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A comparison of handling methods relevant to the religious slaughter of sheep

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Abstract

Legislation governing non-stun slaughter of sheep in England requires that they are individually and mechanically restrained for slaughter and not moved for at least 20 s post neck cut, until unconsciousness or insensibility occurs. Complying with the need for individual handling, in what is a flock animal, has the potential to adversely affect welfare, in turn contravening the general legislative requirement to reduce any avoidable distress at slaughter. This study investigated the effects of individually loading and restraining lambs compared with the normal practice of group loading and restraint of lambs prior to slaughter when using a V-shaped restrainer. Rotating and static design loading pens were also compared to represent the range of conditions and facilities found across English abattoirs. Plasma cortisol and lactate concentrations were significantly lower in group-loaded animals and significant reductions were observed in the time duration of a range of components of handling as well as the average total time to load each lamb. Loading pen type had a less marked impact upon results, however, individual loading and restraint of lambs within a V-shaped restrainer appears particularly stressful for sheep in comparison with group loading. The loading pen type had a mixed effect although the rotating crowding pen is likely to have minimised physical exertion in lambs during loading and restraint. Based on these findings, group loading in a V-shaped restrainer, whilst complying with the 20-s standstill, is likely to be preferable in religious, non-stun slaughter of sheep.

Keywords: *animal welfare, lamb, non-stun religious slaughter, pre-slaughter handling, sheep, V-shaped restrainer*

Introduction

It is widely accepted that the slaughter process is stressful for animals (Ferguson & Warner 2008). Events or situations which trigger a stress response are commonly referred to as 'stressors' and are generally categorised as being either physical or psychological in nature (Grandin 1997). Psychological stressors of particular importance within the abattoir include the novelty of the environment, handling, isolation and restraint and associated physical fatigue and injury. Within the slaughter process, sheep are often restrained for stunning and/or slaughter which in itself is stressful for the animal, however, when restraint is combined with isolation this can evoke a significant stress effect in sheep (Apple *et al* 1995). Isolation is thought to make sheep anxious and restless and hence they may display escape behaviours (Dwyer 2009).

As a prey species, sheep do not generally show overt, outward signs of fear and anxiety, making it difficult to monitor stress by behaviour. However, measuring physiological variables enables the quantification of a stress response, and blood cortisol is commonly used as a measure of stress at slaughter (Linares *et al* 2008; Probst *et al* 2013; Zimerman *et al* 2013). Blood lactate may also be used to assess acute stress and is advantageous due to its rapid response (Probst *et al* 2013); the release of cortisol and catecholamines result in glycolysis and so increased lactate production. Additionally, lactate is indicative of muscle activity and increases during exercise as a result of anaerobic muscle metabolism (Gericke & Belonje 1975). Creatine kinase (CK) also increases with exercise, as well as with injury to muscle (Gericke & Belonje 1975), and can be used to measure physical exertion and so indicate physiological stress pre-slaughter.

In 2012, approximately 13.8 million sheep were slaughtered in the UK (Defra 2013). In order to maintain slaughter line speeds whilst ensuring animal welfare is upheld, effective restraint mechanisms to facilitate stunning and/or slaughter have become increasingly important. Grandin (1995) advocates the importance of systems being designed to take advantage of the animal's behavioural responses and furthermore developed a set of principles for minimising stress during restraint. In particular, sheep have strong flocking and following instincts and can quickly become distressed if separated from their peers (MLA 2013), so should always be handled in groups (Colditz & Dart 2009; Yates *et al* 2010). V-shaped conveyor restrainers, which deliver sheep in a continuous flow from the lairage to the point of stunning and/or neck cutting, are commonly installed in higher throughput English sheep plants. They are designed to utilise the flocking instinct of sheep and provide visual, audio

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and tactile contact with other sheep, which, along with the feeling of being held, encourages sheep to remain calmer (Grandin 1995). In addition, handling systems prior to the restrainer, such as circular rotating crowd pens, have also been designed and incorporated into some plants. Their use minimises handling activity and encourages voluntary loading into the restrainer, thus reducing stress and the potential for injury. This is in direct contrast to the traditional static pens where more physical handling is often required to load sheep to the restrainer which may impact both physically and psychologically upon the sheep.

English legislation dictates that livestock are stunned pre-slaughter in order to induce unconsciousness however animals slaughtered for religious purposes are exempt from pre-slaughter stunning (WASK 1995; PATK 2009). Figures are not routinely kept on the number of animals slaughtered under religious methods in England (Lever *et al* 2010). However, figures from a recent, week-long, Food Standards Agency (FSA) animal welfare survey (FSA 2012), indicated that out of 307,512 sheep and goats slaughtered at the 202 abattoirs surveyed in Great Britain, approximately 51% were slaughtered in accordance with Halal (50%) or Shechita, Jewish slaughter, (1%) methodology. FSA (2012) stated that of the sheep religiously slaughtered, 81% were stunned prior to slaughter and almost a further 1% were stunned post neck cut. These figures suggest that less than 10% of all sheep and goats are slaughtered without stunning for religious consumption which, based on 2012 UK slaughterings (Defra 2013), amounts to approximately 1.4 million sheep and goats per year.

In the case of religious, non-stun slaughter, domestic legislation requires the severance of both the carotid arteries and jugular veins (WASK 1995; WATOK 2013). In addition, animals slaughtered without stunning must be individually and mechanically restrained (PATK 2009) which is currently interpreted by Defra within UK law to mean that only one animal at a time can be loaded onto a V-shaped restrainer, thus in conflict with the design principles of taking advantage of the sheep's natural behaviour. Further, animals must not be released from the restraint mechanism until they are unconscious or insensible. Domestic legislation (WASK 1995) further extends this requirement to state this period of restraint, post neck cutting, must be no less than 20 s.

This study aimed to examine the potential stress effects and handling implications from individually loading and restraining sheep in a V-shaped restrainer, as interpreted and enforced within English legislation for non-stun slaughter, compared with group loading and restraint. Furthermore, the effects of using a circular rotating crowd pen as opposed to a traditional static pen system for pre-slaughter handling were assessed.

PATK (2009) clearly states that throughout the slaughter operations, "animals should be spared of any avoidable pain, distress or suffering". As such, the requirement for individual restraint for non-stun slaughter of sheep when using a V-shaped restrainer, could be argued to contravene the general requirement of not subjecting animals to avoidable stress. Furthermore, pre-slaughter loading is an area unrelated to religious law and so changes regarding this area of the legislation would not infringe any religious rites.

Materials and methods

On the eve of the trial, 200 continental cross lambs (mean [± SD] cold carcase weight 19.8 [± 2.38] kg), reared at grass and sourced from one farm, were transported to a commercial sheep abattoir. The abattoir routinely practiced both pre-slaughter electrical stunning and religious slaughter, without stunning. On arrival, the lambs were penned and allowed to rest overnight with access to feed and water. Groups of ten lambs were selected from the lairage pens and randomised to one of the four treatment groups. Preferentially, lambs were selected from the same lairage pen for each group of ten to better replicate commercial practice. Each treatment was repeated five times, in a randomised order, giving a total of 50 lambs per treatment (see below).

Whilst the principle aim of the trial was to assess the stress response of sheep when complying with legislation for non-stun slaughter, the specific focus was the method of loading and restraint. Thus, all the lambs in the trial were stunned prior to slaughter as this would not be anticipated to alter the overall comparisons between treatments. Stunning was by means of a Jarvis Electric Stunner, with water flow, set at a constant current of 1.05 A. Slaughter was by severance of both carotid arteries and jugular veins.

Two treatments were compared, each with two levels: (IR) Individual loading onto the V-restrainer, using a rotating crowd pen; (GR) Group loading onto the V-restrainer, using a rotating crowd pen; (IS) Individual loading onto the V-restrainer, using a static crowd pen; and (GS) Group loading onto the V-restrainer, using a static crowd pen.

The loading pen treatments consisted of a circular, rotating floor crowd pen, designed to complement a sheep's natural behaviour or a more traditional, static crowd pen with a fixed floor area. Lambs enter the rotating pen and are automatically moved round to the foot of the restrainer. The rotating pen had a radius of 2.4 m giving a total floor area of 18 m^2. Three internal, centrally pivoting gates enable the pen to be split into three sections each of which hold an average of 25 lambs when in full operation (Figure 1), although in this trial, only one section was used at a time to allow for ease of transition between the alternating treatment groups. The static floor loading pen was formed by gating off the rotating pen to form a semi-circle with a floor area of 9 m^2 and the rotation disabled (Figure 2). When using the rotating crowd pen treatment, as sheep were loaded into the restrainer and more pen space became available, the gates were moved to decrease the floor area, in turn moving animals closer to the base of the V-restrainer, as would be the case during normal commercial operation (Figure 1). During static pen loading the rotating floor was disabled and the moveable gates were not used (Figure 2). Lambs were allowed to move freely around the pen, mimicking the increase in space available to animals in a static pen stunning system. At any time, and with all treatments, there was always one handler (a member of the abattoir lairage staff), present within the pen during loading, as would be the case under normal commercial working.

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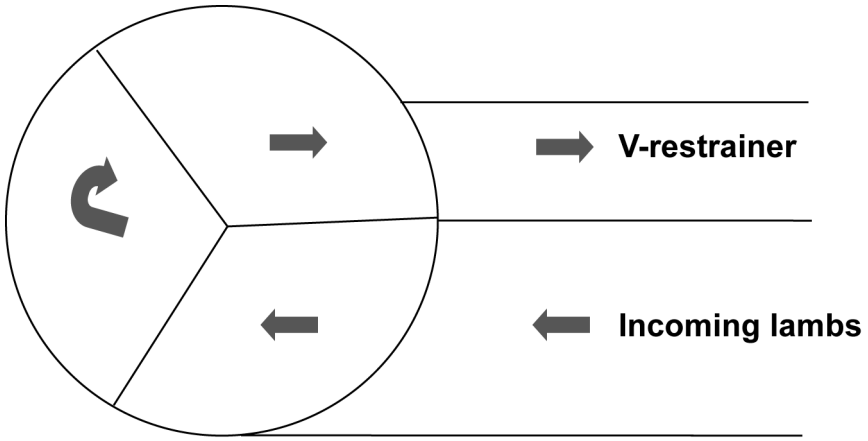
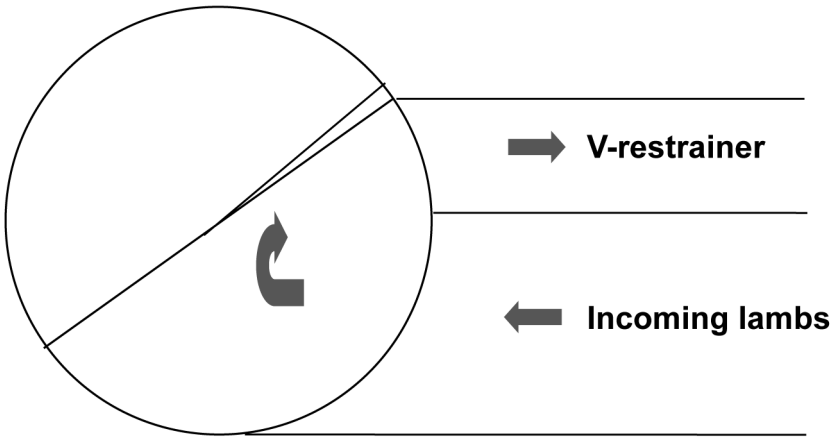
Figure 1



The rotating crowd pen as normally used by the abattoir and as used in treatment groups IR and GR. The three radial gates can be made to move independently to move sheep and alter pen sizes and the circular floor can be rotated, either manually or by electric motor.

Figure 2



The rotating crowd pen set for use as a static pen as used in treatment groups IS and GS.

With the conveyor/restrainer, the individual loading of lambs mimicked handling conditions in non-stun religious slaughter under legislation as currently applied. In individual loading only one lamb was permitted on the V-restrainer at any one time and was conveyed individually to the head of the conveyor/restrainer. Following a stun then a neck cut on the conveyor, the lamb was held for 20 s before unloading during which time subsequent lambs were prevented from entering the V-restrainer. In group loading, lambs were conveyed together in a line, sequentially, to the head of the V-restrainer for stunning as is the case in conventional pre-stun slaughter. However, unconventionally, post stunning, the neck cut was performed on the conveyor and each lamb was held for 20 s prior to release as per non-stun slaughter requirements. These steps were taken to enable a valid comparison between treatments to be made.

Pre-slaughter handling and loading assessment

In order to assess the potential effect of handling on the stress response of the lambs, the type and level of handling interactions between sheep and handler during loading into the restrainer was recorded. A copy of the footage from one of the plant's CCTV cameras, positioned to show a clear view of the loading pen and entrance to the restrainer, was obtained.

Using OBSERVER® XT10.0 software (Noldus Information Technology, Wageningen, The Netherlands), for each individual lamb, the time-stamped footage was analysed for the length of time in seconds within the loading pen that:

- an individual lamb was in voluntary motion towards, and voluntarily loading onto the restrainer;
- the handler was in motion towards an individual lamb;

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• the handler spent having physical contact with an individual lamb (ranging from a gentle touch to physically guiding the lamb to the foot of the restrainer);

• the handler held each individual lamb at the foot of the restrainer (normally to prevent access to the V-restrainer); and

• was spent, in total for each lamb to load in the restrainer, timed from when the group were moved into the loading pen to entering the restrainer.

The behaviours were treated as mutually exclusive.

In addition, the presence or absence of escape behaviour (attempts to move away from the conveyor entrance and/or pen) during loading was scored. Escape behaviour within the restrainer was also scored, however, because CCTV footage only covered the entrance to the restrainer and not the length of the restrainer, this was manually scored during the trial on either a presence or absence basis by one researcher at the base of the restrainer and a researcher at the head of the restrainer.

Vocalisation at both the base and during conveyance along the restrainer was also scored on the trial day. However, as very few vocalisations were made, there were insufficient data for analysis (at base of conveyor; only one bleat, on conveyor; GR = 0, GS = 1, IS = 3 and IR = 4).

Collection and analysis of blood samples

Blood was collected from each lamb immediately post neck cut. Two tubes were collected per lamb, one tube containing oxalate and fluoride (OF) preservative for lactate analysis and one plain tube for analysis of cortisol and CK. OF tubes were centrifuged within 20 min of mixing, while plain tubes were left for at least 1 h to prevent serum gelatinisation. All tubes were centrifuged at 4,000 rpm for 10 min. After spinning, plasma was pipetted into 'LKB' tubes which were placed into liquid nitrogen for storage and transportation to Langford Veterinary Services Diagnostic Laboratories for analysis. Lactate was determined using a Konelab prime 60i autoanalyser (Thermo Fisher scientific, Vantaa, Finland) with reagents by Trinity Biotech (Co Wicklow, Republic of Ireland). A standard coupled enzyme method (Thermo Fisher Scientific, Waltham, MA, USA) was used to measure CK activity. Cortisol was measured using a chemiluminescent immunoassay using the Immulite 1000® immunoassay system (Siemens, Germany).

Twenty-three samples were mislabelled or became clotted due to lack of thorough mixing and had to be removed from the analysis. These did not disproportionately affect any particular group and for the data analysis were treated as 'missing at random'.

Statistical analysis

The multilevel statistical software package MLwiN (Rasbash *et al* 2009) was used for all analyses as it allowed the statistical models to properly account for the hierarchical data structure; the clustering and possible correlations within the ten sheep within each treatment application. All main effects (individual/group loading and static/rotating crowd pen) and their interactions (individual/group loading × static/rotating crowd pen), were tested in the model as was a term for an order effect (a continuous variable with values from 1 to 200). If either of the interaction term or the order term was not significant they were dropped from the model and the model refitted. A general linear model was fitted within MLwiN for the continuous outcome variables and a binary logistic regression for the binary outcome variables. The results from logistic regression are reported as odds ratios, except for the case where an interaction term was significant. In this case, results are reported as probabilities. The data for plasma cortisol, CK and lactate were natural log-transformed to satisfy the assumptions required for the statistical models.

Results

The parameter estimates from the statistical analyses of the outcome variables are shown in Table 1. The constant refers to individual loading from the static pen and parameter estimates show the effects that group loading and rotating pen have on each of the assessed variables.

Blood variables

Group loading and restraint, as opposed to individual loading and restraint, had significantly less increased cortisol concentrations ($P = 0.024$). Whilst lambs loaded to the restrainer using the rotating pen had lower cortisol concentrations in comparison with the static pen, the difference was not significant ($P = 0.169$). CK activity was not significantly different between individual and group loading, however, using the rotating pen for loading significantly reduced CK compared with using the static pen ($P = 0.033$). Lamb order had a significant effect on CK activity ($P = 0.046$), with those lambs loaded later having a mean decrease in CK concentration of 0.002 natural log units per lamb. Group loading showed a significant reduction in lactate concentrations in comparison with individual loading ($P = 0.004$), as did loading from the rotating pen rather than the static pen ($P = 0.020$).

Handling

There was no significant difference between either the loading method or loading pen type in the time that a lamb would voluntarily approach the restrainer to self-load. The time spent in voluntary approach was greater with group loading, but this only tended toward statistical significance ($P = 0.071$). There were, however, highly significant differences in the duration of approaches made by the handler towards the lamb during loading, with a significant interaction effect between the two treatments ($P = 0.003$), and handler approach time shortest for GR treatment (1.9 s), followed by IR (2.1 s), GS (10.3 s) and then IS (19.6 s).

The duration of physical handling for group loading was significantly reduced ($P < 0.001$) compared with individual loading, but loading pen types were not significantly different. Lamb order was found to be highly significant ($P < 0.001$) in relation to duration of handling, with those lambs slaughtered later in the trial recording a mean increase in handling time of 0.0184 s per animal. In individual loading the average time that a lamb had to be held back from getting on to the conveyor was 19.5 s greater than the mean for a lamb in group loading. There were no significant differences in the duration of time held between rotating pen or static pen loading.

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Table 1 The parameter estimates from the statistical analysis of the outcome variables.

Continuous variables	Constant	Group	*P*-value	Rotating pen	*P*-value	Group × Rotating pen	*P*-value	Order	*P*-value
LnCortisol (Ln nmol L^{-1})	4.162 (± 0.067)	–0.1756 (± 0.0781)	0.024	–0.1074 (± 0.0781)	0.169	–	–	–	
LnCK (Ln IU L^{-1})	6.462 (± 0.110)	0.0219 (± 0.0906)	0.81	–0.1941 (± 0.0907)	0.032	–	–	–0.0021 (± 0.0008)	0.008
LnLactate (Ln mmol L^{-1})	1.154 (± 0.101)	–0.3398 (± 0.1166)	0.003	–0.2715 (± 0.1166)	0.02	–	–	–	
Duration lamb approach (s)	5.811 (± 1.778)	3.7091 (± 2.0532)	0.071	–2.7413 (± 2.0532)	0.181	–	–	–	
Duration handler approach (s)	19.595 (± 1.566)	–9.3356 (± 2.2144)	< 0.001	–17.4932 (± 2.2144)	< 0.001	9.167 (± 3.132)	0.003	–	
Duration handling (s)	2.227 (± 0.740)	–3.0978 (± 0.6085)	< 0.001	–0.0282 (± 0.6088)	0.98	–	–	0.0184 (± 0.0053)	0.001
Duration holding (s)	22.767 (± 1.856)	–19.5244 (± 2.143)	< 0.001	3.199 (± 2.143)	0.136	–	–		
Total time (s)	211.21 (± 11.62)	–144.957 (± 13.419)	< 0.001	2.291 (± 13.419)	0.864	–	–		
Binary variables	**Constant**	**Group**	***P*-value**	**Rotating pen**	**P-value**	**Group × Rotating pen**	***P*-value**	**Order**	***P*-value**
Escape behaviour, pen	–0.720 (± 0.478)	–1.6638 (± 0.5262)	0.002	0.3911 (± 0.4453)	0.379	–	–	–0.0089 (± 0.0040)	0.026
Escape behaviour bottom of restraint	0.193 (± 0.414)	–0.8947 (± 0.4258)	0.036	1.1945 (± 0.5398)	0.026	–1.7866 (± 0.6850)	0.009	0.0066 (± 0.0029)	0.020

The treatments 'Group v Individual Loading' and 'Type of Crowd Pen' were tested within a model of each outcome variable together with their interaction and also the effect of 'Order of Slaughter'. Where the interaction and/or order effect were not significant they were dropped from the model. The parameter estimates and their standard errors are reported together with the significance of the parameter estimates. The 'Constant' in the model is tied to the Individual Loading treatment and to the Static Loading Pen treatment, thus the parameter estimates show the differential effects of the Group Loading and the Rotating Crowd Pen on the outcome variables.

There was a highly significant difference ($P < 0.001$) between group and individual loading in the total time taken to load lambs into the restrainer. This was measured as the time from when the group of ten lambs were moved into the loading pen to the time the last animal entered the base of the restrainer, which for group loading showed a mean reduction of 145 s per group over individual loading ($P < 0.001$). Total loading time was not significantly different between the static loading pen and the rotating loading pen.

Escape behaviour shown by lambs within the loading pen was significantly lower ($P = 0.002$) in group loading than individual loading. The odds ratio for displaying escape behaviour in the loading pen during group loading was 0.189 compared with individual loading. No significant differences were found between static or rotating loading pens. Lamb order was significant ($P = 0.024$), with those lambs loaded as the trial progressed showing less likelihood to display escape behaviour at this point in the handling system than those loaded earlier.

Escape behaviour shown by lambs loaded at the bottom of the restrainer was shown to be associated with a significant interaction effect between the treatments ($P = 0.009$), within the logistical regression model. The estimated coefficients were used to calculate the predicted probabilities of displaying escape behaviour in the treatments. The greatest probability for escape behaviour to be displayed was within the IR treatment group (0.800), followed by the IS (0.548), GS (0.332) and GR (0.215) groups. Lamb order also had a significant effect ($P = 0.020$), with those lambs loaded later showing a greater likelihood to show escape behaviour, as the trial progressed.

Discussion

Overall, the results from this study indicate that there is an additional behavioural and physiological stress placed upon lambs when individually loaded and held in the V-restrainer. The study also provides evidence that the use of a circular rotating crowd pen for loading sheep onto a V-restrainer can facilitate handling and therefore improve welfare of sheep during this activity.

The higher concentration of cortisol and lactate in lambs individually loaded indicates increased muscle activity compared with those group loaded, as lactate increases with exercise (Apple *et al* 1994). This increase in muscle activity is likely to be attributable to the increased handling and holding and associated struggling and probability of display of escape behaviour by lambs during individual loading. Although CK activity increases with exercise (Gericke & Belonje 1975), it showed no significant difference between loading groups. This may be because CK activity was likely to already be increased due to handling on-farm, transportation and handling in the lairage (TGK unpublished data) and so any differences in activity may have been partially masked by high activity prior to the study treatments.

Cockram *et al* (1994) ascertained that complete isolation of sheep without visual or physical contact of other sheep led to a significant increase in cortisol concentrations. Various research further identified that sheep exposed to both isolation and restraint had higher concentrations of cortisol and lactate (Apple *et al* 1995; Moolchandani *et al* 2008). Furthermore, Grandin (1995) advocates the calming effect

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that physical and visual contact within a restrainer conveyor system can have on animals in comparison with individual restraint situations, with Anil (2012) confirming that sheep do not appear distressed when loaded sequentially with other sheep. The elevated concentrations of cortisol and lactate in lambs individually loaded and restrained within this trial would concur with these research findings and reinforce the fact that isolation and individual restraint of sheep is more stressful than group loading and group restraint of sheep.

In meeting the legislative standstill requirements for time to loss of brain function (WASK 1995; WATOK 2013), group-loaded lambs remained within the restrainer for longer periods than those restrained and held individually. This goes against the recommendations of FAWC (2003), who advocate that animals should only be restrained for short periods of time and are more likely to become stressed if they are held within the restrainer for longer periods. PATK (2009) also states that restraint time should be minimised as it is likely to cause distress. However, the trial results would suggest that in this particular situation the time duration spent within the restrainer was insignificant compared with the isolation factor of individual restraint. In addition, the reduction in the physiological measurements seen in group-loaded lambs would indicate that they did not find witnessing the treatment of the preceding lambs to be stressful.

'Individual' restraint is required for religious slaughter (PATK 2009). Under current legislation this is interpreted by Defra to mean that only one animal at a time can be loaded onto a V-shaped restrainer. However, each animal is individually restrained and does not rely on the one in front or behind to restrict its movement, but is held within the system itself, thus group loading could be considered to fall outside this requirement. Understanding and taking advantage of animal behaviour principles led to the development of restrainer conveyor systems to reduce stress (Grandin 1995). Individual loading into these systems goes against these design principles and therefore ultimately increases the potential for animals to be exposed to unnecessary stress. The duration of handling and the display of escape behaviour were significantly reduced in the group situation, which in turn were likely to reduce the physical exertion and stress effect of the lambs. During their lives, sheep tend to be extensively reared, having minimal contact with humans, thus handling and close proximity to people can be stressful (Grandin 1997). Sheep are a flock species in which the presence of a conspecific can help to buffer stress (Porter *et al* 1995), and they rely heavily on their natural flocking instinct in the presence of a perceived threat (Dwyer 2004). The results, shown by the assessed handling variables, reinforces the fact sheep are easier to handle in groups (Colditz & Dart 2009; Yates *et al* 2010). Sheep that are isolated may tend to panic, as indicated by the increase in escape behaviour during loading and at the foot of the restrainer, and thus increase the chance of becoming injured, further exacerbating their stress (Grandin 1998). Therefore, sheep loaded individually may be less able to cope under stressful situations.

The 'following' instinct of sheep was particularly apparent in individual loading, shown by the time lambs had to spend being held back, when trying to follow the previous lamb into the restrainer, to ensure they did not enter until the previous lamb had been released. This is an essential factor, with the majority of current systems in use, to ensure compliance with the legislative requirements for individual restraint in non-stun religious slaughter. Unsurprisingly, the total time from the lamb entering the loading pen to being loaded in the restrainer was shorter for group loading than for individual loading. Whilst in group loading the restrainer is constantly occupied with lambs, taking into consideration the additional 12 s per lamb to be conveyed to the top of the restrainer in individual loading, the mean group loading time was still almost 25 s quicker than individual loading.

As with restraint itself, loading of lambs and pre-slaughter handling can be particularly stressful for sheep. Sheep readily follow another sheep (MLA 2013). This is a key factor in the design of V-shaped restrainers and handling systems using curved raceways and circular crowd pens, used extensively across the world, where following behaviour is encouraged to create a flow of movement. Apple *et al* (1994) found exercising lambs prior to slaughter led to elevated cortisol and lactate concentrations. Furthermore, in pigs, CK activity and lactate concentrations were found to be reduced in low stress, pre-slaughter handling systems compared with poorer handling systems (Warriss *et al* 1994). The significant reduction in lactate and CK activity in lambs loaded from the rotating loading pen suggest less physical exertion was placed on the lambs and in turn they found this system to be less stressful. The rotating floor helped minimise physical movement of the sheep and by altering the pen size using the rotating gates, an optimum floor space could be maintained to ensure the pen was always kept full and this assisted with keeping sheep as a group and maximising the following behaviour (Grandin 1998). Differences between the loading pen types may have led to greater muscle activity in lambs as opposed to the different loading types and thus account for the significant difference seen in CK between the static and rotating pen.

The duration of the approaches by the handler was over 17 s less in the rotating pen system than the static pen which is likely to be due to being able to keep the floor area to an optimum size, in turn keeping the lambs bunched close to the handler and the foot of the restrainer. Interestingly, lambs loaded from the rotating pen showed an increase in the display of escape behaviour when physically restrained at the foot of the V-shaped restrainer compared with those loaded from the static pen. However, on closer inspection, the significant interaction effect highlights that the probability of lambs making an attempt to escape are lower for GS and GR treatments than IS and IR treatments. Thus, individual loading would appear to be a far more important factor. Individual loading effectively blocks waiting lambs from following their peers which has the potential to add further stress or may even cause them to become frantic and thus result in the display of escape behaviour (MLA 2013). This further supports the fact that a conspecific can help buffer stress (Porter *et al* 1995).

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The static pen used in the trial was created by halving the circular rotating pen. This does not precisely replicate the system in plants where the static pen may be rectangular or have straight edges and corners. It could be argued that the curved side will have assisted the movement of lambs and encouraged following behaviour despite not having the benefit of manipulating the floor area. Thus, it may have been that less significant differences were found between the static and rotating pen used in this trial than may have been seen within a traditional static pen where the sheep could gather and crowd together in a corner, making movement of sheep more difficult and potentially necessitating more physical handling. Such a pen design may lead to greater differences than seen in this trial.

Animal welfare implications

Legislation clearly states that throughout slaughter, avoidable distress, pain or suffering must be minimised (PATK 2009). This work highlights that stress experienced by lambs in non-stun religious slaughter can be reduced through group restraint as opposed to individual restraint. Loading sheep in groups rather than individually should therefore increase the welfare of the animals involved without compromising any religious requirements regarding pre-slaughter handling.

Further research

In the first instance it would be interesting to repeat the work using a static pen with straight sides and corners to further assess the differences between loading pens, and also to investigate improved methods of restraint that do not require separation of individuals from the group. Furthermore, the work could be extended to examine the effects of individual restraint in the V-shaped restrainer on meat quality. Stress at slaughter results in a decrease in meat quality (Chambers & Grandin 2001; Ferguson & Warner 2008) and this would be an effective driver for the implementation of improved welfare. Apple *et al* (1995) suggested stress due to restraint and isolation was sufficient to bring about dark, firm, dry meat whereas stress due to physical exertion had little impact upon meat quality (Apple *et al* 1994).

Conclusion

Restraining lambs individually within a V-shaped restrainer, in accordance with welfare legislation for non-stun slaughter of lambs under religious methods, is more stressful for sheep than restraining them sequentially as a group, whilst still in compliance with the required 20-s standstill period post neck cut (WASK 1995; WATOK 2013).

Allowing lambs to be restrained in groups would enable them to display more natural flocking behaviour and have decreased loading time and duration of handling and holding by the stockman. Consequently, sheep would appear less stressed and show less escape behaviour and lower general muscle activity, together with decreased plasma cortisol and lactate concentrations.

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References

Anil MH 2012 *Effects of slaughter method on carcass and meat characteristics in the meat of cattle and sheep.* http://www.eblex.org.uk/wp/wp-content/uploads/2013/04/slaughter_and_meat_quality_feb_2012-final-report.pdf

Apple JK, Dikeman ME, Minton JE, McMurphy RM, Fedde MR, Leith DE and Unruh JA 1995 Effects of restraint and isolation stress and epidural blockade on endocrine and blood metabolite status, muscle glycogen metabolism, and incidence of dark-cutting longissimus muscle of sheep. *Journal of Animal Science 73*: 2295-2307

Apple JK, Minton JE, Parsons KM, Dikeman ME and Leith DE 1994 Influence of treadmill exercise on pituitary-adrenal secretions, other blood constituents, and meat quality of sheep. *Journal of Animal Science 72*: 1306-1314

Chambers PG and Grandin T 2001 Effects of stress and injury on meat and by-product quality. In: Heinz G and Srisuvan T (ed) *Guidelines for Humane Handling, Transport and Slaughter of Livestock* pp 3-10. RAP Publication: Thailand

Cockram MS, Ranson M, Goddard PJ, Burrels C and Harkiss GD 1994 The behavioural, endocrine and immune responses of sheep to isolation. *Animal Production 58(3)*: 389-399. http://dx.doi.org/10.1017/S0003356100007339

Colditz I and Dart C 2009 The Sheep. *ANZCCART Fact Sheet A9. Revised and republished July 2009*. http://www.adelaide.edu./ANZCCART/publications/A(_SheepFactSheet.pdf

Defra 2013 *UK slaughterings and dressed carcase weights: statistics notice.* http://www.defra.gov.uk/statistics/files/defra-stats-food-farm-food-slaughter-statsnotice-130321.pdf

Dwyer CM 2004 How has the risk of predation shaped the behavioural responses of sheep to fear and distress? *Animal Welfare* 13: 269-281

Dwyer CM 2009 The behaviour of sheep and goats. In: Jenson P (ed) *The Ethology of Domestic Animals, Second Edition: An Introductory Text* pp 161-176. CAB International: Wallingford, UK

FAWC 2003 *Report on the Welfare of Farmed Animals at Slaughter or Killing. Farm Animal Welfare Council. Part 1: Red Meat Animals. June 2003.* http://www.fawc.org.uk/reports/pb8347.pdf

Ferguson DM and Warner RD 2008 Have we underestimated the impact of pre-slaughter stress on meat quality in ruminants? *Meat Science 80*: 12-19. http://dx.doi.org/10.1016/j.meatsci.2008.05.004

FSA 2012 *Food Standards Agency, Open Board 22 May 2012. Results of the 2011 FSA Animal Welfare Survey in Great Britain. FSA 12/05/08.* http://www.food.gov.uk/multimedia/pdfs/board/fsa120508.pdf

Gericke MD and Belonje PC 1975 Aspects of forced exercise and the therapy thereof in sheep. *Journal of the South African Veterinary Association 46*: 353-357

https://doi.org/10.7120/09627286.23.3.251 Published online by Cambridge University Press

Grandin T 1995 Animal behaviour and the design of livestock and poultry systems. *The Animal Behaviour and the Design of Livestock and Poultry Systems International Conference.* 19-21 April, 1995, Indianapolis, Indiana, USA

Grandin T 1997 Assessment of stress during handling and transport. *Journal of Animal Science 75*: 249-257

Grandin T 1998 Review: reducing handling stress improves both productivity and welfare. *The Professional Animal Scientist 14(1)*: 1-10

Lever J, de la Bellacasa MP, Miele M and Higgin M 2010 From the slaughterhouse to the consumer. Transparency and information in the distribution of halal and kosher Meat. *Dialrel Reports WP4.3*. http://www.dialrel.eu/dialrel-results

Linares MB, Bórnez R and Vergara H 2008 Cortisol and catecholamine levels in lambs: effect of slaughter weight and type of stunning. *Livestock Science 115*: 53-61. http://dx.doi.org/10.1016/j.livsci.2007.06.010

Meat and Livestock Australia (MLA) 2013 *A producer's guide to sheep husbandry practices*. http://www.mla.com.au/CustomControls/PaymentGateway/ViewFile.aspx?tednd5fr9NoZ6u/e4besUl0h11vNF7HU9dy8UtXGSAA4Ak08AQX66iyr3RNeqoiV3EYMKKAfsht7d1Tnt3BqiA

Moolchandani A, Sareen M and Vaishnav J 2008 Influence of restraint and isolation stress on plasma cortisol in male karakul sheep. *Veterinarski Arhives 78(4)*: 357-362

PATK 2009 *Council Regulation (EC) No 1099/2009 on 24 September 2009 on the Protection of Animals at the Time of Killing*. http://ec.europa.eu/food/animal/welfare/slaughter/regulation_1099_2009_en.pdf

Porter RH, Nowak R and Orgeur P 1995 Influence of a conspecific agemate on distress bleating by lambs. *Applied Animal Behaviour Science 45*: 239-244. http://dx.doi.org/10.1016/0168-1591(95)00630-B

Probst JK, Hillmann E, Leiber F, Kreuzer M and Neff AS 2013 Influence of gentle touching applied few weeks before slaughter on avoidance distance and slaughter stress in finishing cattle. *Applied Animal Behaviour Science 144*: 14-21. http://dx.doi.org/10.1016/j.applanim.2012.12.007

Rasbash J, Charlton C, Browne WJ, Healy M and Cameron B 2009 *MLwiN Version 2.1*. Centre for Multilevel Modelling: University of Bristol, UK

Warriss PD, Brown SN, Adams SJM and Corlett IK 1994 Relationships between subjective and objective assessments of stress at slaughter and meat quality in pigs. *Meat Science 38(2)*: 329-340. http://dx.doi.org/10.1016/0309-1740(94)90121-X

WASK 1995 *The Welfare of Animals (Slaughter or Killing) Regulations 1995. Statutory Instrument 1995. No 731*. http://archive.defra.gov.uk/foodfarm/farmanimal/welfare/slaughter/

WATOK 2013 *The Welfare of Animals at the Time of Killing Regulations 2013*. Draft copy. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/182353/watok-info-note-reg-1099-20121219.pdf

Yates DT, Otis AR, Warner CA, Yates LJ, Halalsheh RA, Horvath MB, Hallford DM and Ross TT 2010 Effects of physical isolation on serum and salivary cortisol components of complete blood counts in yearling ewes. *Sheep and Goat Research Journal 25*: 39-44

Zimerman M, Domingo E, Grigioni G, Taddeo H and Willems P 2013 The effect of pre-slaughter stressor on physiological indicators and meat quality traits on Merino lambs. *Small Ruminant Research 11*: 6-9. http://dx.doi.org/10.1016/j.smallrumres.2012.12.018

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https://doi.org/10.7120/09627286.23.3.251 Published online by Cambridge University Press