

Factors affecting behaviour, bruising and pH_u in a deer slaughter premises

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ABSTRACT

Data from an on-going study at a deer slaughter premises were analysed. Over one year 3856 deer, primarily red x wapiti hybrids, from 101 farms were observed. During overnight lairage a mean of 14 (s.d. 7.6) antagonistic encounters/hr occurred. In the race immediately prior to stunning, rearing was the most common form of unsettled behaviour (17 % of deer). The incidence of unsettled behaviour differed between carriers ($P < 0.001$). Bruising occurred in 24 % of carcasses, increased with load size ($P < 0.01$) and poor weather conditions ($P < 0.05$), and differed between carriers ($P < 0.05$). Half (48 %) of all bruises were small and less than 5 mm deep. Mean ultimate pH (pH_u) was 5.65 (s.d. 0.139), and moderate-high pH_u (> 5.8) was prevalent in the shoulder (18.5 % of carcasses) followed by the loin (10.6 %) then the leg (5.6 %). Behaviour, bruising and pH_u all differed significantly between farms and days ($P < 0.001$).

Keywords: deer; slaughter; behaviour; bruising; pH; meat quality; animal welfare

INTRODUCTION

Since October 1997, behavioural and meat quality (bruising and ultimate pH, pH_u) variables at an Otago deer slaughter plant (DSP), and the background history of the animals processed at the plant, have been monitored on one day each week. The aim of the study was to describe the variables and identify any relationships between the animals' background, behaviour and meat quality. Relationships of this type were seen in a different DSP, where the incidence of bruising was related to season, carrier company, and lairage duration as well as physical condition of the animals (Jago *et al.*, 1993). The intended outcome of the present study was to identify ways to minimise stress prior to slaughter and ensure good quality venison. Ultimate pH is an important indicator of quality as it affects the appearance, texture and shelf life of meat (McVeigh & Tarrant, 1981). This paper presents results from the first year of the study.

MATERIALS AND METHODS

Behaviour recording

Behaviour was recorded during an 8-hour period (2000hr-0400hr) in one 4m x 4m pen (containing 9 to 15 deer), using an infrared video camera and light source. The deer were in lairage prior to slaughter the next day. For 30 minutes at 90-minute intervals the number of antagonistic encounters, and the specific activities (biting, kicking or butting) which comprised each encounter were recorded from the videotapes. At the end of each 30-minute period an agitation score, based on the number of animals in the pen stepping (forward or backward locomotion) during five minutes (none, some animals some of the time, all animals within five minutes, or all animals throughout five minutes) was assigned.

Activities in the 4m raceway leading into the stunning box were recorded on videotape for all animals slaughtered that day. Variables measured from the tape were as follows: whether or not the deer reared, jumped, climbed

the walls or lay down, and the approximate time the deer was in the race. By combining the times at least one of rearing, jumping and climbing occurred, a summary variable was calculated indicating how "unsettled" each animal was.

Weather recording

Weather conditions (rain, wind, cloud cover and temperature) were scored on subjective scales at three times during the kill day: early, mid and late morning. Weather scores were added together to give a "weather index", which increased as weather conditions deteriorated (i.e. as rain, cloud and wind increased and as temperature decreased).

Bruise recording

At approximately 20 minutes post-mortem the MAF meat inspector recorded the number of bruises in the hindquarter, ribs, loin and forequarter regions of the carcass, assigning each bruise to one of five size categories: < 100 mm diameter and < 5 mm deep, < 100 mm diameter and > 5 mm deep, > 100 mm diameter and < 5 mm deep, > 100 mm diameter and > 5 mm deep, or < 100 mm diameter and > 50 mm deep. In the case of the ribs the last category was omitted and instead broken ribs were recorded. Bruising on the hocks was also recorded as either present or absent.

pH recording

At approximately 24 hours post-mortem pH_u was measured in triplicate using an Orion model 265 meter and either a Mettler Toledo 'Ingold' spear tip or an Orion electrode at three locations in the carcass: the leg (*M. Biceps femoris*), striploin (*M. Longissimus dorsi*) and shoulder (*M. Triceps brachii*). Summary variables were calculated indicating whether or not the mean for each location, and for the three locations, was greater than 5.8 and 6.2.

Statistical methods

Differences between farms, dates, loads and breed in means and percentages of variables were analysed by least squares and binomial generalized linear models (glm's; McCullagh & Nelder, 1989), respectively, based on individual animals. The term load refers to farm within day.

Since major differences were found, fallow deer and deer with any defects were then restricted out of the analysis. Frequency of encounters was analysed using a Poisson glm fitting terms for night and observation session (time of night). The effect of carrier on unsettled behaviour, bruising and pH_v was tested as a fixed effect using residual maximum likelihood (Patterson & Thompson, 1971), with load as a random effect.

RESULTS

General

Data from 40 kill days were analysed, comprising a total of 3856 deer, in 142 loads from 101 farms. Most of the deer were red or red/wapiti hybrids (94 %; no distinction has been made between these types as data records were inconsistent between DSP and farm records), with the balance made up of 3 % wapiti and 3 % fallow deer (the fallow deer were from two different farms, and were processed on one day). Sixty-one percent of the deer were stags and 39 % were hinds.

Overnight lairage pen

The mean number of antagonistic encounters, for red and crossbred deer, observed during overnight lairage was 14 (s.d. 7.6) hr. The number of encounters ranged from a low of 3 hr, for a group of 10 red stags in July, to a high of 34 hr, for a group comprising 1 stag and 7 hinds, in June. The frequency of antagonistic behaviour differed significantly between nights (P<0.001), and increased during the night (P<0.001 for linear contrast; Table 1).

TABLE 1: Mean number of antagonistic encounters (plus S.E.) per 30 minutes in successive observation periods during overnight lairage.

Time at start of period	No. encounters 30 minutes	SE
8.00 pm	5.9	0.45
9.30 pm	5.4	0.43
11.00 pm	5.5	0.44
12.30 am	6.0	0.46
2.00 am	8.8	0.55
3.30 am	9.4	0.57

Overall the amount of antagonistic activity was similar across stags, hinds and mixed sex groups (means of 14, 14 and 13 encounters/hr), but the mean agitation score for stags was a relatively low 3.0, compared with 6.0 for hinds, and 5.6 for mixed sex groups. For the one group of fallow deer which was observed in lairage, the number of encounters was low (5), but the agitation score was a maximal 12. There was no clear seasonal pattern, or effect of the number of animals in the pen on the frequency of antagonistic encounters.

The percentages of antagonistic encounters involving 2, 3 or more deer, respectively were 44, 31 and 25. Biting was involved in 66 % of encounters, boxing in 37%, and butting in 28 %.

Lead-in race

Red wapiti deer were more settled in the lead-in race than fallow deer (P<0.001; Table 2). For both red wapiti and fallow deer, the most commonly observed behaviour in

the lead-in race was rearing, seen in 17 % of red/wapiti deer and 39 % of fallow deer. Jumping was seen in only 7 % of red/wapiti deer but in a relatively large proportion (36 %) of fallow deer. Lying occurred at similar levels in both species (8-11 %) as did climbing (3-4 %).

TABLE 2: Percentages of red or crossbred and fallow deer rearing, jumping, climbing and lying in the lead-in race, plus SED between breeds.

Activity	Red/wapiti deer	Fallow deer	SED
Rearing	17.1	39.4	4.0
Jumping	7.2	35.6	3.1
Climbing	3.9	2.9	1.8
Lying	7.5	10.6	2.7

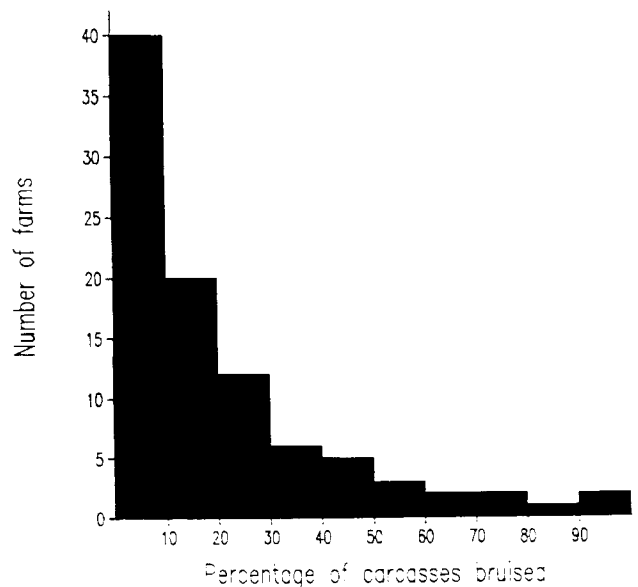
Loads from different farms differed significantly in the proportion of deer which showed unsettled behaviour in the lead-in race (P<0.001), with the incidence of the specific activities rearing, climbing, jumping and lying down ranging from 0 to 55, 20, 40 and 40 %, respectively for each activity, for red/wapiti deer. Unsettled behaviour also differed significantly between carriers and days (P<0.001). Deer which showed climbing, jumping or rearing were more likely to have been held in the race for a long time rather than held briefly (P<0.001). No relationship between antagonism or agitation score during lairage and unsettled behaviour in the lead-in race was evident.

Bruising

Bruising occurred most frequently on the hocks, with 22.4 % of carcasses having bruises in this area, followed by the hindquarters (18.6 %), forequarters (4.6 %), and loins (1.7 %). Overall 24 % of carcasses had bruising in some area other than the hocks. The most common bruises (excluding those on the hocks) were small and less than 5 mm deep (11.6 % of carcasses; 48 % of all bruises were in this category). Twenty-three deer had broken ribs.

The frequency of bruising (in areas other than the hocks) differed significantly between farms (P<0.001; Figure 1), and ranged from 0 to 100 % of carcasses. Bruising

FIGURE 1: Number of farms with different proportions of carcasses bruised.



was positively related to load size ($P < 0.01$), with the proportion of bruised carcasses tending to increase with load size, although a high frequency of bruising was still observed in some small mobs. Bruising differed between carriers ($P < 0.05$) and days ($P < 0.001$), and a significant positive relationship was found between bruising and the weather index ($P < 0.05$).

Ultimate pH

The overall mean pH_u was 5.65 (s.d. 0.139) for red/wapiti deer and 5.89 (s.d. 0.153) for fallow deer, and differed between farms and days ($P < 0.001$). For red/wapiti deer, moderately high pH_u (> 5.8) was most prevalent in the shoulder (18.5 % of carcasses), followed by the loin and then the leg (10.6 % and 5.6 %, respectively; Table 3). For fallow deer, there was less contrast between muscles but a high percentage of carcasses with pH_u in this range (Table 3). Very high pH_u was most prevalent in the shoulder in red deer (2.4 %) but in the leg of fallow deer (10.1 %; Table 3). The percentage of carcasses with moderately high pH_u in all three locations was 4.5 for red/wapiti deer and 58.6 for fallow deer. Very high pH_u in all three locations was only found in 0.5 % of red/wapiti carcasses but not in any of the fallow carcasses. No relationships were seen between behaviour (antagonistic encounters or agitation in the overnight lairage pen, or behaviour in the lead-in race) and either bruising or pH_u .

TABLE 3: Mean pH_u (plus s.d.) and percentages of carcasses with moderately high (> 5.8) and very high (> 6.2) pH, at three locations, for red wapiti and fallow deer

		Leg	Loin	Shoulder	
Mean pH_u	Red	5.60 (0.127)	5.64 (0.158)	5.71 (0.174)	
	Wapiti				
% carcasses	Fallow	5.89 (0.153)	5.93 (0.196)	5.89 (0.163)	
	Red	PH > 5.8	5.6	10.6	18.5
% carcasses	Wapiti				
	Fallow	76.8	68.7	72.7	
% carcasses	Red	PH > 6.2	0.7	1.5	2.4
	Wapiti				
	Fallow	10.1	0.0	2.0	

DISCUSSION

Behavioural and physiological variables indicated that advancements could be made to improve both welfare and meat quality. The high frequency of antagonistic encounters during overnight lairage, and the increasing frequency of antagonism over the eight-hour observation period, suggested that holding deer over this period may be undesirable. A relationship between antagonism in lairage and bruising could be expected but none was found in the present study. This may have been due to high variation in bruise recording which was evident in the data and possibly related to staff changes at the slaughter plant. Other reasons could be that the impacts involved were not sufficient to result in bruising, or there were other stages in the pre-slaughter process where bruising occurred.

Previous studies on deer have revealed mixed effects of lairage. Jago *et al.* (1993) found a greater frequency of bruising in deer held overnight than in those slaughtered

on the day of arrival, but in the latter deer (which were held for a short time only: mean = 16, SE 1.9 minutes) there was a negative relationship between lairage time, and plasma glucose and carcass pH suggestive of recovery from the effects of transport. Grigor *et al.* (1997) studied deer held in lairage with hay, water and straw bedding, for 0, 3, 6 or 18 hours. In that study there was an increase in antagonistic behaviour and a decrease in liveweight over 18 hours of lairage, but an increase in liver glycogen and a decrease in plasma creatine kinase activity suggestive of recovery from transport. The lowest pH_u values (5.52 in the loin) were seen in the deer held for 6 hours (Grigor *et al.* 1997). It was concluded that because behaviour was unsettled, the deer should be slaughtered as soon as possible after arriving at the plant (Grigor *et al.* 1997). Nevertheless, in New Zealand it is still common practice to hold deer overnight before slaughter and further studies on the effects of lairage time on physiology and behaviour are warranted.

In the race immediately prior to slaughter a substantial proportion of the deer showed unsettled behaviour (such as rearing up on the hind legs, seen in 17 % of red deer). It may be possible to modify handling procedures or the facility to reduce this behaviour, for instance by minimising the time spent in this area. Possible reasons for the wide range in behaviour between farms (for example from 0 to 55 % of deer rearing in the lead-in race) include the frequency and nature of prior handling and other aspects of the farm environment. Farms also differed significantly in the amount of bruising, and pH_u values, and these differences too may be related to the previous experiences of the deer. At present one quarter of the farms have sent in repeated consignments, and the data suggests that there is moderate consistency between consignments. As the study progresses effects of farm background details may emerge. The effects of carrier on unsettled behaviour prior to slaughter, and bruising, also warrant further investigation.

Bruising was positively related to load size, as in the study by Jago *et al.* (1993). This could have occurred because deer in larger loads were more crowded and possibly climbed on top of each other. However in spite of this positive relationship, high frequencies of bruising sometimes occurred in small loads. Possible reasons for the differences between days in bruising and pH_u include seasonal and climatic effects, which are already indicated (bruising increased as weather conditions deteriorated) and may become more apparent over the next year as the data set grows.

Ultimate pH is a very important component of meat quality as it affects colour, texture, water-holding properties and shelf-life (McVeigh & Tarrant, 1981), with deleterious effects emerging at values of 5.8 and highly undesirable meat occurring at 6.2 and above. In the present study moderate-high ultimate pH values (> 5.8) were found in a substantial proportion (19 %) of shoulder muscles in red wapiti deer, indicating that there is room for improvement in venison quality. In studies of reindeer, shoulder muscles were also found to have higher pH_u levels than other muscles, and the incidence of $pH_u > 5.8$ in this muscle was 55 % (Wiklund *et al.* 1995; 1996). The loin muscle is most com-

monly reported in studies of pH. The proportion of carcasses with moderate-high pH_v in the loin in the present study (11 %) was much lower than that found in a survey of sheep and cattle plants in New Zealand (31 %; Graafhuis & Devine, 1994).

There is a well established relationship between pH and stress, as physical stress results in depletion of muscle glycogen, in turn reducing the amount of lactic acid produced following slaughter (McVeigh & Tarrant, 1981). However in the present study the only variable related to pH_v was bruising. There was no indication of a relationship between pH_v and fighting or agitation in lairage, or unsettled behaviour in the lead-in race. This may be due to other factors besides physical exertion at the slaughter plant affecting pH_v; for example the fitness of the animal or its nutritional status can also affect muscle glycogen levels (Gregory, 1996; Malmfors & Wiklund, 1996). In addition, behaviour was only measured at two stages in the pre-slaughter process, for instance behaviour in transit and during yarding at the farm were not observed.

Fallow deer comprised two consignments in the study. The high frequency of unsettled behaviour and high pH levels recorded for these animals highlighted the need for specific handling techniques and facilities to prevent problems with animal welfare and meat quality when processing this species (English, 1993; Fletcher, 1995).

To date the study has quantified behavioural and physiological indicators of animal welfare and meat quality which indicate that pre-slaughter conditions might be improved for deer. Differences between days and farms have been highlighted and possible reasons for these differences are being investigated. However due to the wide number of variables involved, experimental work is required to investigate some specific issues, such as the effects of time in lairage on meat quality.

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