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Noise and vehicular motion as potential stressors during the transport of sheep

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Abstract

During three journeys of 15 h in a lorry and two sets of experiments in a trailer, the relative importance of ambient noise and vehicular motion were assessed by measurements of salivary cortisol concentration, heart rate and behaviour. Mean sound levels in the lorry were approximately 96 dbA with occasional episodes at 103 dbA. Vehicular motion was assessed in terms of numbers and magnitude of acceleration events registered by a triaxial accelerometer. The three lorry journeys showed, respectively, that heart rate was correlated with vehicular motion when sheep were loosely stocked (0·41 m^2 per sheep) but not when they were tightly stocked (0·28 m^2 per sheep); that heart rate sometimes tended to increase when ambient sound was greater and that the effect of sound was not as consistent as that of vehicular motion. In the first trailer experiment, salivary cortisol response was the same whether sheep confined in a quiet stationary trailer (60 dbA) were or were not exposed to extra noise (90 dbA) while heart rate was higher in the former condition. In the second trailer experiment when the trailer was being towed on public roads with or without extra noise (92·3 and 100·5 dbA respectively), heart rate and salivary cortisol concentration were both elevated compared with control sheep in a pen but the extra noise had no consistent effect. The sheep showed no orientation away from the noise source, nor was there any difference in their expression of a behaviour (standing with the head below the level of the shoulders) which could indicate discomfort. Hence vehicular motion can result in poor welfare in sheep, especially at loose stocking density but ambient noise was not found to have a consistent effect.

Keywords: *sheep, stress, transport.*

Introduction

During transport livestock may encounter several potentially adverse stimuli. This paper reports experiments aimed to discover whether noise and the physical shocks transmitted to sheep as a result of road or driving conditions, are indeed stressors.

Experiments on noise as a potential stressor during transport have not been reported although there have been studies on the responses of pigs to experimentally generated noise (Talling *et al.*, 1996), of pigs and sheep to recordings made in abattoirs (Anil *et al.*, 1993), of wild sheep to noise from jet aircraft (Weisenberger *et al.*, 1996) and of livestock generally to sonic booms (Ewbank, 1976). Generally, it has been found that after an initial response (measured as change in heart rate or in behaviour) sheep rapidly adapt.

Detailed work on certain aspects of vibration has been reported (Randall *et al.*, 1996). These studies aimed to identify resonant frequencies, which originate from the physical properties of the vehicle and which may evoke similar resonances within the body of the animal, which are well known to be

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stressful. However, as anyone knows who has travelled in a livestock transporter, or even as a standing passenger in a train or bus, while resonances can be perceived, another factor to be considered as a potential stressor is the physical displacement that is experienced when there are sudden positive or negative accelerations due to road conditions or driving style. These accelerations can be resolved into three components, x (up and down), y (side to side) and z (fore and aft).

In this study, observational and experimental studies are reported which attempt to establish whether noise and vehicular motion affect the welfare of sheep during transport, and, if so, which of these potential stressors is more important.

Broom *et al.* (1996) compared the hormonal and physiological effects of sheep undergoing transport in a lorry, with those of sheep confined in a stationary lorry without the stimuli of noise and vehicular motion. The major effects on the measures they used were exerted by the process of loading, and transport itself had only a minor stimulatory effect.

Material and methods

Journeys and experiments

Journey A (May 1995) was in two parts, sheep being taken from Cambridge to a Scottish island, and then, after an interval, south again with a break in lairage during both parts of the study. Heart rates were obtained from the same two sheep during both parts of the study. Another batch of sheep was purchased on the island and heart rate data were obtained from one of these during the southbound part.

Journey B (October 1995) followed the same route as journey A and heart rate data, from two sheep, were gathered during the northbound part. For both journeys the present data come only from the uninterrupted long stages of the journey (15-h duration).

Journey C (November 1994) was the experimental journey of 15 h described by Broom *et al.* (1996). Heart rate data were gathered from one sheep which was also fitted with a temporary jugular catheter for blood sampling.

Experiment D (4 days in September 1995) involved comparison of the heart rate, behaviour and salivary cortisol concentrations of sheep confined in a stationary sheep trailer, with and without extra ambient noise from a petrol-driven generator running without a silencer and venting to the exterior.

Experiment E (2 days in April 1996) involved comparison of the heart rate, behaviour, and salivary cortisol concentrations of sheep confined in a sheep trailer being towed by a car, with and without extra ambient noise provided as described above, with heart rates from sheep in a pen of the same dimensions. Road types included country lanes and motorways.

Vehicles

All journeys used a 7·5-t gross weight livestock lorry (manufacturer: AWD). All experiments used a twin-axle sheep trailer (Ifor Williams type TA5G) with the upper deck panels folded away except for the front section where the generator and video equipment were placed. In journeys A (both parts) and B (southbound only), a generator fitted with standard silencer and an exhaust venting to the exterior was run periodically for the centrifugation of blood samples gathered as part of another study.

Animals and penning arrangements

In journey A there were two batches each of 10 unshorn Clun Forest ewe and castrated male (wether) lambs, mean body weight 45·1 kg. They had been reared together from birth and were randomly selected from a larger flock. One batch ('loose packed') was in a pen of dimensions 1·8 × 2·3 m (0·41 m^2 per sheep) and the other ('commercially packed') was in an adjacent pen of 1·2 × 2·3 m (0·28 m^2 per sheep). The former batch had enough space for all to lie simultaneously while the latter were stocked at a density similar to that observed in commercial practice (S. J. G. Hall, unpublished results). One sheep in each batch carried a heart rate monitor. On the return journey 18 unshorn lambs, the progeny of various crosses among Suffolk, Cheviot and Shetland sheep (mean weight 28·1 kg) and of unknown previous history but probably originating from many different flocks were carried in a pen 1·8 × 2·3 m (0·23 m^2 per sheep). Also in the livestock compartment throughout the journey was an experimenter.

In journey B penning arrangements were as for journey A but the sheep were unshorn mule cross lambs (progeny of various meat sires and Bluefaced Leicester × blackfaced hill breeds), mean body weight 42·5 kg. They had been reared together from birth and were randomly selected from a larger flock. One sheep in each batch carried a heart rate monitor. No experimenter was present with the sheep.

In journey C, the sheep (an unshorn Clun Forest ewe lamb carrying a heart rate monitor) and the penning arrangements were as described by Broom *et al.* (1996) who summarize the heart rate response of this sheep and in the present paper this response is considered in further detail.

In experiment D there were two groups, respectively six mature wethers of various breeds and crosses, mean body weight 72·6 kg, in a pen of dimensions 1·55 × 1·85 m, and six 1-year-old ewes and wethers, selected at random from the 18 sheep brought south in journey A, mean body weight 37·4 kg, in a pen of 1·55 × 1·18 m. All sheep had been shorn about 1 month previously. One sheep in each group carried a heart rate monitor. The former group comprised sheep born in different flocks and kept together for at least 3 years since weaning.

In experiment E, post-breeding unshorn Beulah Speckled Face ewes were used, in groups of six, in the same trailer as in experiment D, in a pen of 1·55 × 3·03 m (0·78 m^2 per sheep). Three sheep in each group carried a heart rate monitor. They had been kept as breeding ewes in the same flock for several years before being culled for age. One group was confined in a pen under cover as a control and the other transported in the trailer. The experiment was repeated with different groups the next day.

Physical measurements
Ambient noise was measured on the linear scale (dbA) with two integrating sound meters (CRL222A, Cirrus Research, Hunmanby, North Yorkshire) reporting to a Grant Squirrel 1200 data logger (as modified by Eltek, Haslingfield, Cambridgeshire). Mean sound pressure levels over periods of 10 min were registered. Calibration was by a Cirrus CRL 511D noise source. Accelerations were recorded with a triaxial accelerometer (EDR1S, Instrumented Sensor Technology, Lansing, Michigan), calibrated by the factory, and set on the basis of previous experience to register shocks of magnitude of at least 0·707 g, and of duration at least 0·012 s in at least one axis. The analogue signal from the accelerometer was digitized at a rate of 400 sample points per s. Dead time after each event was set at 0·48 s. The accelerometer, which is a fully self-contained cube of 13 cm dimension was firmly attached to a pen partition.

The magnitude of each acceleration event in each axis, measured in g, was expressed in terms of PEAK, the largest magnitude positive or negative sample point in each event, root mean square (RMS), the square root of the sum of squares of the deviations from the mean of the sample points divided by the number of samples in the event and the crest factor (CF), which is computed by dividing PEAK by RMS. PEAK measures the extreme of an acceleration event, while RMS is a measure of the average fluctuation about the mean; a high CF indicates an impulsive type of event while a low CF indicates a more vibrational character.

Acceleration data from the present study and from other experiments (S. J. G. Hall, unpublished results) were grouped, giving, for the trailer (and for the lorry in brackets), 2581 (1808) events obtained from 2369 (2627) min of driving time from 7 (5) days of experiments. The loads ranged from six to 20 sheep for the trailer and from 20 to 38 sheep for the lorry. For each vehicle mean PEAK, RMS and CF values were calculated for x (up and down), y (side to side) and z (fore and aft) axes. Variances and means were compared using F and t tests.

Physiological measurements
Heart rate measurements were with the Polar Sport Tester (Hopster and Blokhuis, 1994) except in experiment E when the Polar Vantage was used; this development of the Sport Tester uses coded transmission which enables the simultaneous recording of many animals in a group. Heart rates were registered every min.

Saliva samples were collected on cotton wool buds during experiments D and E for assay of free cortisol (Cooper *et al.*, 1989). Statistical analysis was by analysis of covariance (Helwig and Council, 1979), the concentration after an experimental period being the dependent variable, the concentration before being the covariate and the six treatments being the independent variable.

Behavioural measurements
Video recordings were made during experiments D and E using a tripod-mounted Sony 3CCD camcorder with a semi-fish-eye lens. Behavioural analysis consisted of recording, every minute, the numbers of sheep performing the following mutually exclusive behaviours: lying with or without rumination, standing ruminating, standing not ruminating with the head above the level of the shoulders, or standing not ruminating with the head below the level of the shoulders. These behaviours, among others, were also recorded by Cockram *et al.* (1996).

In experiment D animals were penned in the trailer from 13.00 to 17.00 h on 4 days. Each day was divided into three periods of observation, 13.00 to 14.00 h, 14.30 to 15.30 h, 16.00 to 17.00 h. From the total of 4170 animal-min of observation, records were made from the videotapes every minute of the behaviour, as classified above, of the six sheep in the pen nearer the camcorder. All head butts were noted. Saliva was collected from 12.30 to 13.00 h, 14.00 to 14.30 h, 15.30 to 16.00 h and 17.00 to 17.30 h. Periods of observation were numbered 1 to 12. The unsilenced generator raised ambient noise from about 82 dbA to 96 dbA during periods 5, 6, 8, 9, 11, 12.

In experiment E, when animals had more space to move, records were made from the videotapes every minute of the location and behaviour of individual sheep within the trailer. This was done by dividing the trailer by eye into three equally sized sections, front, middle and rear, and tabulating for each section how many sheep were positioned with their head in that section. Replicated G tests (Sokal and Rohlf, 1981) were applied to test whether, as would be expected were orientation at random, one-third of observations were of sheep with their head in the front section. The six periods of video recording averaged 44 min; 135 min were recorded during periods of the two treatments, driving with extra ambient noise and 128 min during driving alone. The number of sheep standing with the head below the level of the shoulders was compared, between the six periods and between the two treatments by unbalanced hierarchical anovar (Moore and Edwards, 1965).

Data handling and statistical analysis

For journey A, accelerometer data during driving were limited to 35 10-min periods of the northbound part and to 32 10-min periods of the southbound. Spearman correlation coefficients were calculated between the median heart rate of each sheep and the number of acceleration events recorded during each of these periods. Journeys B and C were divided into periods of 10 min and, for each period, median heart rate, number of 10-min periods since the journey began, mean ambient sound pressure level, and number of acceleration events were tabulated. The GLM procedure of SAS was used to carry out multiple regression of median heart rate on the other three variables.

Results

Physical conditions

Acceleration events. Acceleration events were more frequently registered with the trailer than with the lorry (Table 1). RMS in all axes, PEAK x and CF y were more variable with the trailer, CF z with the lorry. The lorry showed greater PEAK and RMS in the z axis but PEAK x and y and RMS in all axes were greater for the trailer. In experiment E, numbers of acceleration events registered were 255 during the 1st day and 195 during the 2nd day.

Noise levels. In journeys A and B, the noise level while the lorry was driving was approximately 96 dbA. This increased to 103 dbA when the generator was run for processing samples. In experiment D, sound levels in the stationary trailer with and without the extra noise from the unsilenced generator were approximately 90 and 60 dbA respectively. In experiment E, when the trailer was towed, the corresponding figures were 100·5 and 92·3 dbA respectively.

Physiological results

Heart rate. For the northbound part of journey A, the correlation coefficients between median heart rate and number of acceleration events were, for the sheep in the commercially packed group, –0·07 (no. = 35, $P > 0{\cdot}05$) and for that in the loosely packed group, 0·52 (no. = 35, $P < 0{\cdot}01$). There were four stops during the northbound part and the median heart rates during each of the intervening periods of driving were, for the former sheep, 81·5, 80, 83, 72, 73 and for the latter sheep 99, 86·5, 90, 88, 76 beats per min (b.p.m.). On the return journey coefficients were, respectively, 0·08 (no. = 32, $P > 0{\cdot}05$) and 0·09 (no. = 32, $P > 0{\cdot}05$). That for the sheep from the batch purchased for the southbound journey only was 0·02 (no. = 32, $P > 0{\cdot}05$). There were five periods of driving and median heart rates during each were as

Table 1 *Comparison of the acceleration characteristics of the lorry (journeys A-C) and of the trailer (experiment E) (F and t statistics are given for comparison of variances and means, when these were statistically significant)*

	Driving time (min)	No. of events	Events per min	PEAK			RMS			CF		
				x	y	z	x	y	z	x	y	z
Lorry	2627	1808	0·69									
mean				0·5516	0·6897	1·2744	0·1122	0·1480	0·2689	4·5862	4·5381	4·8328
s.d.				0·4756	0·5566	0·9126	0·0423	0·0554	0·0812	1·9604	1·5867	1·7271
Trailer	2369	2581	1·1									
mean				0·9643	0·7754	1·2548	1·2145	0·1639	0·2817	4·5542	4·6018	4·5698
s.d.				0·5672	0·5189	0·5536	0·0707	0·0628	0·0819	1·9341	1·6940	1·6453
F				1·422			2·789	1·286	1·018		1·140	
t				26·12	5·055		59·80	8·877	5·116			–5·06

Significance levels for $P < 0{\cdot}05$: F, 1·00; t, 1·96.

Table 2 *Journey B: multiple regression of median heart rate during a 10-min period, upon time elapsed since start of journey, mean sound pressure level (SPL), and number of acceleration events during that period*

(a) Heart rate of sheep in commercially stocked group
$F_{3,77} = 23{\cdot}48, P < 0{\cdot}001, R^2 = 0{\cdot}478$
Significances of contributions of independent variables to total type 1 SS:

time elapsed	$F_1 = 51{\cdot}26$ $P < 0{\cdot}001$
SPL	$F_1 = 16{\cdot}42$ $P < 0{\cdot}001$
accelerations	$F_1 = 2{\cdot}77$ $P = 0{\cdot}1003$

(b) Heart rate of sheep in loosely stocked group
$F_{3,71} = 9{\cdot}57, P < 0{\cdot}0001, R^2 = 0{\cdot}288$
Significances of contributions of independent variables to total type 1 SS:

time elapsed	$F_1 = 9{\cdot}51$ $P < 0{\cdot}01$
SPL	$F_1 = 5{\cdot}85$ $P < 0{\cdot}05$
accelerations	$F_1 = 13{\cdot}33$ $P < 0{\cdot}001$

follows, for the three sheep respectively: 78·5, 63, 60, 58, 56; 88, 69, 65, 62, 67; 142·5, 119, 106, 106, 118·5 b.p.m. Similar results were obtained for journey B (Table 2); stocking rate was found to influence response to acceleration events in that the heart rate of the sheep in the loosely stocked group was elevated when road conditions were rough while that of the sheep in the commercially stocked group was not. For both sheep, response was strongest to time elapsed since the start of the journey, i.e. the heart rate declined as the journey proceeded. Increased ambient noise was, for both sheep, associated with increased heart rate.

In journey C (Table 3), time elapsed was of prime importance in influencing heart rate and the effect of number of acceleration events may have been closer to significance than that of ambient noise. Heart rate was around 100 b.p.m. at the start of the journey and 80 b.p.m. at the end.

In experiment D, mean heart rates during quiet confinement were higher than when there was extra noise, 77·9 (s.e. 0·276) and 65·8 (s.e. 0·568) for the first sheep and 66·6 (s.e. 0·269) and 61·6 (s.e. 0·278) for the second; differences between treatment and day were significant ($F_{3,2898} = 296{\cdot}5$ $P < 0{\cdot}001$).

Table 3 *Journey C: multiple regression of median heart rate during a 10-min period, upon time elapsed since start of journey, mean sound pressure level (SPL), and number of acceleration events during that period*

$F_{3,79} = 12{\cdot}70, P < 0{\cdot}0001, R^2 = 0{\cdot}325$
Significances of contributions of independent variables to total type 1 SS:

time elapsed	$F_1 = 34{\cdot}71$ $P < 0{\cdot}001$
SPL	$F_1 = 0{\cdot}65$ $P = 0{\cdot}4208$
accelerations	$F_1 = 2{\cdot}75$ $P = 0{\cdot}1013$

Table 4 *Experiment E: mean (s.e.) heart rates. Pairwise comparisons (between control and treatment, and between treatments) within days all indicated significant differences (P < 0·001)*

Day 1			
Control	69·4 (1·2)	Driving	82·9 (1·4)
Control	71·1 (1·2)	Driving extra noise	114·6 (4·3)
Day 2			
Control	65·6 (0·3)	Driving	103·2 (1·4)
Control	68·8 (0·3)	Driving extra noise	86·3 (1·2)

In experiment E, mean heart rates during the treatments and controls were as given in Table 4. Heart rate was elevated during driving, compared with that of sheep in a pen but the response to extra noise differed between days.

Salivary cortisol. In experiment D, the concentration of salivary cortisol at the end of treatment was not significantly influenced by treatment ($F_{11,118} = 1{\cdot}08$), by concentration before treatment ($F_{1,118} = 0{\cdot}17$), or by individual sheep ($F_{11,118} = 1{\cdot}82$, $P = 0{\cdot}058$), and the overall analysis of covariance was not significant ($F_{23,118} = 1{\cdot}39$).

In contrast, in experiment E, treatment did influence the concentration of salivary cortisol, as did the concentration prior to treatment (Table 5).

Behavioural results
In experiment D, there was a total of (695 × 6 = 4170) observations of individual sheep. Numbers of observations of the different behaviours were, lying 2182, standing ruminating 631, standing 1328, standing with the head down 29. At each

Table 5 *Experiment E: analysis of covariance of concentration of salivary cortisol after control, exposure to driving, exposure to driving with extra ambient noise*

$F_{6,37} = 12{\cdot}70, P < 0{\cdot}001, R^2 = 0{\cdot}58$
Significances of contributions of independent variables to total type 1 SS:

treatment	$F_5 = 8{\cdot}00, P < 0{\cdot}001$
concentration before	$F_1 = 11{\cdot}17, P < 0{\cdot}05$

Least-squares means with superscript indicating significant differences of means (Duncan's test):

Control day 1	$1{\cdot}77^a$
Control day 2	$2{\cdot}46^a$
Drive day 2	$4{\cdot}76^b$
Drive and extra noise day 2	$4{\cdot}98^b$
Drive day 1	$7{\cdot}17^b$
Drive and extra noise day 1	$8{\cdot}62^b$

Table 6 *Experiment D: mean number and analysis of variance of number of sheep lying or standing ruminating at each scan*

			Mean no.
Lying			
	Treatment:	confinement in trailer	3·15
		confinement in trailer with extra noise	3·13
Results of anovar:			
treatment		$F_{1,683} = 0{\cdot}021$	$P > 0{\cdot}05$
batch		$F_{10,683} = 19{\cdot}95$	$P < 0{\cdot}001$
Standing ruminating			Mean no.
	Treatment:	confinement in trailer	1·13
		confinement in trailer with extra noise	0·65
Results of anovar:			
treatment		$F_{1,683} = 41{\cdot}39$	$P < 0{\cdot}001$
batch		$F_{10,683} = 11{\cdot}44$	$P < 0{\cdot}001$

observation, when there was no extra noise, the average number of sheep lying was 3·15 and when there was extra noise, 3·13. Considering numbers standing ruminating, corresponding figures were 1·13 and 0·65 (Table 6).

In experiment E, there was a total of (263 × 6 = 1578) observations of individual sheep. Numbers of observations of the different behaviours were, lying 138, standing with or without rumination 999, standing with the head down 441. No butting was detected. When the unsilenced generator was operating 28·5% of observations were of sheep with their head in the front section of the trailer. When it was quiet, this proportion was 24·8%. These proportions are both significantly different from what would be expected were sheep distributed evenly among the trailer sections (respectively G = 4·4 and 55·8, d.f. 1, $P < 0{\cdot}05$ and 0·001). At each observation, when there was movement alone, the average number of sheep standing with the head lowered was 1·850 and when there was movement and extra noise, 1·855. There was heterogeneity between observation periods ($F_{4,232} = 7{\cdot}56$, $P < 0{\cdot}001$) but not between treatments ($F_{1,232} = 0.001$, $P > 0{\cdot}05$). With movement alone, the average number of sheep lying was 0·469 and when there was extra noise, 0·607.

Discussion

Previous studies have suggested that the response of sheep to transport in a lorry is not very different from that to confinement in a stationary lorry (Broom *et al.*, 1996). The dominant event in terms of evoking a cortisol response is novelty, and such responses though marked at the beginning of a journey become less obvious as the journey proceeds, implying that adaptation progresses. The present study has shown that sheep can respond to increased levels of ambient noise and to vehicular motion. While the high level of ambient noise in livestock transporters has been commented upon (Knowles *et al.*, 1993) this is the first assessment of its likely significance for welfare. With standards for vehicle design currently under discussion it is essential to know the importance of reduction in noise and improvement in ride quality. It is clear that, as Randall *et al.* (1996) showed for vibrations of a resonant character, vehicles differ markedly in the kinds of shocks they impart to livestock. As would be expected, the lorry imparted a less variable and less extreme range of shocks than the trailer, except that in the fore and aft axis the trailer was less violent. Perhaps the better characteristics of the lorry in the side to side and up and down axes reflect a more advanced suspension design while the less severe fore and aft accelerations of the trailer may have been a reflexion of it being more carefully driven to avoid excessively violent acceleration, braking and gear changing. The greater variability noted with the trailer probably reflects the varied loads carried on the journeys that contributed to the data analysed here.

On the long journeys, measures of heart rate consistently showed the importance of time elapsed. Whether vehicular motion was correlated with changes in heart rate depended on whether sheep were tightly or loosely packed. There was some evidence of high levels of ambient noise being linked with elevation of heart rate during the long journeys but this was not consistent. The multiple regression analysis of the long journeys showed an elevation of heart rate during periods when there were many acceleration events and to a lesser extent when ambient noise was increased.

When sheep were exposed to extra noise in the stationary trailer (experiment D), heart rate was reduced and there was no change in salivary cortisol concentration. There was no difference in lying behaviour, so it seems unlikely that the extra noise caused a depression of more active behaviours thus reducing heart rate. However, standing rumination seemed to have been inhibited by the extra noise but this would only account for a small proportion of the change — Baldock *et al.* (1988) found that ruminating increased heart rate by about 2 b.p.m. over standing alone. Previous studies (Bradshaw *et al.*, 1996) showed that social interactions could be important while sheep are being transported but in the present studies butting scarcely occurred. Indeed, it is not a simple matter to select behaviours as potential indicators of stress in sheep during transport; lying down is an obvious behaviour but there is a strong imitative and idiosyncratic element. One behaviour sometimes seen during long journeys (S. J. G. Hall, personal observation) and quantified though not discussed in detail by Cockram *et al.* (1996) is standing with the head below the level of the shoulders. As this is also seen in sheep during such presumably unpleasant experiences as exposure to driving rain, it could indicate distress. This behaviour (standing head down) is considered in detail elsewhere (S. J. G. Hall, unpublished results).

Standing head down was seldom seen in the experiment with the stationary trailer and in the experiment with the moving trailer with or without extra ambient noise (experiment E), incidence of this behaviour did not vary with noise level. However sufficient variability in its expression was seen to justify further research.

When on the moving trailer, heart rate increased with extra ambient noise during the 1st day of observations but not when a different batch of sheep was tested during the 2nd day. Salivary cortisol showed a suggestion of an increase with the extra noise but this was not statistically significant and there was no difference in behaviour.

The general conclusion is that the hypothesis that in transport, the most stressful events are those associated with novelty and loading, continues to be supported. The effects of vehicular motion may be reduced when stocking density is high and evidence of any effects of ambient noise on the stress indicators currently available is not strong.

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