EFFECTS OF WINTER HOUSING, EXERCISE, AND DIETARY TREATMENTS ON THE BEHAVIOUR AND WELFARE OF RED DEER (*CERVUS ELAPHUS*) HINDS

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*To assess the welfare of red deer (*Cervus elaphus*) confined at pasture or in indoor housing over winter, behaviour, productivity, skin damage and adrenal response to ACTH challenge were measured in six groups of eight weaner hinds over 91 days from June to September 1990 in Otago, New Zealand. The hinds were confined either indoors (I), indoors with daily exercise (IE), or outdoors (O); (n = 2 groups to each treatment). All groups were fed concentrate* ad libitum *plus 100g lucerne head^{-1} day^{-1}.*

Indoor confinement was associated with a greater incidence of nosing/chewing other hinds, aggression, chewing of the enclosure, and closer distances between individuals, compared with outdoor confinement ($P < 0.05$). Ad libitum *provision of hay over a 2-week period reduced the incidence of chewing of indoor enclosures ($P < 0.01$). Weight gain was greater for indoor groups than outdoor groups in August and September ($P < 0.05$) and overall weight gains for indoor groups (from two weeks into the study, until the end) were higher for the exercise treatment ($P < 0.05$). Intake of concentrates did not differ significantly between treatments. Skin damage was greater for indoor than outdoor groups ($P < 0.05$), and positively related to weight gain ($P < 0.01$) and receiving aggression ($P < 0.01$), which in turn was negatively related to liveweight ($P < 0.001$). A negative relationship was found between pre-challenge levels of plasma cortisol and the number of aggressive interactions received ($P < 0.05$). Pre-challenge cortisol was greater for IE than I ($P < 0.05$), and the increase in cortisol post-challenge was greater for outdoor groups than indoor groups ($P < 0.01$). Conclusions were that indoor confinement had a positive effect on weight gain, but increased aggression and skin damage, indicating that the deer were compromised socially. Provision of ample forage reduced chewing of the walls. The slightly greater weight gain in IE compared with I deserves further investigation.*

Keywords: *animal welfare, behaviour, confinement, farming, red deer*

Introduction

The majority of red deer (*Cervus elaphus*) farmed in New Zealand are kept under extensive pastoral conditions (Moore *et al* 1985). However, indoor wintering of young deer does occur, particularly in the colder regions where benefits include protection of pasture from trampling, protection of animals from inclement weather, and ability to manipulate photoperiod to improve weight gains (Walton 1994; Matthews 1995).

From a welfare perspective, positive aspects of inwintering include protection from wet and cold, but there may be negative aspects including limitations on social spacing and locomotory behaviour. The response of the deer to differences between indoor and outdoor environments may be expressed behaviourally; for instance pacing of enclosure boundaries may indicate motivation to escape (Moore *et al* 1985), while play may indicate that environmental needs have been met (Fraser & Broom 1990). In the present study, the behaviour of groups of deer confined at pasture was compared with that of groups housed indoors, with or without daily exercise, during 91 days over winter (June to September 1990). Productivity (feed intake and weight gain), skin damage and the adrenal output of cortisol following ACTH administration were also measured.

Methods

Study site

The study was carried out at Invermay Agricultural Centre in Otago, New Zealand (45° 52'S, 170°23'E). Mean annual rainfall at Invermay is 691mm and the mean monthly air temperature ranges from 5°C in July to 14°C in January and February (35 year means obtained from New Zealand Metereological Service records).

Animals

Forty-eight hinds born in November-December 1989 and weaned the following March were randomly allocated to six groups of eight, and studied during winter confinement (91 days from June to September). They were fitted with plastic collars for identification at the start of the trial. The deer were given a multi-strain clostridial vaccine on day 14 of the trial and an anthelmintic drench on day 68. In Group 1 (see below), animal G8 died on day 38, with gut lesions consistent with malignant catarrhal fever.

Confinement treatments

Three different methods of confinement were used, with two groups assigned to each method as follows: Indoor with exercise (IE; Groups 1 and 2): 6x4m indoor pens with 2m high solid wooden walls and a sawdust floor. Exercise consisted of daily access for 20min, starting at 1000h or 1020h, to a larger pen (20x4m) and weekly confinement of both groups together outdoors in a 60x40m paddock for 3h starting at 1000h; Indoor (I; Groups 3 and 4): indoor pens as above but without exercise; Outdoor (O; Groups 5 and 6): grazed on short ryegrass pasture in 60 x 40m paddocks, sheltered from the southerly winds by a 5m high hedge (*Cupressus macrocarpa*).

Feeding treatments

For all but 2-weeks of the study, each group was given concentrate feed pellets (deer nuts) *ad libitum* in two, 2m long troughs situated 1m above the floor (indoor groups; IE & I) or one, covered 2.5m trough (pasture groups; O). Water was provided in a trough in the corner of each pen and paddock. The deer were fed each day by the same person. Lucerne hay (80g per animal) was spread in each pen and the pasture enclosures once per day (at approximately 0930h; deer nuts were also replenished at this time). For days 33-46, to increase foraging opportunities, the quantity of hay fed to one IE group (Group 1) and one I group (Group 3) was increased to *ad libitum*, and these groups were given a 40cm high, 30cm diameter (approximately) bark-covered tree trunk (*Pinus radiata*) for chewing.

Measurements

Behaviour during confinement

Behaviour of all groups was observed four times per day (in observation periods starting at 0800, 1000, 1300 and 1500h) on days 26-31 (July) and days 75-79 (September), and indoor groups were observed during these times on days 40-44 (August) during *ad libitum* feeding of hay to Groups 1 and 3. Observations were made from a hide above the indoor pens, or from a car parked 30m from the paddocks, and began when none of the deer were oriented towards the observer. No 1000h or 1300h observations were carried out on days 28, 42 or 77, when both IE groups were exercising outdoors.

For each observation period, all indoor groups were observed together, and both outdoor groups were observed together, with the order of observation (indoor or outdoor groups first) and order of observation of the separate groups, randomized. Each observation period lasted 25min, with each group scanned every 5min and the numbers of individuals performing the following activities recorded: standing, eating (pasture, deer nuts or hay), nosing/chewing others (contacting another animal with the mouth), nosing/chewing the enclosure (walls/fences, doors or troughs), moving (usually walking), or sitting (in sternal recumbency).

Between sampling periods each group was also observed for 60s, once per observation period. During this period, the total number and identity of individuals performing the following specific activities was recorded: instigating or receiving aggression (chases, bites or kicks), chewing or licking other animals, performing stereotyped behaviour (defined as any activity with no apparent purpose occurring in bouts with at least one repetition), and running without chasing 'playing'; (it was necessary to define play in this way because the difference between chases related to aggression and play could not be determined). At the end of the 60s the distances between the individuals were recorded using the categories 0-2m or >2m.

Weight

The deer were weighed on days 1, 14, 33, 47, 71, 91 (before release from confinement), day 91 (5h after release) and day 98.

Feed intake

Intake of deer nuts by each group was measured (by measuring weights fed and subtracting residue weights) over each of the five-day periods of behavioural observation.

Skin damage

Coat damage of each individual was scored at day 91 as: 0 (none), 1 (less than 10 small bare areas of approximately 4–6cm diameter and commonly created by bites from other deer) or 2 (more than 10 small bare areas).

ACTH challenge

On day 85, four deer (chosen randomly from each group) were challenged with adrenocorticotrophic hormone (ACTH). The deer were brought into a central handling pen in their treatment groups, the four to be treated separated from the group and manually restrained. A blood sample was taken via venepuncture in the neck into a heparinised vacutainer, then an intramuscular injection of 1ml of 0.25mg ml^{-1} ACTH (Synacthen™: Ciba-Geigy, Switzerland) was given in the neck region. Further blood samples were taken at 30,

60, 90 and 120min post-ACTH challenge. Groups were treated and sampled sequentially; ie all deer were sampled and given ACTH within one period, and subsequently sampled within the same periods. The order of treatment and sampling of groups was as follows: 5, 3, 6, 2, 4, 1. The blood samples were stored temporarily on ice and then centrifuged and the plasma removed and frozen for later analysis.

Plasma cortisol concentrations were determined using a direct radioimmunoassay based on Young (1986). The assay used an antibody prepared in rabbits against cortisol-3-oxine-bovine serum albumin (Endocrine Sciences, Tarzana, California) and [1,2,6,7-3H] cortisol (Amersham PLC, Amersham, UK). Good parallelism between serially diluted plasma samples and the standard curve was demonstrated. The sensitivity of the assay, based on a 95 per cent confidence interval, was effectively 1ng ml^{-1}.

Response to a novel object

On day 87, the time taken for individual deer in each group to sniff (within 10cm of) a novel object (a 2m metal chimney flue) was recorded, by the person who normally fed the deer. The person placed the object in the home paddock or pen, then backed away from the object to a distance of 4m and remained stationary for 5min recording the response to the object.

Statistical methods

For the scan sampling data, the percentage of times each behaviour was observed in each group was calculated for each time of day for each month. Since there were no significant differences in behavioural patterns between July and September, data for each group for these two months were combined, and analysed by an analysis of variance (ANOVA) fitting treatment, with a contrast between indoor and outdoor treatments. This analysis had three residual degrees of freedom. Changes in liveweight between observation times, coat score on day 91, the response to the novel object, and food intake, were analysed in the same way. Data for August were obtained from a different treatment regime, and were fitted using the main effects of treatment (IE or I) and diet (*ad libitum* or restricted hay; $df = 1$).

To assess behavioural differences with time of day, for scan sampling data, three contrasts were derived for each behaviour: comparing 0800h with the mean of the sampling times for the activities standing, nosing/chewing others, nosing/chewing the enclosure, and moving; 1000h with the mean of the other sampling periods for eating; and afternoon with morning samples for sitting. The means and standard errors of the differences (SED) of these contrasts (adjusted for treatment) are presented.

The behavioural counts for activities observed continuously for 60s between scans did not show significant patterns of change throughout the day, and so totals for July and September combined, and August, were obtained. These were analysed as Poisson generalised linear models (GLMs) with treatment structure as above. Individual coat scores, liveweights at days 33 and 71 and initial plasma cortisol levels were analysed by linear regression, fitting terms for treatment and either overall change in liveweight, or the total number of aggressive interactions received in July and September ($df = 43$).

ACTH challenge data at each sample time were subjected to an analysis of variance (ANOVA) for a completely randomized design, assessing differences between treatment groups with individuals as the experimental unit.

Results

General observations

The deer spent most of the time eating, sitting, standing and walking. Play activities were seldom seen, except when IE groups were released each day for exercise. During indoor exercise periods, IE deer alternately nosed the ground and walls (particularly in the exercise pen) and ran between the home pen and the exercise pen, often jumping, kicking, and bending low on the forequarters in front of other deer (apparently attempting to elicit play). During outdoor exercise periods, much of the time was spent running the full length of the available area, in sporadic bursts, initially involving all animals but then fewer individuals as time passed.

Observations between scan samples revealed that aggressive interactions occurred in sequences, with each recipient of aggression being aggressive to another deer rather than retaliating with the instigator.

Behavioural observations

Activities observed during scan sampling in July and September varied noticeably according to the time of day (Table 1a), with standing being the most common activity at 0800h, eating predominating at 1000h, and sitting predominating in the two afternoon observation periods. Within this strong temporal pattern, some differences between the activities of the animals in the different treatments were seen (Table 1b). Most pronounced, was a higher frequency of nosing/chewing other hinds or the enclosure at 0800h in the indoor groups as compared with the outdoor groups. At this time there was also a tendency for the IE groups to be observed moving, rather than sitting, although the significance of this was masked by high individual variation (Table 1b).

Table 1a **Mean percentages of observations in which various activities were observed during scan samples at each time period and given contrasts between time periods for July and September data combined. Significant differences between time periods are indicated (*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$).**

	Activity (% of observations)					
Time period (h)	**Standing**	**Eating**	**Nosing/chewing others**	**Nosing/chewing enclosure**	**Moving**	**Sitting**
0800	44.6	14.0	3.7	8.7	11.9	16.7
1000	19.2	61.5	1.2	2.0	9.6	5.9
1300	12.9	12.7	0.8	1.8	3.3	68.2
1500	17.9	14.1	2.4	3.3	4.3	57.8
Contrast[1]	27.9[2]	47.9[3]	2.2[2]	6.3[2]	6.2[2]	51.7[4]
SED	2.13	0.85	0.38	0.64	1.26	2.80
Sig	***	***	*	**	*	***

[1] Mean values for time periods as follows:
[2] 0800 - (1000 + 1300 + 1500)/3
[3] 1000 - (0800 + 1300 + 1500)/3
[4] (1300 + 1500)/2 - (0800 + 1500)/2

Table 1b **Mean percentages of observations in which various activities were observed during the 0800h scan sampling, for each confinement treatment, plus SEDs between treatments. Significance of differences between indoor and outdoor treatments are indicated (ns-not significant; *$P < 0.05$, **$P < 0.01$).**

Confinement treatment	Activity (% of observations) Standing	Eating	Nosing/chewing others	Nosing/chewing enclosure	Moving	Sitting
IE	48.7	11.8	5.5	12.8	17.1	3.6
I	49.4	11.9	4.9	10.4	9.1	14.2
O	35.6	18.3	0.6	2.8	9.7	32.4
SED	8.28	2.64	1.46	1.70	2.87	10.5
Sig	ns	ns	*	**	ns	ns

Activities observed during the 1min periods between scans did not show a strong pattern of variation with the time of day. The frequency of aggressive instigations and nosing/chewing other deer was greater ($P < 0.05$) for the indoor groups than the outdoor groups (Table 2), while pacing and playing did not differ significantly between treatments. The percentage of observations in which hinds were within 0–2m of another deer varied between treatments, with outdoor hinds observed less frequently (89.9%) in this distance category than indoor groups (97.4% and 95.4% for IE and I respectively, SED = 1.83; $P < 0.05$).

Table 2 **Mean number of observations in which various activities were observed between scan samples in July and September, for each confinement treatment, plus average SEDs between treatments. Significance of differences between indoor and outdoor treatments are indicated (ns-not significant; *$P < 0.05$).**

Confinement treatment	Activity Instigating aggression	Nosing/chewing others	Pacing	Playing
IE	50.5	10.5	16.0	2.0
I	46.5	9.5	7.5	1.0
O	17.5	0.5	9.5	5.5
Average SED	6.1	3.4	3.5	2.0
Sig	*	*	ns	ns

Results from the 0800h scan sampling of the indoor groups during the different dietary treatments in August, showed a higher frequency of eating and a lower frequency of nosing/chewing the enclosure, in the groups given *ad libitum* hay (Groups 1 and 3) compared with the groups fed normally (Groups 2 and 4; $P < 0.05$; Table 3). Other activities, including nosing/chewing of other deer, did not differ significantly between dietary treatments. Of the activities observed between scans, chewing of other hinds was observed in the groups fed normally, but not in the groups given *ad libitum* hay ($P < 0.05$), while levels of aggression, pacing and playing did not differ between the dietary treatments (Table 4).

Table 3 **Mean percentages of observations in which various activities were observed during the 0800h scan sampling in August, for groups fed *ad libitum* or restricted hay, plus SEDs between dietary treatments. Significance of differences between treatments are indicated (ns-not significant; *$P < 0.05$).**

	Activity (% of observation)					
Dietary treatment	Standing	Eating	Nosing/chewing others	Nosing/chewing enclosure	Moving	Sitting
ad libitum hay	43.5	23.4	5.5	6.3	15.3	2.8
restricted hay	55.0	9.8	4.4	14.8	12.1	3.5
SED	2.26	0.69	1.52	0.15	0.33	3.69
Sig	ns	*	ns	*	ns	ns

Table 4 **Mean number of times in which various activities were observed between scan samples in August (total observation time = 18min), for groups fed *ad libitum* or restricted hay, plus SEDs between dietary treatments. Significance of differences between treatments are indicated (ns-not significant; *$P < 0.05$).**

	Activity			
Dietary treatment	Instigating aggression	Nosing/chewing others	Pacing	Playing
ad libitum hay	38.5	0.0	3.5	3.0
restricted hay	39.0	6.0	1.5	1.5
SED	6.3	1.0	1.6	1.5
Sig	ns	*	ns	ns

Weight gain

Weight gain of the hinds was variable and low during the first two weeks of confinement (Figure 1). During August and September (days 40-44 and 75-79) gains were significantly lower for the outdoor groups than the indoor groups. Overall weight gains from (roughly) day 14 until the end of the confinement period for indoor groups were higher for the exercise treatment ($P < 0.05$). Both indoor groups lost weight on the day of release from confinement (Figure 1). During the period of differential feeding of the indoor groups, mean weight gain for those on *ad libitum* hay was 2.3kg, compared with 1.9kg for those fed normally (SED 0.63kg).

Liveweight at days 33 and 71 was negatively related to the number of aggressive interactions received during the observation periods in July and September, respectively ($P < 0.001$).

Coat damage

Coat damage on day 91 was significantly less for outdoor than for indoor groups ($P < 0.05$; Table 5). It was positively related to change in weight over the total study period ($P < 0.01$) and the total number of aggressive interactions received ($P < 0.01$).

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Novel object

The response to the novel object did not vary significantly between treatments (Table 5).

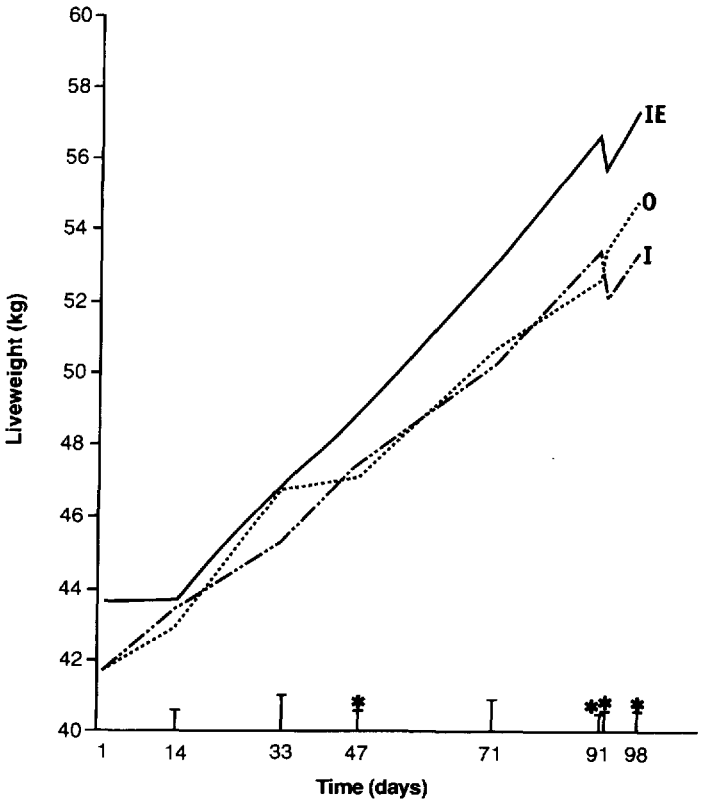

Figure 1 **Mean liveweight (kg) for each confinement treatment at different periods of the study, plus SEDs (* P < 0.05) between indoor and outdoor treatments for changes in liveweight between given and previous times.**

Table 5 **Percentage of deer not sniffing the novel object, and mean coat scores, for each confinement treatment, plus SEDs between treatments. Significance of differences between indoor and outdoor treatments are indicated (ns-not significant; *$P < 0.05$).**

Confinement Treatment	Coat score[1]	% Not sniffing novel object
IE	1.47	26.7
I	1.13	62.5
O	0.63	33.3
SED	0.242	18.4
Sig	*	ns

[1] 0 = none, 1 = moderate, 2 = severe

ACTH challenge

Pre-challenge means showed a significant difference between IE and I treatments (10.6ng ml^{-1} and 5.6 ng ml^{-1} respectively, SED 2.26 ng ml^{-1}; $P < 0.05$; Figure 2). The mean increase in plasma cortisol levels at 30min post-challenge was 61 ng ml^{-1} for Treatment O, compared with 48ng ml^{-1}, (SED 4.0ng ml^{-1}; $P < 0.01$) for Treatments IE and I combined. No further significant treatment differences were found. A negative relationship was found (from fitting the Poisson GLM) between the total number of aggressive interactions received in July and September and initial plasma cortisol levels ($P < 0.05$).

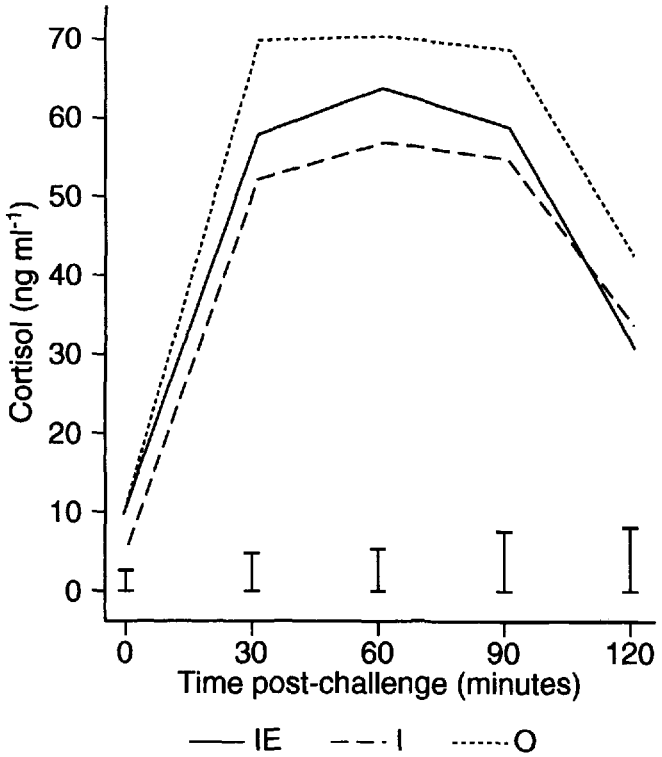

Figure 2 **Plasma cortisol concentrations following intramuscular administration (immediately following sampling at 0min) of 1ml of 0.25ng ml^{-1} ACTH, for I, IE and O groups. Vertical lines indicate SEDs between groups.**

Feed intake

The mean (and SEM) intake of deer nuts consumed per head per day for July, August and September was 1.19±0.02kg, 1.11±0.01kg and 1.39±0.02kg respectively, with no significant difference between treatments.

Discussion

Indoor confinement was associated with more aggression between individuals, reflected in a greater degree of skin damage, compared with confinement at pasture. (The greater degree of skin damage was also possibly related to the higher level of chewing of others indoors.) This suggests that social conditions were more aversive indoors, possibly because the deer

were not able to maintain their desired social spacing (as indicated by the reduced inter-individual distances compared with outdoors). The problem of increased aggression during intensive housing has been previously observed in deer (Hamilton & Soanes 1994; Walton 1994; Matthews 1995), although according to Milne (1994) red deer calves housed indoors for three months following weaning showed lower levels of interaction between individuals than calves grazed at pasture.

Space allowance and group size may be important determinants of the level of aggression in confined deer (Hamilton & Soanes 1994). However, in a study on red deer calves housed in groups of five at densities of 1.8m^2 per head or 4.5m^2 per head, aggressive interactions did not vary with density (Hanlon *et al* 1994). Deer farmers have contended that aggression was minimized when groups consisted of similar-sized individuals (Walton 1994; Matthews 1995), and this was supported in the present study by the finding that the lightest deer received the most aggression. According to one farmer, 'victimization' did not occur in his inwintering groups of 60 wapiti (*Cervus canadensis*) x red hybrid weaner deer, grouped according to size, with a space allowance of 1.35m^2 per individual (Walton 1994).

A second feature of the indoor housing treatments which may have compromised welfare, was the limitation on feeding behaviour. Outdoor groups, which could graze on pasture, spent more time eating (although intake of concentrates was not greater) and less time chewing their enclosure than indoor groups. Indoor deer appeared to compensate for lack of pasture by chewing their enclosure, as this activity was significantly reduced, and feeding increased, when more hay and a tree trunk were provided. Data on chewing of other individuals showed the same trends, although there was an anomaly in that scan sampling showed no difference between dietary treatments, while a difference was observed during sampling between scans. With respect to chewing of the enclosure, Willard *et al* (1977) also found that provision of roughage reduced wood chewing, in a study on horses. Aggression was not affected by roughage allowance in the present study, a finding consistent with a study on pigs (Martin & Edwards 1994).

Provision of daily exercise appeared to have little effect on behaviour of the indoor groups. However, exercise was associated with greater weight gain during the trial. A similar effect was found in a study of pigs, albeit over a limited period within that trial (Murray *et al* 1974), whereas in other studies on pigs, exercise did not affect (Hale *et al* 1984), or reduced (Morrison *et al* 1968; Hale *et al* 1986) weight gain. The apparent effect of exercise in the present study could also be attributed to effects of lighting on weight gain; the pens for I groups were slightly darker than the pens for IE groups, and increased lighting is known to positively affect weight gain over the winter period (Suttie *et al* 1994). Intake of concentrates was not different between exercised and non-exercised groups, a finding consistent with studies on donkeys and ponies (Pearson & Merritt 1991) and cattle (Matthewman *et al* 1993). Some studies on pigs are also in agreement (Hale *et al* 1984, 1986) while in others, exercised pigs have eaten less than those not given exercise (Morrison *et al* 1968; Murray *et al* 1974). The possible effect of exercise on weight gain in young deer housed over the winter warrants further investigation. Demonstration of a beneficial effect of exercise on productivity would encourage farmers to provide it. The deer in the study certainly utilized the opportunity to exercise every day, and the running behaviour of the confined deer when they were released to pasture each week was suggestive of a rebound effect on hitherto suppressed locomotory behaviour (Dawkins 1990).

Responses to the novel object did not differ between confinement treatments. Housing environment might have been expected to alter the reaction of the deer to novelty, as demonstrated in pigs (Pearce & Paterson 1993), rats (Widman & Rosellini 1990) and mice (Chamove 1989).

The ACTH challenge produced interesting results but their interpretation is difficult. The larger post-challenge increase in plasma cortisol levels seen in outdoor deer compared with indoor deer, indicated that adrenal sensitivity differed between deer in the two environments. Studies on other domestic species indicate that chronic stress may enhance or decrease adrenal responsiveness to ACTH (Rushen 1991), so the more stressful environment cannot be identified on this basis. The finding that IE deer had higher baseline plasma cortisol levels than I deer, prior to the ACTH challenge, could possibly be related to anticipation of exercise; in humans, ACTH (and presumably cortisol) levels were elevated prior to a running race (Oltras *et al* 1987). (Anticipation of exercise was also indicated by the tendency for the IE deer to be moving more than other groups at 0800h, prior to the daily exercise period.) The negative relationship between pre-ACTH challenge plasma cortisol levels, and the amount of aggression received by individual deer during confinement, indicated that subordinate animals had the lowest plasma cortisol levels when handling for the challenge began. Studies on other species have shown that the relationship between social status and corticosteroid levels can be positive or negative (Zayan 1991).

Animal welfare implications

Deer confined indoors over the winter are sheltered from bad weather. In the present study they achieved greater weight gains than outdoor deer during August and September, however they may have been compromised socially, as shown by the increased incidence of coat damage and aggression between these individuals when compared with groups confined at pasture. Inwintered deer may also be compromised by limitations on foraging behaviour, but generous provision of foraging substrates should help to overcome this. Possible welfare indicators such as fence/wall pacing and play did not differ between treatments. Although provision of exercise to inwintered groups had no obvious effect on behaviour during confinement, a positive relationship between weight gain and exercise deserves further investigation.

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