting did not prevent collisions altogether, and given a collision reduction rate of 64% (95% CL 8–86%) for capercaillie and an annual mortality rate against fences of 32% (Catt et al., 1994), then even marked fences may still kill 12% (95% CL 5–29%) of capercaillie per annum. Without fence deaths, it is predicted that the decline in capercaillie observed during the 1990s would not have occurred, instead hen numbers may have increased by 6% (±10% S.E.) per annum (Moss, 2001). To this end, the best solution is obviously no fencing at all. However, the described marking technique has quantifiable benefits. The development of more effective marking methods should be encouraged, both in terms of reducing collisions and in the conspicuousness and durability of materials used as the current method is only appropriate within more sheltered woodland environments. Fences that are less hazardous to grouse also need to be developed pending future wider-scale reductions in numbers of red deer that would permit woodland to regenerate without fencing. In the meantime, it would be unwise to consider marking as a means of rendering proposed deer fences acceptable in prime areas for woodland grouse. Neither this study, nor that by Baines and Summers (1997), found deer fences to be a particular hazard to birds other than grouse. Consequently, deer fences could still form an option for woodland regeneration in areas where woodland grouse are not present, or where there is only limited red grouse sporting interest.

Although red grouse formed 42% of all bird collisions, fences are not widely perceived to be a conservation problem with this species. On open heather moorland, the primary habitat for red grouse, fences tend to be fewer and grouse densities higher (Hudson, 1992). Within such habitats, where fences do occur they may locally form a significant mortality source. In these more exposed conditions, the described marking technique is probably not sufficiently durable and other more robust marking techniques may be better for this species.

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