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The importance of physiological measurements in farm animal stress research

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ABSTRACT

Stress research in farm animals is becoming increasingly important as a result of public concern for the welfare of animals and the ongoing need to increase the efficiency of animal production. Changes in the behaviour of animals is often the first indicator that a particular farming practice may be aversive or stressful. For example, cattle housed indoors on concrete floors have fewer resting bouts than those on deep litter or at pasture. Subsequent measurement of a variety of physiological parameters confirmed that lying down on slatted floors is stressful. Changes were noted in the episodic secretory pattern of glucocorticosterioid hormone, in the cortisol response to challenge with a standard dose of ACTH (1-24) and in heart rate.

Ongoing studies with dairy cattle indicate that the frequencies and types of fly-avoidance behaviours utilised by animals without tails differs from those with tails. In addition, animals without tails have a higher number of flies on the body. Physiological parameters will be monitored to determine if the decreased ability of cattle without tails to remove flies results in altered physiological responses indicative of stress.

These studies show that a multi-disciplinary approach is required to quantify the relative stressfulness of various farming practices.

Keywords Stress, welfare, farm animals.

BACKGROUND

The scientific investigation of the welfare of domestic animals is important for several reasons. Apart from public concern about welfare, evidence has accumulated that modern housing and management procedures can be stressful and that stress may cause reduced growth or weight loss, reduced fertility, and increased disease rate (eg. Moberg 1985). Since health and a high level of productivity are the cornerstones of profitable farming, it is important to understand how stress can influence these body functions through analysis of the neuroendocrine and behavioural mechanisms.

In Europe most cattle are kept indoors for a larger part of the year, either in loose housing systems, or individually confined in crates or in tether stalls. Most often they are kept on partially or totally slatted concrete floors. Behavioural observations indicate that the resting behaviour of cattle kept in these housing systems is abnormal in comparison with that of cattle kept on deep litter (Muller *et al.*, 1989). We therefore decided to compare various physiological parameters with behavioural responses in cattle kept under the two systems.

BEHAVIOURAL RESPONSES

Although cattle kept on concrete floors spend as much time lying down as cattle kept on deep litter, the number of lying bouts is dramatically reduced. Whereas cattle on deep litter (or on pasture) have 10 to 15 bouts of lying per 24 h, cattle on concrete floors show only 5 to 10 bouts. Thus, lying bouts are longer for cattle kept on concrete. In addition, cattle on deep litter change body position frequently by standing up and immediately lying down again on the other side or by changing sides while remaining recumbent by rolling over on the hind legs. These changes in position do not appear to occur in cattle kept on concrete floors.

Prior to lying down cattle perform an intention movement in that they lower their head to the ground, as if inspecting the lying area. Cattle on deep litter or on pasture will perform this intention behaviour once only prior to lying down. Cattle on concrete floors, however, perform the behaviour several times prior to settling down. As a result the latency from the first intention movement to lying down is about 8 seconds in cattle on deep litter, but varies from several minutes to one hour in cattle on concrete floor.

Behavioural observations of calves kept on concrete floors have shown that animals weighing up to 150 kg show normal lying behaviour and that the behaviour becomes increasingly abnormal as body weight increases. Taken together, these observations indicate that the process of lying down and resting on concrete floors is somehow aversive to cattle.

PHYSIOLOGICAL RESPONSES

To study the possible effect on neuroendocrinology we conducted two experiments, one on Friesian bulls in which the adrenal secretion of cortisol was studied (Ladewig and Smidt 1989) and one on Friesian heifers in which heart rate was measured (Muller *et al.*, 1989). In the first study, adrenocortical function was analysed, in two ways. One, by determining the episodic secretory pattern of cortisol, and two, by challenging the adrenal glands with synthetic ACTH(1-24). The rationale for the former is that, since cortisol is secreted in humans in an episodic fashion, rather than at a steady rate, determination of the frequency and amplitude of secretory peaks is necessary to reveal changes in adrenocortical activity (Hellman *et al.*, 1970). The principle of the adrenal challenge is based on the observation that adrenocortical response to acute stress or a standard dosage ACTH is changed in chronically stressed animals (Daniels-Severs *et al.*, 1973).

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The episodic secretory pattern of cortisol was determined by continuous collection of blood over 24 h. Blood was collected via intravenous catheters and fractioned into 20 min samples (Ladewig and Stribrny 1988). The 24 h periods at the beginning and end of the tethering period (one month duration) were selected for analysis. The adrenal challenge test was conducted after one month of tethering by injecting 1.98 IU ACTH(1-24) per kg $BW^{.75}$ intravenously and collecting blood from 1 h before till 6 h after injection. All bulls were treated simultaneously. Based on the plasma cortisol concentrations, a response curve was calculated for each animal and the area below the curve measured.

Heart rate was recorded in control and experimental animals telemetrically over a 24 h period three months after tethering.

At the beginning of the tethering period, the episodic secretory pattern of cortisol was significantly different under the two housing conditions (Figure 1). The frequency of secretory episodes was reduced and the amplitude of the secretory episodes increased in tethered animals. After one month of tethering, however, the secretory pattern was similar to that of loose housed bulls on straw. Stimulation of the adrenal cortex with ACTH (1-24) revealed a significantly reduced cortisol response in tethered bulls after one month of tethering (Figure 2). Therefore, the normalisation of the episodic secretory pattern of cortisol is unlikely to have been due to a reduction in perceived stress but rather may represent a return to prestress levels due to negative feedback mechanisms at the adrenal level. Heart rate was significantly elevated in tethered heifers during all phases of the lying-down process (Table 1). Taken togther, these results strongly support the conclusion derived from behavioural observations that lying down on a hard surface is aversive to cattle.

FIGURE 1 Episodic secretory pattern of cortisol in a bull kept tethered 2-3 days (A) and 33-34 days (B) compared to that of a bull kept on deep litter (C and D). The horizontal bar indicates the night time period. (From Ladewig and Smidt, 1989)

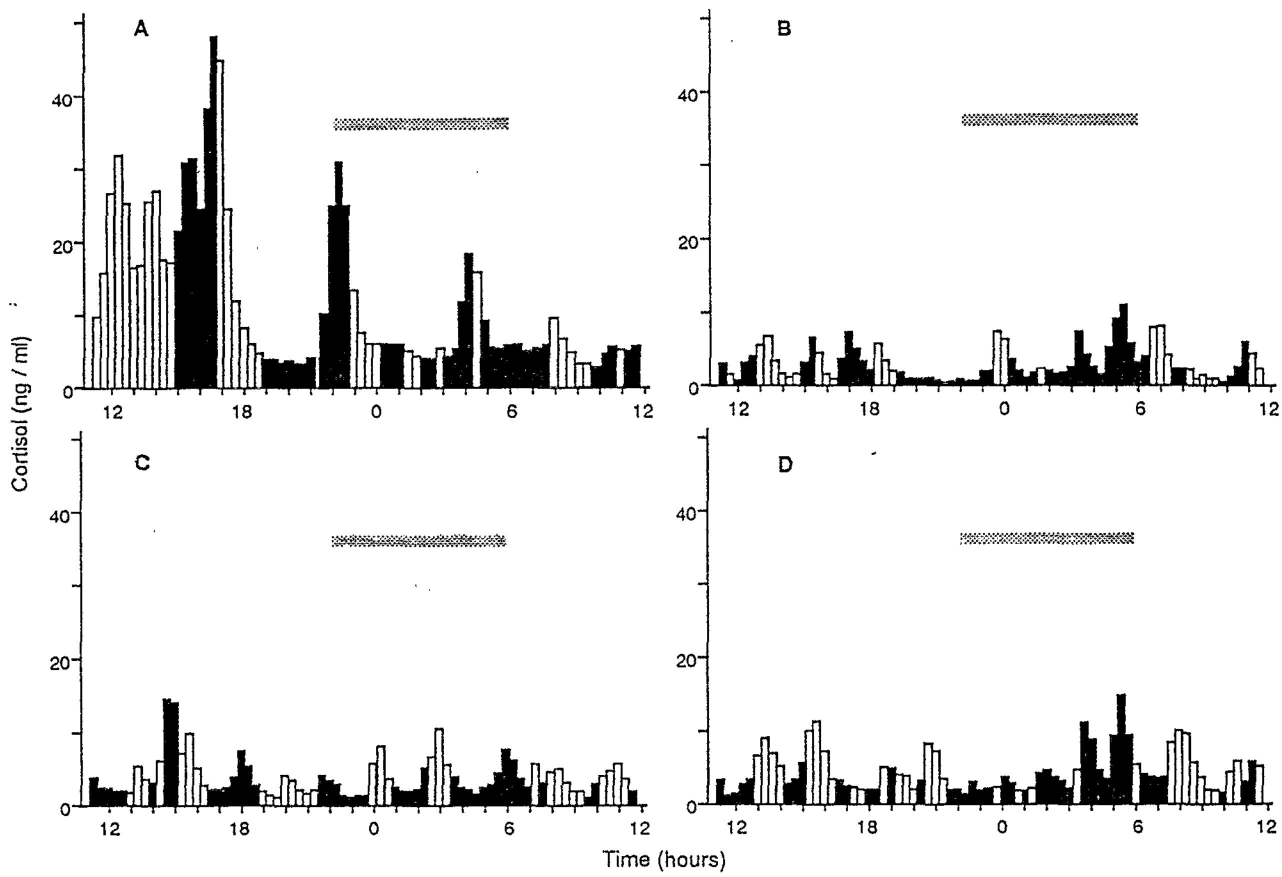


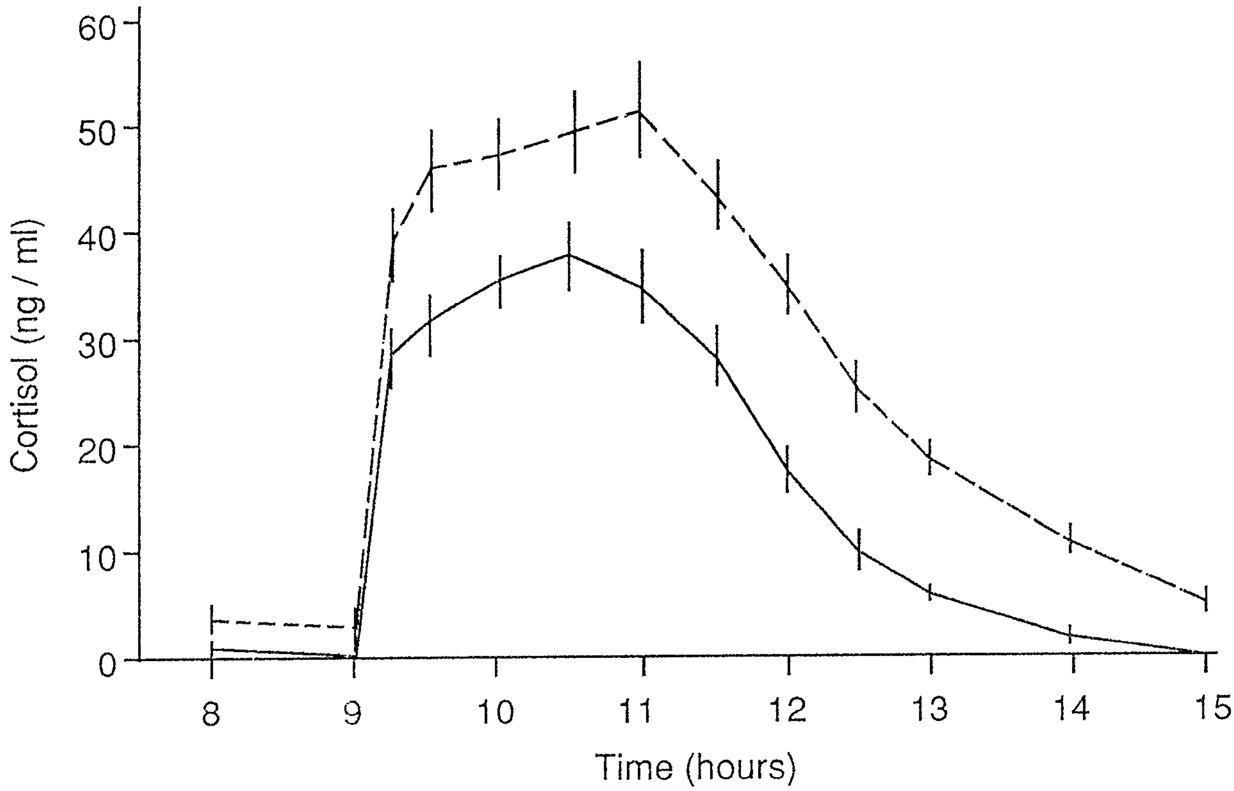
TABLE 1 Heart rate (HR: mean±SD) during rumination, before, during and after lying down, and during intention to lie down in tethered heifers on partially slatted floor and control heifers on deep straw after 12 weeks in each system

	Tethered heifers (n=7)*	Control heifers (n=8)	P
During rumination	97.1 ± 5.9	77.8 ± 8.5	\0.001
5 min before lying†	105.2 ± 8.2	76.8 ± 6.1	\0.001
During lying†	122.7 ± 13.5	91.9 ± 5.8	\0.001
5 min after lying†	96.5 ± 10.5	73.3 ± 7.2	\0.001
During lying intention†	125.5 ± 9.4	76.8 ± 6.1	\0.001

* Due to technical problems only 7 heifers could be analysed

† For each heifer, HR was measured during two different lying procedures (From Muller et al., 1989)

FIGURE 2 Response of the adrenal cortex to intravenous ACTH(1-24) (Synacthen, Ciba/Geigy) in bulls kept tethered on partially slatted floors over a 1-month period (——— , n=8) and control bulls kept loose on deep straw (— — —, n=8). ACTH dosage 1.98 IU/kg BW$^{.75}$. (From Ladewig and Smidt, 1989)



NEW ZEALAND PRACTICES

Similar studies can be undertaken to determine the influence of farming practices under New Zealand conditons on stress in animals', eg. tail docking in dairy cows is a current area of concern. From ongoing studies on twin heifers at Ruakura, half of which have docked tails, the other half intact tails, we know that heifers without tails increase the frequency of fly avoidance behaviour, use different behaviours from non-docked animals and that more flies land on docked animals (Table 2). Under conditions with low numbers of flies (cool weather, rain), tail docking has little effect on the behaviour of the heifers. When fly numbers are high, however, tail-docked heifers are increasingly forced to use alternative behaviours, such as leg stamping and head turning to rid themselves of flies. If fly attacks are sufficiently intense, we have indications that other behaviours (eg. grazing, rumination) are disturbed. Altered adrenocortical responses in tail docked animals would provide additional evidence of the effect of tail docking on cattle stress levels.

Considering the ease with which neuroendocrine processes can be disturbed with resulting syndrome influences on welfare and productivity, many other farm practices (such as estrus synchronisation, superovulation, birth induction) should be initially scrutinised from a behavioural physiological point of view, before such practices can be recommended on a routine basis.

TABLE 2 Frequencies of (a) fly avoidance behaviours (tail flicks and leg stamps) and (b) numbers of flies present on heifers with and without tails at three different times of the day

(a)		Behaviour frequency (per side/2 min)		
		8.00 am	11.00 am	1.00 pm
Tail Flick	Without tail	20	50	70
	With tail	8	20	25
Front leg stamps	Without tail	1	2	3
	With tail	1	4	3
Rear leg stamps	Without tail	1	6	8
	With tail	0	1	2
(b)		No. of flies (per side/2 min)		
Flies present	Without tail	2	7	8
	With tail	1	2	4

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