HORMONAL RESPONSES OF LAMBS TO TRUCKING, HANDLING AND ELECTRIC STUNNING

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SUMMARY

The history and behaviour of 1028 lambs electrically stunned and slaughtered at a large freezing works and 46 lambs at a small abattoir were examined. Blood samples were collected at sticking and carcasses were scored for ecchymosis. A further 20 samples were obtained from non-stunned lambs at each location. Cortisol, noradrenaline, and adrenaline levels in non-stunned lambs indicated a high degree of agitation in the slaughterhouse environment. Electrical stunning caused a discharge of noradrenaline and adrenaline into the bloodstream resulting in levels respectively 20 and 14 times higher than in non-stunned lambs. Differences in hormone concentrations emerged between slaughtering locations and between mobs but no relationship was evident between hormone levels and the incidence of ecchymosis, either on an individual or on a mob basis. The potential use of endocrine profiles in the assessment of the stress response of slaughter animals is discussed.

INTRODUCTION

A relationship between ante-mortem stress in animals and meat quality is increasingly recognized (Hendrick, 1965; Norris, 1976). Reactions of susceptible animals to the handling and transportation encountered during the slaughter process can result in defects in the ultimate meat quality, such as dark-cutting beef (Ashmore *et al.*, 1973) and pale, soft, exudative pork (Naudé and Klingbiel, 1973). More severe physiological responses include transport tetany (Ross, 1948) and the high transport mortality among some modern pig breeds (Lendfers, 1970). Less severe, but widespread and costly, are the weight losses and, in some circumstances, the bruising attributable to ante-mortem stress. Few behavioural, physiological or endocrinological studies have been made of the chain of events occurring from the pasture to the point of slaughter despite the economic advantage in minimizing agitation in the slaughter animal.

Electric stunning was recently introduced into New Zealand freezing works. This causes small haemorrhages (ecchymosis or blood splash) in some lamb carcasses (Warrington, 1974). Among the explanations for the differences observed between

mobs in the incidence of ecchymosis is that the degree of pre-slaughter stress in some manner alters the susceptibility to the lesion (Charles, 1960). The results in the present report form part of an investigation into the involvement of ante-mortem stress in the aetiology of ecchymosis.

METHODS AND MATERIALS

Seven mobs totalling 1028 lambs (27 to 588 lambs per mob) were killed over a period of 3 hours from 8 a.m. at a large freezing works. All lambs were electrically stunned before slaughter and all had been trucked from the farms of origin the previous day, washed and held overnight. Details of farm locations, distance travelled and hours on the road were gathered at the time of arrival. Carcasses were examined for ecchymosis and scored using the scale developed by the Meat Industry Research Institute of New Zealand. Blood samples of 20 ml were collected from the severed carotid artery of approximately every third lamb on the chain, as soon as possible after sticking and within 8 to 15 seconds of stunning. The samples were collected into heparinized bottles; 229 were retained as being representative of all mobs and ecchymosis score categories. A further 46 samples were collected at a small research abattoir from stunned lambs and 20 samples from non-stunned lambs at each location. Plasma cortisol was analysed by the protein-binding method of Murphy (1967) as modified by Fairclough and Liggins (1975), the catecholamines, noradrenaline (NA) and adrenaline (A), by a modification of the methods of Laverty and Taylor (1968) and Campuzano *et al.* (1975). The levels of these hormones are considered to reflect the reactions of animals to the environment.

RESULTS AND DISCUSSION

In comparison with the resting levels of catecholamines of less than 0.5 ng/ml (Callingham and Barrand, 1976) the concentrations found in unstunned lambs at sticking indicate a high degree of behavioural arousal in the slaughterhouse environment (Table 1). The mean cortisol levels at both locations were also considerably elevated above basal levels of less than 10 ng/ml (Thurley and McNatty, 1973). As plasma cortisol levels at sticking are not affected by the stunning process owing to a stimulation-secretion delay of approximately 3 minutes (Beaven *et al.*, 1964) data from both stunned and non-stunned lambs are pooled. On the other hand, stunning causes a massive stimula-

TABLE 1: HORMONE LEVELS IN LAMBS SLAUGHTERED AT LARGE AND SMALL ABATTOIRS (MEAN ± S.D.)

	Catecholamines (ng/ml)			*Cortisol*[1] *(ng/ml)*	
	No.	*NA*	*A*	*No.*	
Large abattoir:					
Stunned	188	73.8 ± 40.0	96.9 ± 51.0	127	61.3 ± 26.1
Non-stunned	20	3.2 ± 3.1	8.7 ± 9.2		
Small abattoir:					
Stunned	46	40.5 ± 18.6	60.6 ± 31.1	58	40.1 ± 23.7
Non-stunned	20	3.6 ± 5.9	4.5 ± 8.1		

[1]Pooled stunned and non-stunned lambs.

tion of the sympathetic nervous system resulting in the release of large quantities of NA and A from the adrenal medulla and plasma levels outside normal physiological experience.

Differences in cortisol ($P < 0.01$) and A ($P < 0.02$) in unstunned lambs emerged between the two locations, reflecting the reduced level of handling, lower killing rate, absence of dogs, and the quieter environment of the smaller abattoir. When levels of NA and A found in the stunned lambs at the large slaughterhouse are corrected for the imbalance in the numbers analysed from the different mobs, a higher level ($P<0.1$) of both hormones was associated with the larger works. However, this tendency may be an artefact arising from easier access at the small abattoir and consequent slightly earlier blood collection following sticking.

Although hormonal levels varied between the 7 stunned mobs examined at the large freezing works ($P < 0.001$) these were not related to the mean mob level of ecchymosis (Table 2). Similarly, when individual assay data from the largest mob are grouped according to carcass ecchymosis score, there is no relationship to be observed. Lamb maturity or the effects of transportation and handling on adrenal catecholamine stores could be factors in the observed mob variation in NA and A.

The mean level of cortisol rose with an increase in transport time up to 2 hours. Subsequently there was a slight fall as travelling time further increased to 8 hours (Fig. 1). It was also noted that plasma cortisol in the largest mob fell over the 90 minutes taken to slaughter this mob. The difference between cortisol levels in lambs killed in the first (80.8 ± 26.6 S.D.) and second

TABLE 2: MEAN (± S.D.) CATECHOLAMINE AND CORTISOL CONCENTRATIONS IN MOBS OF STUNNED LAMBS SLAUGHTERED AT LARGE ABATTOIR

Mob No. (Killing Order)	*Mean Mob Splash Score*	*No. in Mob*	*No. Analysed for NA/A*	*NA (ng/ml)*	*A (ng/ml)*	*No. Analysed for Cortisol*	*Cortisol (ng/ml)*
4	0.44	27	10	57.3 ± 40.1	181.0 ± 59.8	11	48.8 ± 10.9
1	0.83	92	2	99.7	70.4	9	69.7 ± 21.1
2	0.97	29	4	31.9 ± 15.6	43.4 ± 9.9	11	69.8 ± 19.2
7	0.98	40	13	51.1 ± 11.1	83.6 ± 17.8	12	22.7 ± 6.0
3	1.06	141	26	71.6 ± 33.8	81.0 ± 28.3	13	77.8 ± 16.4
5	1.12	111	24	91.6 ± 43.9	99.4 ± 45.2	16	60.7 ± 20.9
6	1.46	588	109	75.7 ± 41.2	96.4 ± 51.8	42	73.1 ± 26.8
All samples				73.8 ± 40.0	96.9 ± 51.0		63.7 ± 26.3

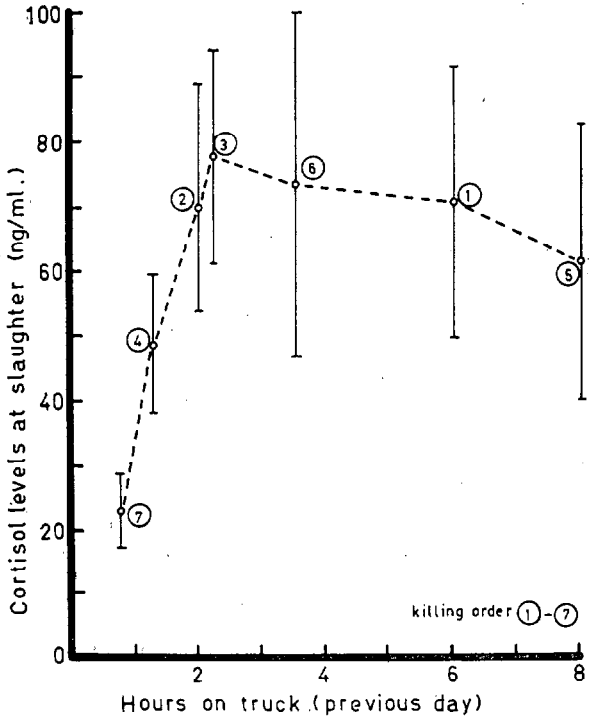

FIG. 1: *Lambs; slaughter stress and transport.*

(55.1 ± 21.9) halves of the mob was significant at the 0.5% level. Whether this is an adaptive or exhaustion phenomenon is unclear.

Although there are technical problems to overcome, the measurement of physiological and endocrinological responses of animals *en route* to slaughter would permit the testing of new procedures and the improvement of established procedures with the combined aims of more humane treatment and more efficient utilization of the meat animal. The catecholamines are particularly important in this respect in view of their effects on pre- and post-mortem muscle biochemistry (Lawrie, 1966).

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