# TRANSPORT STRESS AND EXERCISE HYPERTHERMIA RECORDED IN SHEEP BY RADIOTELEMETRY

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**Abstract** *Animal Welfare 1999,* ***8:*** 27-34

*Deep body temperature was measured in four wethers and four ewes surgically implanted with biotelemetry devices. Records were taken over several days in the home pen (baseline data) and also in response to three potentially stressful procedures: transport, exposure to a sheepdog, and forced exercise. Loading the animals into a vehicle and transporting them for 2.5h produced a rise in core temperature that, in males, persisted for several hours. Moving the sheep into an outside pen and subsequent exposure to the dog appeared to produce transient increases in body temperature, although these changes were not statistically significant. By contrast, exercise for 30min resulted in a rapid and pronounced (approximately 2°C) temperature rise that was followed by an equally abrupt return to baseline. Sustained increases in deep body temperature or changes in circadian temperature rhythms in healthy sheep may be a response to psychological distress and, therefore, indicative of poor welfare.*

**Keywords**: *animal welfare, exercise, hyperthermia, sheep, stress*

## Introduction

The physiological basis of body temperature regulation has been extensively studied in sheep both under normal conditions and in animals treated with pyrogens. However, it is not known whether increases in core temperature occur in stressful situations where welfare may be compromised, or whether psychological and physical factors differentially affect thermoregulation in sheep. Nevertheless, it has recently been observed that lambs appear to show an increase in rectal temperature during road transport (D Buchanaeur personal communication 1996).

Hyperthermia is caused by the inability of heat loss mechanisms to compensate adequately for the effects of a thermal or thermogenic stimulus, or by a change in thermoregulatory set-point (fever). However, although exercise causes hyperthermia (Tanaka *et al* 1993), stress can also induce hyperthermia in several species (eg rats, Nakamori *et al* 1993; foxes, Moe 1996; pigs, Parrott & Lloyd 1995; and man, Marazziti *et al* 1992). Moreover, this stress hyperthermia may be prostaglandin-dependent (Singer *et al* 1986; Morimoto *et al* 1987; Parrott & Lloyd 1995) and, therefore, similar to fever (Kluger *et al* 1987). Stress hyperthermia, however, has not been studied in sheep.

Implantable biotelemetry devices provide a convenient means of measuring deep body temperature and have recently been used to investigate the effects of environmental stress in silver foxes (Moe 1996) and ambient temperature in cattle (Lefcourt & Adams 1996). The aim of the present study was to investigate the effects of procedures which might reasonably be supposed to reduce welfare, ie transport, dog exposure and physical exertion, on telemetered deep body temperature in sheep.

## Methods

All procedures were carried out under Home Office Project Licence No 80/1269 and Personal Licence No 70/02655. As four transmitters (VHT-T-1, Mini Mitter Co Inc, Sunriver, Oregon, USA) were available, an investigation was first carried out using four, 10-month-old Dorset wethers and then repeated using four mule ewes of a similar age. The sheep were housed indoors in separate pens (1.5x1.6 m), illuminated by natural daylight and fed hay and concentrates with water available *ad libitum*. Individual sheep were anaesthetized with closed-circuit halothane anaesthesia (1%–2% Fluorothane™, ICI Pharmaceuticals, Cheshire, UK) and, using sterile precautions, implanted with a telemetry device in the abdominal cavity.

The transmitter signals were detected by an aerial mounted above the pens and sent, via an interface, to a portable computer loaded with data processing software (Datacol 5.0™, Mini Mitter Co Inc). Body temperatures were recorded every 5min (although there were some periods where the record was incomplete); the data were also edited to remove occasional aberrant readings. Records were taken over consecutive days (7 days for group 1, 6 days for group 2) in the home pen to provide baseline data (Pen) and used to calculate average daily rhythms for individual sheep. Because these results indicated a nadir between 0600h and 0800h, temperature records taken at 5-min intervals for the subsequent 24h were expressed as the change (in °C) from the mean during this period.

The experimental treatments, all of which were administered when the ambient temperature was low (in November and December), were as follows. In the 'Drive' condition, the sheep were loaded onto a cattle lorry and placed in a communal pen (2.3x1.8 m) with the aerial mounted above and the vehicle driven for 2.5h along major roads. The 'Dog' treatment involved transferring the animals to an outdoor pen (1.5x1.5 m) where they were held for about 2h before a sheepdog was brought into close proximity for 30min. The forced exercise in the 'Run' situation involved driving the sheep around a paddock (41x46 m) for 30min. After each treatment, the animals were returned to their pens.

The mean temperature during the pre-treatment period (ie from 0800h to the start of treatment) was taken as a basal reading, and the changes from this baseline (net change) during and after treatment were calculated. Paired *t*-tests (two-tailed) were then used to compare whether net changes between days spent in the home pen (control) or undergoing treatment (experimental) were significantly different.

## Results

The average changes in core temperature on 'Drive', 'Dog' and 'Run' days are displayed separately for male and female sheep in Figures 1–3, respectively. Each figure also gives the same control data set (Pen). Although estimates of variance have been excluded from the figures for reasons of clarity, overall treatment effects with their SEDs and probability values are given in Table 1.

Both male and female sheep showed a pronounced tendency for body temperature to increase during transport (Figure 1); the mean increase during the 2.5h of driving was 0.59°C in the males and 0.56°C in the females (Table 1). When compared with changes observed during the same time period under control conditions in the home pen, the treatment effect was significant for the females ($P = 0.002$) but only approached significance for the males ($P = 0.07$, Table 1). However, body temperature during the post-treatment period in male sheep was higher (0.31°C, $P = 0.04$) than when they were in the home pen (Figure 1, Table 1).

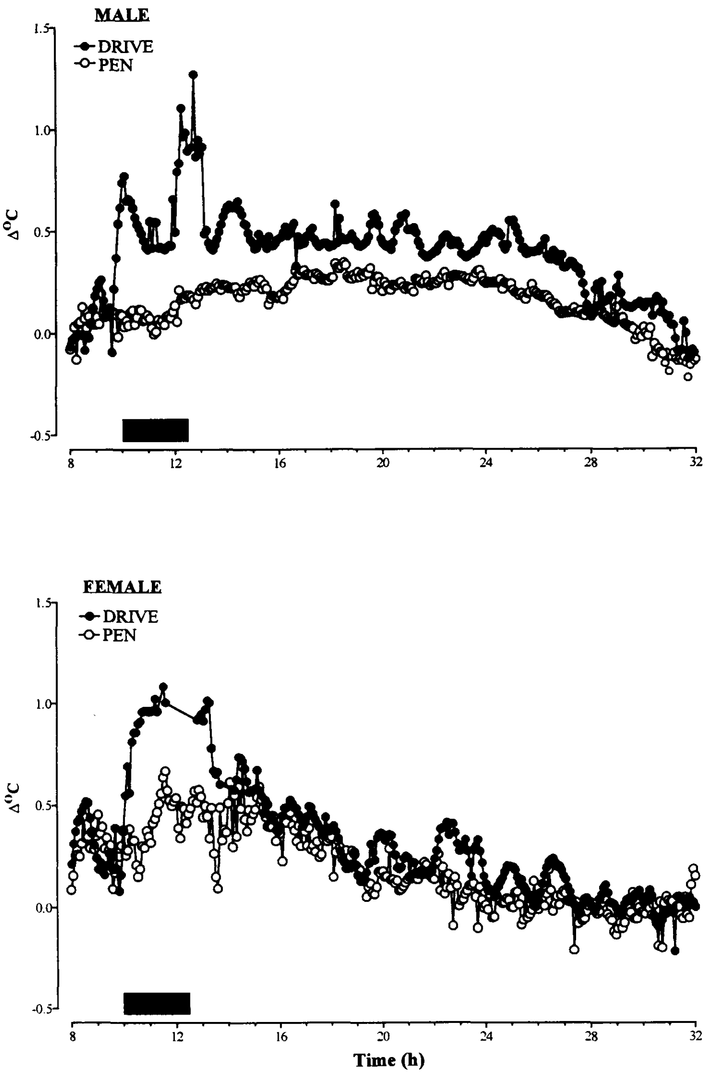


**Figure 1** **Change in deep body temperature (°C; mean of four animals) in male and female sheep on the day of transport (● DRIVE) and in the home pen (O PEN). The 2.5h period of driving is indicated by the shaded bar and the x-axis indicates a 24h time period starting at 0800h. Significant treatment effects are described in the text.**

**Table 1** **Mean changes from baseline core temperature (Δ °C) during and after experimental treatments (Drive, Dog, Run) in male and female sheep, based on data averaged over the relevant time periods; and the between-treatments SEDs and probability values (ns – not significant).**

| **DRIVE** | Male during | Male after | Female during | Female after |
|---|---|---|---|---|
| Control | 0.02 | 0.11 | 0.12 | -0.13 |
| Experimental | 0.59 | 0.31 | 0.56 | -0.05 |
| SED | 0.20 | 0.58 | 0.04 | 0.14 |
| *P* | (0.07) | 0.04 | 0.002 | ns |

| **DOG** | Male pen | Male during | Male after | Female pen | Female during | Female after[1] |
|---|---|---|---|---|---|---|
| Control | 0.03 | 0.12 | -0.21 | 0.03 | 0.08 | 0.12 |
| Experimental | -0.03 | 0.17 | 0.29 | 0.25 | 0.48 | 0.14 |
| SED | 0.22 | 0.24 | 0.29 | 0.26 | 0.34 | 0.05 |
| *P* | ns | ns | ns | ns | ns | ns |

| **RUN** | Male during | Male peak | Male after[2] | Female during | Female peak | Female after[2] |
|---|---|---|---|---|---|---|
| Control | 0.09 | 0.32 | 0.11 | 0.13 | 0.27 | -0.17 |
| Experimental | 0.23 | 2.46 | 0.28 | -0.03 | 2.17 | -0.10 |
| SED | 0.13 | 0.36 | 0.11 | 0.05 | 0.27 | 0.67 |
| *P* | ns | 0.01 | ns | (0.06) | 0.006 | ns |

[1] Records incomplete, see text for details.
[2] Post-peak analysis, 15-32 h period in Figure 3 only.

Both groups of animals appeared to show transient increases in core temperature on entering the outdoor pen and, again, when exposed to the sheepdog (Figure 2). However, none of the averaged changes observed during any part of the 'Dog' tests were significant (Table 1) and the record for the ewes was incomplete due to a receiver fault at 1700h.

The effects of exercise (Run) are shown in Figure 3. Body temperature started to increase in response to exercise, although the mean rise during the 30-min period in the males (0.23°C) was not significantly different from the change observed over the same time period under control conditions (Table 1). In the case of the ewes, the change in core temperature during the exercise period approached significance ($P$ = 0.06) but was actually in the negative direction (-0.03°C) when compared with the control data (Table 1). Subsequently, however, both groups of sheep showed a large increase in body temperature with the peak change differing significantly from control values for both the males (2.46°C, $P$ = 0.01) and the females (2.17°C, $P$ = 0.006; Table 1). No significant differences were detected in the post-peak period (ie the period 15–32 h in Figure 3) for either group of sheep (Table 1).

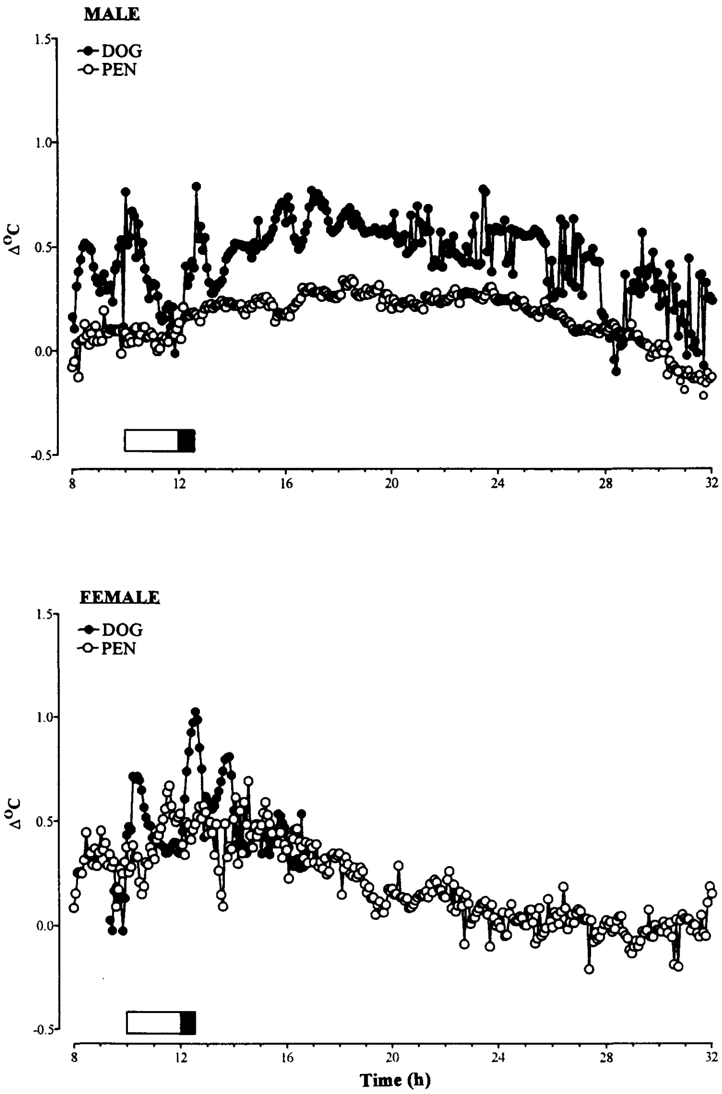


**Figure 2** **Changes in deep body temperature ( °C; mean of four animals) in male and female sheep on the day of dog exposure (● DOG) and in the home pen (O PEN). The bar indicates the time spent in the outdoor pen; the period of exposure to the dog is indicated by the shaded portion. The x-axis indicates a 24h time period starting at 0800h.**

## Discussion

Several investigators (Bligh *et al* 1965; Brown 1971; Mohr & Krzywanek 1990; Johnson 1991) have used telemetric devices or data loggers to record deep body temperature rhythms in sheep. Moreover, data collected outside (Bligh *et al* 1965) or indoors (Mohr & Krzywanek

1990) in temperate regions have revealed a circadian rhythm characterized by a higher core temperature during the day and a low point around sunrise. Similarly, the present study indicated a nadir between 0600h and 0800h, which is in broad agreement with data from sheep housed indoors in the winter (Mohr & Krzywanek 1990).

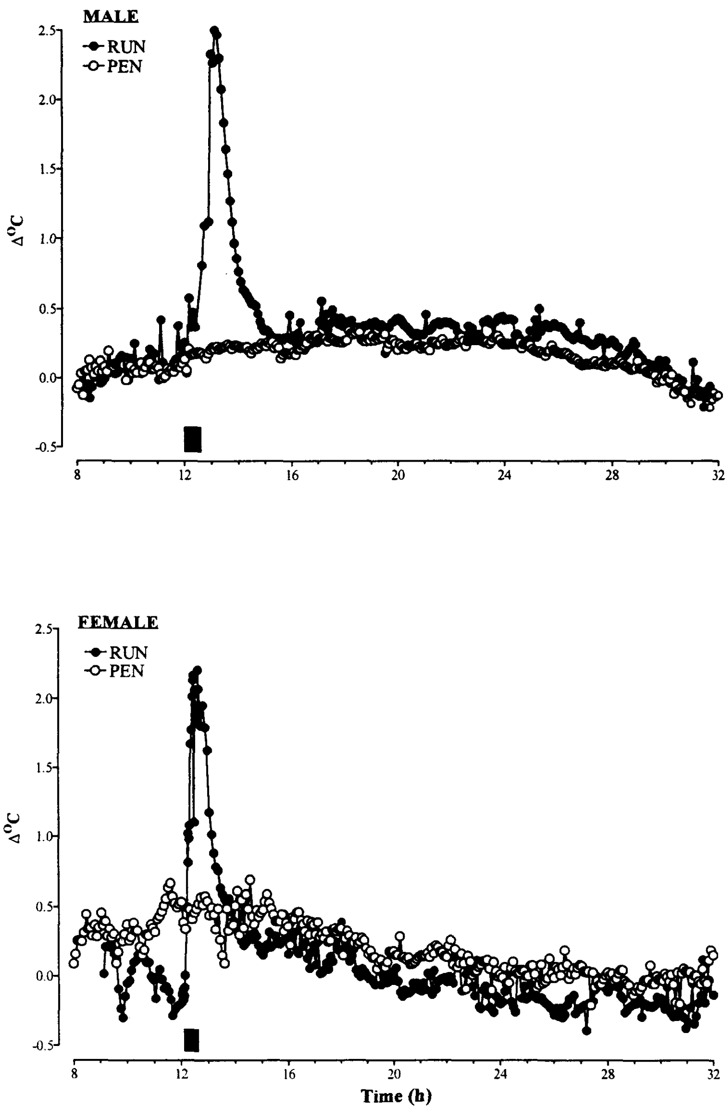


**Figure 3** **Change in deep body temperature (°C; mean of four animals) in male and female sheep on the day of exercise (● RUN) and in the home pen (O PEN). The shaded bar indicates the period of exercise and the x-axis indicates a 24h time period starting at 0800h. Significant treatment effects are described in the text.**

Road transport, especially in its early stages, induces stress hormone release in sheep – although much of this initial effect may be due to loading and the novelty of the situation (Broom *et al* 1996). In the present study, there was an increase in core temperature during transport which persisted for many hours in male sheep, confirming previous observations made using rectal thermometers. The fact that hyperthermia was prolonged in wethers, but not in ewes, may possibly have been related to differences in breed or previous experience.

Factors which may be responsible for the hyperthermia observed during transport include, exertion during loading, muscular activity associated with the maintenance of balance coupled with the inability to dissipate heat effectively within the vehicle, and the effects of psychological stress. Loading would seem to be an unlikely cause of sustained hyperthermia because the exercise data (Figure 3) show that the effects of physical exertion disappear rapidly. Overheating while in the vehicle would also seem to be improbable because there were only four sheep at any one time in a spacious pen within a large, well-ventilated cattle lorry and records were made during the winter when the ambient temperature was low. Moreover, the persistence of the hyperthermic response beyond the transport period does not seem to favour a physical explanation for the observed phenomenon. Instead, the results appear to indicate that psychological factors associated with loading and transport may have been the cause of the hyperthermia. In this connection, it is of interest that long-term perturbations in body temperature rhythms have been reported in rats following acute social stress (Meerlo *et al* 1996).

Exposure to sheepdogs might be expected to induce arousal, and possibly also fear, in sheep. However, no endocrine data are available to indicate whether changes in stress hormone concentrations occurred under the particular experimental conditions used in this study. Although there may have been a transient increase in body temperature when the dog first approached the sheep pen, no significant hyperthermic effects were detected. Therefore, it would seem that if psychological factors can produce hyperthermia in sheep, dog exposure may not be sufficiently aversive for this to occur.

In contrast to the above, the 'Run' treatment induced a large increase in core temperature followed by an equally rapid return to baseline and no sustained after-effect. This suggests that the hyperthermia generated by physical exertion was rapidly dissipated by activation of heat loss mechanisms, ie countercurrent cooling of the blood during panting. However, the fact that core temperature returned to baseline in the home pen in the 'Run' but not in the 'Drive' test implies that different thermoregulatory mechanisms may have been operating.

In conclusion, the results of this study provide suggestive evidence that psychological stimuli associated with road transport can increase body temperature by altering the thermoregulatory set-point (stress hyperthermia), whereas physical activity merely induces a transient thermogenesis.

### *Animal welfare implications*

In addition to recently published data from this and other laboratories indicating that loading and transport can increase heart rate and plasma cortisol concentrations in sheep, the present study suggests that stress hyperthermia may also be induced by such procedures. Moreover, in some individuals, the thermoregulatory changes may outlast the other physiological effects. These findings provide further evidence to support the view that transport compromises the welfare of sheep.

## Acknowledgements

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