EFFECTS OF LIGHTING ON HEART RATE AND POSITIONAL PREFERENCES DURING CONFINEMENT IN FARMED RED DEER

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Two experiments were carried out to determine whether lighting conditions during handling affected heart rate or behaviour in farmed red deer. In Experiment 1 heart rate was measured in 24 individual deer, held under restraint in a mechanical deer crush for two minutes, under either dark (0lux) or light (1500lux) conditions. A stethoscope was used to monitor heartbeat which was indicated vocally by the stethoscope operator on to a Dictaphone. In Experiment 2, 10 groups of three deer were confined for four minutes in an unfamiliar 4x6m light-proof pen with lighting provided either on the left or right-hand side of the pen, to provide a gradient across the pen from approximately 12 to 1000lux. For the first two minutes the deer were alone and for the second two minutes a person stood in the pen. An infrared video camera was used to record behaviour.

In Experiment 1, heart rate was lower ($P < 0.05$) in the dark compared with in the light when recording commenced, thereafter it decreased overall with similar ($P > 0.05$) values observed for the different lighting treatments. In Experiment 2, the mean position of the groups across the pen varied according to whether lighting was on the left or right, with groups displaced to the right when the lights were on the left, and standing in the middle of the pen when the lights were on the right ($P < 0.05$). During testing, groups moved away from whichever side the lights were on ($P < 0.05$). The experiments suggested that stress during restraint was reduced by providing darkness and that deer preferred dim lighting compared with bright lighting when confined in unfamiliar surroundings.

Keywords: *animal welfare, handling, heart rate, lighting, preferences, red deer*

Introduction

During the establishment of the deer farming industry in New Zealand during the 1970s it was common practice to use darkened handling pens, as darkness was believed to quieten the animals (Wallis & Hunn 1982). However, darkened facilities were difficult to work in and poorly ventilated, and more recently farmers have advocated good lighting (Hart 1986; Duffy 1988). Nevertheless there are times, particularly during transportation and prior to slaughter, when providing darkness would not compromise handling efficiency and might be beneficial to the animals.

As a first step in determining whether darkness might be beneficial, groups of 10 deer were confined in a novel pen under either well-lit or dark conditions. When confined in the

dark, the deer showed more exploratory behaviour and maintained greater inter-individual distances compared with in the light (Pollard & Littlejohn 1994). Both of these effects indicated that the deer were less fearful in the dark, as fear inhibited exploration by animals (Archer 1979), and was associated with reduced inter-individual distances in other species of deer (Putman 1988), and in horses and sheep (Fraser & Broom 1990). To obtain more information on the possible benefits of providing darkness to deer, the following two experiments were carried out. In the first, deer were held in restraint (to prevent confounding effects of activity) and heart rate was measured under light and dark conditions, and in the second, deer were given a choice between light or dark areas of an unfamiliar pen.

Experiment 1 Effects of lighting on the heart rate of restrained deer

Methods

Animals

Sixteen entire and eight castrated male red deer aged approximately 10 months were studied on two consecutive days (1 and 2). The deer were kept at pasture as one group except during experimental sessions, which were carried out indoors. Individuals were tested in the same order on both days, and were identified by numbered plastic ear tags. To facilitate drafting, successive groups of six deer were drawn from the larger group. Each group of six contained four entire males and two castrates.

Procedure

Two people were involved with handling the deer and recording heart rate, and they performed the same tasks on both days. One person drafted the test animal from the handling pen, down a two metre race, and into a mechanical deer crush, where it was restrained for approximately two minutes. During entry to the crush, curtains surrounded the area so that the second person (operating the crush) was not visible, and the lighting was dim (3lux). Once the deer was restrained, lights were either turned on (1500lux; Treatment L) or off (0lux; Treatment D), and the curtains were drawn back. A stethoscope was placed against the left hand side of the restrained deer and a timer was started. Heart rate was monitored as successive 10-beat intervals, indicated vocally by the stethoscope operator and recorded on a Dictaphone. The operator also indicated vocally whenever the deer struggled. The counting of beats was usually not possible during struggling bouts. Counting ceased two minutes after the timer was started, then the curtains were re-drawn around the area, dim lighting was restored, and the animal was released into a post-treatment holding pen.

Twelve deer received Treatment L on Day 1 and Treatment D on Day 2, while 12 deer received the treatments in the reverse order. Within the successive groups of six drawn from the larger group, three deer received L and three received D. Allocation to treatments and testing order was random.

Statistical analysis

Heart rate was estimated at the 'summary times' 0, 30, 60 and 90s from the start of recording, using the rate over the interval including each summary time for each animal on each day, as shown in Table 1. These, together with their differences were analysed using ANOVA, with animal tag as the block structure, and sex (castrate/entire), lighting treatment

plus day, and their interaction as the treatment structure. There was no evidence of a crossover effect.

Table 1 **Example of heart beat monitoring and transformation to heart rate at summary times, for animal 230 on Day 1.**

Sample Number	Time/10 heart beats (s)	Cumulative time/10 heart beats (s)	Heart rate (bpm)	Summary Time (s)
1	7.91	7.91	75.9	0
2	8.55	16.46	70.2	
3	8.75	25.21	68.6	
4	9.36	34.57	64.1	30
5	10.25	44.82	58.5	
6	9.79	54.61	61.3	
7	9.48	64.09	63.3	60
8	9.84	73.93	61.0	
9	8.73	82.66	68.7	
10	8.78	91.44	68.3	90
11	10.02	101.46	59.9	
12	8.21	109.67	73.1	

The number of animals struggling at time 0s, and over the subsequent 30s intervals were analysed as a binomial generalized linear model (McCullagh & Nelder 1989), fitting terms for day, sex, lighting treatment, and the interaction of sex and lighting treatment.

The relationship between heart rate at the summary times and struggling leading up to these times was analysed by residual maximum likelihood (Patterson & Thompson 1971), modelling heart rate by the fixed terms day, sex, lighting treatment, and the interaction of sex and lighting treatment plus an indicator factor as to whether struggling had occurred, with animal tag as a random effect.

Results

Mean heart rate during the light treatment was significantly greater than during the dark treatment at the start of the observation period ($P < 0.01$; Figure 1). Heart rate then decreased ($P < 0.001$) overall, with values for the light treatment not being significantly higher than values for the dark treatment (Figure 1). There was a significant sex x day interaction at each summary time ($P < 0.05$; Figure 2), with entire stags showing higher heart rates on the first day than on the second day, in contrast to the castrates.

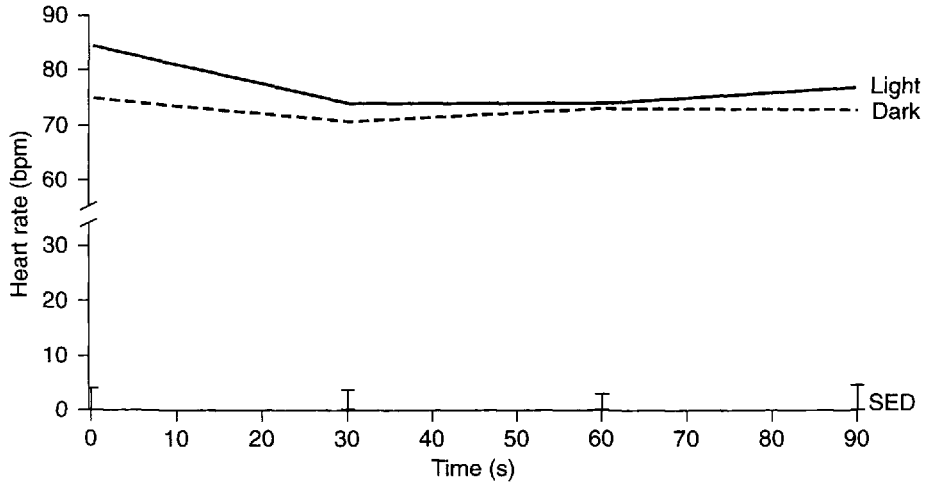

Figure 1 **Mean heart rates (bpm) for deer in light and dark treatments. Vertical lines indicate the SED between treatments at each time interval.**

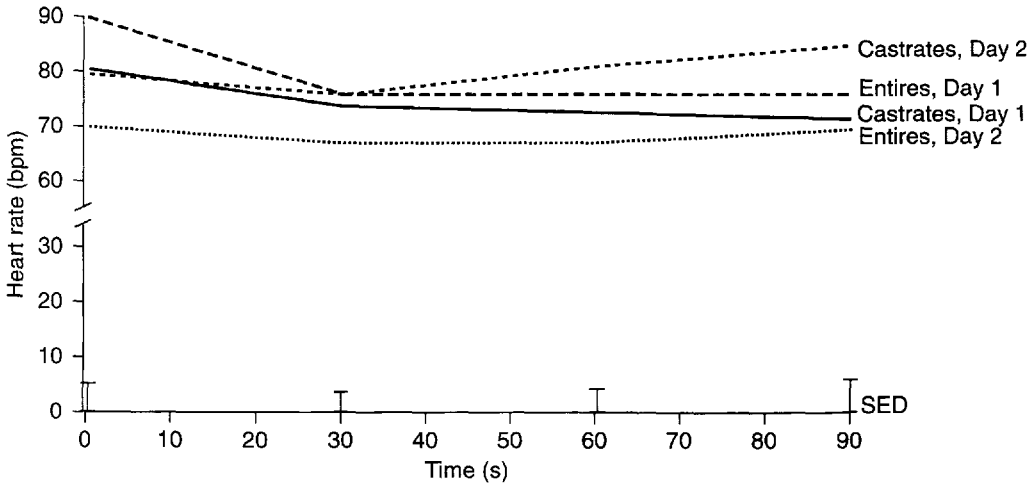

Figure 2 **Mean heart rates for castrated and entire stags on Days 1 and 2. Vertical lines indicate the SED between castrated and entire stags at each time interval.**

No evidence was found that the amount of struggling varied with any of the fitted terms. Up to 30s, there was no evidence that heart rate varied with struggling (Table 2), while at 60s heart rate was 10.6 (standard error of difference (SED) 3.3)bpm higher for struggling animals than for those that were not struggling.

Table 2 **Mean heart rate (bpm), and SED between means, for deer which struggled and did not struggle during the interval immediately prior to heart rate measurement. Significant differences between means are indicated (ns not significant; ** $P < 0.01$).**

	Time (s)			
	0	30	60	90
Heart rate (bpm)				
Struggled	82.0	74.0	82.5	76.1
Did not Struggle	79.6	72.9	71.9	74.3
SED	5.30 ns	4.90 ns	3.29 **	5.44 ns

Discussion

Heart rate was initially lower when deer were restrained in the dark compared with under bright lighting conditions. The effect of lighting on heart rate appeared to be psychological, as it was not related to struggling activity. As elevated heart rates have been associated with stress in deer (Pollard *et al* 1993; Price *et al* 1993) this result suggests that the stress of initial restraint was reduced under dark conditions. Similarly, Hale *et al* (1987) found that heart rate and plasma cortisol levels were lower in cattle restrained in a darkened breeding box compared with a conventional cattle chute (although in that study the animals in the dark were also adjacent to a herd-mate). Nevertheless, in the present study the lower heart rate seen in the dark situation did not provide conclusive evidence that stress was reduced, as lowered heart rate has also been associated with difficult situations (Fraser & Broom 1990) and with increased attention to environmental stimuli (Campos 1976; Haroutunian & Campbell 1981).

Experiment 2 Preferences for light versus dark areas of an unfamiliar pen

Methods

Animals

Thirty red deer stags aged approximately 11 months were, for the purposes of the experiment, allocated randomly to ten groups of three deer. All the animals were normally grazed at pasture as one group, and were accustomed to yarding for weekly weight recording, but had not entered the testing pen prior to the experiment.

Procedure

Each group of three deer was tested on two occasions in an indoor deer handling facility. For testing, the group was drafted by a handler down a 20m handling race and confined for four minutes in a light-proof pen. The testing pen measured 4m wide x 6m long x 4m high and was constructed of wood with a concrete floor. A grid painted on the floor of the pen divided it longitudinally into quarters (Quarters 1–4), and crosswise into thirds (Zones a–c), to make a total of 12 zones annotated 1a to 4c working from left to right, from the front of the pen, where a door (1m wide x 1.8m high) was situated (in Zone 1a), to the back. Three lights (2000 watt halogen flood lamps) were mounted 0.5m from the ceiling, along both left and right walls. When lights on one wall were turned on, the lights on the opposite wall

were turned off, to provide a gradient from approximately 12 to 1000lux across the longitudinal quarters of the pen.

The groups were tested in pairs, within which one group was tested with the left-hand lights on (Treatment L), the other group was tested with the right-hand lights on (Treatment R), and then the tests were repeated with the treatments reversed. The order of presentation of Treatments L and R were allocated randomly within pairs. During the first two minutes of each confinement session there was no human in the pen (P test) and after this a person entered the pen and stood with one foot in each of Zones 2a and 3a for a further two minutes (H test).

Measurements

An infrared video camera was used to record behaviour during confinement. The number of feet in each zone, for the whole group, was recorded. Recording for the P test started at 0, when all feet of the deer were in the pen, then at 2s, 5s, and thereafter at 10s intervals after 0. Recording started for the H test when the deer jumped/oriented as the door opened, and was carried out at the same intervals as for the P test.

Statistical analysis

For each group at each sample time, mean x- (position across pen) and y- (position along pen) coordinates were calculated such that x ranged from -1.5 (Quarter 1) to 1.5 (Quarter 4) and y ranged from -1.0 (Zone a) to 1.0 (Zone c). These were summarized to the mean and linear contrast (or slope) for 0–10s and for 10–120s for each test type (P or H), within each confinement session. The rationale for these divisions was that the groups were unsettled at the start of each test as they entered the pen (P) or as the human entered the pen (H). Having found no evidence of a crossover effect, these summary statistics were analysed by analysis of variance, with session within group defining the blocking structure and lighting treatment, test type and their interaction defining the treatment structure.

Results

A period of mobility at the start (0–10s) of each test was expressed through significant differences in mean and slope between test types (Table 3 and Figure 3). At the start of P tests the group mean position moved sharply towards the right and back of the pen (away from the entrance at the front left). At the start of H tests there was little overall change in lateral position (although all groups showed some movement, but in either direction), while there was a drift further towards the back of the pen from groups not already close to it.

During the 10–120s periods of P and H (Table 3 and Figure 3), the mean x coordinate (x) varied according to whether lighting was on the left or right hand side of the pen ($P < 0.05$), with the groups on average displaced towards the right when the left hand lights were on (x = 0.53) but near the middle of the pen when the right hand lights were on (x = 0.04; SED 0.156). There was also a tendency ($P < 0.05$) for the groups to drift towards the right hand side during the test if the lights were on the left (mean slope 0.009) but to drift towards the left hand side if the lights were on the right (mean slope -0.002; SED 0.0038).

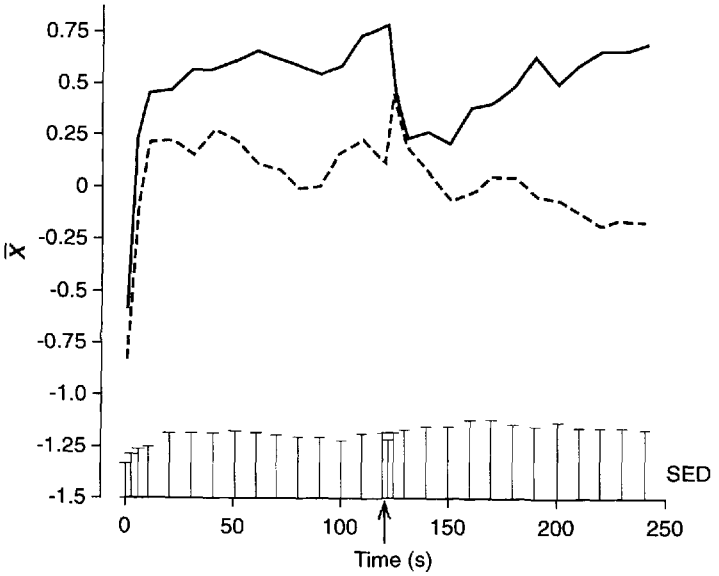

Figure 3 **Mean x coordinate positions during P (0–120s) and H (120–240s), when the lights were on the left (solid line) and right (broken line). Vertical lines indicate the SED between left and right treatments. The arrow indicates entry of the human into the pen.**

Table 3 **Mean values for x and y coordinates, and linear contrasts over time, for initial settling (0–10s) and subsequent (10–120s) periods when the light was on the left or right, and for P and H tests. SEDs and significance of differences between left and right treatments, and between P and H tests, are indicated (ns not significant; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$).**

Coordinate		Mean		Slope	
		0–10s	10–120s	0–10s	10–120s
x	*left*	0.20	0.53	0.053	0.009
	right	-0.10	0.04	0.104	-0.002
	SED	0.191 ns	0.156 *	0.0335 ns	0.0038 *
	P	-0.35	0.36	0.152	0.004
	H	0.46	0.21	0.005	0.003
	SED	0.127 ***	0.140 ns	0.424 **	0.0036 ns
y	*left*	0.58	0.97	0.126	0.008
	right	0.49	0.90	0.135	0.007
	SED	0.066 ns	0.063 ns	0.167 ns	0.0007 ns
	P	0.12	0.86	0.239	0.007
	H	0.94	1.00	0.022	0.008
	SED	0.055 ***	0.067 ns	0.0299 **	0.0007 *

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There was no evidence that the x coordinate varied significantly with test type, or that the y coordinate varied with lighting treatment (Table 3). Nor was there any evidence ($P > 0.05$) of any interaction between light treatment and test type for any of the variables tested.

Discussion

The deer showed a preference for the darker side of an unfamiliar pen, regardless of whether or not a human was present. The preference was expressed both in terms of mean position across the pen, and also in a tendency to drift during the test towards the darkened side. The deer did not confine themselves exclusively to the darkest area. This raises the question as to whether dim lighting might be favoured over darkness.

Animal welfare implications

Overall, the two experiments supported the suggestion of Pollard and Littlejohn (1994) that stress in red deer was reduced in dark environments, and indicated that dim lighting was preferable to bright conditions. In both experiments, however, bright lights were present and the findings could be related to a fear of bright lights rather than of light environments. Further research into the effects of different lighting conditions is warranted. It would be useful to carry out such research in environments where dark conditions could be provided without compromising handling efficiency, and where stress is known to occur, for instance during transport, lairage and stunning (MacDougall *et al* 1979; Selwyn & Hathaway 1990).

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