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Heart rate response as a measure of stress and welfare in cattle

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ABSTRACT

Problems exist in welfare quantification of stressors due to variation in animal responses. A theory, based on adaptation to repeated exposure of a stressor, is proposed for objective assessment of welfare.

Cattle of three ages were exposed repeatedly to transport, or aspects of transport. Cattle aged 6 weeks showed a declining tachycardic response to repeated transport ($p<0.05$). Cattle aged 3-6 months showed no consistent pattern of heart rate response to transport, although bradycardia was observed in some animals. Bradycardia was also observed in 2 year old bulls, the incidence of which declined with repeat exposure to trailer loading. Heart rate decreased over transport in bulls unfamiliar with trailer loading ($p<0.05$), while no change in heart rate was seen in bulls familiar with a trailer.

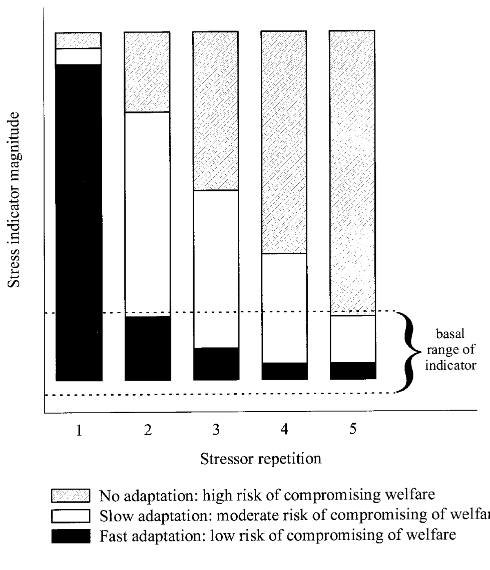
Keywords: stress; welfare; heart rate; adaptation.

INTRODUCTION

Assumptions about the welfare of an animal may be drawn from it's responses to stress. However, physiological and behavioural stress responses can vary widely. Different stressors may elicit different responses in the same animal, and the same stressor may elicit different responses in various individuals (Moberg, 1985). This can complicate objective assessment of welfare.

The aim of the present study was to examine, preliminarily, a method for quantifying welfare by determining an animal's ability to cope through adaptation to repetition of a stressor. Monitoring adaptation rate to repetition of a stressor, based on a declining response of stress indicators, may provide an individual index of the welfare repercussion (Figure 1).

FIGURE 1: Schematic representation of repeat stressor and adaptation rate model for the assessment of animal welfare.



Cattle responses to an acute stressor, such as transportation, include increases in heart rate, adrenaline, cortisol and non-esterified long chain fatty acids (Stephens and Toner, 1975; Kent and Ewbank, 1983; Kenny and Tarrant, 1987; Agnes *et al.*, 1990; Sartorelli *et al.*, 1992). These acute stress indicators exhibit habituation with repeat exposures to stress such as sham-shearing in sheep (Hargreaves and Hutson, 1990), and transport simulation in pigs and calves (Stephens, 1982; Locatelli *et al.*, 1989). As these indicators respond in an acute fashion, and are subject to habituation with stressor repetition, they are ideally suited for use in the present study. Due to the preliminary nature of the work, a single stress indicator that can be obtained non-invasively, heart rate, is presented in this paper. Confirmation of an adaptation model may then suggest use of multiple stress indicators, as multivariate approaches facilitate more reliable interpretation of stress and welfare studies (Moberg, 1985).

Animal age affects aspects of cardiovascular control (Ferrari *et al.*, 1989; Barringer and Bunag, 1991; Sebastiani *et al.*, 1994), and also learning (Strayer and Kramer, 1994), therefore age was included as a factor in the experiment.

MATERIALS AND METHODS

The experiment was conducted in two trials:

Trial 1

Four 6 week (65-85 kg liveweight) and four 3-6 month (80-150 kg liveweight) old Friesian cattle were used. Animals were handled daily for 7 days prior to the trial and were acclimatized to wearing remote telemetric electrocardiogram (ECG) units (MIRINZ, Hamilton).

ECG telemetry units were fitted 40 minutes before transportation of calves in a trailer for 40 minutes on sealed rural roads. ECGs were recorded immediately before loading, after unloading, then again 40 minutes later. The transportation procedure was repeated a further two times for a total of three transportations per animal.

Trial 2

Forty rising 2 year old Friesian bulls (490-520 kg liveweight) were randomly allocated into two groups of twenty.

A total of five familiarisation training sessions were conducted with one of the groups of bulls over two weeks. In each training session ECGs were recorded prior to loading on a trailer where 5kg of meadow hay had been spread. After 15 minutes, bulls were unloaded and ECGs again recorded.

Five days after completion of training, both groups of 20 bulls were transported to the abattoir on a single commercial truck and trailer unit. ECGs were recorded from all 40 bulls prior to loading. Care was taken to ensure the mobs were not mixed before, during, or after the transport. Transit time was 2 hours. After unloading, ECGs were again recorded.

ECG's from Trial 1 and 2 were later used for the derivation of heart rate.

Statistical Analyses

Trial 1 data were analysed for the effect of transport, and it's repetition, on heart rate within each age group. The effect of age and familiarisation on heart rate response (change in heart rate) to the transportations was assessed using differences in heart rate from pre-loading to immediately after unloading. Trial 2 data were analysed to assess the effect of training on heart rate during training, and after training, when both trained and untrained bulls were transported to an abattoir. Statistical analyses were conducted using analysis of variance (ANOVA). On detection of a significant treatment difference, Student-Newman-Keuls pairwise multiple comparisons were used to assess the effect of group means within treatments. Analyses were conducted using SigmaStat™ statistical software (Jandel Scientific Software, USA, 1992).

RESULTS

Mean heart rate of the 6 week old calves was significantly affected by the first transportation ($p < 0.05$), demonstrating an increase of 22 beats per minute (bpm) from pre-loading to immediately following unloading after transport. Heart rate measured 40 minutes after unloading was not significantly different from pre-loading (Figure 2).

On the second and third transportations of 6 week old calves, mean heart rate measured immediately following unloading was not significantly different from that measured pre-loading or 40 minutes after unloading (Figure 2).

In 3-6 month old calves mean heart rate was not significantly affected by initial or subsequent transportations (Figure 2). Heart rate of 3-6 month old calves was significantly lower ($p<0.001$) than those of 6 week old calves throughout all transportations.

The effect of familiarisation on change in heart rate was dependant on age ($p<0.10$). The 6 week old calves showed the greatest change in heart rate with initial transport. This change decreased steadily with transport repetition, and by the third transportation, heart rate change was less than half that demonstrated in the initial transport. In comparison to this, 3-6 month old calves showed mean changes in heart rate, with initial and subsequent transport, smaller in magnitude than the standard errors of the mean (SEM, 6.1-7.6 bpm).

In trial 2 data from the second training session were lost because of a computer fault. No significant differences were found in mean heart rate across training sessions, or between loading and post unloading heart rates within training sessions (Figure 3).

When transported to the abattoir, heart rate was significantly lower ($p<0.01$) in the trained than the untrained group before and after unloading (Figure 4). The untrained

FIGURE 2: Mean (±SEM) heart rate of 6 week and 3-6 month old calves, pre, post and 40 minutes after 3 transportations carried out on separate days.

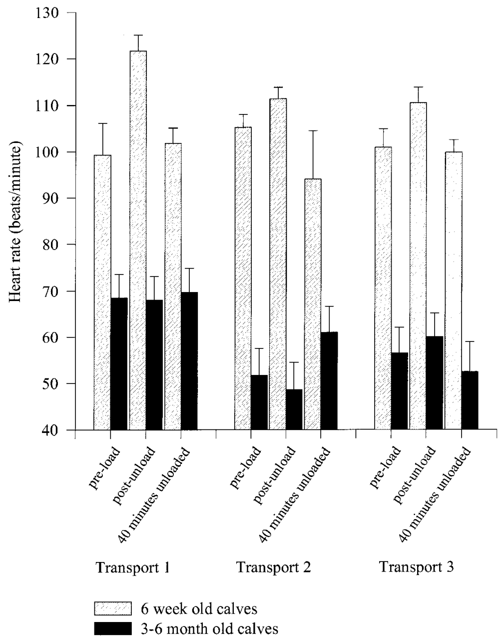


FIGURE 3: Mean (±SEM) heart rate of 2 year old bulls before and after loading on a transport trailer during 5 familiarisation training sessions over 2 weeks (n=20).

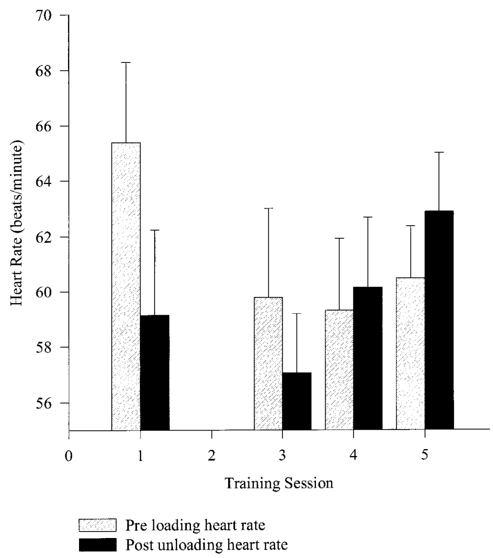
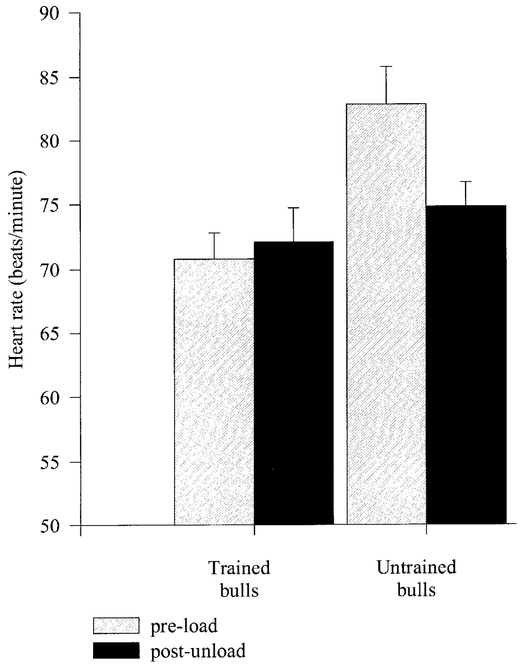


FIGURE 4: Mean (± SEM) heart rates of two groups of bulls (n = 20 per group), one familiar with transport trailer loading and unloading (trained), the other not (untrained); before and after 2 hour transportation to an abattoir.



bulls showed a significant decline in mean heart rate ($p<0.05$) over the transportation procedure. The trained group, however, demonstrated no significant difference between heart rates recorded before loading and immediately after unloading.

DISCUSSION

Changes in heart rate with transportation have been recorded previously in cattle, usually as an increase in heart rate (Stephens and Toner, 1975; Kenny and Tarrant, 1987). Six week old calves in the present study similarly showed an increased heart rate in response to initial transport. The 3-6 month old calves, however, displayed no consistent pattern with transport.

Heart rates of the 3-6 month old cattle recorded before and after transport appeared low in comparison to the 6 week old calves in the present trial, and with heart rate of young cattle reported in the literature (Stephens and Toner, 1975; Amory *et al.*, 1993). Heart rates below 60 bpm (and particularly below 48 bpm) have been considered bradycardic by some researchers (Clabough and Swanson, 1989; McGuirk *et al.*, 1990). Individuals in the 3-6 month old group recorded heart rates as low as 42 bpm immediately after transport, suggesting some bradycardia. None of the 6 week old calves demonstrated heart rates that could be considered bradycardic.

In trial 2 basal heart rates were estimated as the 99% confidence interval around the mean heart rate obtained before loading for the 4 training sessions. This provides a basal range of 58-65 bpm, a range supported by literature (Clabough and Swanson, 1989; McGuirk *et al.*, 1990). If bradycardia is considered to have occurred when heart rate fell below 58 bpm, then of the 20 trained bulls, 9 demonstrated bradycardia after unloading in the first training session. This incidence of bradycardia declined with training and no trained bulls demonstrated bradycardia with transportation to an abattoir.

Emotional stimuli and fear may cause bradycardia (Porges, 1985; Sebastiani *et al.*, 1994). Possibly, in the present study some of the 3-6 month old calves, and 2 year old bulls were initially displaying a fear-elicited, or a fear contribution to the, bradycardic response.

The untrained bulls showed a mean decrease in heart rate after transportation to an abattoir. This decrease may not necessarily represent bradycardia, as pre-transport heart rate in this group appeared elevated (83 bpm) in comparison with literature (Clabough and Swanson, 1989) and estimated basal heart rate range for the trained bulls. After transport, the lowest heart rate recorded in the untrained bulls was 58 bpm. This suggests the possibility of a gradual return of the group to a normal basal heart rate over transport. Alternatively, bradycardia may have been expressed post-transport in this group.

A higher pre-loading heart rate, prior to abattoir transport, of the untrained bulls may be explained by the adjacent presence of trained bulls in the yards, from which ECGs had been recorded prior to yarding the untrained bulls. Social stimuli in transport situations can increase heart rate in young bulls (Kenny and Tarrant, 1987).

Transport not only produced a bradycardic, rather than tachycardic, response in some cattle in the present study, but also this response appeared more prevalent in the two older age groups.

In pigs, baroreflex sensitivity increases from birth to six weeks of age (Patton and Hanna, 1994), and balance between parasympathetic and sympathetic activities also changes with age (Smirne *et al.*, 1987). These observations support the speculation that age related changes in autonomic heart rate control may have contributed to the bradycardia observed in the present trial.

Familiarisation may alter the magnitude, and type of heart rate response (tachycardia or bradycardia) to a stressor. The 6 week old calves showed a decreased tachycardic response to repetition of transport, suggesting adaptation. This is supported by other transport studies using adrenal response (Locatelli *et al.*, 1989). Results also suggest that familiarisation may reduce the magnitude of heart rate response (bradycardia) to transportation procedures in 2 year old bulls. The 3-6 month old calves in the present study demonstrated no clear adaptation. This may indicate either (1) failure of the 3-6 month old calves to adapt, (2) may be a reflection of a respective variation in chronological stress response development of individual calves, or (3) a dynamic phase in development of heart rate control. Should point (3) prove correct, it would suggest that heart rate may not be an ideal stress indicator for assessment of welfare in 3-6 month old calves.

In terms of welfare, the present study indicates that in cattle aged 6 weeks or 2 years old, heart rate response to a novel stressor in the form of transport can be reduced with repeated application of the stressor. This supports the possibility of using adaptation to a stressor as a potential welfare indicator.

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REFERENCES

Agnes, F.; Sartorelli, P.; Abdi, B.H. and Locatelli, A. (1990). Effect of transport loading or noise on blood biochemical variables in calves. *American Journal of Veterinary Research* **51:** 1679-1681.

Amory, H.; Rollin, F.A.; Genicot, B.C.; Beduin, J.L. and Lekeux, P.M. (1993). Comparative study of the body surface electrocardiogram in double-muscled and conventional calves. *Canadian Journal Veterinary Research* **57:** 139-145.

Barringer, D.L. and Bunag, R.D. (1991). Autonomic regulation of reflex bradycardia in rats declines with age. *Experimental Gerontology* **26:** 65-75.

Clabough, D.L. and Swanson, C.R., 1989. Heart rate spectral analysis of fasting-induced bradycardia of cattle. *American Journal of Physiology* **257:** R1303-R1306.

Ferrari, A.U.; Daffonchio, A.; Gerosa, S. and Mancia, G. (1989). Age-related alterations in cardiac parasympathetic responsiveness: a preliminary report. *Journal of Hypertension. Supplement* **7:** S16-17.

Hargreaves, A.L. and Hutson, G.D. (1990). Some effects of repeated handling on stress responses in sheep. *Applied Animal Behaviour Science* **26:** 253-265.

Kenny, F.J. and Tarrant, P.V. (1987). The reaction of young bulls to short-haul road transport. *Applied Animal Behaviour Science* **17:** 209-227.

Kent, J.E. and Ewbank, R. (1983). The effect of road transportation on the blood constituents and behaviour of calves. I. Six months old. *British Veterinary Journal* **139:** 228-234.

Locatelli, A.; Sartorelli, P.; Agnes, F.; Bondiolotti, G.P. and Picotti, G. B. (1989). Adrenal response in the calf to repeated simulated transport. *British Veterinary Journal* **145:** 517-522.

Mc Guirk, S.M.; Bednarski, R.M. and Clayton, M.K. (1990). Bradycardia in cattle deprived of food. *Journal of the American Veterinary Medical Association* **196:** 894-896.

Moberg, G. P. (1985). Biological response to stress: key to assessment of animal well-being? *In:* Animal Stress. Ed. Moberg, G.P. American Physiological Society, Maryland. pp 27-49.

Patton, D.J. and Hanna, B.D. (1994). Postnatal maturation of baroreflex heart rate control in neonatal swine. *Canadian Journal of Cardiology* **10:** 233-238.

Porges, S.W. (1985). Spontaneous oscillations in heart rate: potential index of stress. *In:* Animal Stress. Ed. Moberg, G.P. American Physiological Society, Maryland. pp 97-111.

Sartorelli, P.; Dominoni, S. and Agnes, F. (1992). Influence of duration of simulated transport on plasma stress markers in the calf. *Journal of Veterinary Medicine. Series A* **39:** 401-403.

Sebastiani, L.; Salamone, D.; Silvestri, P.; Simoni, A. and Ghelarducci, B. (1994). Development of fear-related heart rate responses in neonatal rabbits. *Journal of the Autonomic Nervous System* **50:** 231-238.

Smirne, S., Ferini-Strambi, L., Montanari, C. and Canal, N. (1987). Age-related modifications of heart rate during sleep-wakefulness cycle. *Functional Neurology* **2:** 465-470.

Stephens, D.B. (1982). Transport of animals intended for breeding, production and slaughter. *In:* Transport of Animals Intended for Breeding, Production and Slaughter. Current Topics in Veterinary Medicine and Animal Science, Volume 18. Ed. Moss, R. Martinus Nijhoff Publishers, The Hague. pp 187-206.

Stephens, D.B. and Toner, J.N. (1975). Husbandry influences on some physiological parameters of emotional responses in calves. *Applied Animal Ethology* **1:** 233-243.

Strayer, D.L. and Kramer, A.F. (1994). Aging and skill acquisition: learning-performance distinctions. *Psychology and Aging* **9:** 589-605.