Behavioural responses of red deer to fences of five different designs

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Abstract

Capercaillie, a large species of grouse, are sometimes killed when they fly into high-tensile deer fences. A fence design which is lower or has a less rigid top section than conventional designs would reduce bird deaths, but such fences would still have to be deer-proof. The short-term behavioural responses of farmed red deer (Cervus elaphus) to fences of five designs, including four that were designed to be less damaging to capercaillie, were measured. Five deer were located on one side of a fence with a larger group (20 animals), from which they had been recently separated, on the other. The efficacy of fences in preventing deer from the small group from rejoining the larger group was also recorded. In addition to a conventional deer fence (C) the four new designs were, an inverted “L” shape (L), a fence with offset electric wire (E), a double fence (D) and a fence with four webbing tapes above (W). Four replicate groups of deer were each tested for 3 days with each fence design. Deer paced the test fence line relatively frequently (a proportion of 0.09 scan observations overall) but significantly less when deer were separated by fences E or C compared to L, W or D (overall difference between fence types, P < 0.001). Deer separated by fence E spent significantly more time pacing perimeter fences than deer separated by fences of other types (overall difference between fence types, P < 0.01) but deer separated by fence C maintained a low level of fence pacing overall. Analysis of behaviour patterns across the first day and the 3 days of exposure suggested that the novelty of the test fences, rather than the designs per se, influenced the behaviour of the deer. Over the course of the study, no deer crossed either C or L. Three deer crossed E and two deer crossed both W and D. On this basis, field testing, particularly of fence L, would be a useful next step. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Red deer; Fence efficiency; Grazing behaviour

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1. Introduction

In order to contain farmed red deer (*Cervus elaphus*) and to restrict the movement of populations of wild deer, particularly onto agricultural land or areas of afforestation, high-tensile steel netting fences, 1.8–2.0 m high, are usually employed. One of the disadvantages of the use of such netting is the damage it inflicts on animals and birds colliding with it. In Scotland, collisions with deer fences are a major cause of mortality of full-grown capercaillie (*Tetrao urogallus*), a large species of grouse (Catt et al., 1994; Baines and Summers, 1997; Summers, 1998; Moss et al., 2000). The Scottish capercaillie population is small, about 1000 (Wilkinson et al., in press) and, based on current estimates of survival and breeding success, it is declining (Moss et al., 2000). It has been red-listed in the Bird Species of Conservation Concern because its range has contracted by over 50% in the period from 1968–1972 to 1988–1991 (Gibbons et al., 1996). Collisions can be reduced but not eliminated by marking fences with strips of orange plastic netting (Andrew and Baines, 1997). Although marking fences is one partial solution, there may be other fence designs that would further reduce collisions or mortality resulting from collisions. As part of the investigation into the efficacy of fences to contain deer, we recorded the behavioural reactions of farmed deer towards fences that would reduce damage to birds by being either lower or less rigid than conventional deer fences. Against a benchmark of a conventional deer fence, fences were chosen presenting both vertical and horizontal physical challenges to the deer, without necessarily being the height of a conventional deer fence.

2. Methods

2.1. Experimental procedures

The study was conducted at the Macaulay Land Use Research Institute’s Glensaugh Research Station in eastern Scotland using yearling farmed red deer. The study took place between 20 July and 13 September, 1998. Two adjacent paddocks were used, enabling two designs of fence to be tested simultaneously. Each test fence was approximately 100 m long and used to divide one of the two 2.07 ha gently-sloping grass paddocks into areas of 1.57 and 0.50 ha. The perimeter of each paddock was of conventional deer fencing. Each of five fences was tested for four 3-day periods. For two of these periods, yearling hinds were used and for the other two, yearling stags. The test procedure involved dividing a group of 25 familiar animals so that five animals were separated from the remainder by the test fence. The five test deer were assigned to the smaller, downhill area. The fence designs (Fig. 1) were designated:

<table>
<thead>
<tr>
<th>Design</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>C</td>
<td>conventional deer fencing;</td>
</tr>
<tr>
<td>L</td>
<td>inverted “L” shape;</td>
</tr>
<tr>
<td>E</td>
<td>fence with offset electric wire;</td>
</tr>
<tr>
<td>D</td>
<td>double fence;</td>
</tr>
<tr>
<td>W</td>
<td>fence with four webbing tapes above.</td>
</tr>
</tbody>
</table>
Fifty male and 50 female yearling deer were used. At the start of the study, deer of each sex were divided into two groups, balanced for liveweight, and grazed in those groups for at least 1 week. Prior to the testing of each fence, the appropriate groups of deer were gathered and five from each group randomly selected (five different deer on each occasion) to be located in the smaller section of each paddock while the remaining 20 deer were grazed in the larger section of each paddock. The five test deer received individual coloured collars to facilitate identification. Each group was tested against each of the fence designs, and within each group five different “test” deer were used for the different test periods. If any deer crossed the fence during the 3-day test period, it was not returned to the test group. Deer were checked regularly by the stockman when the observer was not present to ensure that any deer, which might become entangled in the fences, could be rapidly freed although in fact no deer were seen to become entangled.
2.2. Behavioural observations

Behavioural observations were made for a total of 52 h for each fence design in order to
gauge the reaction of the deer towards the fences. An observer positioned outside the
paddock made observations on five test deer at 10 min intervals by scan sampling,
according to the following schedule:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First day</strong></td>
<td>5 h commencing immediately after the deer were</td>
</tr>
<tr>
<td></td>
<td>introduced — approximately 10.00–15.00 h;</td>
</tr>
<tr>
<td><strong>Second day</strong></td>
<td>5 h; 9.00–12.00 and 13.00–15.00 h;</td>
</tr>
<tr>
<td><strong>Third day</strong></td>
<td>3 h; 9.00–11.00 and 13.00–14.00 h.</td>
</tr>
</tbody>
</table>

The times were chosen to cover the period immediately after introduction and, for
comparative purposes, broadly similar periods on the following 2 days. At the start and end
of each day, the number of deer remaining in the smaller paddock was recorded.

2.3. Statistical analysis

Data for both posture and activity were initially summed across each hour (6 × 10 min
observations for each of five deer) and subjected to an angular transformation prior to
analysis in order to accommodate the large number of occasions when zero counts were
recorded and the resultant distribution of residuals. An analysis of variance (ANOVA)
procedure was performed on the transformed data using Genstat 5.3 (Lawes Agricultural
Trust, 1994). Group mean data were compared since data from individual deer could not be
considered independent. In the tables of results, the data are presented as untransformed
means with standard errors. In addition to considering the combined data in relation to each
fence type from the 3 days of observation, the change in behaviour with time over the first
day deer were exposed to the fences and the effect of day on the observations made between
13.00 and 14.00 h (when observation times coincided) was analysed. An initial ANOVA
showed that although there were some differences in the posture and activity of the deer in
relation to their sex, there were no significant interactions between the sex of the deer and
the paddock in which they were located or fence type; consequently data from the four
replicate groups were combined in the subsequent analysis.

3. Results

3.1. Effect of fence type on posture and activity

Table 1 shows the effect of fence type on the posture and the activity of the deer. Deer
spent significantly more time moving and less time standing when separated from the
remainder of the group by fence C compared to the other fence types. There was no effect
of fence type on the proportion of time spent lying. While pacing the test fence line
occurred relatively frequently (0.09 of scan observations overall), significantly less pacing
was observed when deer were separated by fences E or C. However, deer next to fence
E spent significantly more time pacing perimeter fences, while deer separated from other
Table 1
Proportion of observations ‘test’ deer spent in one of three postures or various activities over 3 days (means (S.E.))

<table>
<thead>
<tr>
<th>Fence design&lt;sup&gt;b&lt;/sup&gt;</th>
<th>C</th>
<th>L</th>
<th>E</th>
<th>D</th>
<th>W</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standing</td>
<td>0.14 a (0.036)</td>
<td>0.32 b (0.017)</td>
<td>0.33 b (0.040)</td>
<td>0.33 b (0.027)</td>
<td>0.37 b (0.022)</td>
<td>***</td>
</tr>
<tr>
<td>Moving</td>
<td>0.36 b (0.029)</td>
<td>0.21 a (0.050)</td>
<td>0.22 a (0.040)</td>
<td>0.21 a (0.031)</td>
<td>0.22 a (0.054)</td>
<td>*</td>
</tr>
<tr>
<td>Lying</td>
<td>0.50 (0.054)</td>
<td>0.42 (0.066)</td>
<td>0.40 (0.080)</td>
<td>0.41 (0.052)</td>
<td>0.40 (0.033)</td>
<td>ns</td>
</tr>
<tr>
<td>Activity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacing test fence</td>
<td>0.02 a (0.015)</td>
<td>0.12 b (0.037)</td>
<td>0.01 a (0.002)</td>
<td>0.13 b (0.020)</td>
<td>0.15 b (0.021)</td>
<td>***</td>
</tr>
<tr>
<td>Pacing perimeter fences</td>
<td>0.01 a (0.008)</td>
<td>0.06 b (0.016)</td>
<td>0.13 c (0.020)</td>
<td>0.05 b (0.016)</td>
<td>0.05 b (0.021)</td>
<td>***</td>
</tr>
<tr>
<td>Grazing</td>
<td>0.37 (0.050)</td>
<td>0.31 (0.019)</td>
<td>0.33 (0.040)</td>
<td>0.31 (0.023)</td>
<td>0.32 (0.022)</td>
<td>**</td>
</tr>
<tr>
<td>Alert</td>
<td>0.24 b (0.024)</td>
<td>0.02 a (0.012)</td>
<td>0.03 a (0.012)</td>
<td>0.01 a (0.005)</td>
<td>0.01 a (0.003)</td>
<td>ns</td>
</tr>
<tr>
<td>Interacting</td>
<td>0.007 b (0.0019)</td>
<td>0 a (0)</td>
<td>0.002 a (0.0019)</td>
<td>0 a (0)</td>
<td>0.001 a (0.0013)</td>
<td>***</td>
</tr>
</tbody>
</table>

<sup>a</sup> Values in rows with no letters in common are significantly different ($P < 0.05$ or less).

<sup>b</sup> C: conventional deer fence; L: inverted ‘L’ shape; E: fence with offset electric wire; D: double fence; W: fence with webbing above.

ns: not significant.

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$. 
deer by fence C maintained a low level of fence pacing. Fence type did not affect grazing behaviour but a larger proportion of alert behaviour and more interactions occurred in relation to fence C (although the occurrence of both of these activities was not common: across all fence designs 0.06 and 0.02 of scan observations showed alert and interacting activities, respectively). Many other activities were recorded but they occurred too infrequently to allow meaningful analysis.

3.2. Effect of hour of observation — day 1

The only interaction between sex and hour of observation on day 1 occurred with standing: males showed a greater decline in standing behaviour with time than females ($P < 0.01$). There was a significant effect of hour of observation on both posture and activity of the deer. Over the 5-h period, standing and moving declined while lying increased (Table 2). Only with movement was there a significant interaction between fence type and hour of observation, with fences L and C showing the greatest reduction in moving over the 5-h period. Grazing and pacing both the test fences and the perimeter fences declined with time. While the time spent alert did not alter, rumination increased with time.

3.3. Comparison between the 3 days

The observation period 13.00–14.00 h was the only period common to the 3 days and thus, amenable to direct comparison. At this time, there was a significant effect of day on standing, moving and lying postures and fence pacing activity (Table 3). Data from all five fence designs were pooled as there were no significant fence $x$ day interactions. Standing and lying posture increased across the 3 days, while moving decreased. Pacing both the test fences and the perimeter fences declined between days 1 and 2.

3.4. Deer crossing the fences

No deer crossed fences C or L. Of the 20 deer from the four test groups exposed to each fence design, a total of three deer crossed fence E, one immediately after being located in the paddock, one after an hour in the paddock and one deer from the larger group crossed the fence to join the smaller group. Two further deer were observed to receive an electric shock from the electric wire immediately after being located in the paddock. These did not attempt to jump the fence. A third deer was observed temporarily between the fence and the electric wire but eventually returned to the small paddock. Fence D was jumped by two deer, one of which was initially located between the two fences but jumped over the second fence when approached by the stockman. The other jumped the fence whilst being herded into an adjacent paddock. Fence W was also crossed by two deer but neither crossing was witnessed. During the observation periods, one attempt to cross (an apparently deliberate collision) fence E and 6 attempts to cross fence W were recorded.

3.5. General comments about the fences

Deer were often seen to ran under the flat part of fence L, and to scratch on it (especially the stags rubbing their velvet). Running under this fence caused a pronounced track to
Table 2
Proportion of observations ‘test’ deer spent in one of three postures or various activities over 5 h during day 1 (means (S.E.))

<table>
<thead>
<tr>
<th>Approximate times of observation (h)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10.00–11.00</td>
</tr>
<tr>
<td><strong>Posture</strong></td>
<td></td>
</tr>
<tr>
<td>Standing</td>
<td>0.36 bc (0.116)</td>
</tr>
<tr>
<td>Moving</td>
<td>0.62 d (0.112)</td>
</tr>
<tr>
<td>Lying</td>
<td>0.01 a (0.006)</td>
</tr>
<tr>
<td><strong>Activity</strong></td>
<td></td>
</tr>
<tr>
<td>Pacing test fence</td>
<td>0.21 c (0.044)</td>
</tr>
<tr>
<td>Pacing perimeter fences</td>
<td>0.23 b (0.018)</td>
</tr>
<tr>
<td>Grazing</td>
<td>0.44 d (0.069)</td>
</tr>
<tr>
<td>Alert</td>
<td>0.02 (0.015)</td>
</tr>
<tr>
<td>Ruminating</td>
<td>0 a (0)</td>
</tr>
</tbody>
</table>

* Values in rows with no letters in common are significantly different ($P < 0.05$ or less).
ns: not significant.
** $P < 0.01$.
*** $P < 0.001$. 
develop on the ground (more so than with the other fences) which may result in long-term erosion of the ground at the fence base in areas where deer congregate, ultimately making it less secure. The wind caused the tape at the top half of W to flap and thus it became highly visible (and also slack). The deer also rubbed against this fence, especially the stags who were trying to remove their velvet. The tape soon tended to sag and needed frequent tensioning.

4. Discussion

Deer fences designed to reduce the effect of damage caused to birds which collide with them need to remain secure in preventing crossing by deer; while not all of the fences examined in this study proved entirely effective in retaining deer this may be influenced by the reaction of deer towards them. The farmed deer used in the study were familiar with fence C and, as such, this fence served as a reference standard to the other four designs. It is thus surprising to note that deer separated by this fence moved more and were more alert than when separated by fences of alternative designs although this movement was not in relation to pacing the test fence. These observations may suggest some form of social disturbance (Diverio et al., 1993; Goddard et al., 1996). Deer separated by fence C also showed the largest number of interactions, again tending to suggest that they were unsettled (Abeyesinghe et al., 1997). However, the fact that these deer also paced test fence line C least contradicts this view: fence line pacing may indicate distress (Hodgetts et al., 1998) and we have evidence that this activity is associated with high plasma cortisol concentrations (Goddard, unpublished data). The fact that the farmed deer were already familiar with fence C strengthens the contrast with the other fence designs.

A strong temporal pattern in the daily behaviour of deer has been recorded in many studies (e.g. Pollard and Littlejohn, 1998) and these inherent variations in the circadian activity pattern of deer render general comparison between the 3 days inappropriate. However, the 13.00–14.00 h period can be compared between the 3 days. It is particularly interesting to note the significant decline in fence pacing between days 1 and 2. Fence
pacing may be as a direct result of preventing access to a resource (Moore et al., 1985) or if the deer are otherwise motivated to escape (Pollard et al., 1992) and thus the behaviour may act as an indicator of welfare status. It is often seen in newly captured animals or those attempting to join others. In the present study, fence pacing may also relate to the novelty of the test fences, since pacing the test fence in the C paddocks was significantly less than for the other designs (except E) and pacing the perimeter fences was always less for deer in the C paddocks. This aspect of habituation was also apparent from the decline in pacing both the test and perimeter fences over the course of 5 h on the first day of exposure although, as noted above, this may be due to a circadian activity pattern.

The data on the posture of the deer support the view that the deer were affected by the novelty of the fences or the experimental situation in general: deer moved less and lay more on days 2 and 3 than on day 1. Increased movement may suggest that the deer were more stressed (Diverio et al., 1993; Goddard et al., 1996). On the other hand, the overall effect of fence design on posture is inconsistent, since although deer next to fence C moved more, they stood less than when next to other fences, with no effect on lying. There was a tendency to observe more grazing in paddock C, but here the deer were more alert and were observed to be interacting in a greater proportion of the scans. Thus, the fence design clearly affected deer held in close proximity to the fences, with some marked changes in basic posture and activity, but no clear conclusions regarding the effect of fence design can be drawn.

The general lack of statistically significant interaction between fence design and hour of observation on day 1 suggests that novelty per se and/or diurnal variation rather than the fence design itself are responsible for the significant changes noted in both posture and activity other than fence pacing itself.

Crossings of the test fences were rare. As expected, the conventional deer fence (C) was not crossed but neither was the L-shaped fence (L). At the outset, there was concern that deer may attempt to jump this fence and become entangled in the top, horizontal section. The use of angled extensions on roadside deer fences is not recommended as deer have been known to become trapped on such fencing (Blamey & Blamey, cited by Putman, 1997). While this did not occur, a welfare concern remains especially if, in the field, inspection by humans of this fence is infrequent. While the other three fences were crossed by the test deer, the relatively small number of crossings recorded (three, two and two for fences E, D and W, respectively) make it difficult to make a choice between them on the grounds of efficacy. However, it may not be necessary for any fence to be 100% effective. A lesser deer-proof performance may be acceptable in practice, especially if large areas are available to the deer although under severe pressure these fences may be less secure.

In relation to the objective of determining effectiveness of the fences in relation to injury to capercaillie, there is now clearly a need to test at least some of these fences in the field and to extend the study to determine the likelihood of collisions by capercaillie, compared to conventional deer fences.

Acknowledgements

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