Final Report: Pilot study on design of lairage, handling and stunning facilities and the potential impact on animal welfare and meat quality.

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1.0 EXECUTIVE SUMMARY

While there is evidence that pre-slaughter stress, both acute and chronic, affect animal welfare and meat quality, little is known of the relative importance of handling pre-slaughter and the effect of design features of animal holding and raceways in Australian abattoirs on handling, stress and stun efficacy.

This pilot study aims to record facility design, animal and stockperson behaviour and use of dogs at 6 sheep abattoirs in Victoria. Such preliminary data can inform an evaluation of the importance of facility design and the development of design principles to facilitate flow of movement and ease of handling, reduce stress and thus limitations of stress on animal welfare and meat quality.

Before commencement of the project a literature review was conducted on facility design at abattoirs and the potential effect on pre-slaughter stress and meat quality. The aim of this review was to examine the current knowledge of the influence of facility design on ease of handling and pre-slaughter stress in sheep. There is considerable evidence that pre-slaughter stress can have deleterious effects on meat quality and animal welfare in sheep. However there is limited evidence in commercial conditions identifying the main stressors and their effect on ease of handling.

The literature review indicated that while there are many recommendations on the design of handling facilities included in books, articles and Codes of Practice, most are based on anecdotal evidence and industry experience. For example, the effectiveness of using circular raceways and solid sides on raceways and pens in abattoirs has not been studied and may depend on other circumstances. Lairage can be a main source of stressors, rather than the place for rest and recovery it is meant to be. Human-animal interactions are also a key feature in lairage. Technical skills and knowledge are important attributes that determine how well stockpeople care for and handle their animals in lairage. Research particularly in Australia has shown that the attitudes and behaviour of stockpeople are related to both sheep behaviour and stress. Thus efforts to develop and implement training programs targeting the care and handling of animal in lairage should continue since the stockperson in a critical element in minimising pre-slaughter stress in animals in lairage. Ongoing improvement in stock handling, handling facilities and stock management must be identified and encouraged. As other authors have concluded (e.g., Ferguson and Warner, 2008), the impact of pre-slaughter stress has been underestimated and that it is imperative that the issue receives more research, development and education attention. The imperative for this is safeguarding animal welfare and meat quality.

A total of 6 abattoirs in Victoria were recruited and during visits cohorts of lambs were observed at each abattoir. In addition, a questionnaire was conducted at 5 of the 6 participating abattoirs from 15 stockpeople on opinions of facility design and adaptations and

additions considered for the future. Such preliminary observational and questionnaire data informed an evaluation of the importance of facility design in animal handling and pre-slaughter stress in sheep and will assist in the development of design principles to facilitate flow of movement and ease of handling, reduce stress and thus limitations of stress on animal welfare and meat quality. From the literature, the questionnaire and the observations the following conclusions and recommendations were made:

Laneways - Four out of the six observed abattoirs lacked well-designed laneways leading up to the stunning area. Instead, movement of sheep occurred through a number of lairage pens. This resulted in frequent handling and problem areas for animal flow. These were older facilities that were expanded over time with additional lairage space. When expanding lairage areas, upgrading these facilities to include purpose build laneways should be considered.

Lairage areas – Generally two different type of lairage areas were observed. Newer facilities included large lairage pens with low stocking density away from frequent human and animal movement. However, older facilities often included smaller lairage pens that were also used as default laneways. This resulted in overcrowding, frequent handling and sheep that were very alert to all the activity occurring around them. This leads to sheep that are stressed before slaughter and may also impact on meat quality. Lairage should be a period of recovery from the stresses of transport and for animals to rest. Overcrowding and activity around lairage pens should be minimized.

Animal handling – Handling skills differed greatly between individuals and between abattoirs and had a large influence on animal movement. While well-designed facilities enhanced animal movement, handling skills of the stockpeople had a large effect on both animal movement and stress responses of sheep during handling. Calm, quiet handling resulted in calm sheep that moved with seemingly little effort. Where handling was impatient and excessive handling and loud noises were used, sheep appeared more alarmed and reactive, making them harder to move as desired. Stockperson training in good animal handling practices may be the easiest way of overcoming poor facility design and may assist in reducing pre-slaughter stress.

Dog use – Dogs were not used in all abattoirs, however no obvious correlation between dog use and ease of movement were observed. The presence of dogs is very stressful to sheep and their use should be kept to a minimum. While they may be useful in some cases when moving large groups over a distance, handling in close contact (near the forcing pen and raceway) can be done effectively without the use of dogs. Particularly when dogs are not well trained or left unsupervised near sheep they can be a major cause of pre-slaughter stress. Wherever possible, dogs should not be used when moving sheep at abattoirs.

2.0 INTRODUCTION

There is increasing community interest and concerns about the welfare of farm animals post-farm gate, including handling pre-slaughter (Grandin, 2007). Recent research has shown considerable variation between abattoirs in the pre-slaughter behaviour and stress of sheep and cattle (Hemsworth et al., 2011). Several factors, such as the environment, management, facility design and the behaviour of stock people can be associated with stress at lairage. Studies have shown that pre-slaughter handling is known to be associated with behaviour and stress of sheep and cattle (Hemsworth et al., 2011). Stress prior to slaughter does not only affect the welfare of lambs, but can also affect meat quality (Deiss et al., 2009).

A current AMPC-funded project undertaken by the Animal Welfare Science Centre (AWSC) at the University of Melbourne ("Relationships between fear of humans, temperament and handling pre-slaughter and lamb welfare and meat quality", P.H Hemsworth) investigated the on-farm behavioural characteristics and the lairage behaviour and pre-slaughter stress response of 400 lambs. The results of this project will be utilized to identify key behaviours indicative of stress that will be recorded in this proposed AMPC project.

While the aforementioned project relates stockpeople behaviour to attitudes and beliefs of those people, facility design may also influences animal handling, with poor design inviting poor handling practices. Dogs are often used in abattoirs to move sheep during unloading and moving sheep from lairage all the way to the raceway leading to stunning. However, increased cortisol concentrations have been found in response to use of dogs when moving sheep, so facilities should be designed to minimize the use of dogs prior to slaughter.

Observations at commercial abattoirs indicate that aspects of the design of the lairage and handling facilities may create problems in animal handling and animal flow. However, there is a lack of objective data on design facilities at abattoirs in relation to ease of handling and particularly stress. In addition, variability in placement of electrodes, due to the design of the facility and the movement of animals, may affect the quality of stun.

In addition, there are developments in relation to electronic animal identification (RFID) and automatic drafting in or around the forcing pen to draft animals on weight ranges. Drafting animals prior to slaughter will increase handling, which may result in additional stress if facilities are not well designed and handling involves negative handling and use of dogs. If drafted animals are mixed prior to slaughter with unfamiliar animals from different sources this may also contribute to additional stress pre-slaughter.

While there is evidence that pre-slaughter stress, both acute and chronic, affect animal welfare and meat quality, little is known of the relative importance of handling pre-slaughter and the effect of design features of animal holding and raceways in Australian abattoirs on handling, stress and stun efficacy.

This pilot study aims to record facility design, animal and stockperson behaviour, use of dogs and effectiveness of stunning at 6 sheep abattoirs in Victoria. Such preliminary data would inform an evaluation of the importance of facility design and the development of design principles to facilitate flow of movement and ease of handling, reduce stress and thus limitations of stress on animal welfare and meat quality.

3.0 PROJECT OBJECTIVES

The objective of this project is to identify facility design features that impact on animal handling and pre-slaughter stress in sheep. Results of this pilot study can be used to develop a future study on ease of movement and reduction of handling associated stress pre-slaughter.

This project will deliver an extensive overview of the literature, including published scientific articles as well as research reports held by MLA and AMPC and Trade Journal Reports, on facility design at abattoirs and the potential effect on pre-slaughter stress and meat quality.

The pilot study will use observational (animals and facilities) and interview (stockpeople) techniques to examine the relationships between facility design (lairage pens, laneways, forcing pen and single file race) and animal handling, ease of movement and welfare.

Pre-slaughter stress can affect the quality of meat resulting in significant economic losses for processors. However, little is known of the effects of handling prior to slaughter and the effect of facility design on ease of handling and animal stress prior to slaughter.

Identifying facility design features that may be associated with negative handling behaviour by stockpeople and/or results in increased pre-slaughter stress in lambs will be important information when designing stockperson handling training packages (Prohand) and will enable processors to consider design features when modifying or adding new facilities.

This pilot study builds on previous research and current AMPC–funded research by the research team to determine stockperson handling behaviours and lamb behaviours related to pre-slaughter stress. More specifically, the proposed project will collect information on sheep handling practices and sheep behaviour in relation to design features at 6 sheep abattoirs in Victoria. In addition, the opinions of abattoir management on design features, problem areas and future developments will be sought through a survey.

Such preliminary survey data would inform an evaluation of the importance of facility design in animal handling and pre-slaughter stress in sheep and assist in the development of design principles to facilitate flow of movement and ease of handling, reduce stress and thus reduce limitations of stress on animal welfare and meat quality.

4.0 METHODOLOGY

Before commencement of the project a literature review was conducted on facility design at abattoirs and the potential effect on pre-slaughter stress and meat quality. This literature review does not only include published scientific articles, but also research reports held by MLA and AMPC and Trade Journal Reports.

This project utilized key behaviours indicative of stress that were identified in a current AMPC-funded project undertaken by the Animal Welfare Science Centre (AWSC) at the University of Melbourne ("Relationships between fear of humans, temperament and handling pre-slaughter and lamb welfare and meat quality", P.H Hemsworth).

A total of 6 abattoirs in Victoria were recruited and during visits cohorts of lambs were observed at each abattoir for the following:

1. Observations were made of cohorts in lairage and immediately prior to slaughter. Stockperson handling and the behavioural responses of the lambs were observed as a measure of ease of handling and stress prior to slaughter.

2. At the same time the use of dogs was observed. Observations included number of interactions and type of interactions (including barking).

3. Animal flow was observed, by observing baulking, running and slipping when cohorts were moved from the lairage pen to the forcing pen and through to stunning.

4. A diagram was drawn of the design of the lairage area, yards and raceways. Observations also included stocking density in lairage, access to water and flooring.

In addition, a survey was conducted at 5 of the 6 participating abattoirs from 15 stockpeople on opinions of facility design and adaptations and additions considered for the future. The survey included questions on opinions on the best and worst aspects of the design features and how design could be improved. Such preliminary observational and survey data informed an evaluation of the importance of facility design in animal handling and pre-slaughter stress in sheep and will assist in the development of design principles to facilitate flow of movement and ease of handling, reduce stress and thus limitations of stress on animal welfare and meat quality.

5.0 PROJECT OUTCOMES

Literature review

The effect of facility design on ease of handling and pre-slaughter stress of sheep in abattoirs

1. Background

There is increasing community interest and concerns about the welfare of farm animals post-farm gate, including handling pre-slaughter (Grandin, 2007). Recent research has shown considerable variation between abattoirs in the pre-slaughter behaviour and stress of sheep and cattle (Hemsworth et al., 2011). Several factors may affect stress at lairage, such as the environment, management, facility design and the behaviour of stock people can be associated with stress at lairage. Studies have shown that pre-slaughter handling may affect behaviour and stress of sheep and cattle (Hemsworth et al., 2011). Stress prior to slaughter does not only affect the welfare of sheep, but can also affect meat quality (Deiss et al., 2009).

While previous research has linked handling behaviour of stockpeople to their attitudes to handling and working with sheep (Coleman et al., 2012), facility design may also influence animal handling, with poor design encouraging poor handling practices. Dogs are often used in abattoirs to move sheep during unloading and moving sheep from lairage all the way to the raceway leading to stunning. However, dogs can be a stressor to sheep. Kilgour and de Langen (1970) examined a range of stressors that sheep are commonly exposed to and found that chasing or biting by dogs caused the highest cortisol response in sheep, so facilities should be designed to minimize the use of dogs prior to slaughter.

Observations at commercial abattoirs indicate that aspects of the design of the lairage and handling facilities may create problems in animal handling and animal flow. However, there is a lack of objective data on design facilities at abattoirs in relation to ease of handling and particularly stress.

In addition, variability in placement of electrodes, due to the design of the facility and the movement of animals, may affect the quality of stun. There are also developments in relation to electronic minimal identification (RFID) and automatic drafting in or around the forcing pen to draft animals on weight ranges. Drafting animals prior to slaughter will increase handling, which may result in additional stress if facilities are not well designed and handling involves negative handling and aversive use of dogs. If drafted animals are mixed prior to slaughter with unfamiliar animals from different sources, this may also contribute to additional stress pre-slaughter.

While there is evidence that pre-slaughter stress, both acute and chronic, affect animal welfare and meat quality, little is known of the relative importance of handling pre-slaughter and the effect of design features of animal holding and raceways in Australian abattoirs on handling, stress and stun efficacy. This literature review describes current knowledge of design

features and some associated factors that may affect pre-slaughter stress in sheep.

2. Loading ramps, lane/race ways and forcing pens

While there are text books and published papers on the design of sheep yards and race ways, few are based on scientific research. Anecdotal evidence, industry experience and personal observations are mostly used when recommending design features for sheep handling facilities. In addition, facilities are often designed to accommodate human requirements.

2.1 Raceways

Sheep will naturally follow other sheep and will walk well in single file, and therefore single file raceways are suitable to move sheep (Grandin, 2007). Single file raceways should be narrow enough so animals cannot turn around. Triangular entry to a raceway should have tapered sides on a 30^{o} angle and the sides should be closed in to direct the attention of the sheep towards the exit. A large diameter roller at the race entry could prevent jamming of sheep (Barber and Freedman, 2007). Races should have solid fences, so distractions outside are not visible. A curved raceway works well for cattle and may also be useful for sheep. A raceway that delivers animals to the stunner needs to hold enough animals to ensure continuous delivery of animals to the stunning area. However a very long raceway may be stressful if animals have are kept there for some time while they are waiting in single file (Grandin, 2007).

Sheep movement is generally better on flat ground, rather than up- or downhill and sheep prefer inclines to declines (Hitchcock and Hutson 1979). Sheep move faster through wide straight raceways, where they can move as a group rather than single file, with covered sides (Hutson and Hitchcock, 1978) and an unobstructed view of the exit or where they are moving (Hutson, 1980). Any changes in appearance of the raceway could obstruct flow of movement. Particularly shadows and changes in construction material or floor type should be avoided (Hudson, 2007). Animals prefer to move from a dark area to a lighter area (Grandin, 1996). Therefore raceways should ideally be well lit with indirect light and without shadows and reflections (Grandin 2007). Sheep are also reported to move easier in daylight than in the dark (Burnard et al., 2015).

Curved forcing areas and raceways may facilitate movement as sheep move better around corners. This may be particularly true for narrow races (Hutson and Hitchcock, 1978). An open outer curve and an open drafting gate may facilitate movement as to not give the impression of a dead end. However, open sides on raceways may cause sheep to baulk when there are distractions outside the race and sheep have been found to move faster through a race with solid sides (Hutson and Hitchcock, 1978). However it is important that solid sides do not obstruct a view of an open exit (Franklin and Hutson, 1982). Vette (1985) observed sheep movement in 26 sheep-processing plants in New Zealand and observed problems that inhibited stock flow such as visibility through floor gratings, striped light patterns, too many

corners, poorly designed blanking of walls and no overall stock flow plan. In those systems intensive forcing stimuli are needed, usually provided by dogs, resulting in unnecessary animal stress.

2.2 Ramps

While sheep generally prefer to move on flat ground often ramps at abattoirs are needed, particularly for unloading of sheep and moving sheep to elevated stunning areas. Ramps have also been recognised by transporters as an important facility that could influence ease of moving sheep (Burnard et al., 2015). The angle of the ramp for unloading and to the stunner should be below 20^{o} and the floor should be of non-slip material (Anon, 2002). A flat area prior to an ascent or descent facilitates movement (Grandin, 2007) and a flat area of at least 1 m is required (Anon, 2002). The inside of the walls of the ramp should be smooth, the ramp should be a minimum of 500 mm wide and a walkway for stockpeople should be provided on the outside for sheeted and multi deck ramps to facilitate movement (Anon, 2002).

2.3 Holding pens

According to Barber and Freedman (2007), sheep density in holding pens should not exceed 1.5-2 sheep/m^2 and no more than 2.5-3 sheep/m^2 in forcing pens, based on space requirements of sheep in full wool. For ease of control of the animals, a forcing pen should hold no more 100 sheep. Handling problems can occur when holding pens are overcrowded, and thus only partly filling a pen and moving animals in small batches may facilitate handling (see Grandin, 2007).

Scobie et al (2015) observed that sheep in a forcing pen were more likely to jump a solid plywood wall than open pipe rails. Jumping over solid panels has been reported by others in relation to their height, with bigger sheep jumping over 800 mm solid walls (see Scobie et al., 2015).

The transition from a group to single file can obstruct animal movement. Hutson and Butler (1978) proposed placement of the race entrance in the middle of one side of the forcing pen, rather than using a funnel design. This would prevent jamming and baulking sheep from obstructing animal flow (Hargraves and Hutson, 1997). Long narrow pens assist with movement of sheep when sheep are moved through holding pens.

3. Lairage

Lairage provides the opportunity for rest and recovery from the effects of transport (Cockram et al., 1997). The key lairage requirements include sufficient space to lie down, sufficient time to allow recovery, and access to water to recover from dehydration. Lairage times can vary from several hours to more than 24 h, depending on time of arrival, holding capacity and the number of animals required for slaughter. While in Europe and North America, sheep are

generally slaughtered at the day of arrival at the abattoir, in Australia sheep are often slaughtered the day after arrival or can be held for longer periods (Ferguson and Warner, 2008). When conditions in lairage are not optimal dehydration and depletion of muscle glycogen can result, which are both related to reduced meat quality (Toohey and Hopkins 2006; Jacob et al. 2005, 2006).

Currently, the Australian Model Code of Practice for the Welfare of Animals: Livestock at Slaughtering Establishments (Anon. 2002) recommends that holding pens should provide no less that 0.6 m^2 per sheep. Anecdotal observations indicate that current industry practice at abattoirs may not comply with the recommendations in this Code of Practice and can reach space allowances of less than 0.3 m^2 per sheep, depending on the expected holding time of the sheep. Weeks (2008) made similar observations in the UK, with stocking densities as low as 0.23 m^2 per sheep. However, several studies have found that reducing space allowance decreases lying behaviour and an allowance greater than 1 m^2 per sheep is required before all or most sheep in a pen lie down (Jarvis and Cockram, 1995; Kim et al., 1994; Jongman et al. 2000). Sheep do not distribute throughout a pen evenly and prefer to lie next to an open sided fence, rather than in the middle of the pen (Hargreaves and Hutson, 1997). Therefore pen shape may also influence lying behaviour.

Jarvis and Cockram (1995) observed the resting behaviour of sheep in lairage after 4 h of transport and found a large variation in the number of sheep lying down. While the median was only 17%, it ranged from 1 to 63% across different pens and over several hours. They found no significant effect of slats or straw on the total percentage of time spent lying down. However, the presence of human activity in the lairage area has been associated with increased alertness and movement and decreased lying behaviour (Kim et al., 1994). Similarly, Eldridge et al. (1989) recommended that movement of cattle in and out of lairage pens past resting animals should be minimised in order to minimise stress.

Water should be available in lairage and water troughs should be of sufficient size so all animals can access drinking water within one hour of arrival (Anon, 2002). Very little is known about drinking behaviour in sheep in lairage, and sheep may be left for considerable time without water prior to and during transport. In addition, there is some suggestion the stress around transport and lairage, through elevated cortisol concentrations, may induce higher urine output and prevent thirst in dehydrated animals (Hogan et al. 2007). Rehydration may therefore be limited during lairage. For example in a study at two different abattoirs in Australia Jacob et al. (2006) found up to 50% of lambs dehydrated at slaughter, indicating that they failed to drink enough water to rehydrate following water deprivation during the farm curfew and transport periods. In addition, Jongman et al (2008) found that 20% of sheep did not drink during 24 h in lairage, despite water deprivation of 15 – 28 h and hot summer conditions. While stocking density ranging from 0.3 to 1 m^2/sheep did not affect access to water in that study, there is no information on the possible effect of trough size and placement. It is also not known if the equivalent phenomenon of a ‘shy feeder’ occurs in relation to drinking, i.e. a ‘shy drinker’. It is likely that the combination of stress and unfamiliarity of the water trough and change in taste of water (due to different water sources) may inhibit some sheep from drinking.

4. Pre-slaughter handling, stress and meat quality

When well-designed facilities are combined with skilled stock people sheep can be moved through an abattoir facility without behavioural signs of stress (Grandin (2007). However, traditional handling methods to move sheep rely on fear provoking stimuli such as dogs and auditory (e.g., shouting), visual (e.g., waving) and tactile (e.g., pushes and slaps) stimuli. The effectiveness of these forcing signals appear to reduce as sheep approach an area which provokes fear. Usually more force is applied which escalates in sheep becoming more aroused, which in turn results in less predictable and more erratic responses from the sheep (see Hutson 2007). Noisy equipment and stock people shouting and using auditory signals can be a source of stress and should be minimised (Grandin, 2007).

Handlers should use flight distance and the strategy of reverse movement when moving sheep (Hutson, 2007). Rather than using fearful stimuli from behind on confined animals, a more effective method of moving sheep can be accomplished by moving towards confined animals, which can provoke movement in the opposite direction (Hutson, 1982). Handling when moving sheep in abattoirs should not result in animals falling. Grandin (2010) stipulates that, while conducting an audit, if more than 1% of animals are observed falling during handling, handling practices or floor surfaces are considered unsatisfactory.

While there is good evidence that pre-slaughter stress has a detrimental effect on meat quality in several species (Warner et al., 2007 (beef); D'Souza et al., 1998 (pigs)) the evidence in sheep in somewhat unclear. While 15 min of exercise immediately prior to slaughter does not appear to affect meat quality in sheep (Warner et al., 2005), washing sheep prior to slaughter has been associated with negative effects on meat quality in several studies (Petersen, 1983; Geesink et al., 2001). Therefore the nature of the stressors and the stress response may determine the effect on meat quality in sheep (Ferguson and Warner, 2008). Similarly, Hemsworth et al (2011) found correlations between increased cortisol post stunning and increased interactions with dogs, increased head down posture of sheep (a behavioural indicator of stress) but reduced handling (touches, pushes and whistles) by stockpeople.

Forceful handling by stock people is partly explained by negative attitudes towards interacting with livestock (Hemsworth et al., 1989; Coleman et al., 1998; Lensink et al, 2001) and similar correlations have been found in abattoirs (Coleman et al., 2003; Coleman et al., 2012). In a study at 16 Australian abattoirs correlations between stockpeople's attitudes and their behaviours were examined. While awareness of the effect of poor flooring on the footing of the animals made stockpeople more careful in their interactions with sheep, perceived time constrains resulted in more forceful handling. The perception that the use of arousal and goads was not stressful also resulted in more forceful handling, while the belief that the facilities made livestock hard to handle had little effect on stockperson behaviour, other than an increase in whistling (Coleman et al., 2012).

It has been proposed by Hemsworth and Coleman (2011) based on relationships between attitudes, job satisfaction and work motivation, that including training targeting the attitudes and behaviours of stockpeople towards farm animals in conjunction with the technical skills

and knowledge of stockpeople is likely to not only reduce the stress associated with handling and husbandry procedures involving humans, but also improve the motivation in stockpeople to learn new technical skills and knowledge and to apply these competencies to the management of the animals under their care.

5. Dog use

While handling of sheep by humans is a known stressor, handling by humans with dogs is considered more stressful than handling by a human alone (Baldock and Sibly, 1990). The presence of dogs are a known stressor to sheep. In fact exposure to a barking dog for several minutes is a standard stimulus to induce stress in experimental settings, resulting in increased concentrations of cortisol (Cook, 1997). Dogs are a known predator of sheep (Robel et al., 1981) and sheep respond to exposure to a dog with behaviours similar to a response to a predator (Beausoleil et al., 2005), which includes high vigilance, flight and flocking and behavioural inhibition once refuge has been reached (Dwyer, 2004). In confined handling situations a dog may also be counterproductive, as sheep may face a dog if there is no escape (Hutson, 2007).

The use of a herding dog makes use of the natural gathering instinct of the dog. This instinct is part of canine predatory behaviour and is modified by training (Coppinger and Coppinger, 2007). The stalking posture of the dog is innate, modified by the handler using acoustic signals such as shouting commands and whistling (McConnell, 1990). Repeatedly rising notes such as short high whistles, have been shown to increase motor activity levels in dogs (McDonnell 1990). However the use of loud auditory cues to control the behaviour of the dog may in itself be stressful to sheep (Hall and Bradshaw, 1998). Dogs used in abattoirs should be well trained and muzzled.

While dogs are very useful in moving sheep in wide open spaces on farm, the need to use dogs in confined spaces such as abattoirs should be minimised by well-designed facilities. Dogs are widely used by transporters, although in a recent survey transport operators dismissed without evidence their impact on sheep behaviour (Burnard et al., 2015).

6. Sheep behaviour

Previous experience and breed are acknowledged to be an important factor affecting ease of movement (Burnard et al., 2015). Sheep respond to a predator by flocking and flight (Dwyer, 2004) and it is this behaviour that sheep handlers use to move sheep. A sheep separated from a group will run towards other sheep regardless of the presence of a handler or a dog (Kilgour (1977). A clear view towards the exit or towards where sheep have to move is a crucial design feature for sheep handling facilities (Hutson, 1980). Sheep can be moved in large groups due to their natural following behaviour. Because flocking and following is such a key feature of sheep behaviour any handling that involves separating or disrupting groups of sheep may

cause difficulty in handling. It is considered that a group of sheep should consist of at least five animals to express normal flock behaviour (Hargreraves and Hutson. 1997).

The flight distance does not only depend on the fear sheep experience but also on the space available for escape. For example Hutson (1982) found that the flight distance in a 4 m wide laneway was twice that compared to a 2 m wide laneway.

Sheep have very good eyesight and vision is an important factor when designing sheep handling facilities. It is important to consider changes in light, visual cliffs and different colours (Hargreaves and Hutson, 1997). While auditory cues are less important than visual cues and sheep generally habituate to constant noise, they do respond to intermittent or sudden noise. In addition, breed, sex and age all have an influence on ease of handling. For example Njisane and Muchenje (20013) reported that Merinos and Merino crosses were calmer when handled than Dorpers and ewes were calmer than castrates.

7. Stunning

In most sheep abattoirs in Australia the head-only stun is used by applying a hand held unit with prong electrodes, and usually animals are held in a V-type restrainer while being stunned.

Signs of efficient stunning in sheep include tonic and clonic activity and absence of normal rhythmic breathing (Velarde et al, 2002). Positioning the electrodes anywhere else than between the eyes and the base of the ears means that more of the current may flow through lower resistance pathways and not entirely through the brain, thus reducing the effectiveness of the stun. However the Model Code of Practice for the Welfare of Animals: Livestock at Slaughtering Establishments (Anon 2002) recommends placement of prong electrodes behind the ears in front of first cervical vertebrae. While the presence of wool, a dry skin, or placement of the tongs in caudal position behind the ears can affect the effectiveness of stunning (Velarde et al, 2000), less is known about prong electrodes. While tong electrodes were found to be ineffective on lambs with dry skin and wool (Velarde et al., 2000), prong electrodes penetrate wool more easily, so may be more effective in that situation.

With small areas of contact between the sheep's head and the electrodes, wool-burning and marked carbonising of the electrodes can occur. This, in turn, leads to a poor electrical contact due to an increased electrical resistance in the pathway and special care is necessary to keep the electrodes clean. Effective head only stunning in sheep should be induced using minimum currents of 1.0 ampere. A minimum of 250 volts should be used to deliver the current. Duration of current flow should be a minimum of two seconds and maximum stun-to-stick interval is suggested to be between eight seconds (EFSA, 2004) and 15 seconds (Anil and McKinstry, 1991).

With any type of restrainer, if the electrodes are being applied manually, the operator must be able to stand in a comfortable position. Ideally, placement of electrodes should be from above, rather than from the front, to prevent animals from shying away. Electrodes are more

likely to be poorly positioned if the animals are difficult to reach, resulting in increased frequency of ineffective stunning.

With head-only electrical stunning, the position of the electrodes is extremely important, with the electrodes in a position that spans the brain so that sufficient current is passed through it to induce immediate insensibility. With automatic head-only electrical stunning of restrained animals, applying the electrodes at the optimum position is relatively easy to achieve and is consistent as the animals are presented in a fixed position each time. However, with manual head-only electrical stunning of unrestrained, free-standing animals, applying the electrodes at the optimum position is more difficult to achieve and it is much less consistent. This can ultimately result in the stun being ineffective and the welfare of the animal being compromised. According to Grandin (2010) in order to pass an audit tongs must be placed in the correct position at least 99% of the time.

8. Conclusions

The aim of this review was to examine the current knowledge of the influence of facility design on ease of handling and pre-slaughter stress in sheep. There is considerable evidence that pre-slaughter stress can have deleterious effects on meat quality and animal welfare in sheep. However there is limited evidence in commercial conditions identifying the main stressors and their effect on ease of handling.

While there are many recommendations on the design of handling facilities included in books, articles and Codes of Practice, most are based on anecdotal evidence and industry experience. For example, the effectiveness of using circular raceways and solid sides on raceways and pens in abattoirs has not been studied and may depend on other circumstances. Lairage can be a main source of stressors, rather than the place for rest and recovery it is meant to be.

Human-animal interactions are also a key feature in lairage. Technical skills and knowledge are important attributes that determine how well stockpeople care for and handle their animals in lairage. Research particularly in Australia has shown that the attitudes and behaviour of stockpeople are related to both sheep behaviour and stress. Thus efforts to develop and implement training programs targeting the care and handling of animal in lairage should continue since the stockperson in a critical element in minimising pre-slaughter stress in animals in lairage.

Ongoing improvement in stock handling, handling facilities and stock management must be identified and encouraged. As other authors have concluded (e.g., Ferguson and Warner, 2008), the impact of pre-slaughter stress has been underestimated and that it is imperative that the issue receives more research, development and education attention. The imperative for this is safeguarding animal welfare and meat quality.

Questionnaire results

Questionnaires were conducted at 5 of the 6 abattoirs and were answered by a total of 15 stockpeople. A copy of the questionnaire questions can be found in Attachment 1. Below are the results of the analysis of the individual survey questions.

Questions 1-3 were scored from Strongly Agree (1), Agree (2), neither agree/disagree (3), disagree (4), strongly disagree (5). The average score is presented.

Q1. Relative to other sheep, the following sheep require more physical effort to move than do others.

Respondents ranked different classes of sheep in order of hardest to move:

1. Rams (1.50),
2. Ewes (2.06),
3. Wethers (2.12),
4. Lambs (2.77)

Q2. Relative to other sheep, the following sheep require more use of a handling aid.

Respondents ranked all classes very similar:

1. Rams (2.28)
2. Ewes and wethers (both 2.38)
3. Lambs (2.44).

Q3. How much do you agree with the following statements?

Respondents agreed with all of the below statements, ranked from the most agreed below:

*1. Running sheep over uneven/changes in flooring can cause them to be uncertain of their footing (*1.56)

2. Poor facilities make sheep hard to handle (1.63)

2. Differences between breeds make some sheep more difficult to handle (1.63)

2. Wool blindness makes sheep hard to handle (1.63)

3. Running sheep over wet ground can cause them to be uncertain of their footing (1.75)

*4. Previous handling on farm or during transport has the biggest effect on ease of handling sheep at the abattoir (*2.06)

*5. Sheep with horns are hard to handle (*2.19)

Q4. What aids do you use to move animals?

Below are the aids ranked from the most used according to the respondents:

Dog 100%

Rattler 64%

Electric prodder 7%

Flapper 7%

Goad 0%

Polypipe 0%

Q5. Tick the things that different kinds of sheep find aversive (that is, things that they try to avoid or that make them upset)

Percentage of stock-people that identified this as aversive, ranked from most aversive:

1. Loud noise 82.8%
2. Isolation 73.4%
3. Dogs 73.4%
4. Hot weather 65.6%
5. People 64.1%
6. Shadows 64.1%
7. Handling 64.1%
8. Stress from other animals 46.9%
9. Aggression from other animals 42.2%
10. Cold weather 34.4%
11. Indoors 21.9%
12. Holding yards 20.3%

Twenty-five % of respondents considered rams to be more sensitive than ewes, wethers and lambs to at least 2 different categories, although opinions differed on which categories.

Q6. Rate sheep in general and the following breeds on each trait. 1=low (e.g. low intelligence), 5=high (e.g. highly intelligent). A score of 3 would mean average.

	Intelligence	Flightiness	Ease of handling	Stubborn	Aggressive
Sheep (average)	2.49	2.89	2.59	2.68	1.57
Merino	2.43	2.43	2.64	**3.36**	1.86
Cross breeds	2.57	2.57	2.57	2.5	1.79
Dorper	2.21	**3.5**	2.29	3.07	1.5
Damara	2.43	3.14	2.64	3.07	1.36
Poll Dorset	2.57	2.79	2.71	2	1.5
Suffolk	2.71	2.93	2.71	2.07	1.43

Data was analysed for differences between breeds with a Mann-Whitney U (Wilcoxon rank-sum) test. Compared to cross breeds, Dorpers were significantly ($P<0.05$) rated higher for flightiness, while there was a trend ($P<0.1$) for Merinos to be rated higher for stubbornness.

Q7. Rate the extent to which the following are responsible for stress in sheep. Score from "Not at all" (1) to "Very stressful" (4).

	Average score
Breed (genetics)	2.4
Temperament	2.7
Loud noise	2.9
Time spent in transport	3.1
Overcrowding	3.2
New or unexpected surroundings	2.8
Poor handling	3.3

Poor handling was identified as most responsible for stress in sheep at an abattoir, followed by overcrowding.

Q8. To what extent do the following cause sheep to baulk or escape? Score from "Not at all" (1) to "A major cause" (4)

	Average score
Messy floor	2.1
Smells from other sheep	1.4
Dogs	3.1
Crowding when entering the forcing pen	2.8
Poor handling	3.2
Bright lights	2.5
Shadows	2.7
People nearby	2.9

Poor handling and the use of dogs were identified as the main cause of causing sheep to baulk or escape.

Q9. At which area within the abattoir are sheep most difficult to handle? Score from 1 (most difficult) to 4 (easiest)

During unloading	2.1
Moving into lairage pen	2.6
Moving from the lairage pen to the forcing pen	2.6
Moving from the forcing pen through the raceway	2.7

Sheep were considered most difficult to handle during unloading (Q9) and unloading facilities were considered most important (Q10). Similarly moving from the forcing pen through the raceway was considered relatively easiest, while facilities in this area were considered least important.

Q10. How important are the facilities when moving sheep (rate from "Not at all" (1) to "Very important" (4))

During unloading	3.63
Moving into lairage pen	3.44
Moving from the lairage pen to the forcing pen	3.44
Moving from the forcing pen through the raceway	3.38

Q11. Which features of the facilities cause sheep to be more difficult to handle? Rate from "Not at all" (1) to "A major cause" (4)

The average score for each feature is presented below.

Floors:
Slippery **3.3**
Uneven **3.1**
Dirty slats 2.4
Transition floor surface **3.2**

Gates:
Narrow gates 2.9
Ease of opening/ closing 2.6
Solid gates (not see-through) 2.7

Lairage:
Large pens 2.3
Long pens 2.1
Crowded pens **3.1**

Laneways:
Narrow laneways 2.3
Pens used as laneways 2.7
Tight corners **3.6**
Round corners 2.2
Shadows **3.4**
Light **3.2**

Ramps and slopes:

Concrete flooring	2.4
Slats	2.8
Steep angle	**3.2**
Flat area top and bottom	2.6

Features identified as a concern (score>3) include slippery and uneven floors, transition from one flooring to another, crowded pens, tight corners and issues with shadows and light in laneways and steep ramps.

Q12. *If there was one design feature you could change at the abattoir you work what would that be?*

Stock people were asked to identify a design feature at their place of work that they would like to change. This question was not answered by all participants. The following features were identified:

"Straight laneways"

"The race- Should be at one level so the sheep don't have to go up a ramp"

"Circular pens not corners"

"Concrete falling away, too steep"

"No sharp edges."

"Pens, gates and sheep ramp."

"Dirt floors until forcing pens."

"Reduce light entry to shed during different times of the day."

Abattoir observations

Observations were conducted at 6 different abattoirs throughout Victoria. A summary of observations is provided, rather than observations for individual abattoirs, to prevent identification of individual abattoirs.

Lairage pens: Most abattoirs contain 2 different types of lairage pens (as well as outdoor paddocks for longer term housing). Often, larger pens are available for overnight lairage with

relatively low stocking density and large water troughs. These pens are normally in a different building, away from the stunning and slaughter area. Smaller lairage pens are generally closer the stunning area, often with smaller water troughs. These pens are also used for overnight lairage if needed, but stocking density can be much higher and these pens were often observed as overstocked. These pens may also function as laneways, where animals are moved several times through different lairage pens towards the forcing pen and stunning area, particularly in older facilities. Movement through several pens results in multiple handling of sheep, with only some animals moved every time a drover enters the pen. While lairage is a time of recovery from transport before slaughter, frequent movement of animals in this area results in very few animals lying down, overcrowding and lack of access to water and sometimes mounting behaviour due to fear and overcrowding.

Movement through pens, rather than laneways, also results in animals moving through gates and animals getting 'stuck' in corners. Gates closing may be very loud and where gates are difficult to operate, stockpeople may jump over gates, rather than opening them. Loud noises and sudden movement contributed to sheep being very alert in these pens. Flooring of large lairage pens were observed as either metal mesh or dirt flooring while flooring of small lairage pens were mesh or slats. Changes in flooring was observed as a cause of baulking.

Laneways: Not all abattoirs are designed with laneways for movement of sheep (other than between buildings). In most abattoirs small lairage pens are used for movement towards the forcing pen. Where present, well-designed wide laneways appear to facilitate sheep movement with very little handling needed. Causes of baulking were found with changes in flooring (dirt/mesh) or changes in light. Gates in laneways and corners also reduced ease of movement. A wide laneway on one side of long narrow lairage pens or a central laneway between lairage pens appeared to facilitate good movement. A curved raceway was only observed in one abattoir and appeared to have good flow of animals.

Shade areas can be improved by lighting and direct sunlight may be blocked, for example with use of shade cloth. Slopes and steps in laneways may slow flow of animals and can become slippery.

(Pre-)forcing pen: All observed abattoirs used a forcing pen to move animals in a raceway to the stunner. They also used another pen before entering the forcing pen, here indicated as 'pre-forcing pen'. While there was variation in the design of these pens, and in particular the gates, movement of sheep was generally not a problem. Much effort was put in moving sheep in the raceway leading to the stunner to ensure a continuous supply of sheep without interrupting the production chain. However, it seemed that much of the effort was excessive with frequent handling bouts to move only a few sheep. Increased pressure on sheep from the back resulted in mounting behaviour and sheep facing against the direction of movement.

Therefore much of the problems seen in the forcing pen were from excessive handling rather than design of the pen. In addition, dogs were frequently used to move sheep in close confinement, meaning that sheep were unable to avoid close contact with the dog, resulting in unnecessary increased pre-slaughter stress.

Handling: A wide variety in handling was observed. Slow, calm handling resulted in sheep moving quietly. No instances of excessive force or cruelty were observed. However, many drovers used loud noises, rattlers, fast movement and clanking gates to move sheep. These behaviours resulted in fearful, flighty sheep that were harder to handle. Effort (noise and movement) by stockpeople to move sheep appeared to be more habit than necessity, and appeared counter-productive, much of the handling was excessive. Where laneways, or lairage pens in particular, did not flow well more forceful handling, such as pushing and pulling animals, was needed. However, even where facilities were sub-optimal, good handling could overcome most of the design problems with calm, patient handling, resulting in good animal flow and calm sheep despite the facilities.

The use of dogs: Not all abattoirs used dogs to move sheep, and dogs were not used in all areas. Dogs were effective when large groups had to be moved and some baulked at areas. With the help of dogs, sheep at the front can be moved, rather than pushing sheep from the back in an attempt to move the front of the group. However, in most cases handling could be performed effectively by drovers and dogs were not needed, although often used. Particularly in the forcing pen, dog use at time was excessive, with some dogs poorly trained or left in the pen with sheep without supervision.

6.0 DISCUSSION

The survey of stockpeople identified several factors that were considered important by them when handling sheep. In terms of animal factors, they identified rams as being harder to move than other classes of sheep and also identified some breed differences. While Dorpers were considered more flighty than other breeds, the Merino was considered more stubborn. In general, Dorpers were considered harder to move, although it is not clear if this relates to genetics per se or if experiences with handling on farm also play a role. Dorpers are a popular breed for hobby farmers and therefore may have different experiences in being handled than sheep from commercial farms.

Facility design and flooring were considered very important factors when moving sheep. Features identified as a concern included flooring, crowded pens, tight corners and lighting in laneways as well as steep ramps.

Interestingly, unloading was considered to be when sheep were most difficult to handle and where facilities were considered most important. Moving sheep from the forcing pen through to the raceway was considered the easiest area and although facilities were considered very important here too, they were considered less important than elsewhere. It is not clear if facilities for unloading were less well designed, contributing to the difficulty in handling and perhaps emphasizing the need for good facilities. While unloading was not observed at most abattoirs, as trucks are often unloaded after hours, much of the handling effort (including dogs) and specialized facility design was observed around the forcing pen and race.

Poor handling, overcrowding and time spent in transport were identified as most responsible for stress in sheep at an abattoir, while loud noise, isolation and dogs were identified as most aversive. Dogs and poor handling were identified as the major cause of baulking or escape.

Observations at the different abattoirs indicated in particular the lack of well-designed laneways. Often sheep were moved through small lairage pens, necessitating frequent handling bouts to move few sheep. Particularly small lairage pens were often overcrowded, which can increase handling problems (Grandin, 2007). Generally these abattoirs started off small and have extended over time around the old facilities. Where purposeful facilities (long lairage pens and wide laneways) were present, sheep flowed much easier as was also found by Hutson and Hitchcock (1978). These facilities resulted in a quieter environment for lairage in large pens with lower stocking density, enabling sheep to rest. In facilities with movement through small lairage pens, the frequent moving of people and animals resulted in sheep that were very alert and seldom seen lying down. The effect of human activity in the lairage area has previously been reported by Kim et al (1994). Rest and recovery from transport is considered an important aspect of lairage (Cockram et al, 1997) and Eldridge et al (1989) recommended that movement of animals in the lairage area should be kept to a minimum.

Changes in flooring (concrete, dirt and mesh) as well as changes in lighting (shadows, gaps, sunlight) were a frequent cause of baulking and seen in most abattoirs. Hutson (2007) also commented on the importance of avoiding changes in construction material and floor type and both Hutson (2007) and Grandin (2007) recommend the avoidance of shadows and reflections.

However, despite the effect of facility design, handling by stockpeople appeared to have the largest effect on sheep movement and stressful responses (running, escape, baulking). A skillful and patient stockman was able to easily move sheep quietly through a facility with seemingly minimal handling and calm moving sheep. In these instances dogs were not used or used only when strictly required. On the other hand on in well-designed facilities on occasion poor stockmanship was observed, relying on noise and sudden movement to move sheep. This would result in sheep that were flighty and more prone to running, slipping and baulking or getting stuck in corners. Hutson (2007) also commented on sheep showing more erratic behaviour with forceful handling and increased arousal of sheep. Training targeting attitudes and behaviour of stockpeople may be an effective way to improve sheep movement

and reduce stress, even if facility design is sub-optimal (Hemsworth and Coleman (2011).

7.0 CONCLUSIONS/RECOMMENDATIONS

Laneways - Four out of the six observed abattoirs lacked well-designed laneways leading up to the stunning area. Instead, movement of sheep occurred through a number of lairage pens. This resulted in frequent handling and problem areas for animal flow. These were older facilities that were expanded over time with additional lairage space. When expanding lairage areas, upgrading these facilities to include purpose build laneways should be considered.

Lairage areas – Generally two different types of lairage areas were observed. Newer facilities included large lairage pens with low stocking density away from frequent human and animal movement. However, older facilities often included smaller lairage pens that were also used as default laneways. This resulted in overcrowding, frequent handling and sheep that were very alert to all the activity occurring around them. This leads to sheep that are stressed before slaughter and may also impact on meat quality. Lairage should be a period of recovery from the stresses of transport and for animals to rest. Overcrowding and activity around lairage pens should be minimized.

Animal handling – Handling skills differed greatly between individuals and between abattoirs and had a large influence on animal movement. While well-designed facilities enhanced animal movement, handling skills of the stockpeople had a large effect on both animal movement and stress responses of sheep during handling. Calm, quiet handling resulted in calm sheep that moved with seemingly little effort. Where handling was impatient and excessive handling and loud noises were used, sheep appeared more alarmed and reactive, making them harder to move as desired. Stockperson training in good animal handling practices may be the easiest way of overcoming poor facility design and may assist in reducing pre-slaughter stress.

Dog use – Dogs were not used in all abattoirs, however no obvious correlation between dog use and ease of movement were observed. The presence of dogs is very stressful to sheep and their use should be kept to a minimum. While they may be useful in some cases when moving large groups over a distance, handling in close contact (near the forcing pen and raceway) can be done effectively without the use of dogs. Particularly when dogs are not well trained or left unsupervised near sheep they can be a major cause of pre-slaughter stress. Wherever possible, dogs should not be used when moving sheep at abattoirs.

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