HANDLING, BRUISING AND DEHYDRATION OF CATTLE AT THE TIME OF SLAUGHTER

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The handling of cattle during unloading (n = 39) and movement to slaughter (n = 163) was observed at a commercial slaughterhouse. Most potentially traumatic events and handling events occurred while the cattle were in the race. During the initial 3 hours in the lairage pen, cattle from markets (n = 28) spent significantly more time drinking than those sent to slaughter direct from farms (n = 11; P < 0.05). Most cattle had bruises (99%; n = 181), but there was no difference between the occurrence of bruising in cattle direct from farms and those from markets. Bruise score was not affected by the distance transported from farms 18–201km (11–125 miles). However, cattle from markets >64km (>40 miles) from the slaughterhouse had greater bruise scores than those from nearer markets 0.8–64km (0.5–40 miles) (P < 0.01). No correlations were found between potentially traumatic events at the slaughterhouse and the occurrence of bruising. Plasma total protein concentration and plasma creatine kinase activity in blood collected at exsanguination (n = 170) was significantly greater in cattle from markets than in those from farms (P < 0.05), but there was no difference in plasma osmolality and packed cell volume (PCV). Cattle from distant markets >129km (>80 miles) had higher PCV and plasma total protein concentration than those from markets within 129km (80 miles) (P < 0.05). The overall results suggest that cattle from markets, particularly those transported for a distance greater than 64km (40 miles), would benefit from greater access to water at the market and from improved methods of handling and transport prior to arrival at the slaughterhouse.

Keywords: *animal welfare, bruising, cattle, dehydration, handling, slaughterhouse*

Introduction

Prior to arrival at a slaughterhouse cattle will have been subjected to variable periods of feed and water restriction, transportation and handling. Cattle sold through markets are likely to have experienced more handling and transport, and longer periods of feed and water deprivation than cattle sent to slaughter direct from farms. Water deprivation may cause dehydration of body tissues, loss of carcase weight and other changes in meat quality (Wythes *et al* 1983, 1985). A previous study found 97 per cent of cattle slaughtered at two commercial slaughterhouses had some carcase bruising, and that cattle sold through livestock

markets had more bruising than those sent to slaughter direct from farms (Jarvis *et al* 1995). Bruising can result in economic loss and indicates compromised welfare. Cattle that have been transported for up to 15h can show evidence of dehydration and feed restriction (Warriss *et al* 1995). This study investigated the influence of pre-slaughter procedures on the behaviour, handling, bruising and dehydration of cattle slaughtered under commercial conditions.

Methods

Animals

The pre-slaughter handling and behaviour, and the occurrence of carcase bruising of 220 cattle was observed at a commercial slaughterhouse in Scotland over a five-week period during October and November. The cattle consisted of heifers, steers, young bulls and cows and were predominantly Hereford, Simmental, Charolais, Limousin and Friesian crosses. During the study the slaughterhouse had a daily throughput of up to 213 cattle and slaughtered about 40 cattle per hour. The slaughterhouse's cattle were transported from local farms and local markets whereas similar cattle slaughtered for private buyers also included cattle from more distant markets. Transport distance was calculated from maps as the shortest road distance between the farm or market and the slaughterhouse, and was 0.8–619km (0.5–385 miles) for cattle from markets and 18–201km (11–125 miles) for cattle sent to slaughter direct from farms.

Unloading and lairage

On arrival at the slaughterhouse the cattle were unloaded via an unloading bridge, moved along a central passageway and placed in a lairage pen. The lairage facilities have been described in detail by Cockram and Corley (1991). The lairage consisted of thirteen pens in two rows. Each pen comprised a concrete floor with three solid walls and a tubular metal gate leading on to the passageway, and contained either one or two water troughs or automatic drinking bowls and either one or two hay racks. Floor surface area of the pens ranged from 22.3 to 63.9m^2 and between 1 and 31 cattle were put in each pen. Most cattle were penned overnight in the lairage and killed on the following day. The median time spent in the lairage was 18.5h. Cattle kept overnight were provided with hay and straw bedding either on arrival or before the end of the working day.

Prestunning handling

The cattle were moved towards the stunning pen from the lairage pen along the central passageway and into the race (19.3x0.8m). A length of plastic piping was sometimes used as a driving instrument. If more than 10 cattle were moved from a pen at one time, a temporary holding pen was created at the race entrance by shutting a gate across the passageway. Up to four cattle were then moved along the race and a vertical sliding gate (race gate) was shut behind them to form a pre-stun pen. Handlers used plastic piping and two electric goads from a raised walkway alongside the race to move the animals forward. The cattle were moved singly into the stunning pen and a vertical sliding gate (stunning box gate) was shut behind them before stunning by a captive-bolt. They were then slid out of the stunning box, pithed, shackled by the right hind leg, stuck and bled.

Observations of focal animals

It was not possible to record information for all 220 focal animals at every handling stage, therefore observations of unloading and behaviour in the lairage pen were made on a subset of 39 cattle; prestunning handling on 163; blood sampling on 170; and carcase bruising on 181.

Observations of handling and feeding and drinking behaviour

Cattle from the same farm or market which had been transported together and penned together were defined as a group. Groups of cattle were randomly selected from vehicles that arrived at the slaughterhouse. A focal animal was selected from each group on the basis of a distinguishing feature such as colour, markings or ear tag. Thirty-nine focal animals (n=39) were observed during unloading from the time that the animal walked out of the vehicle until it entered the lairage pen. During the initial three hours in the lairage, the time that each focal animal spent standing, walking, lying, drinking and eating was recorded continuously for five minutes every twenty minutes ie for nine five-minute observation periods. The occurrence of head-butts and mounting directed at the focal animal was also recorded.

Prestunning handling of the focal animals during unloading and in the lairage pen (n = 39), and of additional focal animals selected randomly from other groups (n = 124), was observed as the animals were removed from the lairage pen and driven along the central passageway and race until they entered the stunning pen. During unloading and prestunning handling the occurrences of handling events (use of electric goad and being hit with plastic piping) and potentially traumatic events (hitting a structure, falling, slipping, being head-butted, being mounted, hitting the race gate and stunning box gate) were recorded. The site on the body where each event occurred was classified as back, butt, pin, hip, rump and loin, rib and forequarter (Anderson & Horder 1979).

Blood sampling and analysis

Blood from 170 animals was collected into a beaker at exsanguination as soon as the stick wound was made, and transferred into a tube containing lithium heparin. Packed cell volume (PCV) was determined using a haematocrit method. The blood samples were centrifuged for 15 minutes at 1500g, the plasma extracted and stored at -20°C. Plasma total protein concentration was determined using the biuret method (Randox Laboratories Ltd, Co. Antrim, Northern Ireland). The plasma activity of creatine kinase (Bayer Diagnostics Kit T01-1882-01) was measured on a RA-2000 random access chemistry analyser (Bayer Diagnostics, Basingstoke, UK) at 37°C. Osmolality was determined using the freezing point depression method (Roebling osmometer, Camlab, Cambridge, UK).

Measurement of bruising

After dressing, the size, colour and site of every bruise on 181 animals was recorded. Bruise diameter was recorded as little (< 2 cm), slight (2–8 cm), medium (8–16 cm) or heavy (> 16 cm). Bruise site was recorded as for events. Bruise colour was recorded as bright red (and haemorrhagic), pale red (and non-haemorrhagic), and dark red. Bruise depth was not assessed.

A bruise score based on the Australian Carcass Bruise Score System (Anderson & Horder 1979) was calculated for each carcase. The scores were calculated by multiplying the number of bruises of each size by a weighting factor: little 0.5, slight 1, medium 3 and heavy 5.

The fatness and conformation classifications assigned to each carcase was recorded. Fatness was classified as 1, 2, 3L, 3H, 4L, 4H or 5 to indicate increasing fat cover, and conformation class was designated P, O, R, U or E to indicate improving conformation, based on the shape of the carcase profile (Meat and Livestock Commission 1994).

Statistical analyses

The effect of time after arrival in the lairage, on the time spent by the focal animals performing each behaviour during the five-minute observation periods, was examined using regression analysis. Distance travelled to the slaughterhouse from either the farm or from the livestock market was categorized as < 64km (< 40 miles), 64–129km (40–80 miles) and > 129km (> 80 miles). Mann-Whitney and Kruskal-Wallis analyses were used to examine the effect of source (farm or market) and distance on handling, behaviour in lairage, blood biochemistry and bruising. Spearman's rank correlation was used to examine the relationships between the occurrences of events and bruising, between time spent at the slaughterhouse and blood variables, and between time spent in, and events occurring in the race, on plasma creatine kinase activity.

Results

Events

Relatively few potentially traumatic and handling events occurred during unloading (median 0, range 0–2; Figure 1). A median of 1 (range 0–16) potentially traumatic events and 2 (range 0–11) handling events per animal occurred during prestunning handling. There was no effect of source on the number of potentially traumatic events or handling events during either unloading or prestunning handling. The majority of potentially traumatic events and handling events occurred in the race (Figure 1). Most events occurred on the butt (68%) and back (21%) of the animal, with the remainder on the rump and loin (5%), hip (4%), forequarters (1%), rib (< 1%) and pin (< 1%). A median of seven cattle were put in the race at any one time (range 1–14) and cattle spent a median of 5 minutes in the race (range 1–31). The number of times the animal hit the race gate increased with time spent in the race ($r_s = 0.23$, $P < 0.01$) as did the number of handling events per animal ($r_s = 0.44$, $P < 0.001$). Animals at the front of a group held in the race received fewer handling events than those at the rear ($r_s = 0.39$, $P < 0.001$).

Behaviour in lairage

There was no effect of time in lairage on the time spent drinking. During the nine five-minute observation periods, cattle from markets spent significantly more time drinking (median 3 minutes, n = 26) than cattle from farms (median 0 minutes, n = 11, $P < 0.05$). Cattle typically ate all the hay provided and most of the bedding and there was no effect of source (farm or market) on the time spent eating. Time spent lying increased with duration of lairage ($y = -10.2 + 0.36x$, n = 39, $P < 0.001$), and after 3h in the lairage 26 per cent of the focal animals were lying down. The number of head butting and mounting events decreased with time spent in the lairage pen ($y = 0.12 - 0.08x$, n = 39, $P < 0.001$).

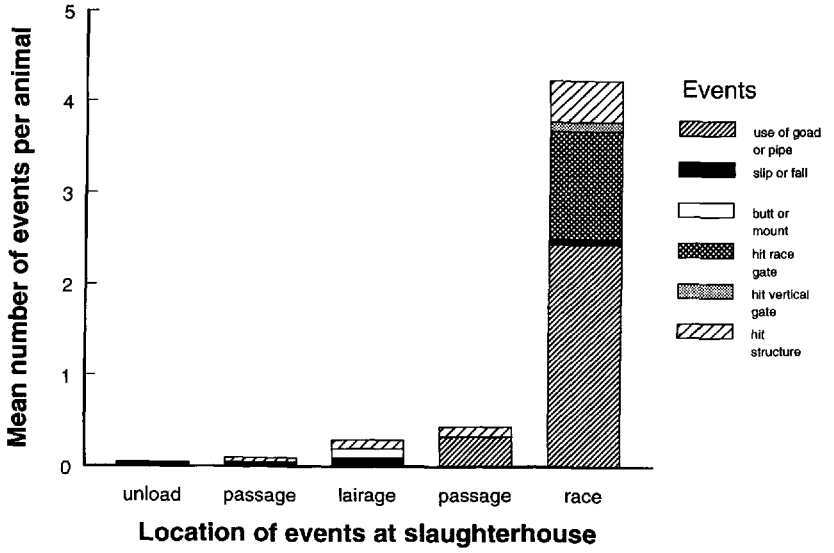

Figure 1 **Occurrence of handling events and potentially traumatic events during each handling stage: between unloading from the vehicle (unload), movement along passageway to lairage pen (passage), nine five-minute observation periods during the first three hours in the lairage pen (lairage), movement along passageway from lairage pen to the race (passage), and movement along race towards the stunning pen (race).**

Carcase bruising

There was a median of seven bruises (range 0–21) and a median bruise score of 12 (range 0–41) per animal. Almost all animals (99%) had some bruising although few animals were heavily bruised (17% had one heavy bruise and 10% had two or more heavy bruises). Bruising was mainly to the back, forequarters and pin bone and the majority of bruises were pale (Figure 2). Most (54%) bruises were slight, 4 per cent were little, 36 per cent were medium and 6 per cent of bruises were heavy.

There was no difference between the bruise score of cattle direct from farms and those from markets. There was no effect of distance travelled on the bruise score of farm cattle. However, cattle from markets within 64km (40 miles) of the slaughterhouse had significantly lower bruise scores than cattle from distant markets ($P < 0.05$, Table 1). There was no effect of source or distance travelled on bruise colour or bruise distribution, except that cattle from local farms (< 64km (< 40 miles)) had more bright red bruises than those from other farms ($P < 0.05$). The median fat classification was 4L (53% of cattle) with 3 per cent classed as 2, 27 per cent as 3, 14 per cent as 4H and 3 per cent as 5. The median conformation classification was R (60% of cattle), with 3 per cent classed as P, 24 per cent as O, 12 per cent as U and 2 per cent as E. There was a negative correlation between bruise score and fat class (r_s = -0.19, $P < 0.05$), and there was a trend for cattle of poor conformation to have higher bruise scores than those of good conformation.

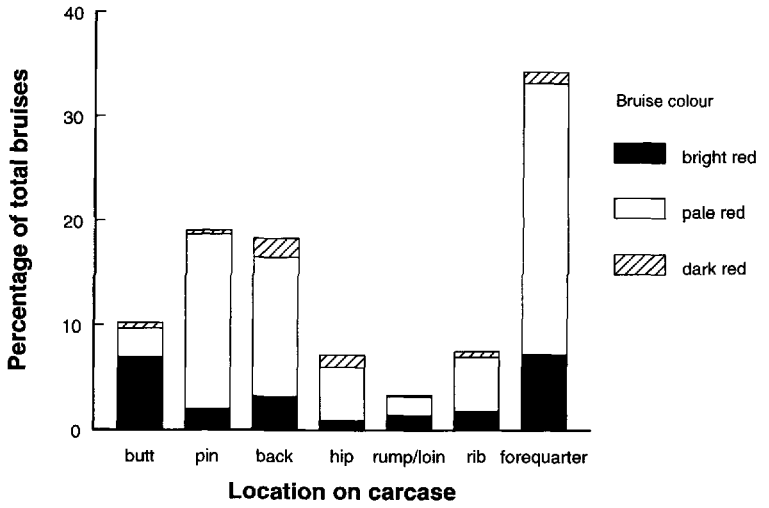

Figure 2 **Colour and distribution of bruises on carcases of cattle.**

Table 1 **Effect of distance travelled to the slaughterhouse from farms and from markets on the occurrence of bruising in cattle.**

		Distance travelled km (miles)			
		< 64km (< 40)	64–129km (40–80)	> 129km (> 80)	*P*
Farms					
Bruise score	median (Q1, Q3)	14 (10, 19)	12 (8, 15)	16 (7, 19)	ns
Number of bruises	median (Q1, Q3)	6 (5, 9)	6 (5, 8)	8 (4, 8)	ns
	number of cattle	26	37	23	
Markets					
Bruise score	median (Q1, Q3)	10^{a}(6, 14)	15^{b} (8, 23)	24^{b} (12, 28)	**
Number of bruises	median (Q1, Q3)	6^{a} (5, 8)	8^{b} (6, 10)	9^{b} (7, 11)	*
	number of cattle	29	35	10	

Q1 = first quartile, Q3 = third quartile
Different superscripts within a row indicate significant differences between columns

Relationship between events and bruising

There was no significant correlation between either the total number of handling or potentially traumatic events observed at the slaughterhouse and the number of bruises per animal. There were also no significant correlations between the occurrence of potentially traumatic events at any body site and bruising on that body site.

Biochemical measurements of dehydration and injury

Cattle from markets had a significantly greater plasma total protein concentration and plasma creatine kinase activity at the time of slaughter than cattle direct from farms, but there was

no significant effect of source on plasma osmolality and PCV (Table 2). There was no significant effect of the time spent in lairage, or the distance transported from farms, on any of the blood variables measured. However, cattle from more distant markets (> 129km (> 80 miles)) had a greater plasma total protein concentration and a greater PCV than those from nearer markets (< 64km (< 40 miles); Table 3).

Table 2 **Effect of source of cattle on measurements of dehydration and injury in blood samples at the time of slaughter.**

Variable	Farm (n = 98)		Market (n = 73)		
	median	(Q1, Q3)	median	(Q1, Q3)	*P*
Plasma osmolality (mosmol)	313	(303, 327)	318	(309, 326)	ns
Packed cell volume (%)	43	(41, 46)	44	(42, 47)	ns
Plasma total protein concentration (g l^{-1})	82	(75, 87)	86	(77, 92)	*
Plasma creatine kinase activity (iu l^{-1})	287	(213, 437)	352	(292, 471)	*

Q1 = first quartile, Q3 = third quartile

Table 3 **Effect of distance travelled to the slaughterhouse from markets, on measurements of dehydration and injury in blood sampled at the time of slaughter.**

Variable	Distance travelled km (miles)						
	< 64km (< 40)		64–129km (40–80)		> 129km (> 80)		
	median	(Q1, Q3)	median	(Q1, Q3)	median	(Q1, Q3)	*P*
Plasma osmolality (mosmol)	314	(307, 327)	318	(307, 327)	320	(317, 322)	ns
Packed cell volume (%)	43^{a}	(41, 47)	44^{a}	(42, 46)	48^{b}	(44, 49)	*
Plasma total protein concentration (g l^{-1})	82^{a}	(77, 88)	86^{ab}	(77, 92)	92^{b}	(86, 100)	*
Plasma creatine kinase activity (iu l^{-1})	405	(326, 505)	320	(220, 435)	362	(267, 444)	ns
number of cattle	29		33		9		

Q1 = first quartile, Q3 = third quartile
Different superscripts within a row indicate significant differences between columns

There was no significant correlation between the plasma activity of creatine kinase and either the number of potentially traumatic events occurring in, or time spent in, the race. There was also no significant correlation between the plasma activity of creatine kinase and the total number of bruises or bruise score.

Discussion

Previous work at two commercial slaughterhouses also found a high proportion of bruised cattle (Jarvis *et al* 1995), indicating that bruising is a potential welfare problem during pre-slaughter handling. In the cattle that were observed at each handling stage there was a median of seven bruises per animal recorded but a median of only one potentially traumatic event (and two handling events) per animal, suggesting that much of the bruising may have occurred prior to arrival at the slaughterhouse. Previous work on the handling and bruising of groups of cattle found few correlations between the occurrence of potentially traumatic events at the slaughterhouse and the occurrence of bruising (Jarvis *et al* 1995). By using focal observations in the current study, rather than observations on groups as in the previous study, any carcase bruising resulting from events occurring within the slaughterhouse at a particular location on an animal should have been easier to detect. However, there were no correlations between the occurrence of potentially traumatic events on specific sites on the cattle and carcase bruising on those sites. This suggests that these events are often not severe enough to cause a bruise and may not be contributing significantly to the carcase bruising seen after slaughter. This contrasts with findings in the USA where wilder cattle are handled in larger numbers and the risk of traumatic injury is greater (Grandin 1993). Also the number of cattle slaughtered per hour in this study was low compared with that in many slaughterhouses in the USA. Although it would have been possible to rate potentially traumatic events on a scale of severity (eg Blackshaw *et al* 1987) or to exclude some events, this would be a subjective assessment as there was inadequate information on the types or severity of events which can cause bruising.

It was not possible to record events in the stunning pen due to the layout of the slaughterhouse and some potentially traumatic events would have occurred here during struggling movements. The activity level of the cattle in the lairage pens was generally low, decreasing over the initial 3 hours, and it is unlikely that a significant number of potentially traumatic events occurred during lairage.

The distribution of bruises on the forequarters, pin bone and back is similar to that recorded by Tarrant *et al* (1992) on cattle slaughtered shortly after arrival at a slaughterhouse. Bruising on the back can be caused by the premature closing of heavy vertical gates on to the animal (Grandin 1980; Blackshaw *et al* 1987). However, no significant relationship was found between bruising on the back and contact with the vertical gates with a rounded edge in this study or in a previous study (Jarvis *et al* 1995).

Gracey and Collins (1992) suggested that the age of a bruise can be estimated from its appearance, with a bright red bruise likely to be up to 10 hours old, and a dark red bruise approximately 24 hours old. In this study relatively few bruises (24% overall) were bright red. This also suggests that a large proportion of bruising may have occurred before arrival at the slaughterhouse. Bruising prior to arrival at the slaughterhouse could potentially occur during on-farm handling, loading and unloading on to vehicles, transport itself and, for those cattle sold at markets, during handling and other procedures associated with marketing. Eldridge and Winfield (1988) found bruising in cattle to be significantly affected by transport conditions, such as space allowance. The occurrence of high bruise scores in cattle has been associated with falling down during transport (Tarrant *et al* 1992) and rough handling (Grandin 1980).

Despite the additional handling and transport associated with selling cattle at markets, there was no significant difference in the bruise scores or distribution of bruises between cattle direct from farms and those from markets. A previous study found more bruises on cattle from markets than on those from farms, and a similar trend for bruise scores (Jarvis *et al* 1995). Horder *et al* (1982) found no difference in the amount of bruising in farm and market cattle in Australia, although there were differences in bruise sites. Eldridge *et al* (1984) found that bruise scores were higher and bruises were more severe in cattle from markets in comparison to farms. In the current study, there was no evidence of an effect of source on bruising, but market cattle had significantly greater plasma creatine kinase activity at slaughter than cattle direct from farms. As the handling procedure at the slaughterhouse for cattle from farms and markets was similar, this difference could reflect greater muscle damage or other non-visible injury in market cattle. However, creatine kinase may also be increased by other factors such as the slaughtering procedure itself (Grosskopf *et al* 1988), making the interpretation of creatine kinase activity difficult.

Cattle from markets >64km (>40 miles) from the slaughterhouse had higher bruise scores than those from local markets. Transport from the furthest markets involved travelling distances of up to 483km (300 miles) to the slaughterhouse and this would typically have taken longer than from local markets. The additional bruising probably occurred during transport, but differences between markets such as handling procedures, length of time spent at the market and length of transport from farms to the market may also have influenced bruising. However, it is unlikely that there were consistent differences between markets in the different distance categories. There was no effect of distance on the bruise score of cattle from farms, probably as a result of the more limited range of distances 48–201km (30–125 miles). Tarrant (1990) considered that the major hazard during cattle transport was the loss of balance resulting in cattle going down during transport, and the risk of this occurring is likely to be increased in proportion to the journey duration. Yeh *et al* (1978) found that for journeys lasting between 3 and 10 days, increasing the journey duration resulted in more bruising in cows but there was no effect in steers.

Unloading from the vehicle and transfer into the lairage pens was not associated with many potentially traumatic events or handling events. Use of the electric goad was confined to the race area and most handling events at the slaughterhouse were found to occur in the race where the goad was used to move cattle towards the stunning box. The large number of animals (up to 14) placed in the race at any one time meant that some animals were confined in the race for up to 31 minutes. The number of handling events increased with time spent in the race. Cockram and Corley (1991) found that the plasma cortisol concentration increased with time spent in the race. Orihuela and Solano (1994) found that animals at the end of the race took longer to reach the stunning area, were more difficult to drive forward and required more handling with the electric goad. In the current study there was no significant correlation between potentially traumatic events in the race and the plasma activity of creatine kinase.

The range in plasma total protein concentration in this study is similar to that obtained by Grosskopf *et al* (1988) for cattle transported 200km (124 miles) to a slaughterhouse and slaughtered from between 0.5 to 24 hours after arrival, and by Warriss *et al* (1995) for cattle transported for up to 15h. Mitchell *et al* (1988) found that plasma total protein concentrations were not affected by either handling or slaughter. The significantly greater plasma total

protein concentrations in cattle that have arrived at the slaughterhouse from markets compared to those transported direct from farms, may suggest that these animals are more dehydrated. Plasma osmolality values in this study were higher than those found by Blair-West *et al* (1989) for cows deprived of water for 26.5h, but similar to those reported by Cole and Hutcheson (1981) in steers deprived of water and feed for 24 and 48h. However, neither of these samples were taken at slaughter. The PCVs in this study were higher than values obtained by Tarrant *et al* (1992) for steers transported by road for 24 hours, but similar to those obtained by Cockram and Corley (1991) for cattle handled under similar procedures at the slaughterhouse. There was no significant effect of source or distance travelled to the slaughterhouse on PCV. However, there was a trend for PCV to increase with distance travelled from markets. Changes in PCV with dehydration are initially small (Mitchell *et al* 1988) and Warriss *et al* (1995) found that transport of up to 15h did not result in increased PCV. PCV can be affected by both handling and the slaughtering process itself (Mitchell *et al* 1988) making the interpretation of samples taken at the time of slaughter difficult.

The blood variables examined do not provide unequivocal evidence of dehydration. However, the significantly greater time spent drinking by market cattle compared to farm cattle when provided with water in the lairage, suggests that market cattle were either more thirsty or more willing to drink than those transported to slaughter direct from farms. Blair-West *et al* (1989) found that cows deprived of water for 26.5h drank within 5 minutes of water being offered and drank 18.5 litres within the first hour (compared to 1.8 litres for cows with continuous access to water). Although animals must be provided with water at all times in slaughterhouse lairages (Ministry of Agriculture, Fisheries and Food 1995), in markets cattle need only have adequate access to water to prevent thirst (Ministry of Agriculture, Fisheries and Food 1990). All groups of cattle had access to water in the lairage pens, however, there was no effect of duration of lairage on any of the blood variables related to dehydration. Warriss *et al* (1995) found that plasma total protein concentration and plasma osmolality of cattle transported for 15h took 1 to 2 days to recover to pre-treatment values. The times spent in the lairage may have been insufficient for the cattle to recover adequately from dehydration, or drinking may have been inhibited by, for example, the unfamiliar environment or drinking troughs. The behaviour of the cattle during the initial 3h in the lairage pens suggests that they did begin to settle, spending progressively less time standing, walking and eating and more time lying down.

As this study was carried out in a commercial situation, there were inevitably many confounding factors. However, experimental work may not always reproduce the commercial situation where there are many potentially cumulative effects that can affect the welfare of animals during the pre-slaughter period.

Animal welfare implications

A large proportion of bruising of cattle in this study may have occurred before arrival at the slaughterhouse. The majority of potentially traumatic events and handling events that did occur at the slaughterhouse occurred in the race. The handling of cattle in the race could be improved by reducing the time spent in the race and by limiting the number of cattle confined in the race at any one time. Cattle from markets furthest from the slaughterhouse spent significantly more time drinking in the slaughterhouse lairage, showed some evidence of dehydration at slaughter and had higher bruise scores than cattle from more local markets.

Provision of water in slaughterhouse lairages is important, particularly for market cattle. Further study on the handling and pre-slaughter management of cattle in markets is required, as this study suggests that cattle transported for a distance greater than 64km (40 miles) would benefit from greater access to water at the market, and from improved methods of handling and transport prior to arrival at the slaughterhouse.

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