Author:
Wigham, Ellie E

Title:
The impact of Animal Welfare Training at slaughter on animal welfare, personnel attitudes and product quality

The impact of Animal Welfare Training at slaughter on animal welfare, personnel attitudes and product quality

Eleanor Elizabeth Wigham

A dissertation submitted to the University of Bristol in accordance with the requirements for award of the degree of Doctor of Philosophy in the Faculty of Health Sciences.

Bristol Veterinary School
September 2019

Word Count – 45,754

Abstract

Ensuring acceptable welfare conditions for animals at the time of slaughter is paramount in meeting legislative and retailer specifications and in producing high quality meat. There is existing evidence that welfare training programmes for members of the farming industry can improve animal welfare and product quality, however, there is limited information on the effects of welfare training in the slaughter industry.

This PhD examined the impact of welfare training at slaughter on animal welfare, personnel attitudes and product quality using a mixed methods design.

Attitudes of slaughter industry personnel and whether they were influenced by training were assessed using questionnaires and interviews. There was limited evidence that the training courses used throughout the thesis resulted in attitude change, however trainees did report the acquisition of new knowledge.

Animal welfare and product quality assessment protocols were developed to assess the impact of introducing a comprehensive welfare training programme in three cattle and two poultry slaughterhouses. Assessments were conducted prior, immediately post and six months post-training. Post-training improvements in welfare measures were seen in all slaughterhouses, particularly when cattle were entering raceways and moving into the stun box, and during bird entry into the water bath. There were less consistent improvements in product quality measures, likely due to the multifactorial nature of carcass quality.

Using CCTV to overcome potential observer bias during these assessments was investigated. It is suggested that the effective use of data produced by CCTV and Remote Video Auditing may improve the impact of welfare improvement measures, such as training.

Finally, interviews were conducted with slaughter industry personnel which identified economic factors as a significant motivator and barrier to welfare change in the slaughterhouse.

The results obtained from this study provide evidence for a positive impact of standardised welfare training and highlight areas which warrant further research.

Acknowledgements

I would like to thank my supervisors for their support and guidance throughout the last three years: Dr Andy Butterworth, Dr Siobhan Mullan, Mr Andy Grist, Professor Toby Knowles, but especially Mr Steve Wotton – thank you for sacrificing the first year of your retirement for this project, and accompanying me on numerous visits. I aspire to have a career as illustrious as yours.

Many thanks to the Humane Slaughter Association, much of this PhD would not be possible without their financial support through the Special Travel Award.

I am incredibly grateful to all those individuals who participated in the studies, by filling out questionnaires and agreeing to be interviewed. Similarly, to all those at the slaughter-plants I visited during the PhD, thank-you for being so friendly and making me feel so welcome in an environment what has the potential to be the opposite.

To Andy Grist, Grace Grist and Claire White – thank-you for all your assistance, support and advice. You all helped me out a huge amount when it was very much needed.

To all my friends at Langford, I fear naming you all in case I miss someone, but thank-you all for the friendships, laughs and coffee breaks. I looked forward to coming into the office every day, mainly because of all of you. You made this experience very special.

Thank-you to my Mum and Dad for their unconditional love and support, although relocating from Scotland to Somerset wasn't strictly necessary, I am very grateful for the occasional escape back to home life.

Finally, Alex, thanks for being one half of the best team I've ever been part of.

Author’s Declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

SIGNED: …………………………...... DATE: …………………............

List of Publications

Publications arising from the work included in this PhD and the author's (EW) contribution to each is listed below:

Journal Publications

- Wigham, E. E., Butterworth, A., & Wotton, S. (2018). Assessing cattle welfare at slaughter – Why is it important and what challenges are faced? *Meat Science, 145*, 171-177.

  E.W. conceived, researched and produced the manuscript. A.B. and S.W. reviewed the manuscript prior to submission.

- Wigham, E., Grist, A., Mullan, S., Wotton, S., & Butterworth, A. (2019). The Influence of Welfare Training on Bird Welfare and Carcass Quality in Two Commercial Poultry Primary Processing Plants. *Animals*, 9(8), 584.

  E.W., A.G., S.W. and A.B. conceived and designed the study. E.W. collected and analysed the data and produced the manuscript. A.G. and S.W. provided the training aspect of the methodology. A.G., S.M., S.W. and A.B. reviewed the manuscript prior to submission. All authors reviewed and approved the submitted version of the manuscript.

Conference Proceedings

- Wigham, E., Wotton, S., Grist, A., Butterworth, A. (2017) The Challenge of Assessing Welfare in Abattoirs, In Proceedings of the UFAW International Animal Welfare Science Symposium, Measuring Animal Welfare and Applying Scientific Advances: Why is it still so difficult? London.

E.W. conceived, researched, produced and delivered the presentation. S.W., A.G., and A.B. reviewed the presentation prior to delivery.

- Wigham, E., Butterworth, A., Grist, A., 2018 Attitudes of slaughter industry personnel towards animal welfare, In: Proceedings of the First Annual Meeting of the European Congress of Behavioural Medicine and Animal Welfare (ECVBMAW), Berlin.

  E.W., A.B., and A.G. conceived and designed the study E.W. collected and analysed the data and produced and delivered the presentation. A.B. and A.G. reviewed the presentation prior to delivery.

Table of Contents

CHAPTER 4. THE EFFECTS OF WELFARE TRAINING ON BIRD WELFARE AND CARCASS QUALITY IN TWO COMMERCIAL POULTRY SLAUGHTER-PLANTS................ 138

List of Figures

List of Tables

Chapter 1. General Introduction.

Parts of the information in this chapter have been published in a scientific review:

Wigham, E. E., Butterworth, A., & Wotton, S. (2018). Assessing cattle welfare at slaughter – Why is it important and what challenges are faced? *Meat Science, 145*, 171-177.

Parts of the information in this chapter formed an oral presentation at the UFAW International Animal Welfare Science Symposium in London, June 27-29 June 2017. An abstract appears in their conference proceedings:

Wigham, E., Wotton, S., Grist, A., Butterworth, A. (2017) The Challenge of Assessing Welfare in Abattoirs, In Proceedings of the UFAW International Animal Welfare Science Symposium, Measuring Animal Welfare and Applying Scientific Advances: Why is it still so difficult? London.

Globally the lives of billions of animals are ended every year at slaughterhouses. In 2018, 26.8 million cattle and over 8.6 billion broilers were slaughtered in the European Union (EU) (Eurostat, 2019). It is estimated that, if current trends continue, the worldwide consumption of meat will be 76% higher in 2050 than it was in 2005/2007 (Alexandratos & Bruinsma, 2012).

The development of purpose built, centralised slaughterhouses began in the early nineteenth century and slaughterhouses have since undergone significant advancement and automation (Fitzgerald, 2010). However, slaughterhouses currently still rely upon stockpersons for the handling and movement of live animals from arrival to the point of slaughter, the extent of this handling varies depending on species and slaughter system. The attitudes, behaviour and knowledge of slaughterhouse personnel and their level of animal welfare and behaviour education and training, have been described as having a significant influence on both the welfare of animals and the quality of their meat (EC, 2009; Gallo et al., 2010; Grandin, 2006).

1.1 What is good animal welfare?

There is still no universally accepted definition of animal welfare or what constitutes ‘good’ or ‘bad’ welfare. Based on a review of animal welfare concepts at the time, Fraser et al. (1997) categorised welfare definitions in relation to their primary welfare ‘concern’. For example, ‘functioning’ based concerns focus on the health and normal biological functioning of the animal. It has been suggested by some observers, that welfare is primarily at risk when there is a degree of physiological change greater than a stipulated level (Barnett & Hemsworth, 1990) or during the presence of disease (Taylor, 1972).

Secondly, some authors have categorised welfare around ‘natural-living’ based concerns, which are centred on the ability of the animal to live a ‘natural’ life. Dawkins (1980) reported that despite increased risks of disease, allowing an animal to live freely provides optimum welfare. Rollin (1993) famously described how ‘good welfare’ allows an animal to live according to its *telos*, allowing the fulfilment of the animals’ ‘natures’.

The third category of concerns are ‘feelings-based’, describing welfare in terms of psychological wellbeing. Dawkins (1988) suggested that it is the subjective feelings of animals, especially that of suffering or pain, which define welfare, and Duncan (1996) argued that welfare is solely dependent on what animals feel, and that good welfare also involves the presence of positive feelings and the absence of negative ones (Duncan, 2005).

As the study of animal welfare continues to develop and evolve, there has been an increasing consensus of animal welfare scientists that the definition of animal welfare is multidimensional, and thus should include consideration for all three categories of concerns, i.e. ‘biological function’, ‘natural living’ and ‘feelings’ (Lerner, 2008; Manteca & Jones, 2009). However, defining what constitutes good animal welfare around slaughter raises some complex fundamental issues. For example, considering the three categories of concerns outlined above:

- The slaughter of an animal may be seen by some as the ultimate insult to its normal ‘biological function’.
- A slaughterhouse cannot be considered a ‘natural-living’ environment for any livestock species.
- The ‘feelings’ of animals may be overridden by fear stimulated by the numerous novel stimuli present in a slaughterhouse. (MacKay et al., 2014)

Due to these innate difficulties, in the literature, welfare at slaughter is often defined in relation to the level of stress faced by the animal. The term stress refers to the behavioural, physiological and emotional status of the animal confronted with a situation that it perceives as threatening with respect to the correct functioning of its bodily or mental state (Désiré et al., 2004; Terlouw et al., 2005). Stress at slaughter may be of physical origin (e.g. inappropriate temperatures, aggression, and pain) or psychological origin (e.g. social disturbance or fear) (Terlouw et al., 2008). The slaughter procedure is complex and often a situation may represent several potential factors which lead to animal stress. In line with this, the Council directive EC 1099/2009 on the protection of animals at the time of killing states that ‘Business operators or any person involved in the killing of animals should take the necessary measures to avoid pain and minimise the distress and suffering of animals during the slaughtering or killing process, taking into account the best practices in the field and the methods permitted under this Regulation’ (EC, 2009). Distress in this context can be defined as an aversive negative state in which coping and adaptation processes fail to return an animal to physiological or psychological homeostasis (Carstens & Moberg, 2000). The transition of stress to distress depends on several factors. Of clear importance are stressor duration and intensity, either of which is likely to produce behavioural or physical signs of distress (Moberg, 2000). An important consideration for any welfare improvement measures (such as training) is its effect in reducing any potential for animal pain, stress and distress. This will be the primary focus when evaluating the impact of the training program used in this project.

1.2 Why is welfare at slaughter important?

Although ensuring acceptable welfare standards for animals at slaughter has moral and ethical aspects, welfare at slaughter also has a potential to significantly influence economic outputs:

1.2.1 *The public, retailers and legislation*

The welfare of animals in the meat industry, especially at the time of slaughter, has become an area of increasing public scrutiny. Within Europe, interest in welfare has been growing over recent years. In 2015 a survey to investigate the attitudes towards animal welfare was completed by 27,672 EU citizens across 28-member states. 94% of respondents were of the view that it is important to protect the welfare of farmed animals, 82% believed that the protection of animals and their welfare should be improved, and 59% indicated that they would be prepared to pay more for welfare friendly products (Special Eurobarometer, 2016). This clear demand for higher animal welfare standards by consumers has been recognised by retailers (Velarde & Dalmau, 2012) and an increasing number of retailers are including welfare requirements in their buying specifications (Mench, 2008). For example, the British retailer Sainsbury’s reported in 2010 a 164% increase in year-on-year sales of products produced under the Freedom Food Scheme, a farm assurance and food labelling scheme encouraging farmers to adopt and maintain higher welfare standards (RSPCA, 2010). Similarly, public interest and political pressure have led to changes in animal welfare legislation (Main & Mullan, 2017). There are insistences where previous legislative change has been evidence based (e.g. the stipulation in UK legislation that only horned animals may be shot in the back of the head (WATOK, 2015) – based on the results of the work by Daly and Whittington (1986)) and non-evidence based (e.g. the introduction of The Mandatory Use of Close-Circuit Television in Slaughterhouses (England) Regulations 2018 which was a result of a public petition. There is no published evidence that CCTV improves animal welfare at slaughter).

It is in the slaughter-plants interest to comply with such standards and legislative requirements, as significant economic consequences can result from a failed audit, and, in the most severe case, this can result in subsequent removal from the approved supplier list or complete cessation of production.

1.2.2 Meat quality

There are many definitions of quality. Groom (1990) defines quality as:

> *"The composite of those characteristics that differentiate individual units of a product and which have significance in determining the degree of acceptability of that unit to the user".*

Many attributes are related to quality of meat including colour, appearance, water-holding capacity and texture (Baracho et al., 2006). There are well documented links between product quality aspects and welfare at slaughter in many livestock species including both cattle and poultry.

1.2.2.1 Bruising in cattle carcasses

Bruising of a carcass appears as a distinct discolouration observable after hide removal. A bruise is caused by vascular rupture, leading to blood accumulation in the muscle and other tissues as a result of impact from an animal's environment, a conspecific or due to human-animal interactions (Costa et al., 2006). Bruising can occur at any point prior to an animal being slaughtered. As well as being indicative of poor welfare practices pre-slaughter, bruising can have an economic impact. Bruised tissue, due to its discolouration and increased capacity for microorganism growth, is unsuitable for human consumption (Strappini et al., 2009) and therefore must be trimmed from the carcass. This process can be time consuming, and may lead to increased labour costs, slower line speeds, reduced efficiency, and a fall in production (McNally & Warriss, 1996). The weight of the tissue removed reduces the yield from that carcass and results in a reduced financial return for the producer. A number of factors have been reported to affect bruising prevalence including: transport conditions, the presence of horned animals (Huertas et al., 2010), movement through markets, animal sex, and age (Romero et al., 2012; Weeks et al., 2002). However, Strappini et al. (2013) concluded that it was the human-animal interactions at the slaughterhouse, especially during unloading and at stunning which causes the greatest potential for traumatic events. The rough handling of animals, and the use of driving instruments (prods, sticks, whips) pre-slaughter, is positively correlated with levels of bruising (Huertas et al., 2010; Jarvis et al., 1995) and is an important factor to consider in relation to animal welfare.

It is important to note that the use of electric prods or goads does not usually result directly in bruised tissue (Strappini et al., 2013; Weeks et al., 2002), however the stress caused by their use in cattle can contribute to meat quality defects (Costa, 2009; Ferguson & Warner, 2008). Warner et al. (2007) demonstrated that acute stress, induced by electric goad use (6-8 prods) in cattle 15 minutes prior to slaughter, detrimentally affected the water holding capacity of the loin muscle and the consumer acceptability of 21-day aged loin meat.

1.2.2.2 Dark Cutting Beef (DCB)

Dark Cutting Beef (DCB) occurs when cattle are exposed to physical or psychological stress for a period of time prior to slaughter. Prolonged or chronic stress results in a severe depletion of muscle glycogen leading to a reduction in lactic acid production post-mortem. The muscle has a higher than optimum pH level as it cools, and the meat appears dark and dry resulting in reduced customer acceptability (Tarrant, 1989). The lack of sufficient acidification of the meat has an important consequence in that it increases the capacity for bacterial growth, and therefore the rate of meat spoilage (Chulayo & Muchenje, 2015). Reductions in customer satisfaction and increased rates of spoilage can have significant economic impact. At the time of the 1995 national beef quality audit in the USA, 6 USD per carcass on average was being lost due to DCB (Smith et al., 1995), and with 35.6 million cattle being slaughtered in the same year (USDA, 1996) the estimated total annual loss amounted to over 210 million USD. This figure had reduced to 5.43 USD per carcass in 2000 however this still totalled a 164 million USD loss to the American beef industry (Miller, 2007). Similarly, the Australian beef industry report the potential annual loss due to DCB to be in the region of 36 million AUD (MAL, 2014). While in Canada the annual loss is estimated at 1.4 million CAD (Holdstock et al., 2014). In a similar circumstance to bruising, a number of factors have been reported to affect the prevalence of DCB. These include: long transport distances for cattle and reduced availability of space in the vehicles where the cattle is transported (del Campo et al., 2010; Ferreira et al., 2006); phenotype, a recent study found that in Canada, cattle most at risk of DCB were low body weight heifers and high body weight steers (Mahmood et al., 2016); the level and intensity of physical activity, such as fighting or physical combat before slaughter, which greatly lowers muscle glycogen (Lacourt & Tarrant, 1985; McGilchrist et al., 2011); extended lairage duration (Mahmood et al., 2017); being transported through livestock markets; mixing unfamiliar animals promoting agonistic behaviour, particularly in young bulls (Warriss, 1990); and animal handling practices, the quality of handling practices and individual variability in temperament and reactions to humans can explain variability in DCB between animals of the same breed maintained under the same diet and transportation to the same slaughter facility (Ferguson & Warner, 2008; Ponnampalam et al., 2017). The importance of education and training in minimising the stress caused by pre-slaughter procedures has been highlighted by a number of authors (Costa, 2009; Ferguson & Warner, 2008).

1.2.2.3 Poultry carcass quality

Producing high quality poultry meat on a commercial level is affected by multiple interacting factors including bird genetics, feeding, husbandry, pre-slaughter handling, stunning and slaughter procedures. It has been suggested that ante-mortem handling and slaughter operations have a greater impact on carcass quality compared to husbandry practices (Kannan et al., 1997a; Petracci et al., 2010). Carcass defects such as broken wings, and bruised legs, pygostyles, wings and shoulders can lead to product downgrading which is an economic concern for slaughter-plants (Kannan et al., 1997b). As with cattle, bruised tissue in poultry carcasses can be a consequence of traumatic events and associated rough handling (Kannan et al., 1997b), but also a result of other pre-slaughter and slaughter processes such as pre-stun shocks (PSS) (Rao et al., 2013) and poor neck cutting combined with tight plucking (Lambooij et al., 2010).

1.3 Animal welfare training for slaughter industry personnel

Learning in the workplace can be categorised as: formal (deliberate and through recognised tertiary education and training courses), or informal (incidental and through life experience) or nonformal (occurring on the job or through structured programmes but not leading to qualifications) (Vaughan & Cameron, 2009). For the purpose of this project, the animal welfare training is both formal (recognised training courses leading to the awarding of a Certificate of Competence (COC) or Animal Welfare Officer (AWO) status) and nonformal (on the job training).

In general, the purpose of commercial animal welfare training is to directly improve animal welfare through the influence of trained people who work with animals (Butterworth et al., 2012). Animal welfare education does not take a fixed form, and educational theories can offer definitions and thought-out criteria for what constitutes a suitable or desirable educational process (Sarid, 2018).
There are a number of educational theories in relation to knowledge transfer; however the majority of these fall into three main psychological schools of thought (Aubery & Riley, 2019):

- Behaviourism, which contests that 'behaviour can be predicted, measured and controlled, and that learning is simply a matter of stimulus and response' (Wallace, 2008).
  Classical and operant conditioning as famously described by Pavlov and Skinner respectively are examples of behavioural leaning theory.
- Constructivist, which argues that meaningful knowledge and understanding are 'actively constructed by learners…which builds on what they already know causing them to change and adapt and invest ideas' (Wallace, 2008). Learning is not something that can be delivered to students by passively listening to a teacher delivering knowledge.
  It is proposed that there are two main forms of constructivism: cognitive and social. Cognitive constructivism suggests that for successful learning to take place, new knowledge needs to be analysed in relation to what the learners already know, while social constructivism argues that the most important aspect of successful learning is social interaction, with emphasis on discourse, language and cultural/social backgrounds (Aubery & Riley, 2019).
- Humanism, which argues that education should focus on the needs of the individual learner, and what is important are the aspects of personal and emotional growth (Aubery & Riley, 2019).

The views of Butterworth (2013) align with the humanist school of thought, when considering animal welfare training it is stated that the type, depth and intensity of training depends on the needs of those to be trained, however in other work

Butterworth et al. (2012) comments that training in animal welfare can be 'challenging and often forms part of a gradual process of involvement in hearts, minds, attitudes and social norms', thus aligning with the social constructivism.

Animal welfare training can be described 'capacity building' i.e. an activity which strengthens the knowledge, abilities, skills and behaviours of individuals and improves institutional structures and processes, such that organisations can efficiently meet their goals in a sustainable way (Butterworth et al., 2012), and numerous authors have highlighted the potential importance of personnel training in improving welfare and meat quality at slaughter (Aghwan et al., 2016; Costa, 2009; Grandin, 1996, 1998c, 2010a; Hemsworth & Coleman, 2011; Jarvis et al., 1995; Khaneghahi Abyaneh et al., 2019; McNally & Warriss, 1996; Miranda-de la Lama et al., 2012; Romero et al., 2012; Strappini et al., 2013; Tucker et al., 2015). However, there is limited data on the direct effects of such welfare education.

One of the challenges associated with training as reported by Grandin (1996) is that although handling practices may be improved for a few weeks following training, employees often revert to poor (or more established) techniques after a period of time. Grandin emphasises the need for good management and supervision for stockpeople in the slaughter industry.

Assessment of workplace learning is seen as a substantial challenge (Zegwaard et al., 2003). Judgement of learning outcomes needs to take place in situations that are as close as possible to the 'real-life' workplace context (Daugherty et al., 2008). The primary outcome of animal welfare training should invariably be an improvement in animal welfare, thus assessing welfare in the slaughter-plant both pre and post training can play a role in the assessment of workplace learning (in regards to animal welfare training).

1.3.1 Training to improve animal welfare outcomes at slaughter

Evidence of the impact of welfare training on animal welfare outcomes at slaughter is limited. In the US, Grandin (1998b) briefly reports that in two beef slaughter-plants with poor facilities and rough handling, 15 minutes of employee animal handing training led to a decrease in the electric goad use from 83% of animals to 17%. A more extensive study carried out in a Chilean cattle plant described that 4 hours of theory followed by 4 hours of practical training for employees led to an increased number of cattle stunned on the first shot with a captive bolt gun and an increase in the number of those shot in the ideal shooting position. There was also a decrease in animals showing signs of recovery following a successful stun (Gallo et al., 2003). In this study the trained employees were supervised for two weeks prior to post-training evaluation. Both Grandin's and Gallo's work focus on a singular welfare outcome (prod use/signs of recovery post shot) rather than an overall depiction of welfare throughout the pre-slaughter, stunning and slaughter process.

To the author's knowledge, prior to the onset of this study, there was no published work that outlines the effects of welfare training in commercial poultry slaughter facilities.

1.3.2 Training to improve product quality

A number of authors have commented that training of personnel (although not those directly working in the slaughterhouse) in the handling of cattle also has the potential to improve welfare and therefore reduce bruising and increase financial returns (Jarvis et al., 1995; McNally & Warriss, 1996; Strappini et al., 2013). In a Canadian study assessing welfare during transport, cattle driven by truck drivers who had taken a livestock trucking training course were significantly less likely to produce DCB than cattle driven by non-trained drivers (Warren et al., 2010). Paranhos da Costa et al. (2012) reported a retailer initiative in which an animal welfare training programme for beef farmers resulted in a significant reduction in the proportion of beef carcasses downgraded due to bruising. Training poultry catching crews (personnel responsible for picking up birds from the floor of housing sheds and placing them in transport containers) in 'better practice' led to a 33% reduction in the incidence of back scratches in broiler carcasses caused by incorrect handling (Pilecco et al., 2013).

1.3.3 Training to improve personnel attitudes

It has been reported that the attitude of stockpeople working in slaughterhouses can influence their behaviour towards livestock, therefore potentially impacting on welfare (Coleman et al., 2003; Coleman et al., 2012) and by extension, be influential with regard to product quality and economic return (Gallo & Huertas, 2016; Huertas et al., 2015).

The Theory of Reasoned Action (Fishbein & Ajzen, 1975) was developed to help understand factors that motivate human behaviour under volitional control. According to the theory, it is a person's intention to perform a particular behaviour, which is the primary cause of such behaviour. In turn, intention to perform a behaviour is determined by an individual's attitude, as well as subjective norms (whether people would approve of their behaviour and what is expected of this individual) which surround that behaviour (Ajzen, 1991). In the slaughterhouse situation, it is likely that subjective norms are dictated, somewhat, by what is expected, and permitted, by management. The Theory of Planned Behaviour is an extension of the Theory of Reasoned Action (Ajzen, 1985) and attempts to explain behaviour that is not under complete volitional control. For example, many behaviours performed by slaughterhouse personnel are conducted in accordance with 'standard operating procedures' rather than through individual choice. The Theory of Planned Behaviour refers to an individual's perception about how easily a specific behaviour can be carried out, and it is implied that this includes previous experience and perceived obstacles. This has provided a basis for predicting behaviour based on an individual's attitude, as the individual's motive for performing a behaviour will likely be stronger given a more favourable subjective norm and attitude (Coleman, 2004).

Although generic attitude-behavioural models, such as the Theory of Planned Behaviour, can be applied to those working across all livestock sectors, there are specific issues that are relevant to individual species and to the contexts in which they are farmed (and slaughtered). Studies have been carried out in Australia which directly compare the attitudes of stockpeople working in slaughterhouses, and their observed behaviours towards animals which are handled by them in the lairage. Coleman et al. (2003) investigated the relationship between attitudes towards pigs and the use of electric prods (goads). High levels of reported 'negative attitudes' were associated with increased negative behaviour, in this case, increased electric prod use. Similar results were reported in cattle and sheep plants, where a correlation was found to exist between stockperson attitude and behaviour. It was specifically noted that; perceived lack of control; time constraints; and poor facilities at the slaughter-plant, were associated with frequent use of forceful handing techniques. The authors of this study concluded that there could be an opportunity to improve stockperson behaviour and consequently improve welfare in slaughterhouses by targeting attitudes with appropriate educational and training material (Coleman et al., 2012).

Rather than focussing on competencies required to handle animals, studies have been undertaken illustrating the positive effects that specific cognitive behavioural training has in improving the human-animal relationship between stockpeople and livestock (Hemsworth et al., 2002, Coleman et al., 2000). The training protocol used as an experimental tool in these studies has been developed into a commercial program 'ProHand' which has been adapted for use in the Australian slaughter industry (Coleman & Hemsworth, 2014b). 'Quality Handling', a multi-media cognitive behaviour training course based on ProHand has been refined specifically for use on European farms, and has been found to improve both the general and behavioural attitude of stockpeople towards the animals in their care (Ruis et al., 2010).

Although there is evidence that these programmes have been effective in improving stockperson attitude on commercial farms (Coleman et al., 2000; Hemsworth et al., 1994; Hemsworth et al., 2002; Ruis et al., 2010), the effects of training courses (such as 'ProHand') on the attitudes and behaviours of slaughterhouse personnel has not been explored.

It may be important to note that, although the majority of the existing studies in the literature have explored the effect of stockperson attitudes on welfare, Grandin (1998, 2005, 2018) describes the significant influence that the attitude of plant management has on the welfare conditions within a slaughterhouse.

1.4 Assessing the impact of animal welfare training in the slaughter industry

1.4.1 Assessing the impact on animal welfare and product quality measures

In order to evaluate the effects of personnel training (and other welfare improvement measures), the welfare status of the animals, during their relatively short period of time spent at the slaughterhouse should be accurately determined. Measuring welfare in a commercial slaughter environment can prove challenging, because some of the most sensitive physiological criteria for quantifying welfare such as heart and respiratory rate (Losada-Espinosa et al., 2018) are unsuitable for use within the complex environment of the slaughter area. Commercial pressures, high processing speeds and the layout of facilities may lead to difficulties in visually observing, and physically measuring animal-based parameters.

There are two basic purposes of welfare audits and assessments. The first is to locate severe problems, allowing government officials or retailers to identify whether a slaughterhouse requires corrective actions or removal from an approved supplier list.

The second is a more in-depth welfare assessment, which has a number of uses including welfare audits and analysing the effects of welfare improvement measures, such as personnel training.

Currently no universally accepted welfare assessment protocol exists for any species at the time of slaughter. The ‘ideal’ welfare assessment protocol should include measures that would be sensitive enough to detect real welfare change, be simple, practical and ‘encompassing’ (i.e. include a range of welfare domains) (Wigham et al., 2018). It could be argued that with increased awareness and resource allocation that an accepted welfare assessment protocol could be developed and implemented in slaughter-plants.

The physical presence of an auditor or assessor can affect the behaviour of slaughterhouse personnel who improve their practices during the audit period but revert back to poor welfare practices when they are no longer being observed. To combat this issue, some of the large American meat producers have installed CCTV cameras, allowing for remote third-party observation of practice, and remote video auditing (RVA) at any time (Grandin, 2010a). RVA can be used to audit animal-based welfare measures, alongside certain product quality outcomes in commercial slaughterhouses, and is currently in use in North America, Australia and the EU. Automated auditing of CCTV footage would be valuable in allowing for continuous assessment of animal welfare measures, reducing labour costs and in further removing any bias. It has been reported that on-farm automatic measurement of animal behaviour has established validity and reliability which is at least as good as that found between human observers, however feasibility has yet to be fully established (Rushen et al., 2012).

Using camera technology to automatically assess ear and tail lesions of pigs has been successfully trialled in a German slaughter-plant (Blömke & Kemper, 2017). A similar system assessing footpad dermatitis in a commercial poultry processing plant found that individual footpad dermatitis scores given by the technology did not agree well with scores given by a human expert, however the overall flock scores were of a similar magnitude (Vanderhasselt et al., 2013). The development of technology to automatically monitor welfare throughout the pre-slaughter and slaughter process (e.g. the automatic assessment of effective stun through detection of return to rhythmic breathing post shot in cattle) could be instrumental in the assessment of future welfare improvement interventions.

Certain carcass quality measures (e.g. bruising) have been shown to be both a valid indicator of animal welfare and feasible to measure in a slaughterhouse (Losada-Espinosa et al., 2018). Therefore, these carcass quality measures could be included in a protocol to assess animal welfare at slaughter. Improved product quality will likely result in improved economic returns and is therefore an important consideration for food business operators when implementing a welfare improvement measure.

1.4.2 Assessing the impact on personnel attitudes

Given the potential impact of attitudes of slaughter industry personnel on animal welfare at slaughter, an understanding of such attitudes and how these can be impacted by training is warranted. It is not possible to measure attitudes directly, however, they can be inferred from responses to questionnaires (Hemsworth et al., 2011) and interviews (Smith, 1975).

There has been previous reported use of questionnaires to assess perception and attitudes of slaughter industry personnel towards animal welfare. Recent work in Brazil used a questionnaire to gather information on the attitudes of livestock inspectors working in slaughterhouses. The authors highlighted that although the participants had overall positive attitudes, there was an insufficient understanding of animal behaviour and welfare, suggesting a need to improve training on such issues (Hötzel et al., 2018).

Paul Hemsworth and Graham Coleman have used questionnaires to gather data on the attitudes of stockpeople working in a variety of livestock sectors, including in Australian cattle, sheep (Coleman et al., 2012) and pig (Coleman et al., 2003) slaughter-plants. This information was used to correlate attitudes with behaviours towards animals. In particular, the perceived pressures imposed by lack of control over actions, perceived time constraints, perceived effect of poor facilities and inappropriate beliefs about arousing livestock were all associated with frequent use of forceful handling behaviours by the stockperson.

Similarly, interviews have also been used to gather information on animal welfare attitudes of slaughterhouse staff. Wickman (2013) interviewed 14 lairage staff working in Swedish slaughter-plants who were then subsequently observed handling animals. The author described those interviewed as having a 'great knowledge' about how to handle animals. Other recent studies have used interviews to explore emotions of meat inspectors (Hamilton & McCabe, 2016) and slaughterhouse lairage and line workers (McLoughlin, 2018) in relation to their work and killing of animals. Although animal welfare and attitudes towards animal welfare were not studied directly, both the work of McLoughlin and Hamilton and McCabe outline the 'emotional detachment' experienced by slaughter-plant personnel. McLoughlin describes that: 'The ideal slaughter worker in the lairage embodies a perception of the animal as a product. Thus, in animal welfare courses, workers learn how bruises cause unsightly discolouration in the carcass which results in economic loss. Therefore, commitment to good welfare is driven by an economic imperative.'

It should be reiterated that there has been little work undertaken to investigate the attitudes of slaughterhouse management personnel. Grandin (2001) states that in slaughterhouses 'attitudes of management is the single most important factor in animal handling'. Therefore, further research on attitudes of management personnel, and what factors can influence them (previous welfare training experience, for example) is warranted.

1.5 Motivators and barriers to welfare change

An understanding of motivators and barriers to change is an important step in recognising why welfare improvement measures, such as training, may or may not result in actual welfare or product quality improvement.

Motivation is the underlying force that directs behaviour (Hemsworth & Coleman, 2011) and can dictate the extent to which people apply their skills and knowledge to animals in their care. Lack of motivation can influence an individual's capacity to effectively care for animals in a production environment (Butterworth et al., 2012). For an intervention, such as training, to be successful in improving welfare, the recipient of the training is required to make changes to their behaviours on behalf of the animals, without always seeing any direct benefit to themselves (Whay, 2007).

Human behaviour change for animal welfare improvement is a complex issue. In order to bring about a change to improve welfare, there must be an awareness that a welfare problem exists and knowledge of possible solutions, which can be accomplished through training. However, awareness of an animal welfare issue and knowledge of a solution does not necessarily lead to positive changes being made (Whay & Main, 2010).

Motivation to change behaviour and improve animal welfare can be influenced by an individual's perceived benefits of, or motivators for change. These can be categorised as 'internal' or 'external' motivators (Whay & Main, 2010). Internal motivators can include ethical viewpoints, pride, and fellowship with others. External motivators can include economic benefits, perception that the change will save time or contribute to assisting others (Ellis-Iversen et al., 2010; Valeeva et al., 2007; Whay & Main, 2010).

As with motivators, barriers to behaviour change can also be broadly categorised as 'internal' or 'external' (Whay & Main, 2010). Example of internal barriers include concern of inconvenience, thoughts that the change would be time consuming, difficulties of implementation within existing routines and fear of change itself. External barriers might include lack of equipment, poor facilities and the negative impact of others (Leach et al., 2010; Whay, 2007; Whay & Main, 2010).

In non-agricultural industries regular training can be a motivating influence contributing to job satisfaction and job performance (English et al., 1992; Lloyd, 1975). In the farming industry, dissemination of knowledge is more likely to be successful when an attempt is made to bridge the gap between science and practice (Spoolder & Ruis, 2015). In relation to welfare training of farmers, Pompe and Ruis (2015) state that 'science must meet the social-psychological dimensions of the farmer in the role of entrepreneur, livestock keeper and stockman in order to make the knowledge transfer work', suggesting that successful training should attempt to address an individual's internal and external motivators and barriers. It has been reported that current intervention programmes for animal welfare may not necessarily target those who are solely in control of the behaviour which is to be changed, they may be subject to managerial rules or conflicting pressures from others (Whay, 2007).

The majority of work investigating motivators and barriers to welfare change has been carried out on farm. One Swedish study described 'lack of knowledge' of management staff as a potential barrier to welfare improvement in slaughter-plants (Wickman, 2013), however there is little evidence outlining other specific motivators or barriers to welfare improvement for those working in the slaughter industry. A knowledge of any motivators/barriers and how they are influenced by welfare training, may be beneficial in understanding why animal welfare training of staff may or may not be successful in improving welfare at slaughter. Furthermore, this knowledge may allow for the development of training to emphasise certain motivators and overcome potential barriers to change.

1.6 Introduction to the thesis

Despite the literature indicating the importance of animal welfare education for improving and maintaining acceptable levels of animal welfare at slaughter, there is currently very limited objective evidence as to the effects of training. A further understanding of the impacts of welfare training on the slaughter industry will be beneficial to the development and tailoring of future education programmes. Dissemination of results may encourage industry uptake, potentially improving animal welfare at slaughter and profitability of food business operators.

1.6.1 Introduction to the AWO/PWO training programme used throughout the thesis

The 'capacity building' potential of animal welfare training (Butterworth et al., 2012) has been recognised in EU legislation. The European Council Regulation (EC) No. 1099/2009 (EC, 2009) on the protection of animals at time of killing which came into force throughout the European Union on the 1st January 2013 created the role of the Animal Welfare Officer (AWO). Unlike the previous situation, the AWO position is now a separate job, not an add-on, with specific responsibilities described within the legislation. The adoption of the role of the AWO was based on the experience gained in some member states that demonstrated that the appointment of a specifically trained and qualified person as an AWO to coordinate and follow up the implementation of animal welfare operating procedures in slaughterhouses has provided positive welfare benefits. The Regulation (EC 1099/2009) states that this measure should therefore be applied throughout the community. The AWO should have sufficient authority and technical competence to provide relevant guidance to line personnel. Wotton and Whittington (1997) reported on the use of multi-media in training and specifically when used in the Animal Welfare Officer training course that was developed by The University of Bristol. This course was developed in 1993 to provide industry with the results of welfare and meat quality research in a 'user friendly' format. The remit of the AWO Training Course is to cover the welfare of cattle, sheep and pigs from the farm through to slaughter. Two years later the Poultry Welfare Course (PWO) was drafted using the same principles as the AWO course. These established and standardised training courses provided unique training opportunities for staff within the UK, EU and worldwide slaughter industry, which for the first time, placed scientific researchers and meat industry personnel in a formal environment to discuss issues and undergo in-depth training in animal welfare. The same EU legislation (EC 1099/2009) also states that all personnel handling animals in slaughterhouses must obtain a certificate of competence regarding their tasks and the AWO must hold a certificate of competence for all operations in the slaughterhouse.

1.6.2 Study species

Both cattle and poultry slaughter-plants were chosen as models. This was to allow the impact of welfare training to be conducted on two species which are slaughtered under contrasting conditions in a commercial environment. Poultry slaughter is an increasingly automated process and both slaughter-plants involved in this study processed over 10,000 birds an hour with live birds only being handled during shackling. On the other hand, cattle slaughter in the study plants required significant human-animal interaction in order to move, restrain, stun and slaughter animals. None of the study cattle plants used in this study slaughtered more than 50 animals in an hour.

1.6.3 Objectives of the thesis

The primary objective of this study was to evaluate the effect of welfare education on animal welfare at slaughter, personnel attitudes and product quality using a mixed methods design:

- Main Objective: To use quantitative measures to assess the impact of training on animal welfare and product quality in commercial cattle and poultry slaughter-plants.
- Secondary Objective: Understand how CCTV and RVA can be used to effectively monitor, assess and improve welfare.

- Main Objective: To use qualitative measures to assess the impact of training on the attitudes of recipients towards animal welfare and working in the slaughter industry.
- Secondary Objective: To gain an understanding of specific motivators and barriers to welfare change in the slaughter industry.

1.7 Thesis Outline

This thesis is in seven chapters with this first chapter introducing the topic and providing an overview of the rest of the thesis.

Chapter 2 utilises a questionnaire to explore the attitudes that those attending training have towards animal welfare, and their attitudes to their work and whether certain factors, including previous AWO/PWO training, gender, and some employment characteristics effects such attitudes.
Contribution to knowledge: This is the largest study of this kind to have taken place in the EU. Previous work assessing attitudes of those in the slaughter industry have primarily focused on stockpeople. However, in this study, information was gathered on the attitudes of those working in a range of roles including managers, veterinarians, meat inspectors and stockpeople.

Chapter 3 describes the use of a novel animal welfare and product quality assessment protocol (the development of which is described within the chapter) to assess the impact of animal welfare training of personnel in three commercial beef slaughter-plants.

<u>Contribution to knowledge:</u> *This is the first study to provide evidence as to the impact of welfare training on objective animal-based welfare measures throughout the pre-slaughter, stunning and slaughter process in commercial beef slaughter facilities.*

<u>Chapter 4</u> describes the use of a novel bird welfare and product quality assessment protocol (the development of which is described within the chapter) to assess the impact of poultry welfare training of personnel in two commercial poultry slaughter-plants on bird welfare and carcass quality measures.

<u>Contribution to knowledge:</u> *This is the first study to provide evidence as to the impact of welfare training on objective bird-based welfare and carcass quality measures in commercial poultry slaughter operations.*

<u>Chapter 5</u> explores the use of CCTV and RVA to overcome the potential observer effect when assessing animal welfare and the impact of welfare improvement measures in the slaughterhouse. Visits to Arrowsight Ltd (a provider of RVA) and a large American cattle slaughter-plant who currently use CCTV and RVA were conducted. The benefits and limitations of these technologies in monitoring and improving welfare at slaughter is discussed.

<u>Contribution to knowledge:</u> *There is currently limited literature outlining the use of CCTV and RVA to improve welfare in the slaughterhouse environment. This study presents details on 'best practice' for the use of these technologies which would be beneficial to food business operators.*

<u>Chapter 6</u> Builds on Chapter 2 by using interviews to assess attitude changes post-training. The interviews were also used to explore potential reasons that the training used throughout this thesis may, or may not, elicit changes in quantitative measures of welfare in processing plants.

<u>Contribution to knowledge:</u> *This is the first study to use information gathered from interviews with slaughter industry personnel to explore in depth, motivators and*

barriers to changes in quantitative measures of welfare, specifically in the slaughterhouse environment.

Chapter 7 summarises the main findings of the research presented in this thesis and includes limitations and recommendations for future research and teaching.

1.8 Ethical Approval

Ethical Approval for an investigation involving live animals (UIN) was granted from The University of Bristol Animal Welfare and Ethical Review Body (AWERB) and given the reference UIN/17/084.
Ethical approval for investigations involving human participants; Chapter 2 (approval number 52881) and Chapter 6 (approval number 60751), was granted from The University of Bristol Faculty of Health Sciences Research Ethics Committee.

1.9 Role of the Author

The role of the author (EW) for each of the studies is outlined below:

- Chapter 2: EW conceived and designed the study, designed the questionnaire, distributed/collected the questionnaire, analysed the data. Steve Wotton (SW) and Andy Grist (AG) delivered the training and distributed/collected the questionnaire when EW was not able to be present.
- Chapter 3: EW, SW and Andy Butterworth (AB) conceived and designed the study. EW designed the assessment protocol and collected and analysed the data. SW delivered the welfare training.
- Chapter 4: EW, SW and AB conceived and designed the study. EW designed the assessment protocol and collected and analysed the data. SW and AG delivered the welfare training.

- Chapter 5: EW, SW and AB conceived and designed the study. EW visited Arrowsight HQ and the Texan processing plant and wrote the report.
- Chapter 6: EW and Siobhan Mullan (SM) conceived and designed the study. EW conducted the interviews. EW and SM analysed the data.

Chapter 2. The impact of training, gender and some employment characteristics on the attitudes of slaughter industry personnel.

The preliminary data from the questionnaire was presented as part of an oral presentation at the European Congress of Behavioural Medicine and Animal Welfare - Berlin, Germany, September 27-29, 2018. An abstract appears in their conference proceedings:

Wigham, E., Butterworth, A., Grist, A., 2018 Attitudes of slaughter industry personnel towards animal welfare, In: Proceedings of the First Annual Meeting of the European Congress of Behavioural Medicine and Animal Welfare (ECVBMAW), Berlin.

The information in this chapter has also been submitted as a scientific paper:

Wigham, E., Grist, A., Mullan, S., Wotton, S., Butterworth, A., submitted. Gender and job characteristics of slaughter industry personnel influence their attitudes to animal welfare.

2.1 Introduction

A person's attitude towards animals and their beliefs about their job are important factors that can influence behaviour towards livestock, therefore potentially impacting on animal welfare (Coleman et al., 2003; Coleman et al., 2012; Lensink et al., 2000; Seabrook, 2001). Work by Coleman et al. (2003) demonstrated that if stockpeople working in a slaughterhouse had 'negative attitudes' towards pigs, they were more likely to use the electric goad on animals. Later work by Coleman et al. (2012) found similar results in cattle and sheep slaughter-plants where frequent use of forceful handling techniques was associated with perceived lacked of control, time restrains and poor facilities.

Specific cognitive-behavioural training courses have been developed to target attitudes and behaviours of stockpeople. (Coleman & Hemsworth, 2014b) Although there is evidence that these programmes have been effective in improving stockperson attitude on commercial farms (Coleman et al., 2000; Hemsworth et al., 1994; Hemsworth et al., 2002), the effects on slaughterhouse personnel has not been explored.

Unlike that of cognitive-behavioural training courses, the primary purpose of the AWO/PWO courses involved in this project is to communicate welfare research findings and legislative change to the slaughter industry. Learning new information has the capacity to alter an individual's attitude towards animals (Ajzen, 1988; Paul & Serpell, 1993).

Alongside training, there is evidence that a person's gender has influences on their attitudes. Research in the livestock industries has indicated that women appear to have more positive views towards animals and their welfare (Lensink et al., 2000; Porcher et al., 2004; Wambui et al., 2018), which may be a result of higher levels of empathy compared to men (Porcher et al., 2004). However, little research has been undertaken on the impact of gender on the attitudes of those working within the slaughter industry.

Certain characteristics of employment within the slaughter industry have been shown to impact stockperson attitudes. The person's professional / employed roles within the slaughterhouse were found to influence reported 'aggression' scores (defined by responses to an 'Aggression Questionnaire'), with those working on the kill floor having notably higher 'aggression' scores than those working in the boning room, however sample size in these case studies was small (Richards et al., 2013). Richards et al also reported that time employed within the slaughter sector did not impact 'aggression' scores or a person's attitude towards animals as measured on the

Animal Attitude Scale (Herzog et al., 1991). Similarly, Wambui et al. (2018) reported no significant association between years of experience of Kenyan stockpeople and responses to animal welfare attitude statements.

It is important to note that, although the majority of the existing studies in the literature have explored the effect of stockperson attitudes on welfare, Grandin (1998a, 2005, 2018) describes the significant influence that the attitude of plant management has on the welfare conditions within a slaughterhouse. Therefore, the attitudes of slaughter industry personnel in managerial roles also warrants further attention.

The aims of this chapter are to gain an improved understanding of the attitudes that those attending AWO/PWO courses have towards animal welfare, and their attitudes to their work and whether certain factors, including previous AWO/PWO training, gender, and some employment characteristics effects such attitudes.

2.2 Materials and Method

2.2.1 Questionnaire development

It is not possible to measure attitudes directly; however, they can be inferred from responses to questionnaires (Hemsworth et al., 2011). A combined approach using review and summarisation of the scientific literature, alongside expert opinion elicitation, was used in the identification of suitable questions to be used in an anonymous, paper-based, two-part questionnaire.

Part one consisted of 20 Likert items (a “Likert item” is a statement that the respondent is asked to evaluate in a survey) for which participants were instructed to respond on a five point scale, from ‘Strongly Disagree’ to ‘Strongly Agree’ regarding their view on certain statements. These included animal welfare, (e.g. ‘It’s important to me than animals have a life worth living' and 'I am willing to spend more money on animal welfare friendly products'), or their work in the slaughter industry (e.g. 'Up to now I feel I have not received enough welfare training', and 'Time constraints mean that stock handlers do not have time to correctly handle livestock'). Part two of the questionnaire consisted of questions designed to gather information on the participants. This included: gender; length of time working in the slaughter industry; species involved with; attendance at previous welfare training courses; professional role in the slaughter-plant; and whether the respondent held a current certificate of competence (CoC) for working with animals. See Appendix 1 for full questionnaire.

For analytical purposes, responses to 'species involved with' were categorised into:

- works with mammals (yes/no)
- works with birds (yes/no)

Responses to 'role' were categorised into:

- Stockperson – handling/shackling/stunning/sticking animals.
- Management – occupying a managerial role (including supervisor) within a slaughter facility.
- Enforcement – employed as a meat inspector or official veterinarian working within, however not directly employed by the slaughter facility.
- Non-abattoir – working in the wider slaughter industry but not based within a primary processing plant.

2.2.2 Questionnaire delivery

Participants on 11 University of Bristol AWO courses, six PWO training courses and two combined AWO/PWO courses held between May 2017 and October 2018 were invited to complete a single questionnaire prior to the onset of the course teaching. Of the 19 courses involved in the study, 17 were held in the UK, one was held in Spain, and one was held in The Netherlands.

To assess the immediate effects of AWO/PWO training on attitudes of slaughter industry personnel, 14 participants attending an AWO course run in June 2018 were given a questionnaire to complete at the beginning of the course, followed by a second (paired) questionnaire, consisting of part 1 questions only, at the end of the course.

2.2.3 Statistical Analysis

Responses to each of the Likert items were analysed independently using SPSS, Version 24.0 (2018). To investigate the influence of 'personal' factors, an ordinal logistic regression with backwards variable selection was used.

A full ordinal logistic regression model including all 'personal information' variables (gender, role, time in industry, species worked with (mammals/birds), previous welfare training, holder of a CoC) was used to estimate effects on question responses. Using backward selection, variables were eliminated from the model one-by-one using a p-value of ≤ 0.05 as the exclusion criteria, starting with variables with the highest p-value, until only variables with a p-value of ≤ 0.05 remained in the model. Forward selection was used to confirm the results of the models developed following the backwards selection process. The final models were checked to ensure that they met the assumption of proportional odds, by using the test of parallel lines. For models which did not meet this assumption, a binomial logistic model with backwards selection was carried out using the same method. To create a binomial dependent variable, responses of 'Strongly Disagree' and 'Disagree' were combined along with 'Strongly Agree' and 'Agree'. Responses of 'Neither Agree nor Disagree' were excluded.

Since sample sizes were small for the paired questionnaire (n=14) it was decided to use Pratt's test to assess for differences between pre-training responses and post-training responses when the correlation between the sets of responses was strong and paired samples t-tests when the correlation was weak (Derrick & White, 2017).

SPSS version 24.0 was used to calculate the Pearson's correlation coefficient between the pre-training and post-training questionnaire responses for each question. For questions with a correlation coefficient less than 0.5, paired samples t-test were used to assess for differences between pre-training and post-training responses. Questions with a correlation coefficient greater than 0.5 were analysed for pre-post training differences using Pratt's test in Prism version 7. Results were deemed significant at $p \leq 0.05$.

2.3 Results

A total of 215 questionnaires were collected, and all responses were included in the analysis.

Time working in the slaughter industry ranged from 0 to 50 years with the median being nine years. The respondents worked with all major livestock species (Table 2.1) with cattle (n=130), and poultry (n=102) being the most prevalent. The majority of respondents (n=142; 67%) worked with more than one species.

Table 2.1 Number of respondents working with each livestock species.

Species	Cattle	Pig	Sheep	Poultry	Deer	Horses	Game	Other	Missing Response
Number of respondents	130	96	94	102	21	18	19	10	2

Over half of the respondents (n=112; 52%) held managerial roles within slaughterhouses, with nearly equal numbers working as stockpeople (n=32; 15%), enforcement officers (Official Veterinarians and/or Meat Inspectors employed by or contracted to government agencies) (n=33; 15%) and in non-abattoir roles (n=31;

14%). All those who answered that they worked in a non-abattoir role were involved in the wider slaughter industry, and this included retail auditors, corporate roles within meat processing companies, livestock buyers and slaughter equipment manufacturers.

Most respondents were male (n=149; 69%), 28% (n=61) were female, and the remainder (n=5; 2%) did not complete the question. Within the different roles, only one respondent was identified as a female stockperson, while there were equal numbers (n=14) of males and females working in an enforcement role (Table 2.2). The majority of total respondents (n=143; 67%) had not previously attended an AWO/PWO training course – and this (non-previous attendance) ranged from 76% of enforcement personnel to 67% of management. Of the total respondents, 50% (n=107) held a current CoC, which ranged from 84% of stockpeople, to 29% of those in a non-abattoir-based role (Table 2.2).

Table 2.2 Characteristics of respondents within each role.

	Respondents, % of total responses within role (n)			
Role	Stockperson	Management	Enforcement	Non-abattoir
Gender:				
Male	97% (31)	70% (78)	42% (14)	65% (20)
Female	3% (1)	30% (34)	42% (14)	35% (11)
No response	0	0	15% (5)	0
Previous AWO/PWO training:				
Yes	31% (10)	33% (37)	24% (8)	32% (10)
No	69% (22)	67% (75)	76% (25)	68% (21)
Holds a CoC:				
Yes	84% (27)	54% (61)	30% (10)	29% (9)
No	16% (5)	46% (51)	70% (23)	71% (22)

The data from the responses to the Likert items is presented in Table 2.3.

Table 2.3 All responses to Likert item questions as percent % (n)

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I enjoy working with animals	0	0.5% (1)	11.6% (25)	40.5% (87)	47.4% (102)
Welfare at slaughter is as good as it's going to get	6.5% (14)	37.2% (80)	26.5% (57)	23.3% (50)	6.5% (14)
Up to now I feel I have not received enough welfare training	7.4% (16)	28.4% (61)	33% (71)	26.5% (57)	4.7% (10)
Working in the slaughter industry is a stressful job	0.9% (2)	16.5% (35)	29.7% (63)	37.7% (80)	15.1% (32)
Current animal welfare legislation is too lenient	3.3% (7)	32.9% (69)	46.2% (97)	17.1% (36)	0.5% (1)
I am willing to spend more money on	1.4% (3)	11.3% (24)	27.7% (59)	50.2% (107)	9.4% (20)

welfare friendly food products					
Livestock animals are all individuals, and each have their own personalities	0	6.5% (14)	22% (47)	38.8% (83)	32.7% (70)
Time constraints mean that stock handlers do not have time to correctly handle livestock	8.9% (19)	30.8 (66)	31.3% (67)	24.8% (53)	4.2% (9)
It is important to me that animals have 'a life worth living'	0.5% (1)	3.3% (7)	10% (21)	44.1% (93)	42.2% (89)
Working in the slaughter industry gives me a feeling of accomplishment	1.4% (3)	4.8% (10)	38.9% (81)	44.2% (92)	10.6% (22)
I get upset when I see someone mistreat an animal	1.4% (3)	0.9% (2)	4.3% (9)	31.8% (67)	61.6% (130)
All abattoir staff handling animals should receive welfare training	0	1.4% (3)	2.4% (5)	26.5% (56)	69.7% (147)
I feel that in the slaughter industry 'Production is everything'	12.8% (27)	21.8% (46)	26.1% (55)	33.2% (70)	6.2% (13)

Animals feel pain just like humans do	1% (2)	4.3% (9)	7.6% (16)	36.7% (77)	50.5% (106)
Public concern about the welfare of animals is exaggerated	6.7% (14)	15.2% (32)	37.1% (78)	33.3% (70)	7.6% (16)
I try to emotionally detach from my day to day job	4.8% (10)	22.5% (47)	41.1% (86)	27.3% (57)	4.3% (9)
I get easily frustrated when working with animals	31.9% (67)	43.8% (92)	18.6% (39)	4.3% (9)	1.4% (3)
Stressing an animal at an abattoir doesn't matter – they are going to be slaughtered anyway	72% (152)	19.4% (41)	2.8% (6)	2.8% (6)	2.8% (6)
I am very concerned about the pain and suffering of animals	7.6% (16)	5.2% (11)	10% (21)	42.7% (90)	34.6% (73)
CCTV is an effective way to improve animal welfare at slaughter	1.4% (3)	6.7% (14)	13.9% (29)	44.7% (93)	33.2% (69)

2.3.1 Influencing factors.

Of the 20 Likert items, the responses from five statements were not significantly influenced by any of the factors included in the analysis i.e. the characterises of the respondents (no factors had a p value of ≤ 0.05 using backwards variable selection ordinal logistic regression model) (Table 2.4).

Table 2.4 The five statements for which responses were not significantly influenced by any factors (respondent characteristics) included in the analysis (no factors had a p value of ≤ 0.05).

Statements with no significant independent variables
- I am willing to spend more money on welfare friendly food products
- Time constraints mean that stock handlers do not have time to correctly handle livestock
- Animals feel pain just like humans do
- CCTV is an effective way to improve animal welfare at slaughter
- Working in the slaughter industry is a stressful job

Factors significantly influencing responses to individual Likert items as extracted by backward variable selection logistical regression at a threshold of p ≤ 0.05 are summarised in Table 2.5 and Table 2.6.

Table 2.5 Factors significantly influencing responses to individual Likert item as extracted by backward variable selection ordinal logistic regression at a threshold of p ≤ 0.05.

Variables	*Mean response[1]*	*Odds ratio[2]*	*95% CI*	*p value*
I enjoy working with animals				
Previous AWO/PWO training				
Yes	4.51	2.06	1.13-3.76	0.019
No	4.28	*Ref*		
Works with mammals				
Yes	4.45	2.85	1.52-5.32	0.001
No	4.05	*Ref*		
Welfare at slaughter is as good as it's going to get				
Gender				
Male	3.01	3.041	1.678-5.509	<0.0001
Female	2.48	*Ref*		
Time in industry		0.965	0.943-0.988	0.003
Up to now I feel I have not received enough welfare training				
Holds a CoC				
Yes	2.71	0.484	0.285-0.823	0.007
No	3.18	*Ref*		
Previous AWO/PWO experience				
Yes	2.52	0.408	0.227-0.731	0.003
No	3.11	*Ref*		
Livestock animals are all individuals, and each have their own personality				
Gender				
Male	3.9	0.514	0.291-0.908	0.022
Female	4.21	*Ref*		
Works with birds				

Yes	3.83	0.592	0.352-0.995	0.048
No	4.12	*Ref*		
It is important to me that animals have a 'life worth living'				
Gender				
Male	4.16	0.443	0.244-0.805	0.008
Female	4.47	*Ref*		
Previous AWO/PWO experience				
Yes	4.42	1.92	1.108-3.405	0.026
No	4.16	*Ref*		
Working in the slaughter industry gives me a feeling of accomplishment				
Role – Enforcement				
Yes	3.23	0.357	0.159-0.799	0.012
No	3.64	*Ref*		
Time in industry		1.032	1.008-1.057	0.008
I get upset when I see someone mistreat an animal				
Gender				
Male	4.48	0.435	0.218-0.866	0.018
Female	4.68	*Ref*		
Time in industry		1.044	1.014-1.074	0.0002
All abattoir staff handling animals should receive welfare training				
Works with mammals				
Yes	4.71	2.353	1.2-4.613	0.013
No	4.44	*Ref*		
I feel that in the slaughter industry 'Production is everything'				
Role – Stockperson				

Yes	3.5	2.689	1.314-5.502	0.007
No	2.89	*Ref*		
Public concern about the welfare of animals is exaggerated				
Holds a CoC				
Yes	3.36	1.704	1.014-2.859	0.043
No	3.02	*Ref*		
I try to emotionally detach from my day-to-day job				
Role-Enforcement				
Yes	3.45	2.239	1.051-4.766	0.037
No	2.97	*Ref*		
Stressing an animal at an abattoir doesn't matter- they are going to be slaughtered anyway				
Works with mammals				
Yes	1.36	0.484	0.245-0.954	0.036
No	1.65	*Ref*		
I am very concerned about the pain and suffering of animals				
Works with mammals				
Yes	4.03	2.292	1.269-4.142	0.006
No	3.58	*Ref*		

[1] Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree)

[2] Probability of differing significantly from the reference category (*Ref*). Derived from backwards selection multivariable ordinal logistic regression models.

Table 2.6 Factors significantly influencing responses to individual Likert item as extracted by backward variable selection binomial logistical regression at a threshold of p ≤ 0.05.

Variables	*Mean Response*[1]	*Odds ratio*[2]	*95% CI*	*p value*
Current animal welfare legislation is too lenient				
Works with birds				
Yes	1.45	2.992	1.32-6.782	0.009
No	1.22	*Ref*		
I get easily frustrated when working with animals				
Role – Stockperson				
Yes	1.31	15.667	4.286-57.29	0.0001
No	1.03	*Ref*		

[1] Binomial scale 1 – combined responses from Strongly Disagree and Disagree, 2 – combined responses from Strongly Agree and Agree.

[2] Probability of differing significantly from the reference category (*Ref*). Derived from backwards selection binomial logistic regression models.

2.3.1.1 Previous AWO/PWO training

Those with previous AWO/PWO welfare training were over two times more likely (Odds Ratio, OR 2.06, 95% confidence interval, CI 1.13-3.76) to report enjoyment of working with animals, and had significantly higher odds (OR 1.92, 95% CI 1.11-3.41) of agreeing with the statement; *'It is important to me that animals have a 'life worth living'*. These individuals were also over two times more likely to disagree (OR 0.408, 95% CI 0.227-0.731) when asked; '*Up to now I feel I have not received enough welfare training'*.

2.3.1.2 Certificate of competence

Respondents holding a current CoC were also over two times (OR 0.484, 95% CI 0.285-0.823) more likely to disagree with the statement '*Up to now I feel I have not received enough welfare training*' and scored significantly more positively when responding to *'Public concern about the welfare of animals is exaggerated'* (OR 1.704, 95% CI 1.01-2.86).

2.3.1.3 Time in industry

An increase in time spent working in the slaughter industry was significantly associated with both an increased likelihood of personnel feeling 'accomplished in their work' (OR 1.032, 95% CI 1.01-1.06) and of 'feeling upset when animals are seen to be mistreated' (OR 1.044, 95% CI 1.01-1.07). Those who have spent longer in the industry were also significantly more likely to disagree with the statement that 'W*elfare at slaughter is as good as it's going to get'* (OR 0.965, 95% CI 0.943-0.988).

2.3.1.4 Species

Personnel working with mammals were found to be significantly more likely to respond that they enjoyed working with animals compared to personnel who do not work with mammals (OR 2.85, 95% CI 1.52-5.32). These respondents were also significantly more concerned about the pain, suffering and stress of animals, and were over two times (OR 2.35, 95% CI 1.2-4.61) more likely to agree that; 'A*ll abattoir staff handling animals should receive welfare training'*. Personnel working with birds had significantly higher agreement scores when asked; '*Current welfare legislation is too lenient'* compared to those who didn't work with birds (OR 2.99, 95% CI 1.32-6.78), yet those working with birds were significantly more likely to have lower agreement scores when answering '*Livestock animals are all individuals, and each have their own personality'* (OR 0.592, 95% CI 0.352-0.995).

2.3.1.5 <u>Role</u>

The odds of those working in an enforcement role within the slaughter industry agreeing they did not feel 'accomplished in their role' and that they tried to 'emotionally detach from their day-to-day job' was 2.80 (95% CI 1.25-6.29) and 2.24 (95% CI 1.05-4.77) respectively. Stockpeople were found to be significantly more likely to agree that 'they get easily frustrated' when working with animals (mean Likert score 1.31) compared to those in other roles (mean Likert score 1.03). There were also significant odds of stockpeople agreeing that 'production is everything' within the slaughter industry (OR 2.69, 95% CI 1.31-5.50).

Working in management or in a non-abattoir-based role did not significantly influence responses to any of the 20 Likert items.

2.3.1.6 <u>Gender</u>

Compared to females, male responders were over three times (OR 3.01, 95% CI 1.68-5.51) more likely to agree with the statement; 'W*elfare at slaughter is as good as it's going to get'* conversely, males responders were 1.95 times (OR 0.51, 95% CI 0.29-0.91) more likely to disagree with the statement; '*Livestock animals are all individuals, and each have their own personality'*; 2.3 times (OR 0.435, 95% CI 1.15-4.59*)* more likely to disagree with the statement; *'I get upset when I see someone mistreat an animal'* and 2.26 (95% CI 1.24-4.10) times more likely to disagree with the statement; *'It's important to me that an animal has a 'life worth living'*.

2.3.2 Repeated Questionnaires

A total of 14 people completed paired questionnaires. Information on each participant is presented in Table 2.7. No participants worked with species other than cattle, pigs or sheep.

Table 2.7 Information on 14 participants who completed paired questionnaires. *St – Stockperson, Su – Supervisor, N – Not abattoir based.

Gender	Nationality	Experience (years)	Works with cattle	Works with pigs	Works with sheep	Holds a certificate of competency	Previous attended a UoB AWO course	Role*
Female	British	0	No	No	Yes	No	No	Su
Female	British	10.1	No	No	Yes	Yes	No	St
Male	British	42	No	No	Yes	Yes	No	Su
Male	British	0.67	Yes	No	Yes	No	No	N
Male	Polish	4	Yes	No	No	Yes	No	St
Male	British	20	Yes	No	Yes	Yes	No	St
Male	British	4	Yes	Yes	Yes	Yes	No	St
Male	British	17	Yes	No	Yes	Yes	No	Su
Male	British	7.67	Yes	No	Yes	Yes	No	St
Male	British	4.5	Yes	No	Yes	Yes	No	St
Male	British	3.83	Yes	No	Yes	Yes	No	St
Male	British	13	Yes	No	Yes	Yes	No	St
Male	British	2.5	Yes	No	Yes	Yes	No	St
Male	British	0.25	Yes	No	Yes	Yes	No	St

The difference in responses to each question immediately post-training is presented in Table 2.8. There was a significant difference (mean difference 0.929, p=0.004) in post-training answers to question 8: "*Time constraints mean that stock handlers do not have time to correctly handle livestock.*" Respondents were more likely to answer agree/strongly agree post training compared to pre-training.

No other questions had a significant difference between pre and post-training responses.

Table 2.8 The difference in questionnaire responses before and after attending an AWO course.

Question	Pearson's correlation coefficient	Test used	Mean post-training – pre-training response ± standard error	Sum of signed ranks (W)	Sig. (exact)	t	df	Sig. (2-tailed)
Q1	0.65	Pratt's	0.214 ± 0.114	39	0.25			
Q2	0.736	Pratt's	-0.286 ± 0.221	-49	0.125			
Q3	-0.067	Paired sample t-test	0.429 ± 0.388			1.104	13	0.29
Q4	0.515	Pratt's	0.143 ± 0.275	19	0.68			
Q5	0.18	Paired sample t-test	0.214 ± 0.239			0.898	13	0.385
Q6	0.803	Pratt's	0 ± 0.113	0	1.00			
Q7	0.807	Pratt's	-0.071 ± 0.127	-13	1.00			
Q8	0.247	Paired sample t-test	0.929 ± 0.267			3.484	13	0.004
Q9	0.862	Pratt's	0.071 ± 0.127	13	1.00			
Q10	0.928	Pratt's	-0.142 ± 0.261	-27	0.5			

Q11	0.714	Pratt's	0.143 ± 0.143	25	0.625			
Q12	0.397	Paired sample t-test	-0.143 ± 0.206			-0.694	13	0.5
Q13	0.428	Paired sample t-test	0.462 ± 0.291			1.585	12	0.139
Q14	0.524	Pratt's	0 ± 0.182	0	1.00			
Q15	0.058	Paired sample t-test	0.001 ± 0.278			0.003	13	0.998
Q16	0.33	Paired sample t-test	0.214 ± 0.261			0.822	13	0.426
Q17	0.598	Pratt's	-0.6923 ± 0.286	-55	0.063			
Q18	0.763	Pratt's	0.214 ± 0.239	16	0.563			
Q19	0.692	Pratt's	-0.071 ± 0.222	-19	0.688			
Q20	0.616	Pratt's	-0.286 ± 0.244	-42	0.219			

2.4 Discussion

In this study, the views of slaughter industry personnel regarding animal welfare in relation to their work were evaluated. To the author's knowledge, this is the largest study of this kind to have taken place in the EU and the first to include attitudes of personnel in a range of different roles in the slaughter industry. As demonstrated in previous published studies, welfare training along with other 'personal factors' can have an influence on a person's attitudes towards animal welfare. Understanding the relationship between such factors, and the attitudes of personnel, may benefit both human and animal welfare by enabling targeting and tailoring of training, recruitment, and provision of resources in the slaughter environment.

2.4.1 Previous AWO/PWO training

Although 35.8% of respondents reported that they had received enough welfare training, almost a third (31.2%) of respondents agreed, or strongly agreed, that they had not received enough welfare training in their current role. Over 96% believed that all staff handling live animals should receive training. It is unsurprising that those with previous AWO/PWO training were less likely to agree that they had not received enough welfare training. Perceiving that the training was 'enough' suggests either that the courses are meeting the needs of those attending them, or that these individual's did not see the benefit or need for further training. Although this cannot be concluded from the results of this questionnaire, further work discussing participant's views on welfare training would be beneficial for the development of future welfare education courses.

Training experience was also associated with a greater enjoyment in working with animals, and increased agreement with the statement that it is important that animals have a 'life worth living'. Unlike the cognitive behavioural training courses designed by Coleman and Hemsworth (2014b), the AWO/PWO training courses involved in this study are intended to provide delegates with the technical knowledge required to improve welfare at slaughter. The acquisition of new knowledge can change attitudes (Hemsworth & Coleman, 2011; Waiblinger et al., 2006) and while AWO/PWO training did 'improve' responses to the questions previously mentioned, it is important to note that there were many questions where training experience was not significantly associated with any significant changes in views.

2.4.2 Certificates of competence

All operatives handling and slaughtering live animals in the EU require a CoC. In order to hold a CoC a person must pass an assessment, for which the majority of slaughter-plants offer some training. The training associated with acquiring a CoC, may partly explain why those personnel with a CoC are significantly more likely to agree that they *'have received enough welfare training'*. Interestingly, these individuals with CoCs were also more likely to agree with the statement that '*Public concern about the welfare of animals is exaggerated'*. Many public facing campaigns by non-governmental organisations emphasise poor welfare practice within slaughterhouses. It could be argued that those responsible for day-to-day handling, stunning and slaughter within these facilities are more 'in-touch' with the reality of animal welfare levels within slaughterhouses. However, Dillard (2008) suggests that those working in the meat industry may acquire a lowered ability to empathise, and also to identify the pain suffered by animals, yet holding a CoC was not significantly correlated with other animal welfare related statements in the analysis.

2.4.3 Time in industry

Previous work has reported that the length of time working within the slaughter industry did not significantly influence an employee's attitude towards animal welfare (Richards et al., 2013; Wambui et al., 2018). This study contradicts these findings, and the results suggest that those who have spent longer working in the feel more accomplished in their work. It may be considered is that those who choose to stay in the industry, do so because they have higher levels of job satisfaction, and this is highlighted in the results by the greater reported feelings of accomplishment in longer standing employees. It has previously been shown that these positive views regarding job satisfaction do correlate with positive attitudes towards animals (Coleman et al., 1998). Although the age of the respondents was not measured (or requested in the questionnaire), this factor may have an important influence on personnel views. Kellert and Berry (1987) have described how older males have a more utilitarian and pragmatic view of animals. It is suggested that the practical value of animals increases in relevance with age, as work and familial responsibilities rise in importance, however, the results of this work suggest that the particular role within the slaughterhouse – and thus levels of responsibility – do not influence such responses.

2.4.4 Species worked with

Those working with mammals reported higher enjoyment levels in working with animals, greater empathy, and increased appreciation for individual differences between animals, when compared to those working with birds. Bock et al. (2007) reported similar findings when investigating relationships between EU farmers and their livestock; poultry farmers were described as having a 'lesser bond' with their animals and viewing birds as 'flocks' rather than individuals. The lack of attachment was explained in terms of a large number of birds staying on the farm for a relatively short time. The results of our study could be explained in similar premise. Large, commercial slaughterhouses in the EU process birds in much greater numbers and at a much higher speeds than mammals, and this is coupled with the smaller monetary value of individual birds compared to any commercially slaughtered mammal (red meat) species. In general, when mammals progress through a slaughterhouse, they experience a greater number of human-animal interactions than do poultry. For example, birds slaughtered by gas killing processes, are not handled by human hands, until they are dead and animal welfare is no longer a consideration. Increased human-animal interactions may be why those people working with mammals are more likely to agree with the statement '*All abattoir staff handling animals should receive welfare training'*. Although human-animal interactions may be minimal, slaughter-plant personal still play a vital role in ensuring adequate bird welfare conditions, for example, ensuring appropriate temperatures (Warriss et al., 1999) and waiting times (Cockram & Dulal, 2018) in the lairage. Working with birds was associated with higher agreement scores with the statement '*current welfare legislation is too lenient',* although this statement did not specify or describe specific legislation, it is assumed that those working with specific species would refer to the regulations related to their area, and so species, of work. Council Regulation (EC) No 1099/2009 governs the protection of animals at the time of killing, and refers to the welfare of both mammals and birds (EC, 2009). To the author's knowledge there has been little previous work on the attitudes towards animal welfare and personnel beliefs about their job of working in the poultry slaughter industry. Targeting these attitudes, for example ensuring slaughter-plant employees understand the importance of welfare on individual animals, may have a positive impact on bird welfare in the slaughterhouse.

2.4.5 Employed role

Those in enforcement roles (Meat Inspectors and Official Veterinarians) were significantly more likely to report that they 'attempt to emotionally detach' from their day-to-day job. Hamilton and McCabe (2016) reported similar findings after interviewing 20 Meat Inspectors working in a UK poultry slaughter-plant. Those working in the slaughter industry experience routine, and day to day intentional killing, which, according to Baran et al. (2016), induces chronic empathetic suffering which in turn influences slaughterhouse workers to distance themselves psychologically from their work. Although over half of the total responders were in agreement, that working in the slaughter industry gives them a feeling of 'accomplishment', working in an enforcement role was significantly associated with lower agreement scores regarding 'accomplishment'. These results may potentially be attributed to the fact that in the UK, the majority of people working in enforcement roles are agency-employed veterinary surgeons, who gained their qualifications from outside the UK. It has been described by some observers that such individuals are 'over-qualified' for slaughterhouse work, and have entered the meat trade due to restrictions in the UK veterinary job market (Hamilton & McCabe, 2016). Although the questionnaire in this study was only distributed to those in the slaughter industry, studies from Denmark have reported that slaughterhouse workers in general derive 'lower levels of meaning' ('meaning' assumed to be a positive attribute of work experience) from this work than do employees in other occupations (Baran et al., 2016).

With the exception of gas killing of poultry, every animal that passes through an EU slaughter facility will interact with a stockperson. These individuals are responsible for the day-to-day, frontline, handling of the animals, and the mechanics of stunning and slaughter. The rate at which animals are slaughtered determines the work rate (often set by the line speed) for the rest of the meat production line. Delays in slaughtering animals can have a direct knock-on effect further down the production line. This can result in operators responsible for carcass dressing waiting for carcasses to arrive at their station, reducing overall production rate. Traditionally, personnel working in the production line, including those handling livestock, have been paid on a piecework basis, where employee pay is based on the numbers of animals processed. It has been reported that such programmes may encourage rough handling due to speed being rewarded (Grandin, 2003).

Stockmen were found to be significantly more likely to agree with the statement '*I feel that in the slaughter industry 'Production is everything''* and significantly more likely to agree that they 'get frustrated when working with animals'. The modern meat industry has been described as one that 'thrives on the mass, speed and efficiency of the production line...workers are under pressure to slaughter a great number of animals in the least amount of time possible' (Hendrix & Dollar, 2017). This feeling of time pressure may increase the likelihood of negative attitudes towards handling animals, and potentially influence the use of negative interactions (Coleman et al., 2003). However, in this study, just over a quarter of participants agreed, or strongly agreed that; *'Time constraints mean that stock handlers do not have time to correctly handle livestock'*, and none of the variables (age, gender, time in the industry), when entered into the model to examine correlations, significantly influenced the responses. Workers' levels of stress and frustration do have a negative impact on animals. If the behaviour of the personnel handling them is adversely affected, altered handling 'quality and care' can ultimately affect the level of production and meat quality (Porcher, 2011). Therefore, the identification of causes of stockperson frustration do appear to warrant further investigation.

2.4.6 Gender

Aligning with previous work, our study found that males had less positive views towards animal welfare when compared to females with regard to a number of the questionnaire statements. Porcher et al. (2004) suggested that males are more affected by emotional distancing when compared to females. In a paper on the emotionography of a slaughterhouse, McLoughlin (2018) described how the ideal slaughter worker echoes the ideals of 'hegemonic masculinity' (Donaldson, 1993) meaning that emotions are commonly denied, diminished or repressed. In this study sample, less than a third of the respondents were female, with only one female stockperson. This low proportion of women may be explained by general female attitudes towards animal killing. A study of stockpeople working on a pig farm reported that females were 'reluctant' to kill pigs (Porcher, 2008), while female vets working in small animal practice have been shown to be more likely to disagree with convenience euthanasia (Hartnack et al., 2016). Although females may be more averse to killing animals, stockwomen reportedly have a higher proportion of positive behaviours towards animals in their care (Lensink et al., 2000). To the author's knowledge, no equivalent studies assessing the difference in handling 'care' between male and female stockpeople, has been undertaken in a slaughter facility.

2.4.7 Methodological considerations

This study aimed to investigate the influence of training and personal factors by using questionnaires to assess responses to statements exploring attitudes towards animal welfare, and attitudes towards working within the slaughter industry. It may be useful to consider that some statements were not significantly affected by any of the factors included in the questionnaire. For example, response to the statements '*Animals feel pain just like humans do'* and '*I am willing to spend more money on welfare friendly food products'* were not influenced by any of the experience or role variables.

Quantitative Likert items were chosen over qualitative survey type questions as completing open-ended response options requires a greater amount of time and mental effort than most close-ended questions (Dillman, 2007). Time available to fill out the questionnaires prior to the onset of the training commencing was limited.

To address the aims of this study in evaluating the impact that previous AWO/PWO training has on attitudes, part two of the questionnaire required participants to answer whether or not they had previously attended a University of Bristol AWO/PWO course. It is possible that those who responded 'no' to this question may have had welfare training on other available, comparable courses which may have impacted their answers to the part one questions. Whether individual participants had attended an AWO, a PWO or both courses was not included in the statistical model, and thus the impact of individual courses on attitudes cannot be assessed. It is assumed, however, that for individuals working exclusively with red meat species that they would attend an AWO course, and those exclusively with poultry would attend a PWO course.

A limitation of this study was the potential for bias introduced by the recruitment methods. The respondents were drawn entirely from delegates who chose, or were supported by their employers, to attend an animal welfare training course. It is possible that these people were more interested than others in animal welfare, and/or are in a position to become qualified Animal/Poultry Welfare Officers (i.e. have sufficient authority and technical competence to provide relevant guidance to slaughter line personnel (EC, 2009)) therefore they may not be representative of the wider population of slaughter industry personnel. Some slaughter-plants require all staff handling live animals to attend AWO/PWO training, and this could act to slightly reduce this potential for bias. To further reduce the sample bias, future questionnaires could be distributed to all slaughter-plant staff, regardless of their attendance on a welfare training course. The distribution method used in this study was chosen to allow for ease of sampling and to encourage completion of the questionnaire.

Response bias also may have influenced results. It can be argued that animal welfare at slaughter is considered a sensitive subject for those in the industry and as such, respondents may have answered in ways that they believed to be 'appropriate' to a welfare discussion, rather than by expressing their true and deeply held opinions. In an attempt to combat such bias, all participants were made aware that all questionnaires would remain anonymous, and that their responses contained no respondent identifiable information. Anonymity reduces some bias, but does not remove it completely.

Likert-type items have been widely adopted throughout the social science community due to their simplicity, and for allowing respondents to provide an overall evaluation of a complex problem (Willits et al., 2016). They are also used to capture qualitatively, data that is difficult to measure or regarding a sensitive subject (Chimi & Russell, 2009). Their use however, has been associated with some controversy in the literature; Peabody (1962) postulates that Likert items primarily capture direction (positive or negative) and to a much lesser degree of intensity (level of agreement or disagreement); Chimi and Russell (2009) accused Likert items of forcing responses into a limited number of categories and not covering the extremes of responses. Chimi and Russell also comment on the ambiguity associated with the middle response category and suggest that the respondent may not be neutral on the matter, rather simply does not care about or lacks sufficient knowledge on the subject of the study.

A Likert item can be positively or negatively worded and both types of question were included in this study. There are biases associated with the processing of both positive and negative information (Alexandrov, 2010). Positivity bias is a cognitive process referring to humans' readiness to generate positive content as an a priori hypothesis about reality (Markus & Zajonc, 1985; Peeters, 1971; Peeters & Czapinski, 1990). On the other hand, negative bias can be summarised in a number of ways; negative evaluations can be stronger than the equivalent positive evaluations; combination of positive and negative stimuli results in a more negative result than the algebraic sum; negative events lead to more complex cognitive processes (Rozin & Royzman, 2001). Likert items also have a problem with acquiescence bias which is a tendency to agree with statements, to some extent irrespective of their content (Schuman & Presser, 1981). Similarly, the nature of Likert items is that they are clear and potentially persuasive assertions and can lead respondents to respond in a certain way and there is evidence that the leading nature of Likert items can impact on questionnaire results (Johns, 2010).

2.4.8 Paired questionnaires

The lack of significant differences between questionnaire responses pre and post AWO training suggests that attending an AWO course does not immediately affect attitudes of slaughter industry personnel towards their work or animal welfare. It should also be considered that participants were required to fill out two identical sets of questions within a relatively short timescale and as such may have completed questions based on memory.

There was a significant difference in pre and post-training responses to Question 8, "*Time constraints mean that stock handlers do not have time to correctly handle livestock.*", with participants scoring higher on the Likert Scale (towards agree/strongly agree) post-training compared to pre-training. A possible explanation for this is that the AWO course aims to teach 'gold standard' animal handling procedures and discourages the use of certain techniques often used to move animals quickly e.g. electric goads.

Due to time constraints within course delivery, the paired questionnaire study design was only implemented during one AWO course run specifically for the project. As such the sample size was small (n=14) therefore, results should be taken as an indication of the immediate effects of training on personnel attitudes.

2.5 Conclusions

Knowledge of the factors influencing the attitudes of slaughterhouse staff may allow those persons delivering welfare training within the EU to tailor the information and training material to certain demographics (such as those working with certain species and with different experience in the industry), and for recruiters to roles in slaughterhouses to recognise that specific challenges may be faced by individuals.

The results of this study suggest that the majority of views held by slaughter industry personnel attending animal AWO/PWO training courses are positive. Gender and factors of employment, including previous AWO/PWO experience does impact responses to some questions designed to assess an individual's attitude however these were not always consistent. Therefore, from these results, it is not clear whether any changes to animal welfare measures at slaughter as a result of

AWO/PWO training (which will be explored in subsequent chapters) is due to attitude change of staff, other factors of employment (experience, species etc.) or as a result of knowledge transfer.

Chapter 3. The effects of animal welfare training on cattle welfare and carcass bruising in three commercial slaughter-plants.

3.1 Introduction

Previous work has suggested that knowledge transfer can influence human attitudes towards animals (Boivin et al., 2003; Waiblinger et al., 2006). Although the results from Chapter 2 suggest that AWO/PWO training has limited influence upon any immediate change in the attitudes of slaughter industry personnel, 96% of respondents agreed that slaughter industry staff should receive welfare training.

Studies using animal-based welfare measures have suggested that knowledge transfer, through the training of slaughterhouse staff, can objectively improve cattle welfare at slaughter (Gallo et al., 2003; Grandin, 1998b). However, these previous studies have used a relatively small number of welfare outcome measures. Using a wider range of objective, animal-based measures will allow for a more detailed understanding of the impact that a slaughter-plant's pre-slaughter procedure has on animal welfare and product quality.

Knowledge of how these procedures are affected by staff welfare training may allow for the further development of welfare education and promote the uptake of welfare training throughout the slaughter industry.

The aim of this chapter is to assess the effects of welfare training on cattle welfare and carcass bruising in commercial slaughter facilities using some objective animal-based measures.

3.2 Development of Methods

3.2.1 Development of welfare assessment

Currently, no universally accepted measurement protocol for cattle welfare at slaughter has been devised. In order to analyse the effects of welfare improvement measures (such as training) a simple, practical and encompassing welfare protocol should be utilised (Wigham et al., 2018). Numerous assessment protocols have been published in the literature and each has associated strengths and weaknesses. It is likely that to produce an ideal welfare assessment system, the particulars of individual slaughterhouses should be taken into consideration (Wigham et al., 2018).

To meet the objective of this study, a welfare assessment protocol, with the aim of evaluating cattle welfare during each stage of the pre-slaughter process, including stunning and slaughter was developed, bruising was included as a measure of both welfare and product quality. A combined approach, using review and summarisation of the scientific literature, expert opinion elicitation and scoping visits to the processing plants involved in the study, was used to select appropriate welfare outcome measures. Outcome measures were included in the protocol if they met the following criteria:

- Sensitive to welfare change as a result of training (e.g. measures of welfare during unloading were not included as, in all study slaughterhouses, this process was carried out by hauliers, who were not included in the training programme).
- Validity: There is evidence in the literature that they are an appropriate measure of animal welfare in slaughterhouses (see section 3.2.1.1).
- Allow the protocol to be completed in one day by an individual observer.
- Enabled the safe observation of processes without causing disruption to the animals or slaughterhouse activities including throughput.

3.2.1.1 Literature Review of measures to be included in the welfare assessment protocol

The measures for use in cattle slaughterhouses and the location in the slaughterhouse of data collection is displayed in Table 3.1. The rationale for their selection is presented in the subsequent sections.

Table 3.1 Welfare assessment measures to be used in cattle slaughterhouses and the location of the observations.

Measures to be included in the assessment protocol	Location of data collection
Mounting	Lairage pens
Butting (mock fighting)	Lairage pens
Slipping	Lairage pens, Raceways, Stun box
Banging into structures	Lairage pens, Raceways, Stun box
Falling	Raceways
Running	Raceways
Turning Around	Raceways
Jumping	Raceways
Moving backwards	Raceways
Noise	Raceways
Tactile Interactions (hand, object, goad)	Raceways, Stun box
Struggling	Stun box
Cattle movement into stun box	Stun box
Time taken to enter stun box	Stun box
Time spent in the stun box	Stun box
Multiple shots	Stun box, Bleed area
Stun-stick interval	Bleed area
Return of rhythmic breathing	Bleed area
Lack of fixed glazed expression	Bleed area
Carcass bruising	Post hide removal

3.2.1.1.a Lairage Pens

Once animals arrive at the slaughterhouse and are unloaded from transport lorries, they are placed in pens within a lairage prior to being moved to the point of slaughter.

3.2.1.1.a.i Agnostic Behaviour

Mounting and mock fighting are the most common forms of agnostic behaviour between cattle, and are increased when groups of unfamiliar animals are mixed (Kenny & Tarrant, 1987). Agnostic interactions can lead to high levels of stress and thus increased levels of dark cutting (Bouissou, 1981; Grandin, 1978) and bruising (Kenny & Tarrant, 1987).

3.2.1.1.a.ii Interaction with environment

Slipping, where an animal temporally loses its footing, can cause cattle to become agitated (Grandin, 1998c). Slipping is indicative of slippery flooring on which animals' risk more serious falls and injury. Cattle also risk pain, injury and bruising from bumping into objects in the lairage pens, raceways and stunning box (Hoffman & Lühl, 2012).

3.2.1.1.b Raceways

To allow the effective stunning and slaughter of cattle in commercial processing plants, groups of animals are required to be processed into single file raceways. Entering and moving through raceways can be associated with several welfare risks arising both from the environment and human-animal interaction (HAI).

3.2.1.1.b.i Interaction with environment

Falling can cause an animal to become highly agitated (Grandin, 2012) and may result in injury. Injury may also result from animals attempting to jump from the raceway. Grandin (1999) reports that when cattle are in an enclosed space, such as a raceway, jumping may be caused by the animals panicking when their flight zone is deeply penetrated by a stockperson, or as a result of being left alone in a pen or raceway. Jumping, therefore, is a clear indicator of impaired welfare. Whilst walking though the raceway, animals may attempt to move away from fear inducing stimuli (such as humans, sounds or light reflections) by walking backwards (Grandin, 1996). Bourguet et al. (2011) found that animals that moved backwards were often involved in compression (due to the presence of other animals or barriers) leading to a slower decline of post-mortem carcass pH explained by a mechanical effect of the compression on muscle functioning. As such, the backwards movement of animals should be avoided, both from a welfare and meat quality perspective.

3.2.1.1.b.ii Human-Animal Interaction

In all slaughterhouses involved in this study, a single stockperson was responsible for moving the cattle into, and along the raceway to the entry of the stun box. Whilst in the single-animal raceway the same stockperson was required to check the ear-tag of each animal for traceability purposes. The interactions between this stockperson and the animal has the potential to influence welfare and product quality (Gregory, 2007).

Sounds produced by humans may be stressful for livestock (Brouček, 2014). It has been reported that noise produced by humans shouting and slamming of metal gates can increase both activity and heart rate in cattle, as such, reducing their incidence should help reduce the level of fear cattle experience during handling (Waynert et al., 1999).

Previous studies have shown that increased tactile interactions between handlers and animals, either using a hand or an object, is associated with fear or stress in cattle (Breuer et al., 2000; Hemsworth et al., 2011) and can adversely affect carcass and meat quality (Warriss, 1990).

Electric goad use is especially stressful for cattle and has a direct negative impact on meat qualities such as increased toughness and reduced consumer acceptability (Warner et al., 2007).

3.2.1.1.c Use of animal welfare scores

As some behaviours are likely to be more indicative of poor welfare, a weighted scoring system may be beneficial in producing an overall welfare score which more closely reflects the impact on the animal (Wigham et al., 2018). In an attempt to measure the overall welfare of animals moving through the raceway each individual measure was allocated an 'animal welfare score' (AW score) based on those used by Hultgren et al. (2014) in their work assessing cattle welfare and operator actions in Swedish slaughter-plants. The choice of AW score used by Hultgren was based on the opinions of experts in cattle slaughter and welfare assessment; a score of 1 was a weak sign of impaired welfare while a score of 3 was a strong sign of impaired welfare. The counts for each behaviour or human-animal interaction are then multiplied by the allocated animal welfare score producing the overall welfare score for each animal, with higher values indicating more negative animal welfare.

3.2.1.1.d Stunning

Moving animals from the raceway into the stun box can be a problem in commercial slaughter-plants, and is associated with an increase in goad use (Bourguet et al., 2011; Jones, 2011). Grandin (1996) reported that factors which impede animal movement in slaughter-plants can lead to stress and bruising, and listed lack of employee training or poor supervision as an important variable leading to such impediment. During the scoping visits to the plants involved in this study, the author commonly observed animals hesitating or balking as they moved into the stun box.

In order to optimise welfare and efficiency of the slaughter process animals should be moved calmly and effectively into the stun box without the use of an electric goad.

Containment in a stun box is stressful (Bourguet et al., 2011; Cockram & Corley, 1991) and thus the time an animal spends in this form of restraint should be reduced. Struggling in the stun box is a sign of distress (Grandin, 1998a). The stun boxes in all the plants assessed in this study were enclosed, and therefore individual behaviours of the animal could not be observed, however due to the metal stun boxes, struggling was defined by the sound of the animal moving side-to-side, kicking, and slipping for a duration of greater than 2 seconds.

Mis-stunning can expose an animal to unacceptable pain (Fries et al., 2012) and can be attributable to a number of factors including poor facilities, worn-out or poor design of the gun, inappropriate storage or inadequate filling of the cartridges or the inexperience of the operator. (Grandin, 1998c, 2002; Gregory et al., 2007; Grist et al., 2019). Mis-stunning should be identified by the operator and the animal re-shot.

3.2.1.1.e Bleeding

The normal slaughter practice for cattle is that once an animal has been stunned, the major blood vessels near the heart are severed (thoracic stick). The time between stunning and sticking is important for the welfare of the animal as, if the stunning process failed to produce adequate brain tissue damage, it is possible for cattle to regain consciousness (Atkinson & Algers, 2007; Wotton et al., 2000).

There are numerous animal-based measures that can be used to assess if an animal is at risk of regaining consciousness (Atkinson et al., 2013) and ideally more than one sign should be considered (Gouveia et al., 2009). However, due the position of the bleed rails, measures were chosen that were easy to identify at a distance; rhythmic breathing is one of the most common signs indicative of ineffective stunning (Gouveia et al., 2009). In addition, the lack of a fixed-glazed expression upon exiting the stun-box (i.e. presence of eyes rolled, blinking or nystagmus) indicates a high risk of recovery. Animals showing these signs of recovery should be re-shot immediately (Atkinson et al., 2013).

Cattle at plant C3 were slaughtered according to halal specification, which in this case consisted of a neck cut followed by stunning. Due to the positioning of the bleed area it was not possible to view the animals once they exited the stun box. Therefore, assessment of welfare at bleeding was not carried out in plant C3.

3.2.1.1.f Bruising

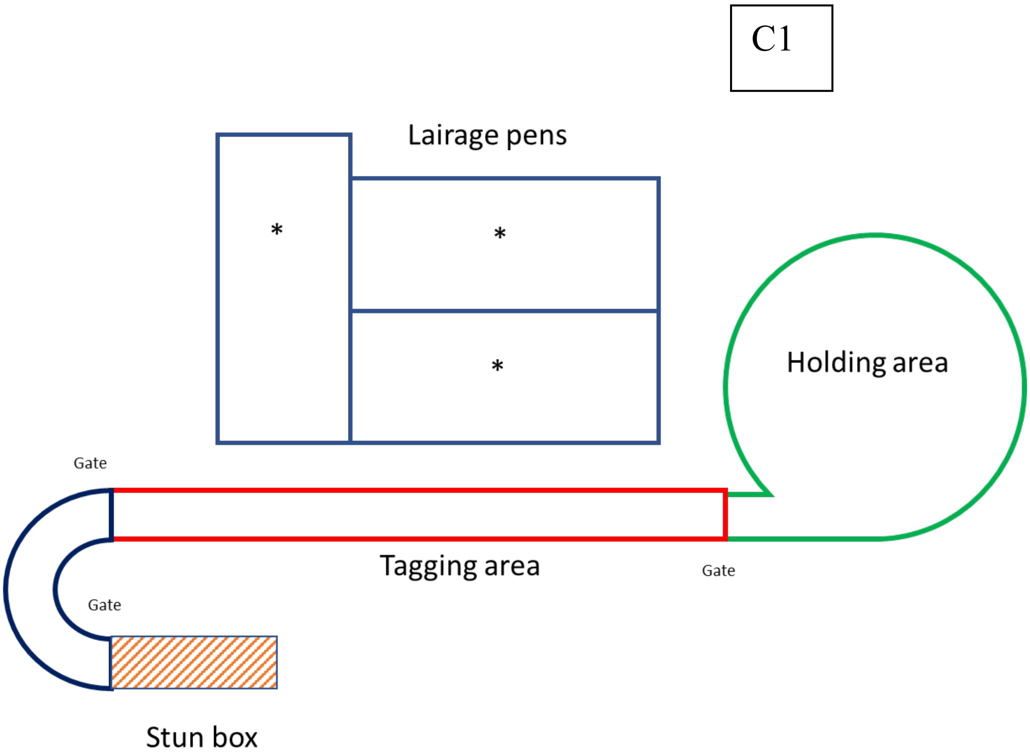
Bruising of a carcass appears as a distinct discolouration observable after hide removal. A bruise is caused by vascular rupture, leading to blood accumulation in the muscle and other tissues as a result of impact from an animal's environment, a conspecific or due to human-animal interactions (Costa et al., 2006). Strappini et al. (2013) concluded that it was the human-animal interactions at the slaughterhouse, especially during unloading and at stunning which causes the greatest potential for traumatic events. The rough handling of animals, and the use of driving instruments (prods, sticks, whips) pre-slaughter, is positively correlated with levels of bruising (Huertas et al., 2010; Jarvis et al., 1995). Although colour can be used to estimate the age of a bruise (Gracey & Collins, 1992), it is not possible to determine exactly when the damage occurred, and it should be noted that bruising can occur post stun, for example, during roll out from the stun box (blood pressure is maintained prior to the thoracic stick). Providing the animal has been adequately stunned and is insensible to pain, bruising occurring post stun is not a welfare concern.

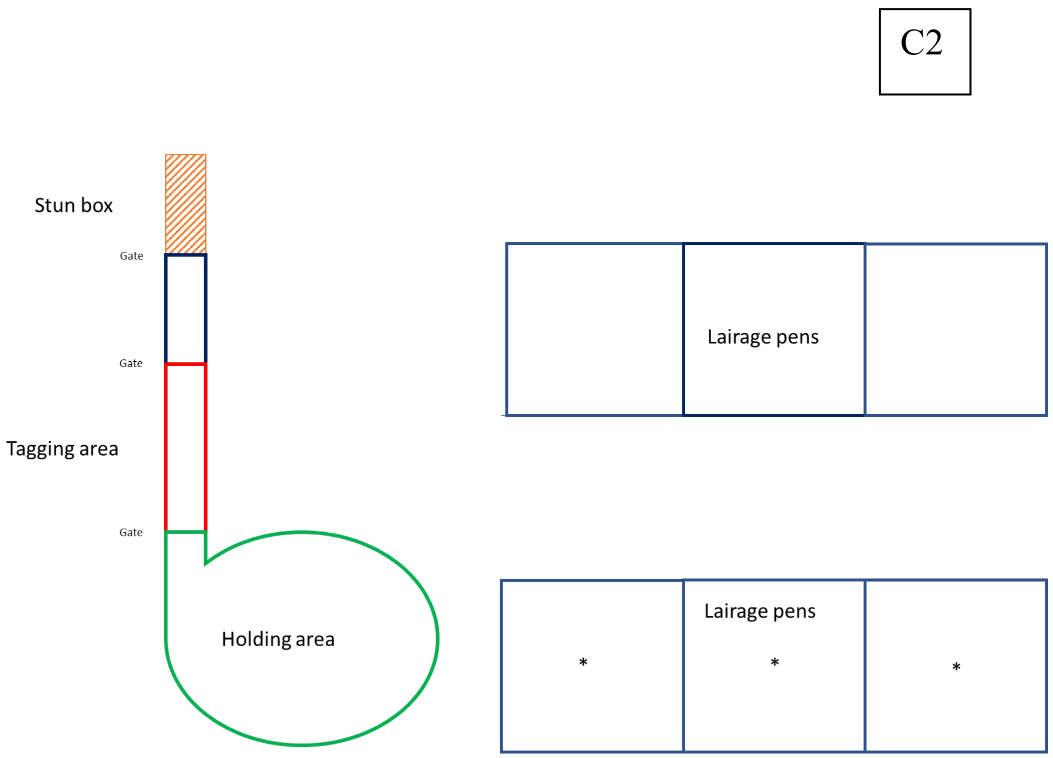
3.3 Methods

3.3.1 Recruitment of slaughterhouses

Three commercial cattle processing plants were recruited for the study based on: willingness to participate; use of captive bolt stunning method; and having a daily throughput higher than 200 animals. Their individual characteristics can be found in Table 3.2. All plants operated one shift per day.

A schematic diagram of the lairage of each slaughterhouse in shown Figure 3.1 (not to scale).


C1
Lairage pens
*
*
*
Holding area
Gate
Tagging area
Gate
Gate
Stun box


C2
Stun box
Gate
Gate
Tagging area
Gate
Holding area
Lairage pens
Lairage pens
*
*
*

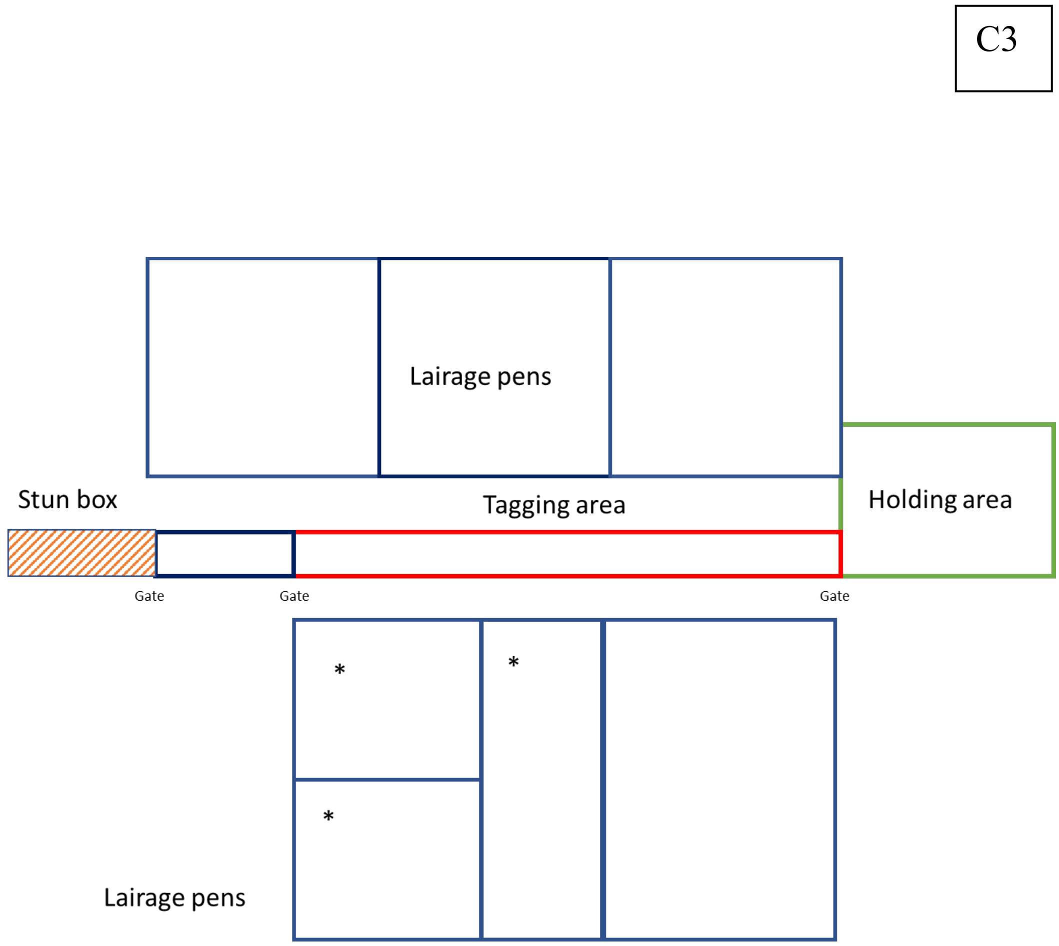


Figure 3.1 Schematic diagram of the lairage of each study plant (not to scale).

Table 3.2 Descriptions of cattle plants involved in the study.

Plant	**C1**	**C2**	**C3**
Location	South Western England	Central Scotland	Northern Spain
Processing speed (cattle per day)	230-320	280-350	180-280
Processing times	0600-1530	0700-1630	1100-2000
Cattle type	Clean cattle, cull cows, stock bulls	Clean cattle, cull cows.	Young cattle, clean cattle, cull cows, stock bulls
Maximum transport time (h)	3	4.5	3
Stunning method	Captive bolt	Captive bolt	Captive bolt – 15s post neck cut
Certified Halal	No	No	Yes

3.3.2 Welfare assessment timeline

The study took place between August 2017 and January 2019.
Each slaughterhouse was visited three separate times:

- pre-T – one-week prior to training.
- post-T – one-week post-training.
- 6mpost-T – six (plant C2 and C3)/fourteen (plant C1) months after training. Due to the installation of a new stun box, 6mpost-T visit to plant C1 had to be delayed.

Visits to C1 and C2 lasted five days, whilst visits to C3 lasted four days (due the plant only operating 4 days per week). The assessment protocol was repeated each day of the visits (Figure 3.2). The assessments were carried out at the same time of day during each visit (commencing one hour after the start of the days production) and undertaken by the same observer (EW).

Plant management were aware that the assessments were taking place. Although operatives were not specifically told that welfare assessments were being undertaken, they were aware that they were being observed.

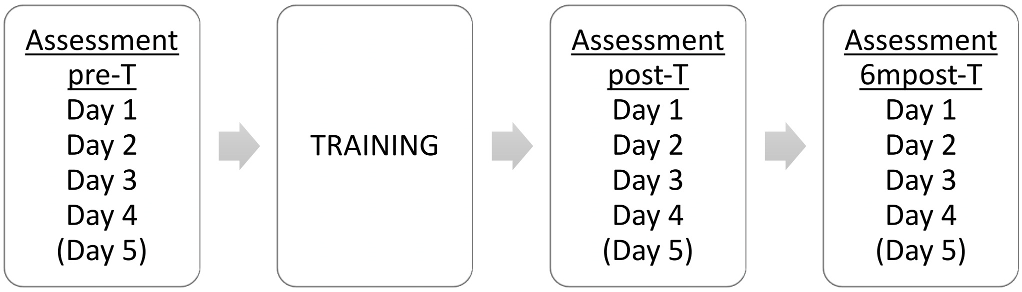


Figure 3.2 Outline of study.

The full protocol and recording sheets can be found in Appendix 2.

3.3.3 Training

Training of plant staff was undertaken after the pre-T visit was complete.

All primary processing plants received the same training programme (except for legislative information which were country specific). The training was based on the Animal Welfare Officer (AWO) Training Course run by the University of Bristol. Training was delivered by an experienced trainer from AWO Training Langford (University of Bristol). The training was designed to deliver continued professional development to the meat industry and provides individuals with the technical competence to achieve Animal Welfare Officer (AWO) status in red meat slaughter-plants.

Senior plant staff (managers, supervisors, corporate staff) attended a full two-day comprehensive AWO training course. Courses were tailored to include local legislations and operating procedures. The training sessions consisted of lectures interspersed with group discussions and quizzes. Participants were assessed on their knowledge throughout the course by answering multiple choice questions using TurningPoint Technology. A full list of topics covered in the course are outlined in Appendix 3. A total of 11 management personnel attended the training from plant C1, 14 from plant C2 and 6 from plant C3.

All slaughter-plant operatives handling live animals received 'on-the-job' training. These 20-minute sessions delivered practical information on 'better practice' in cattle movement, stunning and bleeding. All operatives handling live animals who were employed by the plants at the time of the study received training. Training for operatives was conducted during normal working shifts. Training was delivered by senior, experienced members of Langford Welfare Training, University of Bristol.

3.3.4 Welfare assessment protocol

3.3.4.1 Lairage Pens

Three lairage pens were chosen for observations (identified by * in Figure 3.1), each allowing unrestricted views of the cattle. Following a two-minute acclimatisation period, pens were observed individually for ten minutes using continuous observation. The number of occurrences of each behaviour outlined in Table 3.3 was recorded per pen of animals within each ten-minute observation period. The number of animals in each pen was also noted. The length of time that the animals had been present in the lairage was not recorded as animal arrival time was not documented on the pens in any of the plants, and it was not always possible to locate the lairage supervisor to attain the information.

Table 3.3 Ethogram of behaviours observed in lairage pens.

Behaviour	Description
Mounting	One animal mounts or attempts to mount another
Butting	One animal uses its forehead or horns to direct a blow at another
Slipping	Slips and loses balance temporarily, interfering with normal walking (María et al., 2004)
Banging into structure	A part of the animals' body contacts an environmental object with enough force to make an audible sound

3.3.4.2 Raceways

3.3.4.2.a Entering raceway

In each plant, animals were moved from the lairage into a holding area (outlined in green in Figure 3.1) from which they entered the raceway in single file. In plant C1 and C2 the holding area was a circular pen with a rotating gate. In plant C3 the holding area was a square pen.

During each day of observation, 50 animals were observed being moved from the holding area into the raceway. Animals, and the operator handling them, were observed simultaneously using continuous observations. Observations began when the gate into the raceway was opened and stopped when the gate was closed.
For each animal the number of occurrences of each behaviour and human-animal interaction (HAI) with the operator outlined in Table 3.4 was recorded.

Table 3.4 Ethogram of behaviours and HAI observed when animals entered the raceway and at the tagging area.

Behaviour	**Description**
Slipping	Slips and loses balance temporarily, interfering with normal walking
Falling	A part of the animal's body, other than the hooves, touches the floor. (Grandin, 1998c)
Banging into structure	A part of the animals' body contacts an environmental object with enough force to make an audible sound.
Human-Animal Interaction	**Description**
Sound	Operator makes noise: shouting, clapping, shakes rattle, hits a wall. (Soft speech and whistling were not scored)
Hand gentle	Operator touches animal with hand, no sound is generated by the impact
Hand Hard	Operator touches animal with hand, sound is generated by the impact
Object Gentle	Operator touches animal with object, no sound is generated by the impact
Object Hard	Operator touches animal with object, sound is generated by the impact
Goad	Use of an electric goad

3.3.4.2.b Tagging area

The raceway design and length varied between the plants. In all plants the raceway floor was solid or slatted concrete, the walls were solid, plant C1 had metal bars on top of the raceway to prevent animals jumping out. As animals are moved towards the stun box, their ear-tag number is read by an operative and either manually entered in a computer terminal (C1, C3) or manually associated with a passport (C2). This process occurs between two gates in the raceway and was labelled 'tagging area' (Figure 3.1). The maximum capacity of the tagging area for all plants was 5 animals.

Each observation day, 50 animals were observed moving through the tagging area. Animals and the operator handling them were observed simultaneously using continuous observations. Observations began when an animal passed through the gate into the tagging area and stopped when the animals passed through the gate exiting the tagging area.

For each animal the number of occurrences of each behaviour and human-animal interaction (HAI) with the operator outlined in Table 3.4 in addition to those in Table 3.5 were recorded.

Table 3.5 Ethogram of behaviours observed in the tagging area.

Behaviour	**Description**
Running	The animal runs
Turning Around	Turns, or makes a clear attempt to turn around by itself
Jumping	Animal jumps
Move Backwards	Moves backwards at least two steps

3.3.4.3 Stunning

The stun box design varied between the plants. Plant C1 had a new stun box installed between post-T and 6mpost-T. Plants C2 and C3 and the new box in plant C1 had a hydraulic forcing gate to move the animals into place within the box and an adjustable head restraint. The old box in plant C1 did not have hydraulic system installed, except for the gates letting the animal in and out (Figure 3.3). In plant C1 and C3 the same operative was responsible for moving the animal into the box and for stunning the animal. In plant C2 separate operatives were responsible for moving and for stunning the animal.

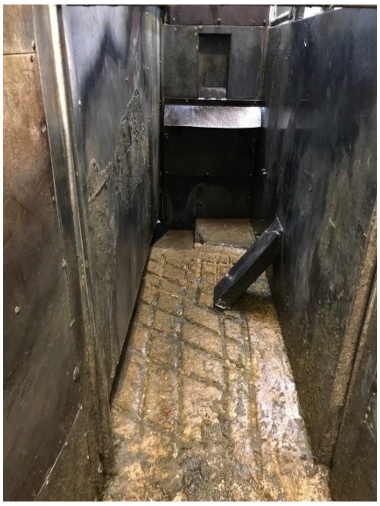


Figure 3.3 Picture of the stun box taken as an ‘animal-eye’ view from the entrance, in use during pre-T and post-T at plant C1.

A standard penetrating cartridge-powered captive bolt gun was used in all plants. In plant C3 to meet halal specifications, the stun was administered 15 seconds after the neck cut.

On each observation day, 50 animals were observed entering the stun box and being stunned. Whether the animal slipped, banged into a structure (including the gate), struggled in the stun box (defined as hearing the animal moving side-to-side, kicking, or slipping for a duration of greater than 2 seconds) was recorded.

Based on the scoring system used by Jones (2011), each animal was scored for ease of movement into the stun box and type of coercion used.

Movement score 0-3

- 0. Animal begins to move into stun box without the need for coercion.
- 1. Animal moves into the stun box once coercion is used.
- 2. Animal enters the stun box, then baulks and backs up.
- 3. Animal refuses to move – a lot of coercion required.

Coercion score 0-2

- 0. No coercion.
- 1. Use of hand or object.
- 2. Use of electric goad.

A stopwatch was used to measure the time taken to enter the stun box (defined as the time from stun box gate opens until the gate closed) and the time taken to stun/cut the animal (defined as the time between stun box gate closure and first shot fired/the start of the neck cut (plant C3). The incidence of multiple shots was recorded.

3.3.4.4 Bleeding

On each observation day, 50 cattle were observed in the bleeding area. In plant C1 one operator was responsible for shackling, hoisting and sticking the animal. In plant C2 one operator was responsible for shackling and hoisting and a separate operator was responsible for sticking. In both plants, animals were stuck once they had been hoisted, except for during 6mpost-T at plant C1, where due to the design of the new stun box, the animals were stuck prior to being hoisted.

For each animal the stun-stick time was recorded using a stopwatch and taken as the time from the first shot administered in the stun box, until the thoracic stick was performed. Each animal was continuously observed for the return of rhythmic breathing and the lack of a fixed glazed expression from entering the bleed area, until one-minute post thoracic stick. Whether a second shot was administered was also recorded.

3.3.4.5 Bruising

After the hide removal process, and prior to trimming and final inspection, twenty – five carcases were assessed for the presence of bruising and scored using the system described by Lee et al. (2017). The scoring system allowed for all carcass bruises to be recorded along with their location and the size category in which they fall. Location was determined by marking on the recording sheet the approximate site of the bruise on the carcass (Figure 3.4). Size of the bruises was categorised as small (< 5 cm in diameter), medium (5 to 15 cm in diameter), or large (> 15 cm in diameter). Severity of the bruise was not addressed as it was not feasible to assess the density and vascularity of the affected tissues in the commercial slaughter facilities visited. In an effort to record bruising which may have occurred at the slaughter-plant, only bright red bruises were scored. Gracey and Collins (1992) described that the age of the bruise can be estimated from its colour appearance in bovine carcasses; a bright red bruise is likely to be up to 10 hours old, whereas a dark red bruise is approximately 24 hours old.

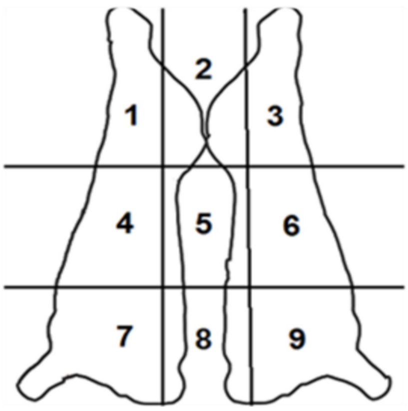


Figure 3.4 Grid used to record carcass bruise location.

3.3.5 Statistical analysis

The data from each processing plant was analysed separately. SPSS, version 24.0 (2018) was used to perform Chi-Square tests, Spearman's rank-order correlation and Kruskal Wallis tests. MLwiN (Charlton et al., 2019) was used for all regression models. In all regression models the pre-training Visit (pre-T) was used as the reference category. Graphs were plotted using GraphPad Prism 7. Results were deemed significant at $p \leq 0.05$ level.

3.3.5.1 Lairage

Each behaviour was analysed separately using negative binomial regression, assessing the effect of visit and number of animals in the pen on the risk of displaying each behaviour. The day of observation was not included in the models due to the small number of pens observed each day.

3.3.5.2 Raceways

For each animal, behaviours and HAI when entering the raceway and whilst in the tagging area was analysed separately. The counts of all animal behaviours were multiplied by the respective AW ratings and added together resulting in a weighted count sum denoted BEHSCORE, based on behaviours with higher values indicating a more negative AW. A corresponding AW score was calculated from all the counts of all recorded HAI denoted HAISCORE.

A preliminary analysis was carried out where each animal was categorised for each behaviour, HAI and overall scores according to the number of occurrences of each behaviour/HAI/BEHSCORE/HAISCORE (0, 1, 2, 3-5, >5). A cross-tabulation was produced where the number of animals in each occurrence category was broken down by visit. Each table was tested for an association between counts in each occurrence category and visit by means of an exact Chi-square test. Due to the large number of tests, and to focus on the aim of the study in assessing the effects of training, it was decided to only test two pairs of visits in each table; pre-T – post-T and pre-T - 6mpost-T.

Subsequently a two-level negative binominal logistic regression was set up in order to predict the effect of visit (the independent variable) on BEHSCORE and

HAISCORE both whilst entering the raceway and within the tagging area. A multilevel model was chosen to account for and to allow the assessment of the variation associated with different days of observation. Individual cattle are nested within days therefore an individual animals score was level 1. The day of observation represented level 2 and was treated as random effects. The estimation procedure applied was the restricted iterative generalised least-squares method 2nd order MQL (Marginal Quasi-likelihood) (Goldstein, 2003) which lead to unbiased estimates of the random parameters. The p-values were based on Wald's test (two-sided).

The models were then used to calculate the incidence rate ratio (IRR) to explore the effect of visit on changes in BEHSCORE and HAISCORE. The IRR represents the change in the dependent variable in terms of a percentage increase or decrease, the precise percentage determined by the amount the IRR is either above or below 1.

The relationship between BEHSCORE and HAISCORE was tested using Spearman's rank-order correlation.

3.3.5.3 <u>Stun box</u>

3.3.5.3.a Behaviours entering and in the stun box

A preliminary analysis was carried out. Animals were categorised for each behaviour according to the number of occurrences of each behaviour (0, 1, 2, 3, >3). A cross-tabulation was produced, where the number of animals in each occurrence category was broken down by visit. Each table was tested for an association between counts in each occurrence category and visit by means of an exact Chi-square test. Due to the large number of tests, and to focus on the aim of the study in assessing the effects of training, it was decided to only test two pairs of visits in each table: pre-T – post-T and pre-T - 6mpost-T.

Subsequently a two-level negative binominal logistic regression model was set up according to the procedure outlined previously. The model was used to calculate the IRR for change in occurrence of each behaviour.

3.3.5.3.b Time taken to enter stun box and time taken to first shot/neck cut.

Multilevel linear models were fitted to the data. An individual animal's score (time to enter the stun box/time for first shot/neck cut) was taken as level 1. The day of observation represented level 2 and was treated as random effects. The estimation procedure applied was the restricted iterative generalised least-squares method 2nd order MQL. Residuals were tested for linearity, homogeneity of variance and normality.

3.3.5.3.c Movement and Coercion score

Multilevel multinomial logistic regression models were used to investigate the risks of an animal being scored in different movement and coercion score according to visit. An individual animal's score (movement/coercion score category) was taken as level 1. The day of observation represented level 2 and was treated as random effects. The estimation procedure applied was a restricted iterative generalised least-squares method 2nd order PQL. Both movement and coercion score 0 was used as the reference category.

3.3.5.3.d Goad Use

The effect of 'visit' on the time taken for cattle who were coerced with an electric goad to enter the stun box was investigated using Kruskal Wallis test. Subsequent pairwise comparisons were performed using Dunn (1964) procedure with a Bonferroni correction for multiple comparisons.

3.3.5.4 Bleeding

Multilevel linear models were fitted to stun-stick interval data. An individual animal's score (stun-stick interval) was taken as level 1. The day of observation represented level 2 and was treated as random effects. The estimation procedure applied was the restricted iterative generalised least-squares method 2nd order MQL. Residuals were tested for linearity, homogeneity of variance and normality.

The effect of visit on the proportion of stunned cattle exhibiting signs of recovery on the bleed line was investigated using exact Chi-square test.

3.3.5.5 Bruising

The effect of visit on bruise size, number and location was tested using an exact Chi-square test.

Individual carcasses were given a score based on the number and size of the bruise. Small bruises (<5cm) were given a score of 1, medium bruises (5-15cm) a score of 2 and large bruises (>15cm) a score of 3. The counts of all bruises were multiplied by the respective score and added together resulting in a weighted count sum denoted BRUISETOTAL.

A negative binomial regression model was fitted to BRUISETOTAL scores. An individual carcass's BRUISETOTAL was taken as level one. The day of observation represented level 2 and was treated as random effects.

3.4 Results

3.4.1 Lairage

Table 3.6 displays the total number of occurrences of each behaviour for each visit in each processing plant. The number of pens in which at least one animal was observed displaying the behaviour and the maximum number of times that behaviour was displayed in an individual pen is also shown. The minimum number of times a behaviour was displayed in an individual pen was 0 for all behaviours across all visits.

Table 3.6 Behaviours assessed in lairage pens.

Behaviour	Processing plant	Visit	Total Occurrences	Number of pens in which at least one occurrence was observed	Max occurrence per pen
Mount	C1	pre-T	5	4	2
		post-T	12	4	8
		6mpost-T	3	2	2
	C2	pre-T	4	3	2
		post-T	6	3	4
		6mpost-T	8	4	4
	C3	pre-T	11	3	9
		post-T	11	5	5
		6mpost-T	12	4	5
Butt	C1	pre-T	17	7	5
		post-T	23	7	6
		6mpost-T	14	4	8
	C2	pre-T	38	10	10
		post-T	23	8	6
		6mpost-T	14	4	5
	C3	pre-T	15	6	4
		post-T	12	3	8
		6mpost-T	18	7	10
Slipping	C1	pre-T	13	6	3
		post-T	10	7	3
		6mpost-T	3	2	2
	C2	pre-T	13	5	7
		post-T	17	7	5
		6mpost-T	4	3	2

	C3	pre-T	1	1	1
		post-T	5	1	5
		6mpost-T	4	4	1
Bang	C1	pre-T	8	6	2
		post-T	22	7	8
		6mpost-T	9	3	7
	C2	pre-T	20	8	4
		post-T	14	5	4
		6mpost-T	8	4	4
	C3	pre-T	2	2	1
		post-T	3	2	2
		6mpost-T	1	1	1

The results from the negative binomial regression models are show in Table 3.7, Table 3.8 and Table 3.9.

Models could not be fitted to 'slipping' and 'bang' data in plant C3 due to the small numbers of animals displaying this behaviour across all visits.

Table 3.7 Negative Binomial regression models of behaviours observed in the lairage pens of plant C1. Significant results (p≤ 0.05) are shown in bold font.

Predictor	**Level**	**Mount**			**Butt**			**Slipping**			**Bang**		
		Coef.	**SE**	***p***	**Coef.**	**SE**	***p***	**Coef.**	**SE**	***p***	**Coef.**	**SE**	***p***
Intercept		-3.98	1.31	0.002	-0.91	0.8	0.258	-1.69	0.756	0.025	-3.13	1.02	0.002
Visit	**pre-T**	(ref)			(ref)			(ref)			(ref)		
	post-T	0.23	0.73	0.75	0.03	0.066	0.54	-0.18	0.42	0.726	0.83	0.67	0.22
	6mpost-T	-1	0.95	0.29	-0.11	0.688	0.77	-1.36	0.72	0.059	-0.08	0.75	0.913
No. of animals in pen		**0.292**	**0.1**	**0.003**	0.1	0.07	0.143	**0.14**	**0.06**	**0.017**	**0.25**	**0.08**	**0.001**

Table 3.8 Negative Binomial regression models of behaviours observed in the lairage pens of plant C2. Significant results (p≤ 0.05) are shown in bold font.

Predictor	**Level**	**Mount**			**Butt**			**Slipping**			**Bang**		
		Coef.	**SE**	***p***	**Coef.**	**SE**	***p***	**Coef.**	**SE**	***p***	**Coef.**	**SE**	***p***
Intercept		-2.17	1.04	0.037	0.68	0.58	0.247	-0.26	0.79	0.74	0.45	0.62	0.471
Visit	**pre-T**	(ref)			(ref)			(ref)			(ref)		
	post-T	0.31	0.95	0.741	-0.5	0.52	0.329	0.3	0.66	0.655	-0.39	0.55	0.48
	6mpost-T	0.91	0.9	0.31	**-1.2**	**0.56**	**0.031**	-1.16	0.8	0.146	-0.92	0.6	0.124
No. of animals in pen		0.07	0.07	0.32	0.023	0.04	0.58	0.009	0.06	0.87	-0.01	0.05	0.77

Table 3.9 Negative Binomial regression models of behaviours observed in the lairage pens of plant C3. Significant results (p≤ 0.05) are shown in bold font.

Predictor	Level	Mount			Butt			Slipping			Bang		
		Coef.	**SE**	***p***	**Coef.**	**SE**	***p***	**Coef.**	**SE**	***p***	**Coef.**	**SE**	***p***
Intercept		-1.991	1.179	0.091	-0.108	0.926	0.907						
Visit	**pre-T**	(ref)			(ref)								
	post-T	-0.254	0.93	0.785	-0.19	0.79	0.81						
	6mpost-T	-0.21	0.97	0.827	0.31	-0.8	0.697						
No. of animals in pen		**0.235**	**0.096**	**0.014**	0.034	0.08	0.656						

Visit was not associated with a change in behaviour counts in any of the plants (when number of animals present in the pens was included and controlled for by the model). The only exception was 6mpost-T in plant C2 which was associated with a significant decrease (p=0.031) in the level of butting compared to pre-T. It should be noted the decrease in risk of slipping in plant C1 during 6mpost-T was approaching significance (p=0.059).

In C1 and C3, the risk of animals mounting each other was significantly increased with an increase in the number of animals present in the pen. In plant C1 an increase in the number of animals in the pen was also significantly associated with an increased risk of animals slipping and banging into structures.

3.4.2 Raceways

The preliminary analysis and results of the Chi-square test is shown for individual behavioural (Table 3.10) and HAI (Table 3.11) counts for animals entering the raceway and in the tagging area.

In all plants, post-training visits were associated with a significant decrease in the number of animals banging into structures whilst entering the raceway. The total number of behaviours observed when entering the raceway also significantly decreased in plant C1 and C3. The number of times sound was used significantly decreased between pre-training and post-training visits in all plants, except for during 6mpost-T in plant C1 where it increased by 12%. 6mpost-T in plant C1 was also associated with a significant increase of 3.2% in the incidence of ‘hand gentle’ and an overall increase in HAI. Except for 6mpost-T in plant C1 and post-T in plant C2, the total number of HAI events whilst entering the raceway decreased in all other post-training visits. There was no incidence of goad use when animals were moving into the raceways in any of the plants.

In the tagging area, post-training visits in plant C1 were associated with a significant decrease (to 0% of cattle during 6mpost-T) in the number of occurrences of running, and the number of times sound was used. However, there was a significant increase in the number of bangs, number of incidences of animals moving backwards and electric goad use. The total number of animals which displayed no recorded behaviours in the tagging area significantly increased (by 20.8% during post-T and 15.2% 6mpost-T), however the number of animals that displayed >5 recorded behaviours also significantly increased (by 11.6% post-T and 12.8% 6mpost-T).

In C2 the incidence of moving backwards and operators using ‘hand hard’ significantly decreased while the use of sound significantly increased after training. Plant C3 had the greatest number of significant changes in counts of post-training behaviours and HAI in the tagging area; there were significant decreases in the incidence of slipping, bangs, moving backwards, any behaviours, use of ‘hand gentle’, use of ‘hand hard’ and any HAI. There was a significant increase in object use, both ‘gentle’ and ‘hard’.

Table 3.10 Percentage of animals with different counts of recorded behaviours while entering the raceway and in the tagging area. (C1, C2 n=250 per visit, C3 n=200 per visit). Italic font highlights baseline measures. * represents a statistically significant difference in proportion from baseline (p ≤ 0.05) calculated using the exact Chi-squared test.

				Entering Raceway						Tagging area					
Behaviour	Processing plant	Visit	AW Score	0	1	2	3-5	>5	Max	0	1	2	3-5	>5	Max
Slipping	C1	pre-T	1	*95.6*	*4.4*	*0*	*0*	*0*	*1*	*94*	*4.4*	*1.2*	*0.4*	*0*	*3*
		post-T		98.4	1.6	0	0	0	1	95.2	3.6	1.2	0	0	2
		6mpost-T		98	2	0	0	0	1	94.8	4.8	0.4	0	0	2
	C2	pre-T		*93.2*	*6.4*	*0.4*	*0*	*0*	*2*	*93.2*	*6.4*	*0*	*0.4*	*0*	*3*
		post-T		90	10	0	0	0	1	91.2	6.4	2*	0.4	0	4
		6mpost-T		91.2	8.4	0.1	0	0	1	96.8	2.8	0.4	0	0	2
	C3	pre-T		*99*	*1*	*0*	*0*	*0*	*1*	*95.5*	*4.5*	*0*	*0*	*0*	*1*
		post-T		99.5	0.5	0	0	0	1	99.5*	0.5*	0	0	0	1
		6mpost-T		99.5	0.5	0	0	0	1	99*	1*	0	0	0	1
Falling	C1	pre-T	3	*100*	*0*	*0*	*0*	*0*	*0*	*99.6*	*0.4*	*0*	*0*	*0*	*1*
		post-T		100	0	0	0	0	0	99.2	0.8	0	0	0	1
		6mpost-T		100	0	0	0	0	0	98.4	1.6	0	0	0	1
	C2	pre-T		*98.4*	*1.6*	*0*	*0*	*0*	*1*	*100*	*0*	*0*	*0*	*0*	*0*

		post-T		98.8	1.2	0	0	0	1	98.8	0.8	0.4	0	0	1
		6mpost-T		99.6	0.4	0	0	0	1	98.4	1.6	0	0	0	1
	C3	pre-T		*100*	*0*	*0*	*0*	*0*	*0*	*99.5*	*0.5*	*0*	*0*	*0*	*1*
		post-T		100	0	0	0	0	0	100	0	0	0	0	0
		6mpost-T		100	0	0	0	0	0	100	0	0	0	0	0
Running	C1	pre-T	2	-						*97.6*	*2.4*	*0*	*0*	*0*	*1*
		post-T		-						98.8	0.8	0.4	0	0	2
		6mpost-T		-						100*	0*	0	0	0	0
	C2	pre-T		-						*99.2*	*0.8*	*0*	*0*	*0*	*0*
		post-T		-						100	0	0	0	0	0
		6mpost-T		-						100	0	0	0	0	0
	C3	pre-T		-						*99*	*0.5*	*0.5*	*0*	*0*	*2*
		post-T		-						100	0	0	0	0	0
		6mpost-T		-						100	0	0	0	0	0
Turning	C1	pre-T	2	-						*100*	*0*	*0*	*0*	*0*	*0*
Around		post-T		-						98.8	0.8	0.4	0	0	2
		6mpost-T		-						100	0	0	0	0	0

	C2	pre-T		-						*98.4*	*1.6*	*0*	*0*	*0*	*1*
		post-T		-						98.4	1.2	0.4	0	0	2
		6mpost-T		-						100	0	0	0	0	0
	C3	pre-T		-						*100*	*0*	*0*	*0*	*0*	*0*
		post-T		-						100	0	0	0	0	0
		6mpost-T		-						100	0	0	0	0	0
Jumping	C1	pre-T	2	-						*99.6*	*0*	*0.4*	*0*	*0*	*2*
		post-T		-						99.6	0.4	0	0	0	1
		6mpost-T		-						98.8	0.8	0	0.4	0	3
	C2	pre-T		-						*100*	*0*	*0*	*0*	*0*	*0*
		post-T		-						99.6	0	0	0	0	1
		6mpost-T		-						99.2	0.4	0	0	0	1
	C3	pre-T		-						*99.5*	*0.5*	*0*	*0*	*0*	*1*
		post-T		-						100	0	0	0	0	1
		6mpost-T		-						99.8	0.2	0	0	0	1
Bang	C1	pre-T	2	*92.4*	*7.6*	*0*	*0*	*0*	*1*	*80*	*10.8*	*4*	*5.2*	*0*	*5*
		post-T		96.4*	3.6*	0	0	0	1	70.8*	21.6*	4.4	3.2	0	5
		6mpost-T		97.6*	2.4*	0	0	0	1	73.6	19.2*	4.8	2.4*	0	4

	C2	pre-T		*90*	*10*	*0*	*0*	*0*	*1*	*84.4*	*9.6*	*3.6*	*2.4*	*0*	*5*
		post-T		97.6*	2.4*	0	0	0	1	80.4	15.2	3.2	0.8	0.4	6
		6mpost-T		95.6*	4.4*	0	0	0	1	88.8	9.6	1.2	0.4	0	3
	C3	pre-T		*87.5*	*12.5*	*0*	*0*	*0*	*1*	*73.5*	*18*	*6.5*	*2*	*0*	*4*
		post-T		97.5*	2.5*	0	0	0	1	84*	14	2*	0	0	2
		6mpost-T		98*	2*	0	0	0	1	86.5*	12.5	0.5*	0.5	0	3
Move Backwards	C1	pre-T	2	-						*58.4*	*26*	*11.2*	*4*	*0.4*	*7*
		post-T		-						35.2*	34.4*	14.8	15.2*	0.4	6
		6mpost-T		-						41.2*	28	14	16.8*	0	5
	C2	pre-T		-						*57.2*	*26.4*	*11.2*	*5.2*	*0*	*4*
		post-T		-						66.4*	20.8	8.4	3.6	0.8	6
		6mpost-T		-						57.6	29.6	9.6	3.2	0	4
	C3	pre-T		-						*34.5*	*42.5*	*14*	*9*	*0*	*5*
		post-T		-						36.5	36	23*	4.5	0	2
		6mpost-T		-						50*	31.5*	11.5	6.5	0.5	6
Any Behaviour	C1	pre-T		*88.8*	*3.6*	*6.8*	*0.8*	*0*	*3*	*52*	*0.4*	*18.8*	*16.4*	*12.4*	*24*
		post-T		95.6*	0.8*	2.8*	0.8	0	3	31.2*	0	26.4*	18.4	24*	26

	6mpost-T	95.6*	2	2.4*	0	0	2	36.8*	0.4	24	13.6	25.2*	20
C2	pre-T	*84.4*	*4.8*	*8*	*2.4*	*0.4*	*6*	*53.2*	*1.6*	*22*	*10.8*	*12.4*	*17*
	post-T	88	8.4	2*	1.6	0	4	57.2	1.2	20.4	10.8	10.4	26
	6mpost-T	86.8	8.4	4.4	0.4	0	4	54	0.4	25.6	14.8	5.2*	17
C3	pre-T	*87*	*0.5*	*12*	*0.5*	*0*	*3*	*26*	*1*	*34.5*	*22*	*16.5*	*18*
	post-T	97.5*	0	2*	0.5	0	3	32.5	0.5	32.5	24	10.5	8
	6mpost-T	97.5*	0.5	2*	0	0	2	44*	0.5	32.5	15	8*	18

Table 3.11 Percentage of animals with different counts of recorded HAI while entering the raceway and in the tagging area. (C1, C2 n=250 per visit, C3 n=200 per visit). Italic font highlights baseline measures. * represents a statistically significant difference in proportion from baseline (p ≤ 0.05) calculated using the exact Chi-squared test.

				Count entering Raceway						Count in tagging area					
HAI	Processing plant	Visit	AW Score	0	1	2	3-5	>5	Max	0	1	2	3-5	>5	Max
Sound	C1	pre-T	1	*60.4*	*39.6*	*0*	*0*	*0*	*1*	*69.9*	*23.2*	*5.6*	*1.6*	*0*	*4*
		post-T		77.2*	22.8*	0	0	0	1	61.2*	28.4	8	2.4	0	4
		6mpost-T		48.4*	51.6*	0	0	0	1	68.8	26.8	3.2	1.2	0	3
	C2	pre-T		*62.8*	*36.8*	*0.4*	*0*	*0*	*2*	*84*	*13.2*	*2*	*0.8*	*0*	*3*
		post-T		72.4*	27.6*	0	0	0	1	78.4	16.8	3.2	1.6	0	3
		6mpost-T		73.6*	26*	0.4	0	0	2	71.2*	25.2*	3.2	0.4	0	3
	C3	pre-T		*15*	*85*	*0*	*0*	*0*	*1*	*38.5*	*51.5*	*9.5*	*0.5*	*0*	*3*
		post-T		39.5*	60.5*	0	0	0	1	43	51.5	4.5	1	0	4
		6mpost-T		42*	58*	0	0	0	1	47	39.5*	12	1.5	0	3
Hand Gentle	C1	pre-T	1	*91.2*	*8.8*	*0*	*0*	*0*	*1*	*75.6*	*20.4*	*3.2*	*0.8*	*0*	*4*
		post-T		92	8	0	0	0	1	70	23.2	5.6	1.2	0	3
		6mpost-T		88*	12*	0	0	0	1	68.4	26.4	3.6	1.6	0	3

	C2	pre-T		90	9.6	0.4	0	0	2	65.2	25.6	7.6	1.6	0	3
		post-T		94.8*	5.2	0	0	0	1	72.8	22.4	4.4	0.4	0	3
		6mpost-T		93.2	6.8	0	0	0	1	65.2	27.2	6.4	1.2	0	3
	C3	pre-T		99.5	0.5	0	0	0	1	31	57.5	10.5	1	0	3
		post-T		98	2	0	0	0	1	40.5*	52	6.5	1	0	3
		6mpost-T		99	1	0	0	0	1	56.5*	32*	9.5	2	0	3
Hand Hard	C1	pre-T	2	99.2	0.8	0	0	0	1	90.8	8	0.8	0.4	0	4
		post-T		99.2	0.8	0	0	0	1	88.4	8.8	1.2	1.6	0	3
		6mpost-T		98.8	1.2	0	0	0	1	94.4	5.2	0	0.4	0	3
	C2	pre-T		98	2	0	0	0	1	86.4	8	4.4	1.2	0	4
		post-T		99.2	0.8	0	0	0	1	86.8	10.8	2	0.4	0	3
		6mpost-T		98	2	0	0	0	1	90.4	8	1.2	0.4	0	4
	C3	pre-T		97.5	2.5	0	0	0	1	86.5	13	0.5	0	0	2
		post-T		100*	0*	0	0	0	0	93.5*	4.5*	1	1	0	5
		6mpost-T		100*	0*	0	0	0	0	98*	1.5*	0.5	0	0	2
Object gentle	C1	pre-T	1	98	2	0	0	0	1	98.8	0.8	0.4	0	0	2
		post-T		99.6	0.4	0	0	0	1	98	2	0	0	0	1

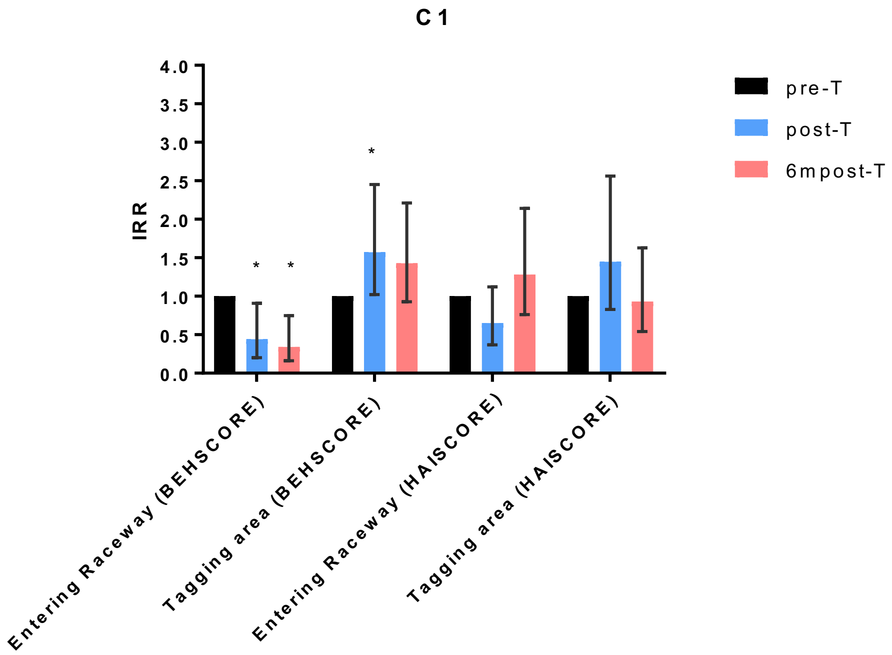
		6mpost-T		100*	0*	0	0	0	0	97.2	2.8	0	0	0	1
	C2	pre-T		*94*	*6*	*0*	*0*	*0*	*1*	*97.6*	*2.4*	*0*	*0*	*0*	*1*
		post-T		85.2*	14.8*	0	0	0	1	98.4	1.2	0.4	0	0	2
		6mpost-T		97.2	2.8	0	0	0	1	99.6	0.4	0	0	0	1
	C3	pre-T		*71*	*29*	*0*	*0*	*0*	*1*	*94.5*	*5.5*	*0*	*0*	*0*	*1*
		post-T		79.5	20.5	0	0	0	1	94	6	0	0	0	1
		6mpost-T		62	38	0	0	0	1	65.5*	30.5*	4*	0	0	2
Object	C1	pre-T	2	*100*	*0*	*0*	*0*	*0*	*0*	*100*	*0*	*0*	*0*	*0*	*0*
Hard		post-T		99.6	0.4	0	0	0	1	100	0	0	0	0	0
		6mpost-T		100	0	0	0	0	0	99.6	0	0	0	0	1
	C2	pre-T		*96.8*	*3.2*	*0*	*0*	*0*	*1*	*100*	*0*	*0*	*0*	*0*	*0*
		post-T		90.4*	9.6*	0	0	0	1	99.6	0.4	0	0	0	1
		6mpost-T		96.8	3.2	0	0	0	1	100	0	0	0	0	0
	C3	pre-T		*96.5*	*3.5*	*0*	*0*	*0*	*1*	*97.5*	*2*	*0.5*	*0*	*0*	*2*
		post-T		97	3	0	0	0	1	100*	0	0	0	0	0
		6mpost-T		98	2	0	0	0	1	95	4.5	0.5	0	0	2
Goad	C1	pre-T	3							*98.8*	*0.8*	*0.4*	*0*	*0*	*3*

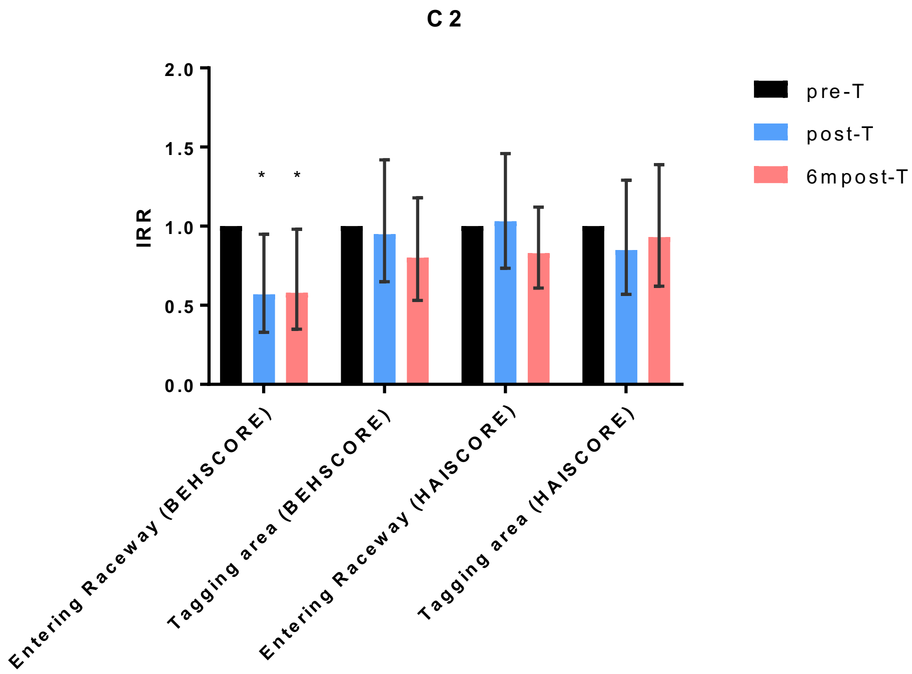
		post-T							95.6*	3.6*	0.8	0	0	4
		6mpost-T							99.6	0.4	0	0	0	1
	C2	pre-T							*99.2*	*0.8*	*0*	*0*	*0*	*1*
		post-T							100	0	0	0	0	0
		6mpost-T							98.8	1.2	0	0	0	1
	C3	pre-T							*97*	*3*	*0*	*0*	*0*	*1*
		post-T							98	2	0	0	0	1
		6mpost-T							98	2	0	0	0	1
Any Action	C1	pre-T	*59.6*	*31.2*	*7.6*	*1.6*	*0*	*4*	*62.4*	*11.6*	*17.6*	*7.2*	*1.2*	*10*
		post-T	75.6*	16.8*	6.4	1.2	0	4	57.6	9.2	17.6	11.6	4	11
		6mpost-T	46.4*	42.8*	10	0.8	0	4	60	13.2	15.6	10.4	0.8	6
	C2	pre-T	*54.8*	*31.2*	*10.4*	*3.2*	*0.4*	*6*	*54.8*	*22.4*	*13.2*	*8.4*	*1.2*	*7*
		post-T	56.8	25.2	12	6	0	5	60.8	19.2	9.6	9.2	1.2	8
		6mpost-T	66.4*	24	7.2	2.4	0	5	52	24.8	12.8	9.2	1.2	8
	C3	pre-T	*7*	*65.5*	*21.5*	*6*	*0*	*3*	*13*	*28*	*38.5*	*20*	*0.5*	*6*
		post-T	31*	50*	18	1*	0	3	21*	36	31	10*	2	11
		6mpost-T	20.5*	59.5	18.5	1.5*	0	3	23.5*	24	27.5*	22	3	9

Negative binomial models for BEHSCORE and HAISCORE were used to calculate IRR for each plant (full models displayed in Appendix 4) IRRs are displayed in Figure 3.5.

There was a significant decrease in BEHSCORE for animals entering raceways in both post-training visits in all three plants. The decrease was greatest in plant C3 (79% (19-95%) post-T; 83% (28-95.8%) 6mpost-T). Post-T in plant C3 was associated with a significant decrease in HAISCORE (48.1% (8.1-30.1%), however no other significant changes in HAISCORE were associated with post- training visits in the other plants.

Post-T in plant C1 was associated with a significant increase in BEHSCORE in the tagging area compared to pre-training visit (57% (2-145%). There were no significant associations between changes in BEHSCORE or HAISCORE in the tagging area and any other post-training visit.


C 1
IRR
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
*
*
*
pre-T
post-T
6mpost-T
Entering Raceway (BEHSCORE)
Tagging area (BEHSCORE)
Entering Raceway (HAISCORE)
Tagging area (HAISCORE)


C 2
IRR
2.0
1.5
1.0
0.5
0.0
*
*
pre-T
post-T
6mpost-T
Entering Raceway (BEHSCORE)
Tagging area (BEHSCORE)
Entering Raceway (HAISCORE)
Tagging area (HAISCORE)

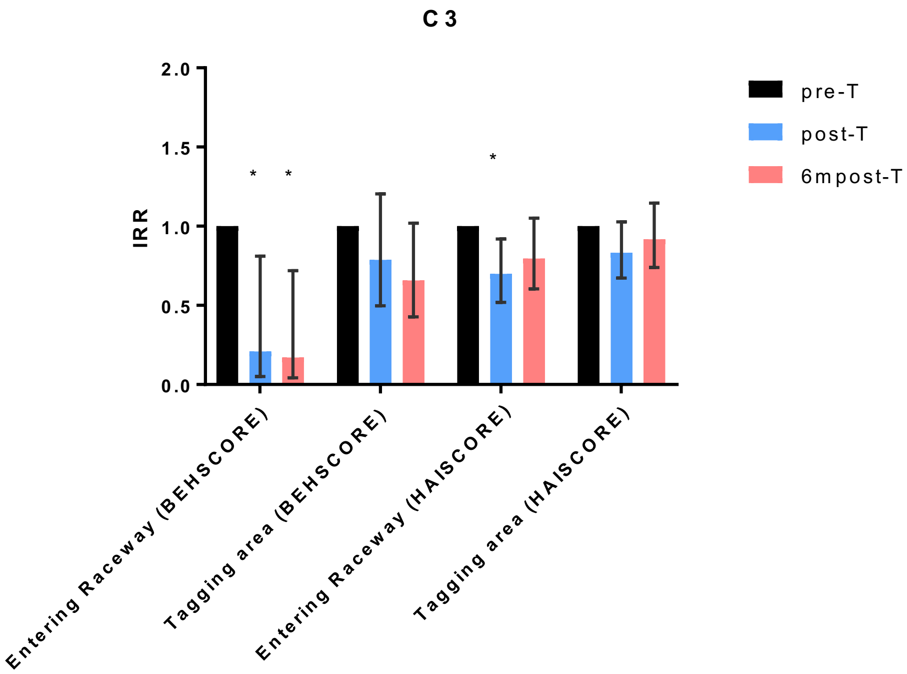


Figure 3.5 The IRR of BEHSCORE and HAISCORE between pre-training and post-training visits calculated by negative binomial regression. An IRR greater than 1 represents a percentage increase in score, an IRR less than one represents a percentage decrease in score. The precise percentage determined by the amount the IRR is either above or below 1. Error bars represent 95% confidence intervals. *represents a statistically significant ($p \leq 0.05$) change from pre-training visit.

was no significant ($p \leq 0.05$) correlation between BEHSCORE and HAISCORE There when entering the race for any of the plants (Table 3.12). Conversely there was a significant positive correlation between BEHSCORE and HAISCORE at the tagging area in all plants.

Table 3.12 Spearman's rank correlation between BEHSCORE and HAISCORE of individual animals.

Plant	Entering Raceway		Tagging area	
	Spearman's rank correlation coefficient	*p*	Spearman's rank correlation coefficient	*p*
C1	0.069	0.059	0.224	<0.0001
C2	0.054	0.143	0.239	<0.0001
C3	0.015	0.716	0.113	0.006

3.4.3 Stunning

3.4.3.1 Behaviours entering and in the stun box

The incidence of slipping whilst entering the stun box significantly decreased in both post-training visits compared to pre-T in plant C1. The proportion of cattle banging intro structures when entering the stun box significantly decreased in 6mpost-T in plant C1 (32.2%) and C2 (11.2%) and in post-T in plant C3 (18.1%). Struggling also decreased significantly in both post-training visits in plant C2 (11.6% in post-T; 10.4% in 6mpost-T) and C3 (29.2% in post-T; 30.2% in 6mpost-T) and 6mpost-T only in plant C1 (13.6%) (Table 3.13).

Table 3.13 Percentage of animals with different counts of recorded behaviours while entering (slipping, bang) and within (struggle) the stun box. (C1, C2 n=250 per visit, C3 n=200 per visit). Italic font highlights baseline measures. * represents a statistically significant difference in proportion from baseline (p ≤ 0.05) calculated using the exact Chi-squared test.

			Count					
Behaviour	Processing plant	Visit	0	1	2	3	>3	Max
Slipping	C1	pre-T	*69.6*	*24.8*	*4*	*1.6*	*0*	*3*
		post-T	82.4*	15.6*	1.2	0.4	0.4	4
		6mpost-T	99.6*	0.4*	0*	0	0	3
	C2	pre-T	*92*	*7.6*	*0.4*	*0*	*0*	*2*
		post-T	94	6	0	0	0	1
		6mpost-T	95.6	4.4	0	0	0	1
	C3	pre-T	*95.5*	*4.5*	*0*	*0*	*0*	*1*
		post-T	97	2.5	0	0.5	0	3
		6mpost-T	92	8	0	0	0	1
Bang	C1	pre-T	*66.4*	*28.4*	*4.4*	*0.8*	*0*	*3*
		post-T	69.6	27.2	3.2	0	0	2
		6mpost-T	99.2*	0.8*	0*	0	0	1
	C2	pre-T	*84.8*	*14*	*1.2*	*0*	*0*	*2*
		post-T	89.2	10.8	0	0	0	1
		6mpost-T	96*	4*	0	0	0	1
	C3	pre-T	*66.9*	*32*	*1.1*	*0*	*0*	*2*
		post-T	85*	14*	1	0	0	2
		6mpost-T	74	26	0	0	0	1
Struggle	C1	pre-T	*78*	*16*	*2.8*	*1.6*	*1.6*	*5*
		post-T	74	16.8	6	2	1.2	5
		6mpost-T	91.6*	8.4*	0*	0	0	1
	C2	pre-T	*82.8*	*17.2*	*0*	*0*	*0*	*1*

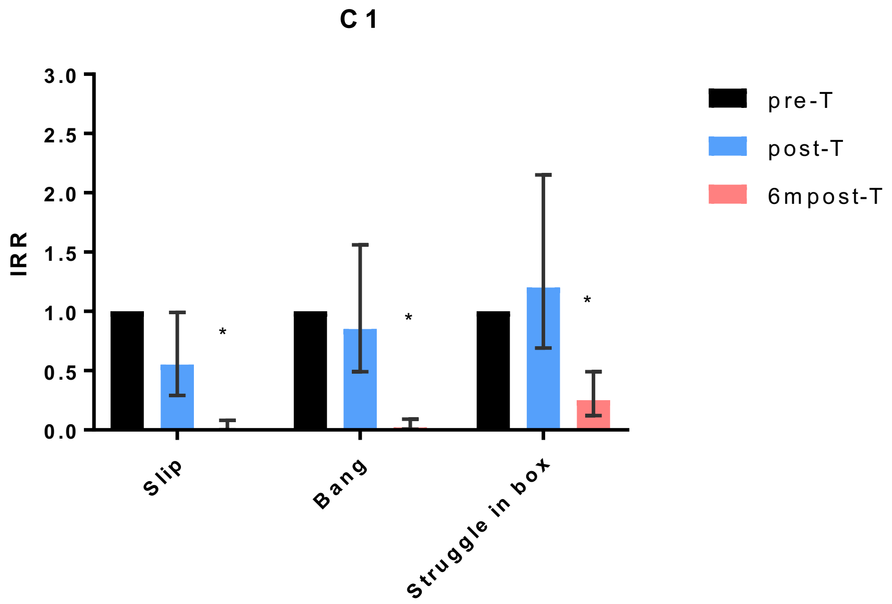
	post-T	94.4*	5.6*	0	0	0	1
	6mpost-T	93.2*	6.8*	0	0	0	1
C3	pre-T	*52.8*	*47.2*	*0*	*0*	*0*	*1*
	post-T	82*	18*	0	0	0	1
	6mpost-T	83*	17*	0	0	0	1

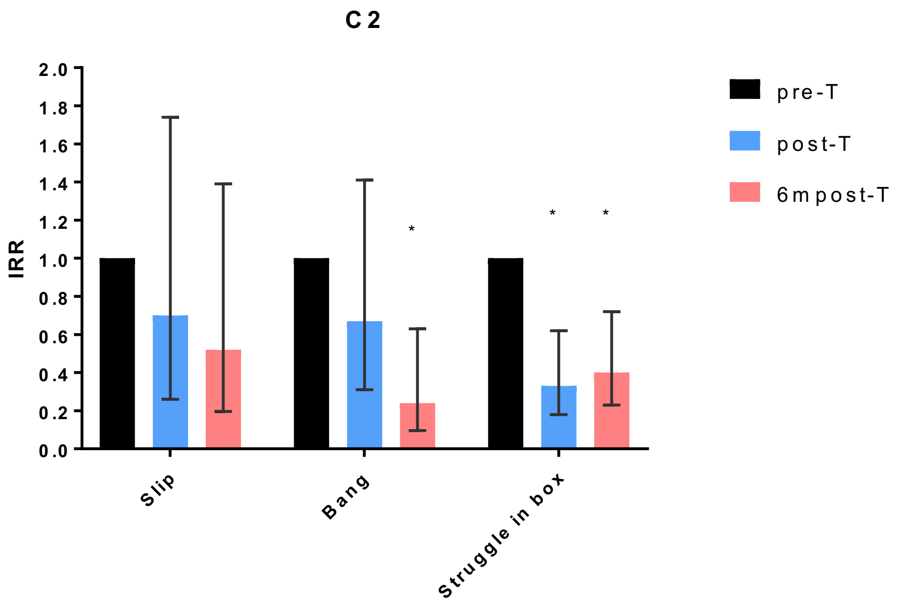
Negative binomial models were then used to include day as a random factor and to calculate IRR (full models shown in Appendix 5).

In plant C1, 6mpost-T was associated with significant decreases in the incidence of all recorded behaviours. There was no significant effect of post-T. (Figure 3.6)

In plant C2, post-T was associated in a significant decrease in the incidence of animals struggling in the stun box. 6mpost-T was also associated in a significant decrease (60% (28-77%)) in animals struggling in the stun box and in the incidence of animals banging into structures whilst entering the box (76% (37-90%)). (Figure 3.6)

In plant C3, the incidence of animals struggling in the box significantly decreased in both post-training (60% (39-73%) post-T; 64% (44-77%) 6mpost-T) visits compared to the pre-training visit. Post-T was also associated with a decrease (53% (31-68%)) in the incidence of banging into structures whilst entering the stun box (Figure 3.6).


C1
3.0
2.5
2.0
1.5
1.0
0.5
0.0
IRR
*
*
*
Slip
Bang
Struggle in box
pre-T
post-T
6m post-T


C2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
IRR
*
*
*
Slip
Bang
Struggle in box
pre-T
post-T
6m post-T

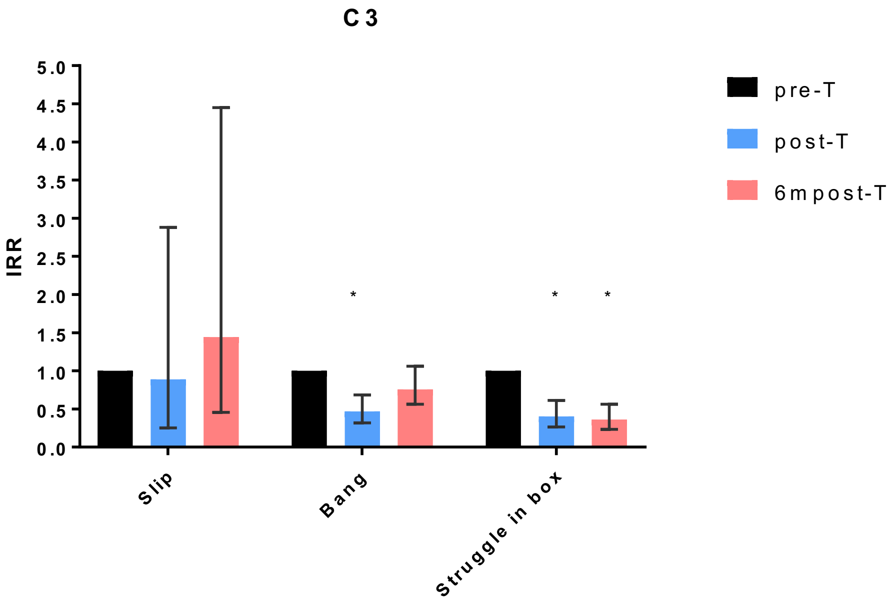


Figure 3.6 The IRR of behaviours entering and in the stun box between pre-training and post-training visits calculated by negative binomial regression. An IRR greater than 1 represents a percentage increase in score, an IRR less than one represents a percentage decrease in score. The precise percentage determined by the amount the IRR is either above or below 1. Error bars represent 95% confidence intervals. *represents a statistically significant ($p \leq 0.05$) change from pre-training visit.

3.4.3.2 Time taken to enter stun box and time taken for first shot to be fired

Table 3.14, Table 3.15 and Table 3.16 show the results of multilevel linear models of time into the stun box and time to first shot for each plant.

Visit post-T in plant C1 was associated with a decrease of time taken to enter the stun box. Time entering the stun box did not significantly change with visit in plant C2 or C3.

Visit post-T in plant C1 was also associated with a significant decrease in time to first shot, however 6mpost-T in the same plant was associated with a significant increase in time to first shot. This increase (17.825 seconds) was much greater than the decrease in post-T (-2.794 seconds).

In both plants C2 and C3 there was a significant association of 6mpost-T and time until the first shot/neck cut; a significant decrease of 3.13 seconds was seen in C2 and an increase of 2.76 seconds in plant C3.

The random effect of observation day was associated with a much greater variance (11.44) in plant C1 compared to plant C3 (0.59).

Table 3.14 Multilevel linear regression models of times into stun pen and time to first shot in plant C1. Significant results (p≤ 0.05) are shown in bold font.

Predictor		Time into box			Time to first shot		
		Coef.	**CI**	***p***	**Coef.**	**CI**	***p***
Constant		20.231	16.74-23.72	<0.0001	11.459	9.9-13.02	<0.0001
Visit	pre-T	*(ref)*			*(ref)*		
	post-T	**-7.488**	**-12.43-2.55**	**0.003**	**-2.794**	**-5.0-0.59**	**0.013**
	6mpost-T	-1.999	-6.94-2.94	0.427	**17.825**	**15.62-20.03**	**<0.0001**
Random Effects		**Var**	**SE**		**Var**	**SE**	
Day		11.44	5.76		1.03	1.16	

Table 3.15 Multilevel linear regression models of times into stun pen and time to first shot in plant C2. Significant results (p≤ 0.05) are shown in bold font.

Predictor		**Time into box**			**Time to first shot**		
		Coef.	**CI**	***p***	**Coef.**	**CI**	***p***
Constant		14.298	11.77-16.83	<0.0001	17.671	15.85-19.49	<0.0001
Visit	pre-T	*(ref)*			*(ref)*		
	post-T	-2.433	-6.02-1.13	0.18	-0.744	-3.32-1.83	0.57
	6mpost-T	-2.14	-5.71-1.44	0.24	**-3.13**	**-5.7-0.55**	**0.017**
Random effects		**Var**	**SE**		**Var**	**SE**	
Day		6.78	3.02		2.8	1.57	

Table 3.16 Multilevel linear regression models of times into stun pen and time to neck cut in plant C3. Significant results (p≤ 0.05) are shown in bold font.

Predictor		**Time into box**			**Time to neck cut**		
		Coef.	**CI**	***p***	**Coef.**	**CI**	***p***
Constant		12.26	10.18-14.34	<0.0001	14.59	12.69-16.49	<0.0001
Visit	pre-T	*(ref)*			*(ref)*		
	post-T	1.15	-1.7-4	0.43	1.29	-1.19-3.76	0.308
	6mpost-T	1.35	-1.51-4.21	0.36	**2.76**	**0.18-5.35**	**0.036**
Random effects		**Var**	**SE**		**Var**	**SE**	
Day		0.59	1.72		2.1	1.51	

3.4.3.3 Second shots

In plant C1, four animals received a second shot in the box during pre-T. Only one animal received a second shot during post-T and 6mpost-T.

In plant C2, during pre-T, one animal received a second shot in the box, another animal received a total of three shots whilst in the box. No animals received a second shot during post-T and one animal received a second shot during 6mpost-T.

3.4.3.4 Movement and Coercion score

The percentage of animals in each movement and coercion score category is given in Table 3.17.

Table 3.17 Percentage of animals in each movement and coercion score category (C1, C2 n=250 per visit, C3 n=200 per visit). Italic font highlights baseline measures. * represents a statistically significant difference in proportion from baseline (p ≤ 0.05) calculated using the exact Chi-squared test.

Processing plant	Visit	Movement Score				Coercion score		
		0	1	2	3	0	1	2
C1	pre-T	*47.6*	*29.6*	*8*	*14.8*	*19.6*	*64*	*16.4*
	post-T	72.4*	15.2*	8.4	4*	28.8*	61.6	9.6*
	6mpost-T	55.6	22.8	6.8	14.8	27.6*	57.2	15.2
C2	pre-T	*57.2*	*14*	*12.8*	*16*	*8.4*	*62.4*	*29.2*
	post-T	53.2	14	6.8*	26*	4.4	61.2	34.4
	6mpost-T	66.4*	8.4	8.4	16.8	11.6	64.4	24
C3	pre-T	*52.8*	*26.4*	*10.7*	*10.1*	*9.5*	*50.6*	*39.9*
	post-T	66.3*	14.1*	12.6	7	6	76*	18*
	6mpost-T	60	21.5	10	8.5	11.5	64.5*	24*

The multilevel multinomial logistic regression models for movement and coercion scores for each plant are given in Table 3.18 to Table 3.23. Due to a poor model fit, the random effect of day was removed from the model of movement scores in plant C3.

Visit post-T in plant C1 was associated with a significant decrease of animals being given a movement score of 1 or 3 compared with 0. No associations were detected between 6mpost-T and movement score. There were no significant association between visit and coercion scores.

The only significant association detected in plant C2 was that animals during post-T were 2.19 times more likely to be given coercion score 2 than score 0 compared to pre-T (p=0.021).

Visit post-T in plant C3 was associated with a significant decrease in movement score 1 (OR 0.42, p=0.001) and a significant increase in coercion score 1 (OR 2.64, p=0.001). Visit 6mpost-T was associated with a decrease in coercion score 2 (OR 0.74, p=0.005).

Table 3.18 Multilevel multinomial logistic regression model for movement categories in plant C1 (score 0 = reference category). Significant results (p≤ 0.05) are shown in bold font.

		Score 1			Score 2			Score 3		
Intercept		-0.49			-1.82			-1.23		
		OR	**CI**	***p***	**OR**	**CI**	***p***	**OR**	**CI**	***p***
Visit	**pre-T**	*(ref)*			*(ref)*			*(ref)*		
	post-T	**0.32**	**0.15-0.65**	**0.002**	0.67	0.32-1.39	0.283	**0.17**	**0.006-1.46**	**<0.0001**
	6mpost-T	0.6	0.3-1.21	0.153	0.68	0.32-1.46	0.323	0.83	0.36-1.88	0.649
Random effects		**Var.**	**SE**		**Var.**	**SE**		**Var.**	**SE**	
	Day	0.203	0.121		0.066	0.131		0.262	0.182	
Covariance										
Between scores 1 and 2		-0.032	0.091							
Between scores 1 and 3		0.059	0.107							
Between scores 2 and 3		0.135	0.116							

Table 3.19 Multilevel multinomial logistic regression models for coercion categories in plant C1 (score 0 = reference category). Significant results ($p \leq 0.05$) are shown in bold font.

		Score 1			Score 2		
Intercept		1.259			-0.147		
		OR	**CI**	***p***	**OR**	**CI**	***p***
Visit	**pre-T**	*(ref)*			*(ref)*		
	post-T	0.86	0.45-1.66	0.208	0.4	0.15-1.04	0.06
	6mpost-T	0.60	0.31-1.16	0.129	0.63	0.25-1.6	0.334
Random effects		**Var.**	**SE**		**Var.**	**SE**	
	Day	0.19	0.101		0.408	0.215	
Covariance							
	Between scores 1 and 2	0.28	0.119				

Table 3.20 Multilevel multinomial logistic regression model for movement categories in plant C2 (score 0 = reference category). Significant results (p≤ 0.05) are shown in bold font.

		Score 1			Score 2			Score 3		
Intercept		-1.522			-1.589			-1.332		
		OR	**CI**	***p***	**OR**	**CI**	***p***	**OR**	**CI**	***p***
Visit	**pre-T**	*(ref)*			*(ref)*			*(ref)*		
	post-T	1.14	0.49-2.64	0.762	0.55	0.19-1.54	0.254	1.75	0.78-3.92	0.175
	6mpost-T	0.52	0.21-1.26	0.147	0.52	0.19-1.43	0.203	0.88	0.38-2.01	0.756
Random effects		**Var.**	**SE**		**Var.**	**SE**		**Var.**	**SE**	
	Day	0.272	0.178		0.41	0.253		0.29	0.158	
Covariance										
Between scores 1 and 2		0.211	0.16							
Between scores 1 and 3		0.206	0.128							
Between scores 2 and 3		0.302	0.16							

Table 3.21 Multilevel multinomial logistic regression models for coercion categories in plant C2 (score 0 = reference category). Significant results ($p \leq 0.05$) are shown in bold font.

		Score 1			Score 2		
Intercept		2			1.25		
		OR	**CI**	***p***	**OR**	**CI**	***p***
Visit	**pre-T**	*(ref)*			*(ref)*		
	post-T	1.82	0.98-3.39	0.059	**2.19**	**1.13-4.26**	**0.021**
	6mpost-T	0.75	0.4-1.4	0.361	0.56	0.3-1.17	0.133
Random effects		**Var.**	**SE**		**Var.**	**SE**	
	Day	0.17	0.09		0.2	0.1	
Covariance							
	Between scores 1 and 2	-0.16	0.09				

Table 3.22 Multinomial logistic regression model for movement categories in plant C3 (score 0 = reference category). Significant results (p≤ 0.05) are shown in bold font.

		Score 1			Score 2			Score 3		
Intercept		-0.693			-1.6			-1.65		
		OR	**CI**	***p***	**OR**	**CI**	***p***	**OR**	**CI**	***p***
Visit	**pre-T**	*(ref)*			*(ref)*			*(ref)*		
	post-T	**0.42**	**0.25-0.71**	**0.001**	0.93	0.49-1.75	0.822	0.55	0.27-1.14	0.108
	6mpost-T	0.72	0.45-1.15	0.168	0.82	0.42-1.6	0.568	0.74	0.37-1.48	0.396

Table 3.23 Multilevel multinomial logistic regression models for coercion categories in plant C2 (score 0 = references category). Significant results ($p \leq 0.05$) are shown in bold font.

		Score 1			Score 2		
Intercept		1.593			1.405		
		OR	**CI**	***p***	**OR**	**CI**	***p***
Visit	**pre-T**	*(ref)*			*(ref)*		
	post-T	**2.64**	**1.48-4.7**	**0.001**	0.74	0.46-1.2	0.228
	6mpost-T	1.19	0.66-2.12	0.56	**0.51**	**0.32-0.82**	**0.005**
Random effects		**Var.**	**SE**		**Var.**	**SE**	
	Day	0.097	0.078		0.018	0.05	
Covariance							
	Between scores 1 and 2	-0.059	0.06				

3.4.3.5 Goad use

Descriptive statistics of time taken to enter the stun box when a goad was used (coercion score 2) is shown in Table 3.24. In both plant C1 and C2 the time taken to enter the box when a goad was used decreased in post-training visits.

In all plants there was a significant difference between visits and time taken to enter the stun box when a goad was used (C1: Test Statistic = 27.255, df= 2, p <0.001; C2: Test statistic = 33.07, df=2, p<0.001; C3: Test statistic = 30.601, df=2, sig <0.0001).

Subsequently pairwise comparisons were carried out for each sets of visits. A significance level of p <0.001 was reached in all pre-training – post-training visit pairs (pre-T – post-T and pre-T-6mpost-T) except for pre-T – 6mpost-T in plant C3 (p=1.000).

Table 3.24 Descriptive statistics of the time taken for an animal to enter the stun box when a goad was used.

Processing plant	Visit	Number of animals observed	Number of animals goaded	Median time to taken enter box when goad used (s)	Min (s)	Max (s)
C1	pre-T	250	41	51.15	22.44	145.6
	post-T	250	24	32.78	14.16	95.68
	6mpost-T	250	38	35.79	16.37	81.34
C2	pre-T	250	73	24.75	13.3	61.53
	post-T	250	86	17.56	7.75	43.47
	6mpost-T	250	60	18.66	6.09	71.13
C3	pre-T	200	71	13.28	5.28	116.94
	post-T	200	36	27.35	10.91	78.03
	6mpost-T	200	48	13.58	5.75	138.76

3.4.4 Bleed

Stun-stick intervals were relatively similar across all visits at both plants. (Table 3.25)
The multilevel linear regressions show a significant increase of 2.96 seconds in stun-stick interval associated with 6mpost-T in plant C1. (Table 3.26). There was no significant association of visit on stun-stick intervals in plant C2. (Table 3.26)

Due to the small numbers of animals displaying signs of recovery on the bleed line (Table 3.27), regression models were not performed. Chi-square tests show no significant differences of proportion of animals showing signs of recovery between visits at either plant.

There were three incidences where animals were seen to display rhythmic breathing on the bleed line and a second shot was not administered: once during pre-T and twice during post-T in plant C1. The number of incidences where animals were not seen to have a fixed glazed expression, and a second shot was not administered was 11 for pre-T, 14 for post-T and 5 for 6mpost-T, all occurring in plant C1.

Table 3.25 Descriptive statistics of stun-stick interval in plant C1 and C2.

Processing plant	Visit	Mean (s)	SD	Min (s)	Max (s)
C1	pre-T	44.01	8.02	13.57	70.44
	post-T	44.5	6.74	16.72	73.38
	6mpost-T	47.02	6.87	31.38	94.53
C2	pre-T	48.37	7.76	5.88	83.81
	post-T	47.41	5.92	27.1	79.81
	6mpost-T	48.67	6.38	4.53	70.38

Table 3.26 Multilevel linear regression model for stun-stick interval for both plants. Significant results (p ≤ 0.05) are shown in bold font.

Predictor		Stun-Stick C1			Stun-Stick C2		
		Coef.	**CI**	***p***	**Coef.**	**CI**	***p***
Constant		44.06	42.26-45.86	<0.0001	48.37	46.4-50.34	<0.0001
Visit	pre-T	*(ref)*			*(ref)*		
	post-T	0.389	-2.14-2.92	0.76	-0.96	-3.75-1.83	0.501
	6mpost-T	**2.96**	**0.41-5.51**	**0.023**	0.30	-2.49-3.09	0.832
Random Effects		**Var**	**SE**		**Var**	**SE**	
Day		3.27	1.55		4.22	1.84	

Table 3.27 Percentage of animals observed showing signs of recovery on the bleed line.

Behaviour/Action	Processing plant	Visit	Percentage of animals (n=250)
Lack of fixed glazed expression	C1	pre-T	4.4
		post-T	6.8
		6mpost-T	4
	C2	pre-T	0
		post-T	0.4
		6mpost-T	0
Return of rhythmic breathing	C1	pre-T	2
		post-T	4
		6mpost-T	2
	C2	pre-T	0.4
		post-T	0
		6mpost-T	0
Second shot received	C1	pre-T	2
		post-T	4.8
		6mpost-T	4.4
	C2	pre-T	0.8
		post-T	1.2
		6mpost-T	0.4

3.4.5 Bruising

The proportion of carcasses presenting with a different number, size, and location of bruises is shown in Figure 3.7 and Figure 3.8. In all plants, carcasses were most likely to have 1-2 bruises. Small bruises were more prevalent than those classified as medium or large, and bruises were predominantly located in the midline and rear of the carcass.

There was some effect of visit on the number and size of bruises in plant C3. Visit also had a mixed effect on the location of bruises; in plant C1 the percentage of bruises in the middle of the carcass significantly increased in both post-training visits (by 20.8% in post-T; 12.8% 6mpost-T); in plant C2 the percentage of bruises on the right of the carcass significantly decreased (13.6%) during 6mpost-T compared to pre-T and in plant C3 there was a significant decrease in the prevalence of bruises on the left (13%), midline (14%), front (24%) and rear (14%) during post-training visits.

Descriptive statistics of BRUISETOTAL score is shown in Table 3.28. The minimum BRUISETOTAL score for each visit at each plant was 0. The negative binomial models of BRUISETOTAL for each plant is displayed in Table 3.29. There was no significant association of visit on BRUISETOTAL scores across any of the plants.

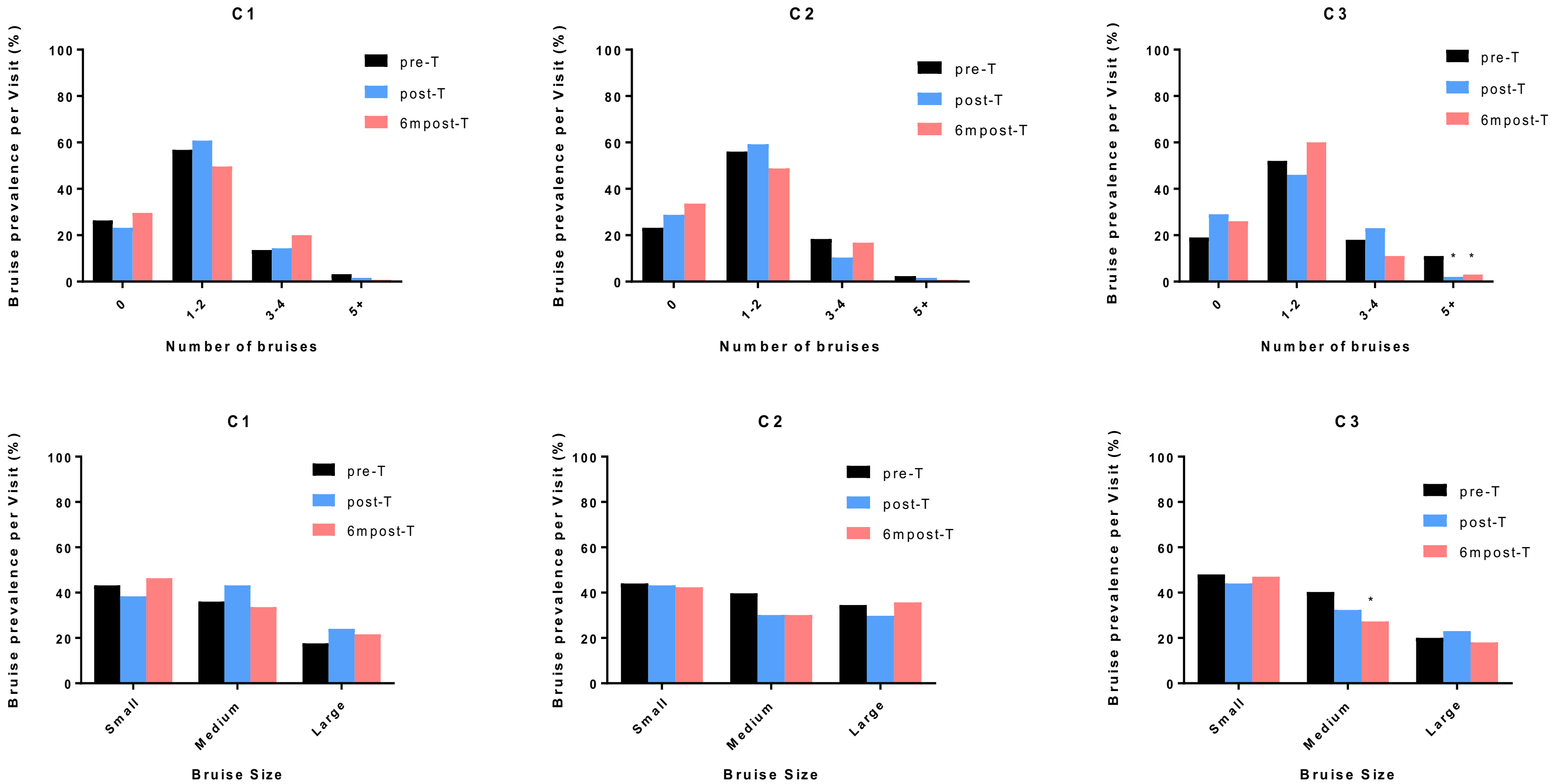


Figure 3.7 Bruise prevalence by number and size for all processing plants * represents a statistically significant difference in proportion from Visit pre-T ($p \leq 0.05$) calculated using the exact Chi-squared test.

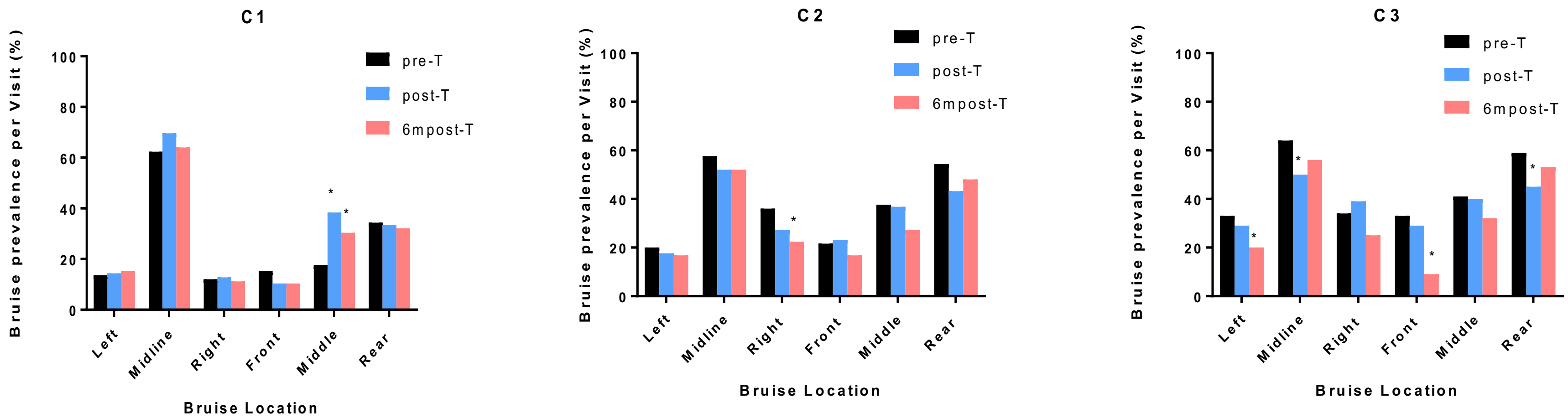


Figure 3.8 Bruise prevalence by carcass location for each processing plant * represents a statistically significant difference in proportion from Visit pre-T ($p \leq 0.05$) calculated using the exact Chi-squared test.

Carcass bruising was classified as follows: left (bruises present in areas 3,6,9); midline (2,5,8); right (1,4,7); front third (7,8,9); middle third (4,5,6); rear third (1,2,3), see Figure 3.4.

Table 3.28 Descriptive statistics of BRUISETOTAL scores for each Visit (C1, C2, n=125; C3, n=100).

Processing plant	Visit	Median	Max
C1	pre-T	2	14
	post-T	2	16
	6mpost-T	3	15
C2	pre-T	2	12
	post-T	2	12
	6mpost-T	2.5	12
C3	pre-T	2	14
	post-T	1	16
	6mpost-T	2	16

Table 3.29 Negative Binomial regression models of BRUISETOTAL score for each plant. Significant results (p≤ 0.05) are shown in bold font.

Predictor		**BRUISETOTAL C1**			**BRUISETOTAL C2**			**BRUISETOTAL C3**		
		Coef.	**SE**	***p***	**Coef.**	**SE**	***p***	**Coef.**	**SE**	***p***
Constant		0.83	0.17	<0.0001	1.04	0.13	<0.0001	1.22	0.15	<0.0001
Visit	pre-T	*(ref)*			*(ref)*			*(ref)*		
	post-T	0.13	0.24	0.58	-0.28	0.19	0.14	-0.16	0.2	0.47
	6mpost-T	0.05	0.24	0.83	-0.25	0.19	0.19	-0.36	0.22	0.11
Random Effects		**Var**	**SE**		**Var**	**SE**		**Var**	**SE**	
Day		0.11	0.05		0.05	0.03		0.06	0.04	

3.5 Discussion

To the author's knowledge this is the first study to assess the effects of animal welfare training on cattle welfare throughout the slaughter operation in commercial primary processing plants. It appears that the training has a number of effects and these will be discussed in the subsequent sections.

3.5.1 Lairage

Visit did not have a significant effect on the welfare measures in the lairage. This is unsurprising; the majority of welfare measures included in the protocol were assessing agnostic behaviour between animals. These behaviours more likely when groups of unfamiliar animals are mixed in the lairage (Kenny & Tarrant, 1987). All plants in this study had a protocol in place before the onset of training which outlined that animals must be put in pens according to the groups in which they arrived.

In a review of welfare of cattle lairages, Weeks (2008) highlighted that ideally a lairage should be quiet, spacious, well-bedded, well-ventilated, thermally-comfortable and allow easy access to clean water (and feed where appropriate). Floors of pens should be grooved to prevent slips and falls (Grandin, 1990). It is the opinion of the author that the lairages in all study plants were adequately structured and managed in order to protect animal welfare.

The AWO training course content includes the specifications of an ‘ideal’ lairage, and covers structural recommendations in depth. In modern, well designed facilities such as the slaughter plants included in this study, this information may be of little benefit. It may be valuable for the training to advise attendees on how to monitor welfare, making staff aware when the welfare of the animals may be comprised and require separating or moved.

3.5.2 Raceways

The preliminary analysis suggests that training has a predominantly positive effect on the welfare of cattle as they are moved into the raceway. The incidence of banging into structures significantly decreased in all plants, suggesting that animals were moved more carefully and calmly. The results of HAI counts in this area were more varied, however the total number of HAI significantly decreased in two plants. When the effect of observation day was included in the IRR analysis of BEHSCORE and HAISCORE, a significant positive effect of training on BEHSCORE was found in all plants. A decrease in the incident of behaviours indicative of impaired welfare conditions is a positive outcome for overall animal welfare during the pre-slaughter process. HAISCORE only significantly improved in C3. As sounds and tactile interactions between handlers and animals is associated with fear and distress in cattle (Breuer et al., 2000; Brouček, 2014) high HAI would likely result in a negative impact on animal welfare. High counts for some stock-people may be explained by problematic personal attitudes towards slaughter animals, a lack of knowledge about animal behaviour, and poor animal handling skills (Hultgren et al., 2014). The results from Chapter 2 suggest that in general that the attitudes of those attending the AWO course are positive; however there is limited impact of the training in actively improving attitudes. Although the AWO training delivers, in depth, the knowledge regarding animal behaviour required to move animals calmly (reducing potential HAI scores) the lack of practical 'skills' training included as part of the course may be a limiting factor in overall improvement in animal handling.

Certain positive measures of handling, such as use of point of balance and animal flight zones, was not recorded as it was deemed difficult to identify for individual animals. This may have increased in the post-training visits, leading to the improvement in BEHSCORES.

The influence of training on animal welfare in the tagging area had more varied results. The only significant effect of training on weighted sum scores in the tagging area was seen in C1 which exhibited an increase in BEHSCORE suggesting 'worse' welfare practice post-training. The counts of individual behaviours in the preliminary analysis show a more positive result, especially in plant C3. It was observed that in this plant the number of animals in the tagging area at any one time was reduced from 5, pre-training to 4, post-training. In all plants the operative in the tagging area had to read the ear tag number of each individual animal. Occasionally when the ear tag was dirty, or obstructed by hair, the operator was required to manipulate the animal's ear in order to get a clear view. It was observed that this often resulted in the animal becoming agitated leading to an increase in behavioural and HAI counts. Results from work by Mpamhanga and Wotton (2015) show that cattle who were restrained in order to have their ear tag read prior to slaughter had significantly higher incidence of carcass blood splash. When restraint was not used, animals showed significant reduction in post-stun/kill limb movement, muscle tone and expression of brainstem functions. Mpamhanga and Wotton concluded that conducting identification processes post-slaughter instead of in the restrained live animal would improve the welfare of cattle as well as the safety of operatives prior to mechanical stunning. Further research regarding alternatives to the manual reading of ear tags on live animals is therefore warranted and should be made a focus of future animal welfare at slaughter research.

Time handling animals is an important factor when measuring stockperson actions and animal behaviours at a slaughter-plant (Hultgren et al., 2014). Extended handling times will give the stockpersons and animals more time to perform such actions/behaviours, thus possibly contributing to high total counts. However, slow, calm handling when moving animals into the raceway may reduce the incidence of certain behaviours, such as banging into objects, as reported in this study. Due to only a single observer carrying out the measurements, time taken by operators to handle individual animals was not recorded.

In a project assessing cattle movement through raceways, Jones (2011) suggests that the raceway leading to stunning pens can potentially be designed based on the behavioural principles of animals to improve their individual welfare, which should remove of the need for excessive coercion. However, it is still vitally important for the stockmen to have a full understanding of the natural behaviour and tendencies of the species entering the lairage in order for animals to be calm, as calm animals are easier to handle and move. The two-day AWO course covers, in detail, using videos and pictures, the behaviour of cattle and how it can be manipulated by stockpeople to

prevent overuse of coercion. This information is delivered the management personnel of the slaughter-plant and therefore relies on these members of staff training those handling the animals in the lairage. Whether this happens in reality is dependent on individual staff and plant culture and priorities.
In this study, information was on cattle behavioural principles were delivered to stockpeople during the 'on the job' training, however without the use of the videos and pictures, which may have reduced the impact of the information.

When assessing human-animal interactions in Australian cattle slaughter-plants, Hemsworth et al. (2011) reported that 'quiet talking' and 'gentle touching' had a positive effect on cattle. In the current study an attempt was made to not count 'quiet talking' in the sound measure, however, the 'hand gentle' measure may have included incidences of 'gentle touching' possibly constituting a positive, rather than a negative indicator of welfare. As far as the author is aware the results of Hemsworth's study were not presented during the AWO training. Therefore, it may be that the changes seen in the use of 'hand gentle' in plant C2 and C3 was an attempt by operators to lessen cattle stress through reducing tactile interactions. The AWO training course predominantly focuses on reducing 'negative' welfare states. Of course this is of paramount importance in a slaughter environment where there is significant risk of substantial welfare compromise however, encouraging 'positive' welfare states (e.g. by the use of gentle contact and quiet talking and recognising signs of positive welfare states) would be beneficial, both in actively improving animal welfare and allowing the development of assessment protocols containing measures of positive welfare states.

3.5.3 Stunning

Moving animals into the stun box can be problematic (Bourguet et al., 2011). Operators are under pressure to keep the bleed line full to ensure the processing line can operate at the set processing speed. This can lead to rough handling and impaired welfare. In this study training appeared to have some positive effects on welfare outcomes; the proportion of cattle slipping, banging into structures and struggling in the stun box decreased in all plants post-training, perhaps linked to improved movement scores. It should be noted that plant C1 had a new stun box fitted during the study. This new equipment, rather than the training, may have led to the significant decrease in recorded behaviours. Unlike the old box, the new stun box had a hydraulic head restraint installed, possibly leading to the significant increase in time the animals spent within the box, recorded during 6mpost-T.

Cattle spent significantly less time in the stun box in C1 (post-T) and C2 (6mpost-T) compared to pre-training scores. Less time in restraint is a positive outcome for cattle welfare (Bourguet et al., 2011; Cockram & Corley, 1991).

The overall proportion of cattle receiving action of an electric goad decreased in plant C1 and C3. The decrease was not as marked as that reported by Grandin (1998b) who described that in two beef slaughter-plants with poor facilities and rough handling, 15 minutes of employee animal handing training led to a decrease in electric goad use from 83% of animals to 17%. Although the number of animals goaded decreased in this study, the time taken by goaded animals to move into the stun box significantly decreased in plant C1 and C2. This may suggest that either the goad is more effective at moving animals, or the operators are resorting to goad use quicker post-training rather than persisting with other methods of coercion (a negative outcome). To establish which outcome was taking place, the time from stun box gate opening to the use of electric goad would need to be measured.

It should be noted that the incidence of goad use increased in plant C2. Animals during post-T were over 2 times more likely to be goaded than not receive any coercion compared to pre-T. The data suggests that during this visit a significantly greater proportion of animals refused to move into the stun box (score 3). The reason for this is unclear, however, lighting and noise levels, air flow and stun box design can all impede movement of cattle (Jones, 2011). This information is given in the training courses (Appendix 3), however improvement is likely to require structural changes, which may take more time than the 1 week between training and post-T.

Fewer animals were goaded in 6mpost-T than pre-T and it was noted by the observer that the sound produced by the adjustment of the stun box was reduced in 6mpost-T compared to post-T.

3.5.4 Bleeding

Legislation requires that after simple stunning (such as with a captive bolt) the animal must be bled 'without delay' and bleeding must be completed before the animals regains consciousness (WATOK, 2015). The mean stun-stick intervals in this study were all inside the 60 second limit stipulated by most retailers and markedly less than the average of 105 ± 17 seconds reported in Swedish cattle slaughter-plants (Atkinson et al., 2013). The only significant difference in the stun-stick interval was seen in 6mpost-T of plant C1, which is likely to be associated with the change in stun box rather than training.

It would have been beneficial to include other methods of stun quality, (for example those outlined in Atkinson et al. (2013) e.g. pain response and corneal reflex) however, this was not possible due to health and safety considerations of being in close proximity to an animal during the onset of clonic seizures.

The lack of a fixed glazed expression is one sign of an inadequate stun (Atkinson et al., 2013) therefore, it is concerning that there were 19 incidences in plant C1 of cattle without a fixed glazed expression not receiving a second shot. The association of lack of fixed glazed expression with risk of recovery on the bleed rail should be emphasised in future training courses.

3.5.5 Bruising

A number of authors have suggested that training of personnel in the handling of cattle has the potential to improve welfare, and reduce bruising (Jarvis et al., 1995; McNally & Warriss, 1996; Strappini et al., 2013), however, this is the first study to objectively test such a hypothesis. No consistent effect of training was found on the number, or size, of bruises. In line with the results reported by Lee et al. (2017), the greatest prevalence of bruises in this study was found on the midline of the carcass.

Plant C3 had the greatest number of significant differences in bruising scores between pre and post-training visits. This may be associated with the reported improvements in pre-slaughter cattle behaviours and handling: In plant C3 significant reductions were reported in the number of animals banging into structures in the raceway and when entering stun box, and the number of animals struggling in the stun box. The use of 'hand hard' and 'object hard' also significantly decreased. However, it can be argued that there were similar improvements in welfare outcome scores in both plant C1 and C2 but no observed improvement in carcass bruising. Although it has been concluded that human-animal interactions at the slaughterhouse cause the greatest potential for traumatic events (Strappini et al., 2013), a number of factors can affect bruising prevalence including: loading and unloading (Strappini et al., 2013), transport conditions, the presence of horned animals (Huertas et al., 2010) movement through markets, animal sex, animal age (Romero et al., 2012; Weeks et al., 2002) and breed (Lee et al., 2017). Only bright, haemorrhagic red bruises were recorded in this study, as these are likely to be 0-10 hours old (Gracey & Collins, 1992), however, a more sophisticated system to age bruises could be beneficial in determining their origin in any future studies.

A Canadian study assessing welfare during transport described that cattle driven by truck drivers who had taken a livestock trucking training course were significantly less likely to produce Dark Cutting Beef (DCB) than cattle driven by non-trained drivers (Warren et al., 2010). Bruising was not assessed in this Canadian study; however, it could be hypothesised that training to reduce factors associated with cattle stress, and therefore DCB, would also likely decrease the prevalence of carcass bruising. Further work on combining welfare training throughout different stages of the beef production cycle is therefore warranted.

3.5.6 Methodological considerations

The studied primary processing plants were to a great extend selected on availability and willingness to participate in the study. The small number of plants studied and the variation between them implies that this study might not give a complete picture of the effects of training in all cattle slaughter facilities.

Although this study was designed to measure the impact of personnel training on animal welfare measures, a number of confounding variables within the methodology may have also resulted in the observed welfare changes. High levels of staff turnover is an issue throughout the meat industry (Grey, 1999) and it was noted in this study that some stock people observed during post-training visits were not present during the pre-T visit and did not attend welfare training. It was not possible to determine whether these stock people received any specific training either from their peers or via the AWO trained management, and the changes observed in animal behaviour and HAI may have been due to individual staff differences (in skill, experience, attitude etc.) rather than the training program. There was no turnover within the management personnel. Although high staff turnover is a reality for the meat industry (and therefore the results from this study may represent the actuality of the impact of staff training on animal welfare in commercial plants) this leads to difficulties in understanding whether training might bring about change through a direct influence on operatives handing animals or by cascading information and 'best practice' to staff across time, or be via influencing managers.
The new stun box installed in plant C1 does not allow a comparison between the pre-training visit and the 6 months post training visit. Therefore it cannot be determined if changes in the stunning were as a result of training. All observations took place 'in person' i.e. the stockpeople were directly observed. There is strong evidence that the physical presence of an observer will alter the behaviour of processing plant personnel who improve their performance during the observation, but this improvement is transient, and normal practice resumes when the observation period

ends (Grandin, 2010a). It is possible that the improvements seen in this study were a result of this observation effect rather than due to the training.

Previous experience and genetic factors can affect the behaviour of livestock during handling (Grandin, 1993), this study was conducted during ‘normal’ operation of the plants, therefore there was no control over the procurement of cattle. There is the potential that a particularly agitated or calm batch of animals could have confounded the results. All the plants tended to slaughter specific types of animals on specific days, for example in plant C1, cull cows were slaughtered on day 2 while prime beef Aberdeen Angus were slaughtered on day 3. It is likely that the difference in temperament of these breeds (Tulloh, 1961) would have caused some day-to-day variation in scores. Day was included as a random factor in several of the statistical models to account for this daily variation.

There are numerous measures that can be used to assess cattle welfare and product quality (Losada-Espinosa et al., 2018) which may have been influenced by the training but were not included in the study due to lack of feasibility, appropriate equipment or time.

Animal welfare trained staff would have been working at each plant prior to the onset of the current study; EU legislation stipulates that slaughterhouses must appoint a ‘technically competent’ animal welfare officer, alongside this, all personnel handling and slaughter live animals must hold a ‘certificate of competence’ (CoC) (EC, 2009). Acquiring a CoC or animal welfare officer status requires the passing of an independent final exam, and it is expected that a level of training is required in order to do so.

It is hypothesised that introducing a comprehensive welfare training programme would have a greater positive effect on animal welfare measures in plants with a low level of prior training. This could be explored by repeating this study, perhaps in countries with less stringent welfare legislation.

3.6 Conclusions

The results from this study provide evidence that animal welfare training may play a role in objectively improving cattle welfare outcomes throughout pre-slaughter and slaughter processes. There were a number of limitations associated with the methodology of this study including confounding variables and therefore the changes reported cannot be explicitly attributed to the training program.

Compared to the changes reported in animal behaviour and HAI, changes observed with carcass bruising was more varied. This is likely due to the multifactorial causes of carcass bruising including transport and plant design.

Results were not consistent across all study plants therefore individual plant factors need to be considered when developing and implementing welfare training programmes.

Chapter 4. The effects of welfare training on bird welfare and carcass quality in two commercial poultry slaughter-plants.

This chapter has formed the basis for a scientific paper:

Wigham, E., Grist, A., Mullan, S., Wotton, S., & Butterworth, A. (2019). The Influence of Welfare Training on Bird Welfare and Carcass Quality in Two Commercial Poultry Primary Processing Plants. *Animals*, 9(8), 584.

4.1 Introduction

Results from the previous chapter suggest that comprehensive welfare training programmes have the capacity to improve some cattle welfare outcomes throughout the pre-slaughter and slaughter process. Compared to cattle, the commercial slaughter of poultry, especially in high-throughput plants is highly automated, with relatively little human-animal interactions.

The worldwide consumption and production of poultry meat is increasing; It is estimated that in 2018 global output reached 121.6 million tonnes, an increase of 1.4% on 2017 (FAO, 2018). In order to meet demands, tens of billions of broilers are slaughtered every year, and the welfare of these animals is a growing concern for the public (Velarde & Dalmau, 2012), retailers (Mench, 2008) and slaughter business operators (Wigham et al., 2018). Those involved with the routine killing of animals for food production have both an ethical obligation and the practical opportunity to minimise any associated suffering with each animal that is killed (Mellor & Littin, 2004).

From arrival to death, bird welfare can be affected by each process within a commercial slaughter facility. Table 4.1 is adapted from a recent EFSA report and highlights the main hazards associated with water bath stunning. Staff training is mentioned as a preventive measure for hazards including inappropriate shackling, pre-stun shocks, poor electrical contact, too short exposure time and inappropriate electrical parameters.

Table 4.1 Hazards associated with electrical water bath stunning, with relevant welfare consequences and preventive measures. (Adapted from EFSA, 2019)

Hazard	Hazard origin specification	Preventive measure/s for hazard
Inversion	Shackling	None
Shackling	Shackling is part of the method	None
Inappropriate shackling	- Lack of skilled operators, operator fatigue, rough handling during catching, crating and uncrating, fast line speed, size and design of the shackle inappropriate for the bird size, force applied during shackling	Staff training Staff rotation Appropriate number of people shackling to match the line speed Shackle carefully Size and design of shackle appropriate for bird sizes Stun the birds before shackling Kill injured birds before shackling
Drops, curves and inclination of shackle line	Poor design, layout and construction of shackle line	Redesign shackle line to avoid these hazards
Pre-stun shocks	Rough handling of birds during shackling, shackling of birds with broken or dislocated wings; absence of breast comfort plates, inappropriate shackle size, inappropriate positioning of the water bath in relation to the shackle line and/or bird size, wing flapping at the entrance to the water bath, overflow of electrified water at the entrance to the water bath, lack of an electrically isolated entry ramp	Staff training Gentle shackling of birds No shackling of birds with broken or dislocated wings Use breast comfort plates and other measures to minimize wing flapping Use appropriate shackle size Position the water bath according to the size and species Avoid overflow of the water at the entrance Implement measures such as electrically isolated entry ramp to prevent wings making contact with water prior to immersion of the head
Poor electrical contact	Inappropriate shackling practices (e.g. shackling of small/underweight birds, shackling by one leg); poor or intermittent contact between shackles and earth bar due to incorrect positioning and dirtiness; shackles inappropriate for the size of the birds; dirty and dry shackles	Staff training Position the earth bar correctly and clean it regularly to maintain good electrical contact with the shackle Use shackles appropriate for the size of birds Clean the shackles using proper detergents Wet shackles before hanging birds

Too short exposure time	Lack of skilled operators, high throughput rate in a multiple birds water bath stunning	Staff training Reduce throughput rate to one appropriate for the electrical stunning parameters
Inappropriate electrical parameters	Wrong choice of electrical parameters or equipment; poor or lack of calibration; voltage/current applied is too low; frequency applied is too high for the amount of current delivered; lack of skilled operators; lack of monitoring of stun quality; lack of adjustment of the settings to meet the requirements	Use parameters appropriate for the current frequency and waveforms Ensure the voltage is sufficient to deliver minimum current to each bird in the water bath Regular calibration and maintenance of the equipment Staff training Monitor stun quality routinely and adjust the equipment accordingly
Inability to deliver minimum current to all the birds	Method incapable of coping with biological variations among birds	Group birds to be as homogeneous as possible Set electrical parameters that allow each bird to receive minimum current required Change the method

Producing high quality poultry meat on a commercial level requires a multi-factorial approach (Petracci et al., 2010; Solomon et al., 1998) there are well documented associations between bird welfare during these pre-slaughter processes and carcass quality (Mir et al., 2017; Petracci et al., 2010). For example, violent wing flapping in shackled birds may be viewed as an index of discomfort (Sparrey & Kettlewell, 1994). At the point of shackling, wing flapping is associated with rough handling and compression of the birds' hock due to tight fitting shackles (Gregory & Bell, 1987; Sparrey & Kettlewell, 1994). Violent wing flapping can also occur as a result of pre-stun shocks when birds enter the water bath stunner, (Terlouw et al., 2008) (a painful electric shock occurring when any part of the bird makes contact with electrically-live water bath prior to head entry)(Sparrey & Kettlewell, 1994). This flapping behaviour is associated with quality defects such as red wing tips (Gregory et al., 1989), broken wings, and wing haemorrhages (Lambooij et al., 2010; Rao et al., 2013). These conditions can lead to product downgrading, and thus can be economically significant for slaughter business operators (Barker, 2006).
Similarly, poor neck cutting has both welfare and product quality consequences. Inadequate neck cutting can result in birds regaining consciousness during bleeding. Ideally the cut should severe all major blood vessels in the neck of the bird (EFSA,

2004) particularly the two carotid arteries which supply oxygenated blood to the brain (Gregory & Wotton, 1986; Raj et al., 2006). Poor cutting may lead to poor bleed out, resulting in residual blood in carcass pygostyles, shoulders (Gregory & Wilkins, 1989) and wings (Lambooij et al., 1999) which appear as haemorrhages post plucking. It should be noted that rough handling of birds by slaughterhouse operators during any pre-slaughter activity has links to product quality defects, such as shoulder and wing haemorrhages (Kannan et al., 1997b), broken wings (Kittelsen et al., 2015) and bruised thighs (Raj, 2004), all of which are a cause of pain and suffering in live birds.

There is evidence that animal welfare training has the capacity to improve animal welfare on farm (Coleman & Hemsworth, 2014a). It has been suggested that such training may also improve the welfare of broilers at slaughter (Jacobs et al., 2017) thus having the potential for improved carcass quality, however there is a lack of published evidence of such effects. This study aims to gain an understanding of the influence that the introduction of a welfare training course for abattoir staff may have on bird welfare and product quality in commercial poultry slaughter facilities, an understanding of which may benefit the development and targeting of future welfare training courses and encourage the uptake of welfare training in the poultry slaughter industry. To the author's knowledge, this is the first study to outline the effects of staff training in such an environment using some animal-based measures.

4.2 Development of methods

4.2.1 Development of welfare assessment

As is the case for cattle (see section 3.2.1) a multi-criteria welfare assessment is required to allow for an overview of broiler welfare during slaughter operations. Few studies have focused on broiler welfare risks during multiple different operational stages in the slaughterhouse. Therefore, a combined approach using review and summarisation of the scientific literature, alongside expert opinion elicitation and scoping visits to the processing plants involved in the study, was used in the development of a welfare assessment protocol, with the aim of identifying potential welfare risks occurring during the consecutive stages of pre-slaughter and slaughter operations.

The welfare outcome measures considered for inclusion in the assessment were decided upon based on the same factors as for the cattle welfare assessment (see section 3.2.1).

The measures for use in poultry slaughterhouses and the location in the slaughterhouse of data collection is displayed in Table 4.2. The rationale for their selection is presented in the subsequent sections.

Table 4.2 Welfare assessment measures to be used in poultry slaughterhouses and the location of the observations.

Measures to be included in the assessment protocol	Location of data collection
Panting	Lairage
Environmental temperature and humidity	Lairage
Vigorous flapping on the shackle line	Hang-on
Single leg shackling	Hang-on
Pre-stun shocks	Entry to water bath stunner
Current reading from poultry stun monitor	Water bath stunner
Number of carotid arteries severed	Post neck cut

4.2.1.1 Lairage welfare measures

Once birds contained in the crates or drawers have been unloaded from the lorry at the processing plant, they are placed in stacks in the lairage.

Thermal challenge, and in particular heat stress is a major welfare risk to broiler chickens during lairaging (Warriss et al., 1999). To assess for evidence of heat stress, birds contained in crate or drawers should be observed for the presence of panting (open mouthed, rapid breathing). Panting is a behavioural response to heat stress, and can also reflect other discomforts or stressors, such as pain (EFSA, 2011). Both environmental temperature and relative humidity can affect the temperature inside the crates or drawers and the position of a crate/drawer within a stack can influence its internal temperature (Quinn et al., 1998) therefore lairage temperature and humidity should be carefully monitored by slaughter facilities.

4.2.1.2 Shackling welfare measures

To allow for electrical stunning, birds are inverted and hung by both legs on shackles. Shackling is carried out by a team of operatives (Figure 4.1). Improper or rough handling during this process has a negative impact on bird welfare (Kannan et al., 1997b) and is associated with compromised product quality (Jones et al., 1998).

4.2.1.2.a Wing Flapping

Violent wing flapping in shackled birds may be viewed as an index of discomfort (Sparrey & Kettlewell, 1994). At the point of shackling, wing flapping is associated with rough handling and compression of the birds' hock due to tight fitting shackles (Gregory & Bell, 1987; Sparrey & Kettlewell, 1994) and thus constitutes an important animal based measure of welfare.

4.2.1.2.b Single leg shackling

Birds shackled by one leg are likely to experience greater shackling force, leading to increased levels of pain and discomfort (Gentle & Tilston, 2000). The increased electrical resistance produced by a single contact with the earthed shackle also increases the risk of a bird not receiving sufficient current in a water bath for an effective stun (Steve Wotton, personal communication). Therefore, to minimise risks to welfare, care should be taken by operatives to shackle all birds by both legs.

Figure 4.1 Operator shackling birds in plant P1.

4.2.1.3 Water bath entry assessment

4.2.1.3.a Pre-Stun Shocks

Once shackled, bids are conveyed to a water bath stunner. Should any part of the bird make contact with the live water prior to head entry, a painful pre-stun shock (PSS) can occur (Rao et al., 2013). PSS can be identified by multiple, separate contractions in response to electrical stimulation (Rao et al., 2013). An increased reaction to PSS may induce wing flapping and consequently the head of the bird may partially or completely miss the water bath (Terlouw et al., 2008).

4.2.1.4 Stun parameter assessment

Effective stunning within the water bath requires that birds are immediately rendered unconscious and insensible until death occurs through blood loss at slaughter or the induction of a cardiac arrest by the stunning current, thereby protecting the animals from avoidable pain, fear, and excessive distress (Hindle et al., 2010).

In order to comply with Annex I of EC regulation (1099/2009) EU slaughterhouses must stun chickens using the minimum current outlined in

Table 4.3 (EC, 2009). However, Raj et al. (2006), measured the electroencephalogram (brain electrical activity) of individual broilers during stunning with sine wave AC current, which resulted in a proposal for changes to the previously accepted current / frequency levels recommendations (
Table 4.3). An ineffective stun can result in birds being conscious and sensible, yet in a state of tonic immobility, during neck cutting (Shields & Raj, 2010).

A factory calibrated poultry stun monitor (Figure 4.2) can be used to estimate the current being passed through each bird along with dwell time within the water bath.

Figure 4.2 Poultry Stun Monitor (PSM - AGL Consultancy Ltd).

Table 4.3 Minimum water bath stunning currents and electrical frequency.

Current per bird	Frequency (Hz) EC Regulation 1099/2009	Frequency (Hz) Raj et al. (2006)
100mA	<200 Hz	Up to 200Hz
150mA	200-400Hz	201-600Hz
200mA	400-1500Hz	601-800Hz
Not recommended		800Hz or more

4.2.1.5 Neck cutting assessment

Inadequate neck cutting can result in birds regaining consciousness during bleeding. Ideally the cut should sever all major blood vessels in the neck of the bird (EFSA, 2004), and most particularly the two carotid arteries which supply oxygenated blood to the brain (Gregory & Wotton, 1986; Raj et al., 2006).

4.2.2 Development of product quality assessment

A product quality assessment protocol was developed with the aim of assessing six aspects of carcass quality on the production line which are indicative of bird welfare conditions. Prior to the onset of the product quality assessments, a scoping visit was carried out in each processing plant to establish appropriate observation points, allowing for access to the carcasses without disrupting production or compromising meat hygiene.

4.2.2.1 Review of measures included in the protocol

The carcass quality measures used in the assessment protocol and their association with animal welfare are presented in the following sections.

4.2.2.1.a Red Pygostyles

Residual blood in the pygostyles of broiler carcasses is indictive of poor bleeding (Gregory & Wilkins, 1989). The effectiveness of bleed out can be affected by the quality of the neck cut (including which vessels are severed (Gregory & Wotton, 1986)), dwell time in the water bath and physical and electrical stimulation post neck cut (Steve Wotton, personal communication).

4.2.2.1.b Shoulder haemorrhage

Haemorrhaging around the shoulder joint of broiler carcasses can have a number of origins (Kranen et al., 1996) including rough pre-slaughter handling (Kannan et al., 1997a), poor bleeding (Gregory & Wilkins, 1989), stun parameters (Wilkins et al., 1999) and induction of ventricular fibrillation at stunning (Gregory & Wilkins, 1989).

4.2.2.1.c Red Wing tips

Wing tip haemorrhage (red wing tips) commonly occurs as a result of violent wing flapping when birds are inverted (Gregory et al., 1989) and has been associated with PSS (Asif, 2009). Gregory and Wilkins (1989) also report an increased incidence of red wing tips when birds experience ventricular fibrillation during stunning.

4.2.2.1.d Wing Haemorrhage

As with shoulder haemorrhage, haemorrhage within the wing tissue can have numerous origins (Kranen et al., 1996) including rough pre-slaughter handling (Kannan et al., 1997a), wing flapping and PSS (Asif, 2009). Poor bleeding can lead to engorged wing veins, which then rupture during the plucking process, leading to wing haemorrhage (Lambooij et al., 1999).

4.2.2.1.e Broken Wings

Wing fractures are more likely to occur during pre-slaughter handling in slaughterhouses compared to on-farm handling, primarily during container evacuation prior to stunning (Kittelsen et al., 2015). PSS (Rao et al., 2013) and violent flapping (Gregory et al., 1989; Lambooij et al., 2010) are also associated with an increased incidence of broken wings.

Wing breaks in a conscious bird are a cause of pain and suffering, however, breaks can also occur in unconscious or dead birds, commonly as the result of the plucking process, which is not a cause of concern for bird welfare. Whether the damage occurred prior or post slaughter can be distinguished by the presence of associated haemorrhage. The bleeding process voids the majority of blood from the carcass, therefore, if the damage is due to machinery there is no associated haemorrhage.

4.2.2.1.f Thigh bruising

Bruising of the thigh muscle can be the result of rough handling during catching on farm and in the slaughterhouse, where it can be caused by ill-fitting shackles and poor shackling technique (Raj, 2004), for example, when handlers apply too much pressure to the thighs at hang-on (Grandin, 2015)

4.3 Methods

4.3.1 Recruitment of processing plants

Two primary processing plants were involved in the study, one situated in Costa Rica (processing plant P1) and one in the UK (processing plant P2). Both facilities used electrical water bath stunning. Processing plant P1 operated two shifts whilst processing plant P2 operated one shift. Their individual characteristics can be found in Table 4.4.

Table 4.4 Characteristics of the poultry plants involved in the study.

Plant	P1	P2
Processing speed (birds per hour)	10500	10400
Processing times	1900-1000	0600-1600
Weight of birds slaughtered(kg)	1.3-3	1.2-2.9
Breed of birds slaughtered	Ross/Cobb mix	Ross
Maximum bird transport time (h)	4	3
Birds containment	Crates	Drawers
Neck cut method	Simmonds automatic neck cutter	Simmonds automatic neck cutter
Certified Halal	No	Yes

4.3.2 Welfare Assessment Timeline

The study took place between January 2018 and January 2019.

Each primary processing plant was assessed on three occasions: once prior to training (pre-T, two months prior to training at plant P1 and one week prior to training at plant P2); once immediately post-training (post-T, assessment commencing the day after training was completed) and once exactly six months after training (6mpost-T). Each assessment visit lasted three days and the welfare assessment was repeated on each day (Figure 4.3). Due to the potential to disrupt production, the stun parameters and neck cut were only assessed on day one of each visit. The assessments were carried out on the same days of the week, and at the same time of day during each visit. Plant management were aware that the assessments were taking place. Although operatives were not specifically told that welfare assessments were being undertaken, they were aware that they were being observed.

Figure 4.3 Outline of study.

The full protocol and recording sheets can be found in Appendix 6.

4.3.3 Training

Both primary processing plants received the same training programme (with the exception of legislative information which was country specific). The training was based on the Poultry Welfare Officer (PWO) training course run by the University of Bristol which has been designed to deliver continued professional development to the meat industry and provides individuals with the technical competence to achieve Animal Welfare Officer (AWO) status in poultry slaughter-plants.

The courses were delivered by an experienced trainer from AWO Training Langford (University of Bristol). Plant management received a two-day comprehensive classroom-based training programme which covered the following topics; legislation, catching, transportation, lairaging, emergency slaughter, hang-on, effective stunning, influence of welfare on product quality and poultry slaughter. The training sessions consisted of lectures interspersed with group discussions and quizzes (A full list of the topics covered in the course are given in Appendix 7.). A total of 26 management personnel attended the training from processing plant P1 and 11 management personnel from processing plant P2 (The greater number of attendees from P1 is to account for the two-shift system run by this plant.).

Operatives, including those responsible for lairaging, shackling and neck cutting of live birds, received a 20-minute group training session delivered by AWO Training Langford (University of Bristol) consisting of an interactive, multi-media-based lecture outlining 'better practice' in bird handling, shackling technique and neck cutting. All operatives employed by the plants at the time of the study received training (including staff working on both shifts in plant P1). Training for operatives was conducted prior to the start of their shift.

4.3.4 Welfare assessment protocol

4.3.4.1 <u>Assessment of Lairaging</u>

Birds in the lairage of processing plant P1 were contained in plastic transport crates while those in processing plant P2 were contained in an Anglia Autoflow Easyload Drawer System. Twenty crates/drawers were scored for the presence of panting birds. Due to the difficulty in observing every individual bird within drawers or crates without disturbing the animals, a drawer or crate was scored 'positive' (+ve) for heat stress if one or more birds which it contained, was observed panting.

In both processing plants the crates/drawers were stored in stacks, 7 crates/drawers were observed at the top of stacks, 7 at the bottom and 6 in the middle. Stacks were observed in different areas of the lairage, however capacity to do this varied depending on the number of stacks present at the time of sampling.

The daily environmental temperature and relative humidity of the lairage were measured using a Kestrel 4000 Pocket Weather Tracker prior to the start of observations. At plant P1 observations commenced at 1930h. At plant P2 observations commenced at 0930h.

4.3.4.2 Assessment of Shackling

Each operator hanging birds in the shackling area was observed handling 100 birds. The number of birds vigorously flapping (prolonged, >2s, bout of rapid wing flapping) immediately after the hang-on operator completely removed both hands from the bird was recorded at each operator position along with the number of birds hung by one leg. The operator shackling birds closest to the water bath stunner was deemed as working at position 1 with each successive operator occupying subsequent positions. Prior to entering the water bath, birds were shackled for a time ranging 16 to 9 seconds in plant P1 and 27 to 20 seconds in plant P2.

4.3.4.3 Assessment of water bath entry

The entry of 500 birds into the electrical water bath stunner was assessed for PSS. The birds were scored based on the protocol described by Rao et al. (2013).

- Score 0 = an uninterrupted entry into the water bath where only a single contraction of the skeletal muscles occurred.
- Score 1 = more than one separate contraction in response to electrical stimulation.
- Score 2 = the bird lifts its head and flies the first stage of the water bath.

4.3.4.4 Assessment of stun parameters

A factory calibrated poultry stun monitor (PSM – AGL Consultancy Ltd) was used to measure the True RMS- (root mean square) current being applied to a known resistor (1000 Ω) in the water bath stunner. The PSM was hung on the shackles at the shackling point and passed through the bath at the operating line speed. This was repeated six times during normal production i.e. with birds present in the water bath.

The frequency and voltage setting of the water bath was not measured, however, the programmed setting on the stunner control panel was noted.

4.3.4.5 Assessment of neck cutting

Fifty birds were selected at random during the bleeding process and removed from the line. Blunt dissection of the neck was carried out to allow a visual examination of the carotid arteries on each side of the neck. A record was made of whether these vessels were intact or severed.

4.3.5 Product quality assessment protocol

The product quality assessment was undertaken immediately after completion of the welfare assessment. All external scoring (carcass quality assessment) was carried out by the same individual (EW) using a subjective comparison against photographic standards (Barker, 2006) (see Appendix 8). Two-hundred carcasses were assessed for each carcass quality characteristic. As the inspection took place on the moving production line, a different set of carcasses were assessed for each characteristic.

Following automated scalding and plucking, and whilst still on the primary processing shackle line, carcasses were scored for external quality. The presence of broken wings with an associated haemorrhage and leg bruising was noted (0 or 1). Due to the potential of wings to be broken by the plucking process, which is not a concern for welfare, wings were only scored as broken if the damage was associated with a haemorrhage as this indicates that the damaged occurred pre-slaughter. Red pygostyles were scored on a scale from 0 (no bruising) to 2 (severe bruising) and Red wing tips, shoulder haemorrhage and wing haemorrhage, were all scored on a scale from 0 (no damage) to 3 (severe damage).

For each quality measure, with the exception of leg bruising, the carcass was given an overall score. If there was a discrepancy between the wing scores (right & left) of an individual carcass, the overall score would be the higher of the two e.g. if one wing of an individual carcass scored 0 for the presence of red wing tips, while the other wing scored 2, the carcass score, would be 2. Carcasses were scored positive for broken wings if either one or both wings were broken. Scores of 2 and 3 represent levels of damage that result in carcass downgrading leading to economic losses for the processing plant (Lines et al., 2011).

Each leg received an individual score (rather than an overall carcass score). This is to account for the potential impact that one-leg catching techniques (whilst harvesting the birds from the farm) may have on the incidence of bruising.

Carcases were not scored if they were:

- Hanging by one leg.
- Uncut, therefore had not been bled.
- Macerated by the scalding or plucking process (occurring when the processing line stops whilst carcasses are in the scald tanks or plucking machine).

4.3.6 Statistical analysis

To assess the significance of the training events on animal welfare metrics, statistical analysis of the data collected and collated during the visits was performed using SPSS vs 24.0. Graphs were plotted using Microsoft Excel. Analysis was carried out separately for each primary processing plant. Results were deemed significant at $p \leq 0.05$ level.

The difference between visits on the number of crates/drawers containing panting birds was tested using the Kruskal-Wallis test. The relationship between environmental temperature, relative humidity and the number of crates/drawers containing panting birds was tested using Spearman's rank-order correlation. Whether training had an influence on operator shackling was investigated using a univariate general linear model (GLM). The dependent variable in the GLM was the number of birds observed vigorously flapping at each operator position against the fixed factors of the visit. Data from the three observation days of each visit were combined to give a total number of flapping birds at each operator position during each visit.

The difference between the visits in the percentage of birds flapping at three operator positions (Position 1, Position 3, Position 6) was calculated and the significance of this difference was investigated using an exact Chi square test.
Kendall's tau-b statistic was used to test for an association between the number of birds receiving each Pre-Stun Shock score during different visits (tested in pairs: pre-T – post T; pre-T – 6mpost-T; post-T – 6mpost-T). The daily counts were combined to give a total for each visit. The percentage of birds receiving shocks (categories PSS1 and PSS2 combined) and percentage of birds receiving severe shocks (PSS2) was calculated for each visit. The significance in the difference in percentage of birds receiving each type of shock between the visits was investigated using an exact Chi square test. To investigate differences in PSM readings between visits, a one-way ANOVA with Tukey post hoc analysis was performed. Due to small sample sizes (n=3), the effects of welfare training on effective neck cutting was assessed by a visual inspection of plots.

To assess the significance of the training events on product quality metrics, statistical analysis of the data collected and collated during the visits was performed using SPSS vs 24.0. Graphs were plotted using Microsoft Excel. Analysis was carried out separately for each primary processing plant. Results were deemed significant at $p \leq 0.05$ level.

For each product quality measurement daily score counts were combined to give a total score count for each assessment visit. To assess the difference between visits, a cross-tabulation of the number of birds in each quality outcome category broken down by visit was produced for each quality measure. Each table was tested for the association between the counts in each quality category and visit, by means of a Chi-square test, for binary outcomes measures, or by using Kendall's tau-b statistic for those with ordered three or four category outcomes. Visits were tested in pairs (pre-T – post T; pre-T – 6mpost-T; post-T – 6mpost-T). Exact statistics were calculated in all cases.

For quality measurements which were made on a scale of 0 to 2, or 0 to 3, levels 0 and 1 are considered to have no economic consequence but levels 2 and 3 will result in downgrading (Lines et al., 2011). For these scales the levels 0 and 1, and 2 and 3, (where applicable) were collapsed to give a binary variable signifying no economic consequence (0) or damage of economic consequence (1). In this way all outcomes measures become binary variables and therefore subjected to a secondary analysis using a Chi-squared test as described above.

4.4 Results

4.4.1 Lairaging

The percentage of crates/drawers containing panting birds out of the 60 observed each visit is shown in Figure 4.4. Temperature and relative humidity measurements are presented in Table 4.5.

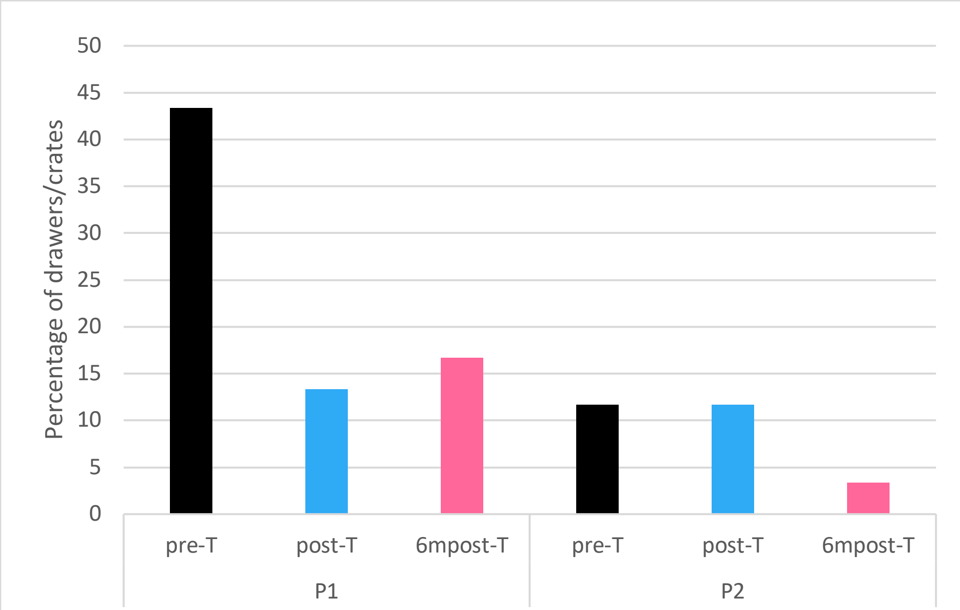


Figure 4.4 Percentage of crates/drawers containing panting birds n=60.

Table 4.5 The temperature (°C) and relative humidity (%) in the lairage as measured at the start of the welfare assessment.

		Temp °C/Relative humidity %		
Processing plant	**Visit**	**Day 1**	**Day 2**	**Day 3**
P1	pre-T	24.7/76.2	23.8/73	24.6/67.4
P1	post-T	25.2/56.5	23.6/58.9	24.7/61.9
P1	6mpost-T	32/94.2	23.2/89.6	25/72.8
P2	pre-T	25/66.5	23.3/64.9	24.3/74.9
P2	post-T	22.6/54.5	20.9/72.6	22.2/58
P2	6mpost-T	13.8/77.5	15.8/64.2	11.3/62.3

A Kruskal Wallis test showed no significant difference in the percentage of crates/drawers containing panting birds between the visits in both processing plants P1 ($\chi^2(2)$ =0.807, p=0.668) and P2 ($\chi^2(2)$ =1.272, p=0.529).

In processing plant P1 the percentage of crates containing panting birds was not significantly correlated with lairage temperature ($r_s(7) = 0.363$, $p = 0.337$) or relative humidity ($r_s(7) = -0.126$, $p = 0.747$). Sprinkler fans were in use in the lairage of processing plant P1, it was observed that the sprinkler was not in use during post-T.

Processing plant P2 also had no significant correlation between lairage temperature ($r_s(7) = 0.324$, p=0.396) or relative humidity ($r_s(7) = 0.184$, p = 0.636) with the percentage of drawers containing panting birds. In the lairage of processing plant P2, it was observed that trucks were often being washed in close vicinity to the stacks of drawers.

4.4.2 Hang on

Processing plant P1 had six operators shackling birds, processing plant P2 had seven operators shackling birds.

Operator position was a significant predictor of the number of birds vigorously flapping immediately after hang-on, in both processing plant P1 ($F_{(1,48)} = 91.244$, $p<0.0005$) and P2 ($F_{(1,57)} = 57.18$, $p<0.0005$).

Visit was not a significant predictor of the number of birds vigorously flapping immediately after hang-on in processing plant P1 ($F_{(1,48)} = 46.445$, p=0.634) or P2 ($F_{(1,57)} = 1.507$, p=0.230).

There was a significant Position * Visit interaction effect in processing plant P1 (($F_{(1,48)} = 10.067$, $p<0.0001$) but not in P2 ($F_{(1,57)} = 0.374$, p=0.69).

To further investigate the interaction effect in processing plant P1 the difference in percentage of birds flapping at each visit was investigated. To account for the effect of other factors which may influence flapping (e.g. number of birds already on the shackle line at the point of hanging) it was decided to investigate the impact of the visit at three operator positions: at the position closest to the water bath (Position 1); in the middle of the hang-on area (Position 3) and at the position furthest from the water bath (Position 6).

At each of the investigated positions, greater percentage of birds flapped after hang-on prior to training compared to post-training. Percentages were lower six months post-training compared to immediately after training (Figure 4.5).

A statistically significant difference in percentage of birds performing vigorous flapping was found in all post-training visits compared to pre-training values. The greatest differences were found at position 6 between pre-T and 6mpost-T in which there was a decrease of 58%.

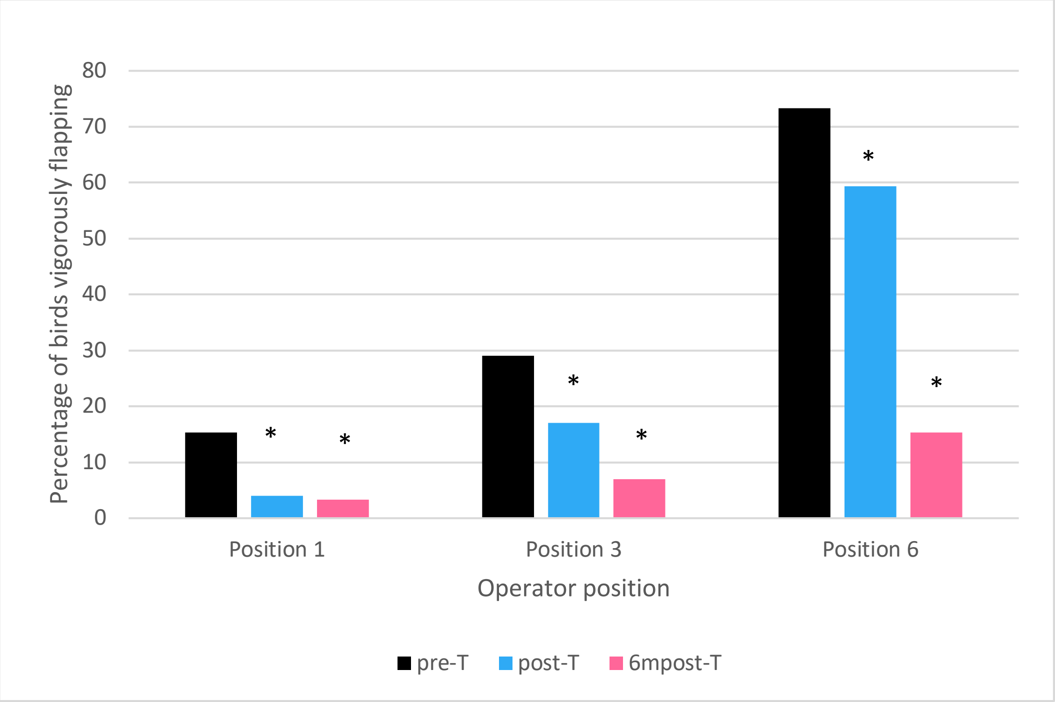


Figure 4.5 Percentage of birds vigorously flapping at hang on at different operator positions for each Visit (P1). *represents a statistically significant difference in percentage from pre-training visit ($p \leq 0.05$) calculated using the exact Chi-squared test.

4.4.3 Single leg shackling

The percentage of all birds observed at hang-on which were shackled by a single leg is presented in Table 4.6.

For processing plant P1, there was no significant difference (as calculated by exact Chi-squared) between the percentage of single-leg shackled birds during pre-T and post-T ($p=0.107$) or pre-T and 6mpost-T ($p=0.109$). There was a significant difference between the percentages in post-T and 6mpost-T ($p=0.001$).

No birds were observed being shackled by a single leg in any of the visits to processing plant P2.

Table 4.6 Percentage of birds (%) shackled by one leg during each visit.

Visit	Processing plant P1 (n=1800)	Processing plant P2 (n=2100)
pre-T	0.44%	0%
post-T	0.94%	0%
6mpost-T	0.11%	0%

4.4.4 Entering water bath

Kendall's tau-b statistic and p values for the associations between PSS scores and pairs of visits is given is Table 4.7. These indicate that there was a difference between every visit pair in the percentage of PSS scores in processing plant P1. Processing plant P2 showed a difference between pre-T and 6mpost-T and between post-T and 6mpost-T but not between pre-T and post-T.

Table 4.7 Results of exact Kendall's tau-b test of association between pre-stun shocks and different visits. Where p ≤ 0.05 the figures are shown in bold.

Visit	Processing plant P1	Processing plant P2
pre-T – post-T	**τb = - 0.388, p<0.005**	τb = - 0.009, p=0.605
pre-T – 6m-postT	**τb = - 0.172, p<0.005**	**τb = - 0.091, p<0.005**
post-T- 6m-postT	**τb = 0.24, p<0.005**	**τb = - 0.082, p<0.005**

In processing plant P1 there was a significant decrease of 35.3% in the percentage of birds receiving a pre-stun shock between pre-T and post-T, and a decrease of 15.9% between pre-T and 6mpost-T, however there was an increase of 19.4% between post-T and 6mpost-T. There was a decrease of 5.1% in the percentage of birds receiving severe shocks between pre-T and post-T and of 4.8% between post-T and 6mpost-T (Figure 4.6).

There were less marked differences in processing plant P2 with no significant change between the percentage of birds receiving PSS in pre-T and post-T. There was a significant decrease of 7.5% between pre-T and 6mpost-T and of 6.7% between post-T and 6mpost-T. Severe shocks were less effected, with a decrease of 0.6% between pre-T and post-T and no significant difference between pre-T and 6mpost-T (Figure 4.6).

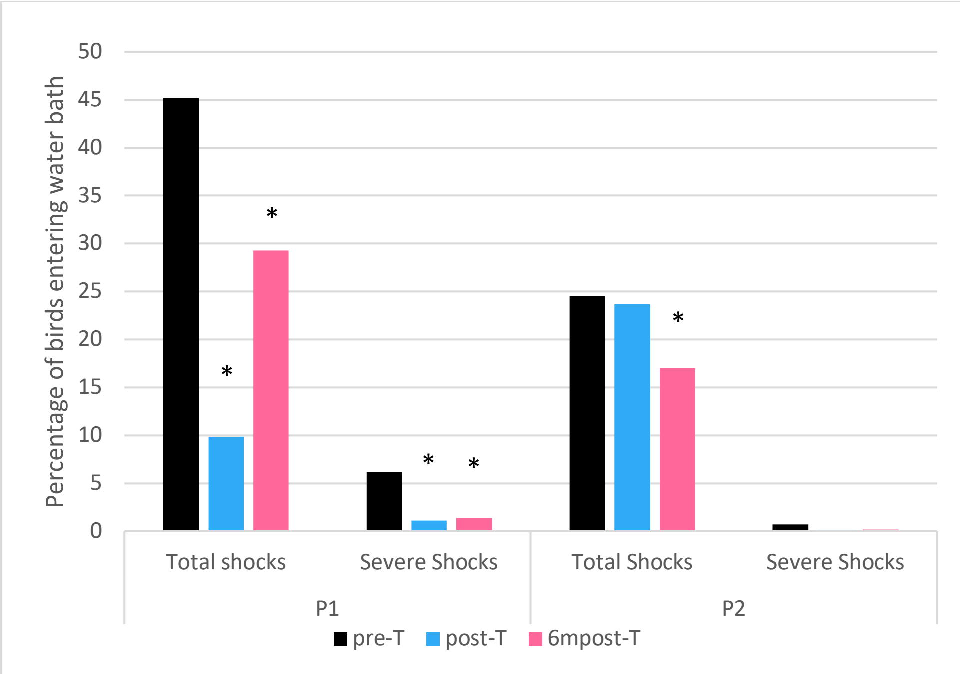


Figure 4.6 Percentage of birds receiving a pre-stun shock (score PSS1 and PSS2 combined) and severe pre-stun shocks (score PSS2) in both plants across each visit. * represents a statistically significant difference in percentage from pre-training visit ($p \leq 0.05$).

4.4.5 Stun parameters

During all visits the water bath in processing plant P1 was set at 400Hz and the water bath in processing plant P2 was set at 1500Hz. In plant P1 the water bath voltage was set at 35V at visit pre-T, 50V at visit post-T and 45V at visit 6mpost-T. In plant P2 the water bath voltage was set at 180V at visit pre-T, 200V at visit post-T and 180V at visit 6mpost-T.

The mean PSM True RMS reading in mA per bird for each visit at both processing plants is shown in Figure 4.7.

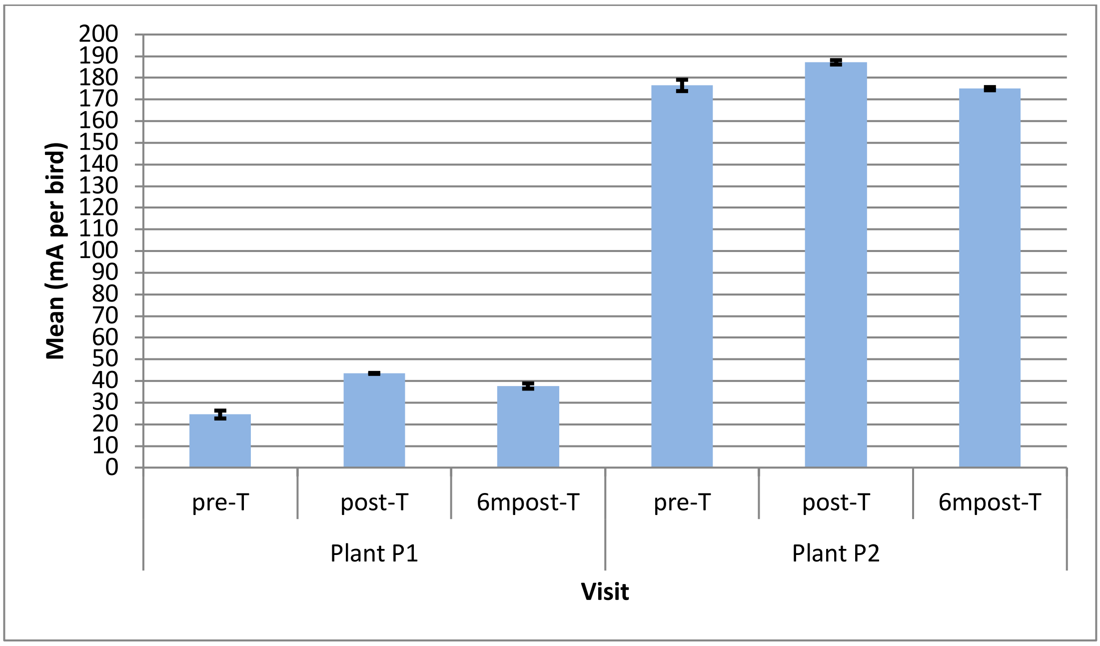


Figure 4.7 Mean PSM reading for each visit (n=6 per visit) at processing plant P1 and P2. Error bars correspond to the Standard Error (SE) of the mean.

The PSM current recorded in processing plant P1, showed a significant difference between visits, F (2,15) = 58.263 p<0.0005 (one-way ANOVA). Tukey *post hoc* analysis was performed, showing that water bath current recorded by the PSM was significantly increased from pre-T to post-T by 19.0 (95%CI 13.1 to 24.91) mA per bird, p<0.0005 and pre-T to 6mpost-T by 13.167 (95%CI 7.00 to 19.33) mA per bird, p=0.001. However, the current had decreased significantly between post-T and 6mpost-T by 5.83 (95%CI 1.86 to 9.81) mA per bird, p=0.011.

The PSM current recorded in processing plant P2, showed a significant difference between groups F (2,15) =15.697 p<0.0005 (one-way ANOVA). Tukey *post hoc* analysis was performed, showing that water bath current recorded by the PSM was significantly increased from pre-T to post-T by 10.67 (95%CI 2.23 to 19.100) mA per bird, p=0.018 but there was no significance between pre-T to 6mpost-T where it decreased by 1.5 (95%CI -9.93 to 6.932) mA per bird, p=0.849. However, the current had decreased significantly between post-T and 6mpost-T by 12.167 (95%CI 8.68 to 51.65) mA per bird, p<0.0005.

4.4.6 Neck cut

In processing plant P1, the percentage of birds with both carotids severed increased from pre-T to post-T and 6mpost-T. The percentage of birds with both carotids intact decreased to zero in post-T and 6mpost-T, while those with one severed carotid also decreased after pre-T (Figure 4.8).

All birds inspected across all three visits in processing plant P2 had both carotids severed after neck cutting (Figure 4.8).

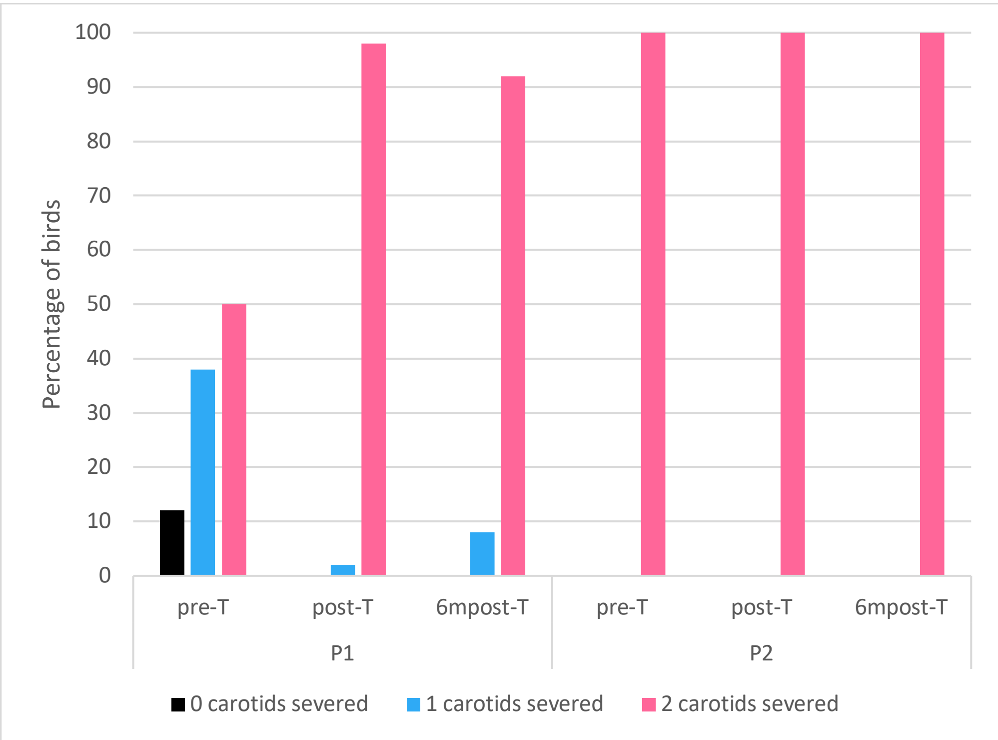


Figure 4.8 Percentage of birds per visit (n=50) categorised by carotid arteries severed after cutting.

4.4.7 Product Quality

In both processing plants, there was a significant decrease in the percentage of birds with broken wings observed in the post-training visits compared to the pre-training visit. (Table 4.8 and Figure 4.9).

Conversely, the number of bruised legs increased post-training. In processing plant P1 there was a significant increase in bruised legs of 3.9% between pre-T and post-T and then a further increase of 7.8% between post-T and 6mpost-T. There was a decrease of 7.7% in the percentage of birds with bruised legs in processing plant P2 between pre-T and post-T, however, in 6mpost-T, the levels of bruised legs was 3.8% greater than those recorded in pre-T (Table 4.8 and Figure 4.9).

Table 4.8 The test of association between the measurements and visits for the exact Chi-square test (broken wings and bruised legs) and exact Kendall's tau-b test (remaining measures). Where p ≤ 0.05 the figures are shown in bold.

Visit	broken wings		red pygostyles		shoulder haemorrhage	
	P1	***P2***	*P1*	***P2***	***P1***	***P2***
pre-T – post-T	**$\chi 2(1) = 4.964$, p=0.036**	**$\chi 2(1) = 8.673$ p=0.004**	**τb = -0.234 p<0.0005**	**τb = -0.137 p<0.0005**	τb = -0.04 p=0.161	τb = -0.031 p=0.283
pre-T – 6m-postT	**$\chi 2(1) = 4.964$, p=0.036**	**$\chi 2(1) = 20.779$ p=<0.0005**	**τb = -0.159 p<0.0005**	**τb = -0.93 p=0.001**	τb = 0.038 p=0.181	τb = -0.056 p=0.48
post-T- 6m-postT	$\chi 2(1) = 0$ p=1.0	$\chi 2(1) = 3.056$ p=0.111	**τb = 0.082 p=0.003**	τb = 0.046 p=0.092	**τb = 0.079 p=0.006**	τb = -0.026 p=0.359

Visit	bruised legs		red wing tips		wing haemorrhage	
	P1	***P2***	***P1***	***P2***	***P1***	***P2***
pre-T – post-T	**$\chi 2(1) = 13.616$ p<0.0005**	**$\chi 2(1) = 44.186$ p<0.0005**	**τb = -0.147 p<0.0005**	τb = -0.006 p=0.825	τb = -0.001 p=0.978	**τb = -0.166 p<0.0005**
pre-T – 6m-postT	**$\chi 2(1) = 82.328$ p<0.0005**	**$\chi 2(1) = 7.012$ p=0.01**	**τb = -0.19 p<0.0005**	**τb = 0.058 p=0.002**	τb = 0.02 p=0.471	**τb = -0.192 p<0.0005**
post-T- 6m-postT	**$\chi 2(1) = 31.605$ p<0.0005**	**$\chi 2(1) = 83.060$ p<0.0005**	**τb = -0.155 p<0.0005**	**τb = 0.079 p=0.003**	τb = 0.022 p=0.417	τb = -0.041 p=0.141

The tests of association between each visit, given in Table 4.8, indicate that there was a difference in the level of red pygostyles between all the visits, except for between post-T and 6mpost-T in processing plant P2. The percentage of carcasses with red pygostyles during each visit in given in Figure 4.10. In processing plant P1 levels of red pygostyles were lower in both post-training visits compared to pre-training levels, however there were no significant changes in processing plant P2. Percentage of carcasses with severe red pygostyles (quality category 2) during each visit is also given in Figure 4.10. In both processing plants P1 and P2 levels of economically significant red pygostyles were significantly lower in both post-training visits compared to pre-training levels.

The only significant change in the levels of shoulder haemorrhage was seen in processing plant P1 between post-T and 6mpost-T (Table 4.8) where there was an increase in percentage of 4% in overall bruising levels and an increase of 2.8% in economically significant bruising (Figure 4.10).

There were no significant differences in the level of red wing tips between pre-T and post-T in processing plant P2, however Table 4.8 suggests there were also differences across the remaining visits.

There was a decrease of 9% in the overall percentage of birds with red wing tips in processing plant P1 between pre-T and post-T, however, the levels increased during 6mpost-T, 5.5% greater than during pre-training observations (Figure 4.10). Processing plant P2 displayed a significant decrease in red wing tips post-training, with the decrease in 6mpost-T, 9% greater than in post-T.
Economically significant red wing tips (quality measurement scores 2 and 3) had significantly increased in both post-training visits compared to pre-training in processing plant P1. In processing plant P2 observed levels were significantly decreased in 6mpost-T compared to pre-T (12.7%) and post-T (14.3%) (Figure 4.10).

There was no significant change in the percentage of overall wing haemorrhage, or economically significant wing haemorrhage between any of the visits in processing plant P1 (Table 4.8, Figure 4.10). In processing plant P2, the percentage of both overall wing haemorrhage and economically significant wing haemorrhage was significantly lower in the post-training visits compared to the pre-training visit (Figure 4.10).

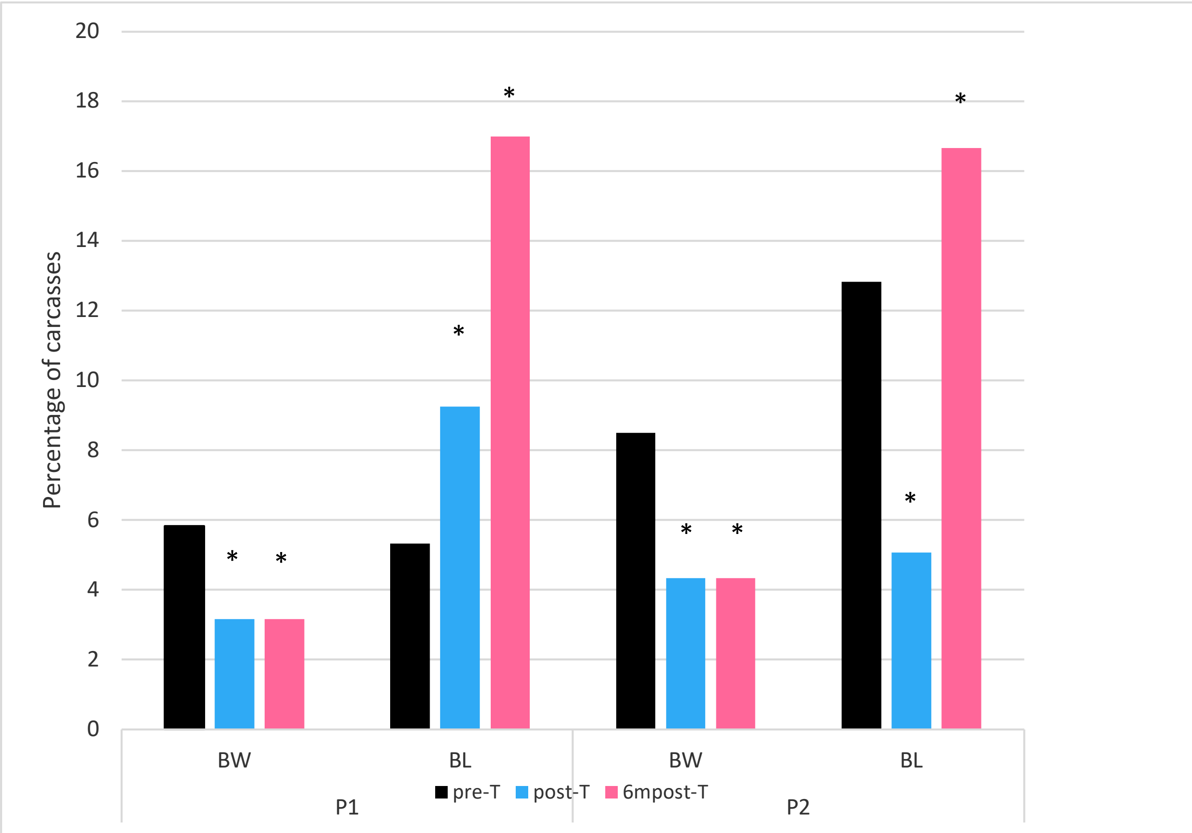


Figure 4.9 Percentage of carcasses with broken wings (BW) and bruised legs (BL). * represents a statistically significant difference in percentage from pre-training visit ($p \leq 0.05$) calculated using the exact Chi-squared test.

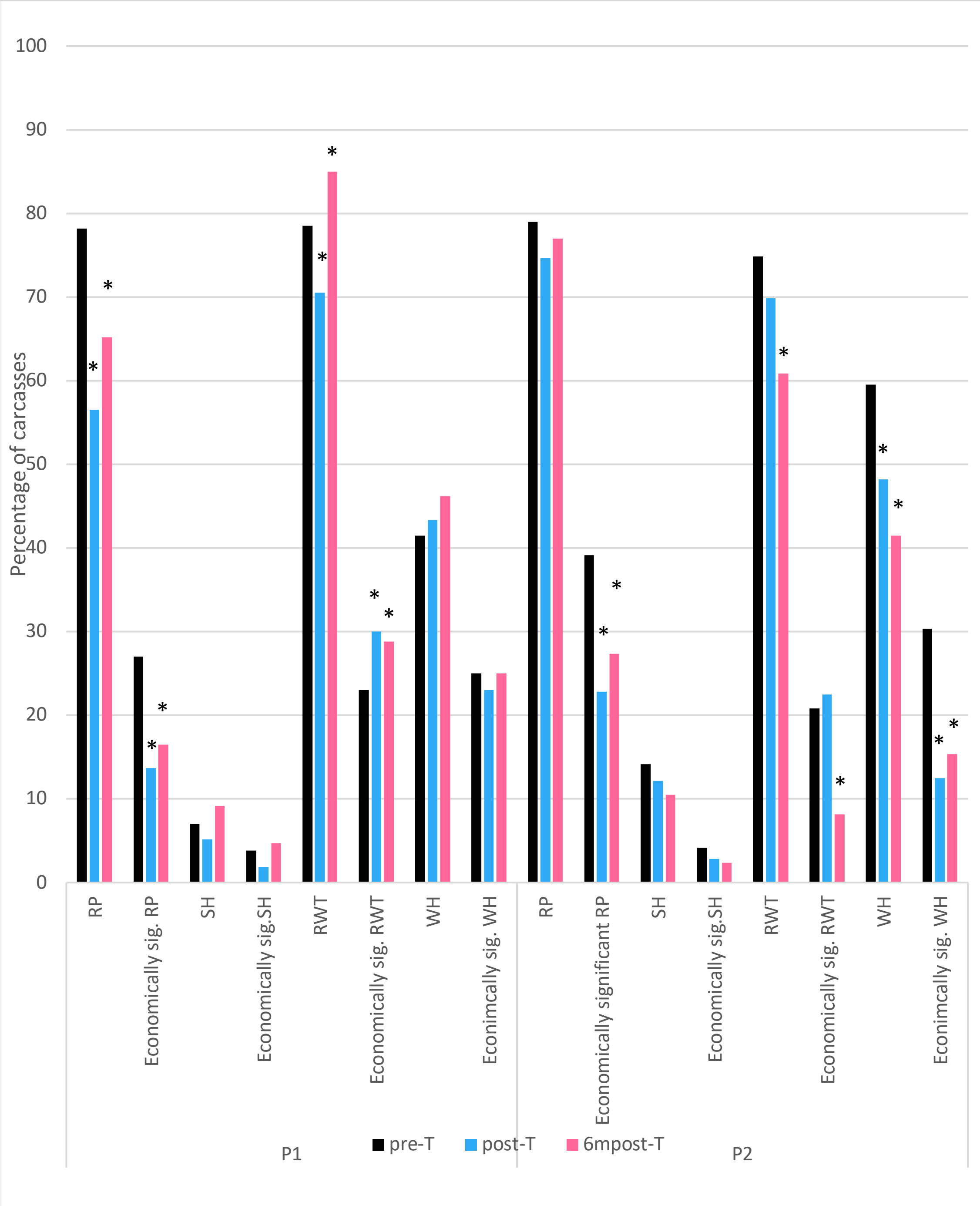


Figure 4.10 Percentage of carcasses with product quality defects (RP-red pygostyles; SH-shoulder haemorrhage; RWT – red wing tips; WH – wing haemorrhage) and economically significant quality defects (RP – quality assessment score 2; SH, RWT, WH – quality assessment score 2 and 3). * represents a statistically significant difference in percentage from pre-training visit ($p \leq 0.05$) calculated using the exact Chi-squared test.

4.5 Discussion

In this study, the effects of introducing a comprehensive welfare training programme for plant management, alongside role specific training for operatives, was evaluated for impact on animal welfare and product quality in two commercial poultry primary processing plants. To the author's knowledge, this is the first study to outline the effects of staff training in such an environment, the impact of which has been assessed using animal-based measures. Understanding the influence of welfare training in slaughterhouses in both developed and developing countries may benefit future education courses by enabling the tailoring and targeting of welfare training programmes, and by encouraging uptake within the slaughter industry.

4.5.1 Heat stress in the lairage

The number of birds experiencing heat stress in the lairage was the only welfare measure included in the study which did not significantly change between the visits to either processing plant. No correlation was found between the number of birds panting and environmental temperature or relative humidity. Quinn et al. (1998) concluded that due to the open nature of poultry lairages, and the activities which go on in them, many factors can influence the 'quality' of this environment. Although the general atmospheric temperature and ventilation can be controlled, it is challenging to elicit changes at a bird level (Quinn et al., 1998). Large ventilation fans were present in the lairage of both processing plants and were in operation during all visits. It was observed that the fans in the lairage of processing plant P1 were installed with a sprinkler function which was in use during pre-T and 6mpost-T but was switched off during post-T. It is possible that the training influenced this change and may provide an explanation for the lower relative humidity recorded during post-T; however this change did not result to an improvement in bird welfare. The PWO course provides detailed information on the importance of minimising heat stress in the lairage and the impact of ventilation fans in reducing environmental temperature and humidity. Given the results of this study suggesting that there is little significant correlation between environmental conditions and the number of birds suffering with heat stress, the training may benefit from including more detail on correct cage/drawer placement and appropriate stocking density (both of which can limit the incidence of heat stress (Grilli et al., 2015).

Humidity readings in processing plant P2 were higher than expected given the environmental temperature. It was recorded that lorries delivering modules of broilers to the plant were often being washed in close vicinity to the stacks of drawers, thus contributing to the high humidity readings.

A longer period in the lairage progressively increases bird body temperature. Warriss et al. (1999) reported that birds killed four hours after arrival at a processing plant had a temperature 0.6°C higher than those killed immediately on arrival, with an increase of 0.3°C occurring during the first hour. Although observations were taken at the same time during each day of observations, the period that the birds had been present in the lairage during the recordings was not known and would likely have differed between the visits.

High stocking densities within crates/drawers can increase environmental humidity due to water evaporation from the respiratory tract and skin of the birds, and through moisture in excreta (Nijdam et al., 2004), however the stocking density of the crates/drawers in this study was unknown, as to avoid disturbing the animals, the crates and drawers were not opened during the observations. Although an effort was made to observe as many birds as possible, it was impossible to view each one, and as such, the total number of birds could not be counted, and the recorded number of crates/drawers containing panting birds may not have been a true representation.

4.5.2 Wing flapping at shackling

Being inverted during shackling is a physically abnormal posture for chickens, and rough handling, inversion and shackling are practices that cause negative welfare consequences in birds such as pain and fear. A recent EFSA report suggested that inappropriate shackling can be prevented by training staff to handle birds with care and compassion, shackling birds gently by both legs, killing injured birds before shackling, by rotating staff at regular intervals to avoid boredom and fatigue and by using shackles that are appropriate to the species and size of the birds (EFSA, 2019). Information on each of these issues was presented in both the managerial and operator PWO training. Given the results of this study which suggest that training did have a positive impact in reducing wing flapping in plant P1 but not P2 implies either that training alone may not be sufficient to improve shackling technique, or the training provided was not fit-for purpose. No practical training was provided as part of the methodology of this study (all training was lecture based). Teaching practical skills is very different from teaching knowledge or theory and requires very precise instructions to enable the learner to follow the process and to repeat the skill (Hampton, 2002). There was also no opportunity for feedback to be given to operators on their post-training performance. Feedback is a vital component of the learning process (Nesbitt et al., 2015) and it may have been difficult for individuals to distinguish whether they are performing the right technique. Incorporating practical feedback when training operators on handling techniques would be a valuable inclusion to future welfare training programs.

It is unsurprising that operator position was a significant predictor on the number of birds vigorously flapping in both processing plants. Loss of visual contact with other birds is an important cause of flapping at shackling (Gregory & Bell, 1987). Operators working at the position furthest from the water bath (position 6 in plant P1 and position 7 in plant P2) are placing birds on an empty shackle line, therefore there is no calming effect of neighbouring birds. In contrast, those working at position 1, closest to the water bath, are hanging birds on a shackle line which is already almost full of birds. It was observed that in both plants, the operator furthest from the water bath was responsible for ensuring that all the crates/drawers were empty of birds before they entered the washing area. The number of birds in each crate/drawer was not uniform, and therefore, if surplus birds were present in the crates/drawers when they reached the final position, these operators were required to shackle multiple numbers of birds. It was often observed that this resulted in an increase in rough handling. When investigating the interaction effect of Position*Visit in processing plant P1, it was decided to further explore flapping at positions 1, 3 and 6 to assess the effects of training at the beginning, middle and end of the shackle and to account for effects of line fill on flapping. Position 6 had the biggest decrease in percentage of birds flapping from pre to post-training visits. This may be due to the higher baseline reading during pre-T, or perhaps the improved handling techniques of operators may elicit a greater effect in this position, due to the lack of the calming effect of other birds on the shackle line, previously described.

It is important to note that the operators rotated their position on the shackle line throughout a shift, therefore the individual working at position 1 on day one of a visit may be working at a different position when assessed on a subsequent day. Due to clothing and PPE requirements, it was not possible to identify individual operators, therefore the presence of particularly ‘rough’ or ‘good’ practice by an individual may have influenced the results.

Several factors may explain the lack of effect of visit on processing plant P2. Some are addressed in section 4.5.8, however, it should be noted that the training of operators in processing plant P1 was carried out using translation services. Although processing plant P2 was based in the UK, several of the operators responsible for shackling birds were EU nationals and spoke little or no English. Translation services were not available for this training, and therefore it is possible that these operators did not understand the training provided.

4.5.3 Single leg shackling

There was not a clear effect of training on the number of birds shackled by one leg. On further inspection of the data it was found that individual operators were often responsible for the majority of occurrences of single leg shackling during a visit. For example, post-T had the greatest percentage of birds shackled by a single leg in plant P1. On day 2 of this visit, the operator at position 2 hung 4 birds by a single leg, while during day 3 the operator at position 6 hung 6 birds by a single leg. As mentioned above it was not possible to determine if this was the same individual. In this case continual monitoring and re-training by the plant managerial team is required. During 6mpost-T there were no occurrences of an individual operator hanging more than one bird by a single leg per observation period, suggesting that re-training may have occurred or that particularly rough individuals had been removed from that role.

4.5.4 Pre-Stun Shocks

Pre-stun shocks usually occur when the leading wing or any part of the bird other than the head touches the water of the electrical water bath before the bird is effectivly stunned (Rao et al., 2013). Proper waterbath design, including a nonconductive entrance (e.g. an electrically isolated entry ramp), will help eliminate pre-stun shocks. The correct level of water (ensuring that birds are immersed up to the base of the wings) is another importance consideration in reducing PSS.

Training had a positive impact on the overall incidence of PSS, and the incidence of severe PSS in both processing plants. At the start of visit post-T the management team of plant P1 were eager to show the observer the new water bath entry ramp that had been constructed as a result of the knowledge gained during the training course. This likely explains the reduction in PSS. The observer did note however, that at the beginning of visit 6mpost-T, the ramp had been modified after the previous visit, which resulted in an increase in PSS. Although levels were significantly lower than those of pre-training, this highlights the importance of continually monitoring welfare measures during the pre-slaughter and slaughter process and manipulating the process accordingly.

Plant P2 did not install a new device at the entry to the water bath, however management did report that they had increased PSS monitoring as a result of the training and adjusted the height of the water bath in attempt to reduce PSS occurrence.

These results suggest that knowledge transfer delivered in the training resulted in an effective improvement in animal welfare. These changes did not require new behavioural techniques (such as that necessary for improved shackling) which may explain the more consistent results. This aligns with work by Grandin (2003) who suggests that changes which require new behavioural principles are less likely to be adopted by the slaughter industry than new equipment.

4.5.5 Stun parameters

If inappropriate electrical parameters are used in a stun bath there will be a failure in achieving epileptiform activity in the brain. This is caused by voltage that is too low to generate sufficient current to achieve an effective stun, frequency that is too high to cause immediate unconsciousness, or electrical resistance of the bird too high to prevent enough current flow through the brain to cause immediate unconsciousness (EFSA, 2019).

It is encouraging that the training resulted in a significant increase in the applied current per-bird in the water bath stunner, however, even post-training, both processing plants were not supplying sufficient current to effectively stun broilers (Raj et al., 2006). It is generally agreed that increased stunning currents can lead to downgrading of the final product, including increased breast muscle haemorrhages and bone fractures (Kranen et al., 1996; Sirri et al., 2017; Wilkins et al., 1998). This is not considered an animal welfare issue as birds are rendered unconscious immediately upon entry. However, associated product quality problems may result in stunning current being set too low, to reduce these downgrading conditions and thereby result in poor bird welfare (Berg & Raj, 2015). The frequency used in plant P2 is higher than that recommended by Raj et al. (2006), as this frequency was chosen in order to meet halal stunning requirements and is therefore unlikely to change as a result of the training.

The changes in stunning parameters suggest that knowledge transfer through training may have some impact in improving electrical parameters and therefore animal welfare, however commercial pressures (downgrading conditions or halal specifications) may be more of a priority for the plants involved in this study.

4.5.6 Neck cutting

Training resulted in a marked improvement in the quality of neck cutting in plant P1. During pre-T, six out of the sample of 50 birds had both carotids intact post neck cut. It is likely that these birds would have regained consciousness prior to the scalding process (Gregory & Wotton, 1986). However, it is possible that due to the low stunning currents used in plant P1, birds were electrically immobilised, rather than unconscious after exit from the water bath (Raj et al., 2006). All birds examined during the post-training visits had at least one carotid severed, and a far greater percentage had both arteries severed, reducing the welfare risk of birds regaining consciousness during bleeding. At plant P1 the observers were informed by managerial staff that the automatic neck cutters, previously set to sever the necks had been readjusted following information given during the training.

4.5.7 Product Quality

In this study, the effects of training on product quality were somewhat more varied than that of the welfare outcome measures. Incidences of broken wings and red pygostyles appeared to decrease post-training, while bruised legs and red wing tips increased. Producing high quality poultry meat at a commercial primary processing line requires a multi-factorial approach (Petracci et al., 2010). Although there is a well-documented link between bird welfare at slaughter and meat quality (Mir et al., 2017), carcass bruising can also be effected by other pre-slaughter factors, prior to arrival at the processing plant, such as catching and transportation (Cockram & Dulal, 2018). Hamdy et al. (1961) reported that approximately 90% of bruises found on broilers in American processing plants occur within the 13 hours prior to slaughtering. A more recent Canadian study found that 5.7% of broilers per load, arriving at the slaughterhouse had wing damage (Dulal, 2017). Jacobs et al. (2017) reported that the incidence of bruised wings tended to differ among different professional catching crews. Training catching crews in 'better practice' can improve carcass quality (Pilecco et al., 2013) however, this was beyond the scope of the current study.

Other factors, not necessarily associated with training, may have influenced results, for example bird factors such as age, sex and weight (Mayes, 1980), loading conditions (Jacobs et al., 2017), environmental conditions (Jacobs et al., 2017; Nijdam et al., 2004), time of day of transportation (Nijdam et al., 2004), length of transport time (Bianchi et al., 2005), and crate/drawer stocking density (Vinco et al., 2016) are all known to have effects on bruising and meat quality. These variables were not controlled by the methodology of this study.

It is unclear why bruising prevalence, especially regarding red wing tips and wing haemorrhage, differed in response to training between processing plant P1 and processing plant P2. Leg bruising may have increased as an unintended result of the training; although operators were told during their training birds should be handled gently, they were also informed that birds should be transferred to the shackle without delay. It is possible that operators may have therefore increased their speed of shackling resulting in poor handling techniques and too much pressure being transferred onto the legs either by the operator hands or by being placed too quickly into the shackle.

Wing flapping and PSS are associated with wing damage (Asif, 2009; Gregory et al., 1989). Results from this study suggest that training improved the incidence of flapping and PSS in processing plant P1, yet the percentage of birds with economically significant red wing tips increased. Although both welfare and product quality assessments occurred on the same day, due to the logistical constrains of working in a high throughput commercial facility, different individual birds were included in the welfare and product quality observations. There is a potential that the physical presence of an observer during the welfare assessments affects the behaviour of processing plant personnel who ‘improve their performance’ during the observation period, but revert back to normal practice when they are no longer being watched (Grandin, 2010a). This ‘Hawthorne effect’ (the alteration of behaviour by the subjects of a study due to their awareness of being observed) may have positively influenced the results of the welfare assessment, without effecting quality measurements.

The potential use of CCTV to assess the effects of training on welfare and quality and thus combatting the Hawthorne effect will be discussed in the next chapter.

There are measures of poultry meat quality that are known to be associated with bird welfare; conditions such as breast meat haemorrhage, meat pH, meat colour and water holding properties (Schwartzkopf-Genswein et al., 2012) which were not included in this study. These measures may have been affected by training, however, restricted access to the cutting rooms and the requirement to take measurements on a fast-moving production line meant that taking such measures was not possible.

4.5.8 Differences between plants

The variation in improvement between the processing plants may be attributed to several factors. Baseline measurements indicate that there was a higher standard of bird welfare prior to training in the UK processing plant when compared to that in

Costa Rica. The importance attributed to animal welfare varies between countries, due to differences in traditions, religion, education, perception and level of economic development and legislation (Koknaroglu & Akunal, 2013; Villarroel et al., 2001).

Legislative requirements regarding welfare at slaughter in Costa Rica and the UK differ. Slaughter facilities in the UK (England) must comply with The Welfare of Animals at the Time of Killing (England) Regulations 2015 (WATOK, 2015) and Council Regulation (EC) No. 1099/2009 on the protection of animal at the time of killing (EC, 2009). These regulations outline numerous welfare requirements, including minimum stunning currents, the requirement of the severing both carotid arteries at bleeding and the obligation to provide training to those handling live animals. The EU legislation also stipulates the requirement for a specifically qualified 'Animal Welfare Officers' in slaughterhouses. The Animal Welfare Officer is responsible for implementing animal welfare operating procedures and document action taken to improve animal welfare in the slaughterhouse. In contrast, the equivalent Costa Rican legislation (La Gaceta, 2013) provides only stunning current recommendations, and stipulates that only one carotid artery needs to be severed at neck cutting. There is also no requirement for an Animal Welfare Officer. However, the Costa Rican legislation does include the requirement that operators handling live birds require training. Such legislative discrepancies may provide some explanation of the differences in the baseline welfare measurements in this study, especially regarding stun parameters and neck cutting.

It is important to consider that in order to meet legislative requirements, both processing plants involved in this study had welfare training programmes in place prior to the onset of the visits. Two members of the management team at processing plant P2 has previously attended a University of Bristol, two-day comprehensive poultry welfare training course, however none of the other attendees had experience of a similar course.

It has been observed in Brazilian beef farms that training stockpeople regarding 'good practice' is associated with both better attitudes and behaviours towards animals (Ceballos et al., 2018). In this study, plant management, alongside stockpeople received training. Although the managerial staff within a slaughter facility rarely handle animals, their attitudes have a significant influence on the welfare conditions within a slaughterhouse (Grandin, 2018). Some of the welfare improvements in this study, for example, the reduction of vigorous wing flapping at shackling, are likely to be as a direct consequence of a stockperson behaviour change, others, such as increasing stun current in the water bath are likely to be implemented by managerial members of staff.

A number of measures included in this study for example, stun parameters, PSS and neck vessels severed, which although showed improvement immediately after training (post-T) did not maintain such improvements six months later (6mpost-T). Paranhos da Costa et al. (2012) reported the results of a supermarket initiative in which beef farmers were trained in animal welfare. The training programme resulted in a significant reduction in the percentage of downgraded carcasses due to bruising, however six months post-training there was an increased percentage of downgraded carcasses. Turnover of staff, where trained staff may have left the processing plant after training and been replaced with untrained staff was not recorded in this study and this may have influenced the long-term changes in welfare outcomes.

It should be noted that in this study, flapping at shackling in processing plant P1 did continue to significantly decline between post-T and 6mpost-T, suggesting that certain positive behaviours of stockpeople may have become routine, or had been regularly reinforced by management.

4.5.9 Methodological considerations

Several methodological considerations in this study have parallels with those discussed in the previous chapter (section 3.5.6).

The studied primary processing plants were to a great extent selected on availability and willingness to participate in the study. During the planning stage, two plants were chosen in Central America, however one withdrew from the study prior to the onset of data collection, and leading to the recruitment of the UK based plant. The small number of plants involved and the variation between them implies that this study might not give a complete picture of the effects of training in all poultry slaughter facilities.

Due to monetary and logistical constraints single visits were performed, each for three days. Results may have been biased by particular 'good' or 'bad' batches of birds. Catching, transport and weather conditions could not be controlled and may have all impacted on the results.

As previously mentioned in Chapter 3, high levels of staff turnover is an issue throughout the meat industry (Grey, 1999), again it is possible that some operators observed during post-training visits did not receive any welfare training and any changes of behaviour may be a result of individual differences rather than behaviour change as a result of receiving training.

It is challenging to distinguish whether the changes observed in regards to animal welfare and product quality were a result of the training or of the confounding variables reported above.

Recorded welfare measurements were selected based on an extensive literature search, expert opinion elicitation and scoping visits. It was imperative that observations did not interfere with normal production. Certain welfare assessment measures, which may have been influenced by the training, such as effective stunning were not able to be included in the protocol due to the limited access to the bleeding area in both plants.

The choice of sample size was based on convenience and feasibility of one observer performing both the welfare and product quality assessment protocol in a single day.

Sample sizes were lower for assessment of stun parameters and neck cutting due to the potential for disruption to the production line (through placing the stun meter on the line and removing cut birds from the line).

It is important to consider that in order to meet legislative requirements, (outlined in section 4.5.8) both processing plants involved in the study had welfare training programmes in place prior to the onset of the study. Two members of management at processing plant P2 has previously attended a University of Bristol, two-day comprehensive welfare training programme and may have implemented welfare changes (due to knowledge transfer) prior to the onset of the study.

4.6 Conclusions

In conclusion, our study supports the view that animal welfare training of stockpeople and managerial staff in commercial poultry primary processing plants has the potential to positively influence aspects of animal welfare and product quality. The methodology of this study does not allow for the influencing factor of the training (e.g. operator training or management training) to be pinpointed. The effect of confounding variables also has to be considered. Legislation, retailer specifications and individual plant culture also play an important role in maintaining high levels of bird welfare and should be considered by those delivering welfare education in the slaughter industry.

Further investigation is required to understand the reasons that the incidence of some negative quality measures increased post-training. The possible product quality effects of combining welfare training in plant with training for catching teams and others throughout the poultry production chain should be explored in future studies, however this was beyond the scope of the current project.

Chapter 5. The use of CCTV and remote video auditing to assess and improve animal welfare at slaughter.

Some of the information in this chapter was presented at an invited oral presentation at the Humane Slaughter Association seminar ‘Monitoring animal welfare at slaughter – CCTV and beyond’ in Castle Donnington, May 9th, 2018:

Wigham, E. Analysis of the use of CCTV data to monitor and improve slaughter plant welfare in the US – what can we learn from our American friends?

5.1 Introduction

5.1.1 General

The welfare assessment methods used in Chapter 3 and 4 were carried out ‘in person’. The physical presence of a researcher is likely to influence the behaviour of both the animals and the stockpeople being observed. Grandin (2010a) reported that, in her experience, slaughterhouse operators tended to ‘act good’ when being observed, therefore the results obtained may not be a true representation of welfare change. The use of CCTV with or without Remote Video Auditing (RVA) will reduce observer bias (FAWC, 2015).

The aim of this chapter is to discuss whether the systematic auditing of CCTV both by RVA and internally (by slaughter plant staff) has the capacity to enhance welfare monitoring and improve animal handling, stunning and slaughter within a slaughterhouse facility.

5.1.2 CCTV

The use of CCTV as a tool to monitor and improve animal welfare is strongly supported by retailers, and assurance schemes, and the issue of use of CCTV has recently been driven in the public domain by Non-Governmental Organisations (NGOs).

In July 2015 a public petition in the UK calling for mandatory CCTV in slaughterhouses with independent monitoring gathered over 112,000 signatures. In August 2017 DEFRA set out a proposal that would introduce mandatory CCTV recording in all live animal areas of registered slaughterhouses as an additional enforcement measure under the Animal Welfare Act 2006. The Mandatory Use of Closed-Circuit Television in Slaughterhouses (England) Regulations 2018, came into enforcement in England on the 5th November 2018. This legislation stipulates that all areas 'where live animals are present' must be covered by CCTV. Authorised officers (e.g. Official Veterinarians (OVs)) have unfettered access to both real-time and retrospective CCTV footage.

There are many reported benefits associated with the use of CCTV in a slaughter environment. An opinion on CCTV in slaughterhouses was published by the Farm Animal Welfare Committee (FAWC) in February 2015, and within this report, it is stated:

> *"CCTV offers a range of benefits in slaughterhouses for the observation and recording of real-time processes, for the recording of individual incidents, for contributing information to the auditing of animal welfare, for aiding the verification of slaughterhouse compliance with legislative and assurance or certification requirements and for the training of slaughterhouse staff"*

However, FAWC also highlighted a distinct limitation of CCTV:

> *"Consultation suggests that a particular limitation of CCTV is that it is rarely viewed or reviewed in a systematic, consistent and effective manner by the FBO or enforcement agencies. CCTV is only as effective as the viewing or review processes employed." (FAWC, 2015)*

The new legislation mandating CCTV means that the UK now has one of the most highly regulated slaughter industries within Europe, if not worldwide, however there is little set out about how some of the critical limitations of use and monitoring of CCTV will be addressed. It remains to be seen if routine CCTV monitoring of all live animal areas within a slaughter facility can feasibly be incorporated into the diverse roles of an OV without any compromise to *'in situ'* verification. Knowledge of the most effective methods of using the data generated by CCTV could be beneficial in the monitoring and improvement of animal welfare at slaughter.

5.1.3 Remote Video Auditing

For the purpose of this chapter, remote video auditing (RVA) refers to the auditing of CCTV footage by individuals or technology which is independent of the processing plant where the footage is collected. The majority of the time, this 'remote' auditing process also takes place at a different site, or in some cases, in a different country to the processing plant.

The primary purpose of RVA is to provide a non-biased audit service, and to give real-time feedback to processing plants. Temple Grandin is quoted as saying "RVA is a big step forward in animal welfare and animal handling practices. Instead of getting a snapshot once a year, we're providing snapshots all year round, with the objectivity of normal plant operations-versus a more controlled setting with live auditors on the ground." (Arrowsight, 2018). Grandin suggests that RVA itself encourages welfare improvement, however it could be argued that an understanding of ‘best practice’ is therefore required by both those being audited, and also by those undertaking the auditing to allow for such improvements. Consequently, welfare training is likely to play an important role in educating both stockpeople and auditors associated with CCTV to facilitate such change.

5.1.4 Arrowsight

There is currently one company known to provide RVA services for animal welfare measures in slaughterhouses: Arrowsight, Inc. is an American RVA company that has been auditing CCTV footage from slaughterhouses for over 13 years. CCTV footage from 125 North American slaughter-plants (not including farms) (see Table 5.1) is audited in Huntsville, Alabama, and clients include Cargill, Tyson, JBS, OSI and Maple Leaf Foods. Arrowsight has recently undergone a period of expansion, with footage from Australia, Germany and the UK also being remotely audited. The overall aim of the RVA service is to change operator behaviour, leading to an improvement in animal welfare and to an increase in product quality, profitability and food safety.

Table 5.1 Arrowsight's 2018 market share.

Species	Percentage of North American market from plants Audited by Arrowsight	Annual numbers of animals processed from plants audited by Arrowsight	Number of years auditing welfare by CCTV
Cattle	57%	18,309,000	13
Pigs	38%	43,500,000	7
Chickens	40%	3,640,000,000	3
Turkeys	68%	203,000,000	13

Alongside animal welfare, Arrowsight carries out a range of different audits throughout the healthcare and manufacturing sector. Reports from the healthcare field indicate a number of benefits of RVA including: increased compliance, an improvement in staff members' overall perception of patient safety (Pedersen et al., 2017), improved quality of patient care (Armellino et al., 2011), and greater employee engagement and collaboration (Armellino et al., 2018).

There is limited published literature on the impact of RVA on animal welfare in slaughter-plants. Edwards-Callaway (2017) describes anecdotal observations from slaughter facilities who have used RVA for several years, which report a significant improvement in animal handling audit scores, suggesting an improvement in employee behaviour.

Knowledge of the benefits and limitations of the use of CCTV and RVA to monitor and improve animal welfare at slaughter would be valuable when conducting future animal welfare assessments and would allow FBOs (Food Business Operators) and OVs to use the tool at its greatest capacity. Therefore, the aim of this chapter is to discuss the use of CCTV and RVA in commercial slaughter-plants and evaluate the potential for its use in monitoring and assessing animal welfare and welfare improvement measures, such as training.

5.2 Methods

In order to gain an understanding of the role of CCTV and RVA in assessing welfare in primary processing plants, the author spent one week at Arrowsight HQ in Huntsville Alabama, where the RVA process was observed. To allow for a comprehensive understanding of the process, numerous discussions with members of the Arrowsight team took place. This visit was followed by a three-day visit, to a large beef processing facility in Texas, which has been using Arrowsight's services for over seven years. The author carried out discussions with members of plant staff regarding the use of CCTV and RVA technology, its impact on animal welfare, and the potential for its use in assessing animal welfare improvement measures.

5.3 Report

5.3.1 The use of CCTV in a large American beef processing facility

5.3.1.1 Overview of Processing Plant and use of CCTV

The processing plant visited as part of this study belongs to a co-operative which operates several beef processing facilities in the USA. At the time of the visit, the Texan facility was slaughtering 5200 cattle a day (average 400 per hour), with the cattle mainly sourced from feedlots. The plant slaughters cattle from 6am-11pm daily Monday to Friday and every second Saturday. Two separate staff shifts operate per day.

Animals arrive at the facility throughout operating hours and are lairaged outdoors in large pens prior to ante-mortem inspection. Ante-mortem inspection is carried out by a United States Department of Agriculture (USDA) Veterinarian, after which the cattle are transferred into adjacent pens before being moved to the point of slaughter. Once ready for processing, cattle are moved in groups of 20 – 30 up a wide raceway or 'serpentine' towards a circular crowd pen. During this process the cattle are hosed with water by lairage staff to try to remove mud and faeces. The circular crowd pen is used to separate the cattle into single file, the animals then continue up the outdoor raceway before entering the plant, where they progress immediately onto a centre track conveyor restrainer. The animals are stunned using a pneumatic powered penetrating captive bolt gun. Shackles are placed on the animal's hind-leg once it is stunned, before it exits the restrainer, and it is subsequently hoisted. Three operators are responsible for bleeding, one operator makes the superficial thoracic cut, the second operator severs the major blood vessels close to the heart, while the third continually monitors all animals for signs of sensibility. The third operator has a cartridge powered captive bolt gun available should any signs of sensibility be observed.

All truck drivers and operators handling live animals receive at least one-hour of computer based, animal welfare training.

The presence of CCTV in slaughter-plants is not a legislative requirement in the USA, however this plant, as with most large facilities in the USA, has had a comprehensive CCTV system in place for 10+ years. This company have been working with Arrowsight for over seven years and uses RVA technology to audit humane handling and hygienic dressing (e.g. knife washing and sterilising).

CCTV did not cover all live animal areas, cameras in some lairage pens were out of order at the time of the visit, and parts of the serpentine race were classified as ‘blind’ spots.

Cameras were focused on areas deemed ‘high risk’ and this included the unloading area, live cattle washing area, the circular crowd pen, the entrance to the restrainer, the stunning and bleeding areas.

The plant CCTV is only routinely viewed (four times daily) by the plant Quality Assurance (QA) team. The USDA Veterinarian or other government officials do not have access. Retail auditors also do not have access to the CCTV footage, but they may request to view internal audit reports.

5.3.1.2 <u>The use of CCTV in plant</u>

[REDACTED DUE TO COMMERICALLY SENSITIVE INFORMATION]

5.3.1.3 The use of CCTV by Arrowsight

Arrowsight works as a vendor and therefore aim to provide a service, they do not act as a regulator of animal welfare at slaughter. Their clients consist of the Food Business Operator (FBO) and therefore audits are built around the information and data requested by the FBO.

[REDACTED DUE TO COMMERICALLY SENSITIVE INFORMATION]

5.3.1.4 **Training of Arrowsight auditors**

[REDACTED DUE TO COMMERICALLY SENSITIVE INFORMATION]

5.3.1.5 **Arrowsight reports**

[REDACTED DUE TO COMMERICALLY SENSITIVE INFORMATION]

5.3.1.6 The use of Arrowsight in plant

Arrowsight use the same camera views as the QA audit team of the Texan beef plant and audit the same measures, however they do not use live footage and audit a smaller number of animals (e.g. they audit 10 animals for goad use rather than 50). Arrowsight does not audit this facility on Saturdays, however, it does audit both shifts Monday to Friday. During the week prior to the author's plant visit, Arrowsight audited 1303 cattle during the first shift (across all measures) and 1292 during the second shift (across all measures).

All the beef processing facilities belonging to this company use Arrowsight technology, and they all use the same measures and criteria allowing for the direct comparison between different plants.

If the audit team at Arrowsight observe a non-compliance or report an audit failure (e.g. due to more than 10% of animals slipping during unloading) they will send an email to the plant immediately, the email outlines the results of the audit, and contains a link to the CCTV footage observed. This is initially sent to the plant's operations team who then re-watch the relevant footage. If the team agree with the Arrowsight audit, the report is forwarded onto the QA department, who implement any corrective actions required. The operations team then inform Arrowsight of the corrective actions implemented.

If the team do not agree with the outcome suggested by Arrowsight, they also reply, outlining the reasons for their disagreement. Plant staff reported that Arrowsight are very receptive and responsive to any disputes they raise. The company require the operations team to respond to all Arrowsight POs within a 24-hour period.

5.3.1.7 Corrective Actions

[REDACTED DUE TO COMMERICALLY SENSITIVE INFORMATION]

5.3.1.8 Plant staff opinions on working with CCTV and Arrowsight

Although not implicitly required by any retailers, when corporate managers were asked why they initially started working with Arrowsight they mentioned that RVA is valued by their customers, and that the company would benefit from independent audits of their operations.

Ten members of plant staff were consulted by the author about their opinion on CCTV and RVA within slaughter-plants. The responses of nine out ten staff members were overwhelmingly positive.

All personnel questioned agreed that CCTV was important in improving and maintaining animal welfare at slaughter, however all also mentioned the importance of a robust internal CCTV auditing programme and a QA team who hold operatives accountable for their actions.

One manager mentioned that when CCTV was first installed, staff were anxious about whether CCTV would be effective, or whether the USDA would be able to have unrestricted access (they do not under current USA legislation). Staff were initially unhappy about being videotaped (and it was mentioned that a small number of operators remain aversive to being videotaped, and therefore, when implementing a corrective action, two managers/QA team members always review the footage with the operator). However, now that operatives are aware they are being recorded, and are aware of the importance of animal welfare, they know that they cannot ‘get away with’ non-compliant behaviour. All staff members interviewed noted that the number of misconducts had decreased since the start of CCTV auditing. The QA team member responsible for the animal welfare audits reported that when she is not present in plant (e.g. away due to vacation) the number of failed audits or non-compliances increases. The majority of staff agree that the number of adverse events has fallen further since the introduction of Arrowsight RVA and stated that Arrowsight was a ‘great tool’.

Interestingly, it was mentioned that since working with the Arrowsight system, the mind-set of employees has changed. The practice of having to actively reply to an independent body with corrective actions to help maintain and improve humane handling, has brought animal welfare to the forefront of everyday practice, and to decision making at all levels. Working with Arrowsight has helped personnel to think more ‘in depth’ about animal welfare.

It was reported that Arrowsight technology is very easy to use in plant, however an operations manager said that the Arrowsight website ‘was not the easiest’ to use. The plant has had no issue, and there were no concerns over security of the CCTV images being audited by Arrowsight.

A QA manger mentioned that RVA is valuable in its role in ‘checking-the-checker’. Although the results of the internal non-biased audits and the Arrowsight audits were mostly equivalent, the manager interviewed reported that if situations arise where the audit outcomes differ significantly (especially around the same time-frame) then the reasons for this should be investigated and may require retraining of the internal auditor.

Although the overall consensus was that Arrowsight technology did improve welfare in plant, it was the view of one staff member interviewed that RVA is not as effective as internal auditing. The plant has a very good QA team who understand the plant infrastructure and organisation in a way that was impossible for Arrowsight auditors to know, which has led to PO alerts being received that the plant dispute. Responding to every Arrowsight PO was time consuming, and it was the opinion of this particular individual, that a full time 'in-plant CCTV auditor' would be more effective in auditing and improving animal welfare. However, it was suggested that in a plant which had a less effective QA team, or auditing system, RVA would be a very valuable tool.

5.4 Discussion

This report provides information regarding the use of CCTV and RVA to monitor and improve welfare in a large processing plant. Considering the recent introduction of the legislation in England stipulating mandatory CCTV in all slaughterhouses, knowledge of effective methods of using the data generated by CCTV could be beneficial in the monitoring and improvement of animal welfare at slaughter. To the author's knowledge no equivalent report currently exists within the scientific literature.

5.4.1 RVA vs internal monitoring of CCTV

By carrying out RVA and viewing CCTV footage in a systematic, consistent and effective manner, the specialised service provided by Arrowsight addresses some of the distinct limitations of CCTV as outlined in the FAWC 2015 opinion mentioned previously. However, internal auditors have the benefit of having an intimate understanding of plant SOPs, it could be argued that this in-depth knowledge of the individual plant may allow for more subtle changes in operator behaviour to be recognised. RVA does offer a valuable 'check-the-checker' service, it removes any bias associated with internal auditing, and the technology allows for audits to be carried out in a much shorter period of time than when using live footage. It also allows the auditing of areas that otherwise may not receive welfare auditing for example, excellent quality camera footage was observed by the author at the Arrowsight office that is used to audit electric tong placement inside an automatic pig stunning system. RVA allows for 24/7 auditing in certain high-risk situations such as in non-ambulatory pens.

All the plant staff interviewed during the visit strongly support CCTV and the role it has in monitoring and improving welfare at slaughter. However, emphasis was always placed on the importance of the auditing programme. The vast majority of interviewees believe that working with Arrowsight has further improved welfare outcomes and helped to maintain high standards of humane handling within their operation. The independent nature of Arrowsight audits, and the ubiquitous measures used across all company facilities, allows for a direct comparison of sister plants. This competitive element acts as a further incentive to perform well on humane handling audits and encourages plants to engage with each other on any animal welfare issues.

Interestingly, the overall aim of the service provided by Arrowsight is to change operator behaviour leading to an improvement in animal welfare and an increase in product quality and food safety. This is consistent with the one of the primary objectives of the AWO/PWO courses. It is likely that combining welfare training with RVA technology could have a further positive effect on animal welfare outcomes, however further work on this is required.

5.4.2 CCTV limitations

The use of CCTV does have its challenges:

- Views can be severely obscured due to inclement weather and not easily or rapidly restored to acceptable levels if lenses become misted or wet.

- Slips were very difficult to observe, especially when a large number of cattle were moving quickly together though the lairage.

- Views of operative interactions can be obscured, for example by the walls of the raceway; it could be observed that personnel were using a flag to move cattle, however it could not be seen if it was being used in an appropriate manner.

- There are limitations in the use of CCTV in determining sensibility or signs of return to consciousness post stun. Auditors are trained to assess for head control and rhythmic flapping in broilers, righting reflex in electrically stunned pigs and head control and righting reflex in cattle. These signs are challenging to assess in fast moving lines (especially in poultry processing), difficult to differentiate from seizures and by the time these behaviours are being exhibited by an animal it is likely that unnecessary suffering has already occurred. Footage of stunning of all species was observed by the author and it is clear that although the quality of views differs significantly between plants, it was only really possible to observe significant movements of animals. More subtle signs of a poor stun or stun recovery such as nystagmus, rhythmic breathing or muscle tone were extremely challenging to differentiate using CCTV footage.

A number of limitations also exist with the use of RVA:

- In the Arrowsight model, welfare is scored on client SOP and requirements; no welfare advice is provided by Arrowsight. The clients can request that certain measures are not recorded even if these are critical to ensure unnecessary suffering (e.g. not recording birds coming out of the scald tank uncut). As a vendor, Arrowsight can advise clients on which welfare measures should be audited but cannot enforce that this is carried out.

- As auditors do not have a further education in animal welfare, certain incidences of welfare compromise, not included in an audit instruction, may be missed. Welfare training such as that provided by the AWO/PWO course may be beneficial in overcoming this limitation.

It should be noted that the processing plant visited by the author, is around ten times the size of the largest cattle slaughterhouse currently in operation in the UK. Auditing 50 cattle at any given point during the pre-slaughter process, either in person or via live CCTV, may take over an hour in the UK, while in the visited plant this takes as little as 10 minutes. The higher levels of production rates, and therefore revenue, in the USA allow for the employment of full-time plant staff to audit animal welfare and CCTV. This is unlikely to be cost effective in the UK. In the absence of a regular routine internal CCTV auditing programme, the service offered by Arrowsight could offer an effective alternative and provide data of sufficient quality to help improve animal welfare in slaughterhouses. Arrowsight charge clients per 'auditing minute' therefore the more auditing performed the greater the economic cost to the processing plant. It is conceivable therefore, that in a small UK plant a large proportion of the throughput could be audited in a short period of time, resulting in a reduced cost. A full economic analysis of the installation of RVA in a UK processing facility would be beneficial to the industry in order to understand if RVA is economically viable.

5.4.3 Automated detection technology.

Technologies have been successfully developed to automatically detect welfare outcomes measures using CCTV including; gait scoring in commercial broiler houses (Dawkins et al., 2009); pig lying behaviour in commercial pig units (Nasirahmadi et al., 2017); lameness in dairy cattle (Poursaberi et al., 2010) and pig tail lesions (Blömke & Kemper, 2017) and broiler footpad dermatitis (Vanderhasselt et al., 2013) in commercial slaughter plants.

Automated welfare assessments have the potential to provide continuous 'outcome' measures of welfare, removing any human bias and reducing labour costs. In a recent article Pinillos (2018) argues that the slaughter industry needs to made use of technology to improve welfare and outlines the concept of 'precision slaughter'.

Pinillos describes movement and sound detection, environmental monitoring and sensor technology as important aspects of precision slaughter.

The use of thermography to non-invasively assess an animal's temperature has been widely described in recent animal welfare science literature. In an overview of infrared thermography applications in animal production systems, (McManus et al., 2016) concludes that animal surface temperature can be used as an indicator trait to accurately estimate the physiological state of an animal in situations of stress and the use of infrared thermography in animal production is innovative, low cost, fast, efficient and provides important information without the need for physical contact with the animals. Thermography has been used in the slaughter environment in the assessment of product quality (Costa et al., 2007) and physiological conditions (Weschenfelder et al., 2013) of pigs. It was found that the temperature measurement taken in the ocular region is correlated with blood lactate levels and pH, however the magnitude of the correlation was low (Weschenfelder et al., 2013). Rocha et al. (2019) also investigated thermography use in pigs, however due to only moderate correlation between temperature readings and other measures of welfare (heart rate and salivary cortisol) it was suggested that although thermograph may provide a tool for the real-time evaluation of the physiological condition of pigs during handling, it should be combined with other stress indicators.

CCTV monitoring could also be paired with biosensors. The term biosensors encompasses devices that have the potential to quantify physiological, immunological and behavioural responses of livestock and multiple animal species (Neethirajan et al., 2017). Biosensors can allow the monitoring of real-time autonomic responses e.g. respiratory and heart rate, however the majority of biosensors require the animal to wear the technology (Neethirajan, 2017) which is not feasible in a commercial slaughter environment. However, the use of mechanical and acoustic sensors may provide a practical alternative, for example, including a microphone in the lairage of pig slaughter plants, which automatically turn on the sprinklers (known to calm the animals) when the level of vocalisations increases (a measure of distress in pigs), or pressure sensors within cattle stun pens which provides real-time feedback to the slaughterman and provide an alert when the pressure exceeds a certain limit.

Given the advances in technology and their application to the field of animal health and welfare, it seems that, in the near future, the existence of automatic welfare assessments in the slaughter environment might be a reality, allowing a precise automatic welfare assessment and intelligent management at a commercial level. However, different technologies are still facing major limitations for their implementation at a commercial scale. Data collection and processing refinement is still needed, equipment must be developed to resist the harsh slaughter house conditions and must be cost-efficient. Major technical and software advances have yet to take place in order to develop technology systems that provide reliable results (Ben Sassi et al., 2016).

5.4.4 CCTV for training

CCTV can play a role in training operators, using footage of the workplace where an individual is actually based can form an important component of authentic, work-based learning (Teague & Green, 2012). This can be beneficial not only in counselling employees when a deficiency in behaviour is noted, but facilities recognise that showing employees when they are performing a behaviour well, is important in maintaining a high standard of animal welfare (Edwards-Callaway, 2017).

The AWO and PWO courses used in this thesis present CCTV footage to attendees (although the plant from which it is sourced is not provided) and both ‘good’ and ‘poor’ practice is showcased and discussed.

The development of novel technology e.g. augmented reality (e.g. 3D goggles) and the ‘virtual abattoir’ (Noelia Yusta, personal communication) could allow for remote and instant education (Pinillos, 2018) for members of the meat industry and veterinary professionals.

5.4.5 Methodological considerations

There are several limitations to this study:

- Due to confidentiality requirements of individual plant data, the author was not able to have access to results of past audits therefore quantitative evidence of welfare change as a result of RVA was not gathered.

- Recording equipment was not permitted in Arrowsight HQ or the processing plant visited. The discussions with Arrowsight and plant stuff were informal and arranged by the author at a convenient time for the member of staff. The discussions were carried out with the aim of gaining information about the welfare auditing and monitoring process. The members of staff were aware that the discussions were informal. Permission was given for the author to make written notes of the discussions, however not to take voice recordings.

- It is possible that bias was introduced in the reporting. Arrowsight and the plant included in this study were aware of the purpose of the visits and therefore it is probable that an emphasis on the positive aspects of the technology were presented to the author.

- Only one processing plant was visited in this study, it is likely that other processing plants, especially those slaughtering different species, may have an alternative method for using CCTV and RVA to improve animal welfare.

5.5 **Conclusions**

In conclusion, CCTV can be used to assess some measures of animal welfare at slaughter without introducing observer bias. Due to its current limitations it should be used in association with 'in situ' verifications. Further welfare training of those auditing CCTV is likely to improve identification of welfare compromise.

The effective monitoring and use of the data generated by CCTV is pivotal in producing welfare change. RVA provides an independent service using CCTV generated data to supply detailed information on aspects of animal welfare in individual plants, however it is still the prerogative of these plants to implement welfare improvement measures, such as training, should it be required.

With the exception of plant P1, all of the processing plants involved in Chapters 3 and 4 had a sophisticated CCTV system in use at the time of the studies (although not RVA). Results from these studies suggest that even with welfare training and CCTV, not all had a clear improvement in animal welfare measures. Some potential reasons and barriers for welfare change as a result of the training will be explored in the next chapter.

Chapter 6. Using interviews with official veterinarians to assess attitudes towards training and potential motivators and barriers to welfare change.

6.1 Introduction

The influence of attitudes on a person's behaviour has been discussed in previous sections. Questionnaire results from Chapter 2 suggest that attending the AWO/PWO training used throughout this thesis has limited immediate impact on participant attitudes towards animal welfare. However, the use of questionnaires is limiting and there is scope for understanding attitude change beyond that of the 20 statements included in the questionnaire described in Chapter 2.

Recent studies have used semi-structured interviews conducted with members of the slaughter industry. Hamilton and McCabe (2016) interviewed meat inspectors in a British poultry primary processing plant, whilst McLoughlin (2018) interviewed office, line and lairage workers in an Irish cattle plant. Both these studies aimed to explore the emotions of the participants in relation to their work and regarding the killing of animals. Although animal welfare and attitudes towards animal welfare were not studied directly, factors such as the impact of routine killing on emotional detachment towards animals and hegemonic masculinity (a practice that legitimises men's dominant position in society) were discussed in detail in relation to working in the slaughter environment.

Semi-structured interviews could be used to gain further information on participant's attitudes, and potential attitude change as a result of training. It is known that the attitudes of those working in the slaughter industry can have a direct impact on animal welfare (see section 2.1) and this study aimed to provide further detail on the impact of welfare training on an individual's attitude.

Chapters 3 and 4 demonstrate that welfare training has a role in driving positive welfare change within commercial primary processing plants. Understanding motivators for change is an important step in recognising why attending welfare training may result in welfare improvement. Furthermore, exploring potential barriers to change may offer some explanation as to the variation in results between slaughterhouses, and the lack of improvement of certain welfare measures. Additionally, knowledge of such motivators and barriers may support the development of further welfare training courses where they could be addressed.

There are two aims of this study:

1. To expand on the previous study described in Chapter 2 in identifying attitude changes post-training.

2. To gain an understanding of potential reasons that the training used throughout this thesis may, or may not, elicit welfare change in processing plants.

6.2 Methods

Initially interviews were to be carried out with participants who attended the training as part of the studies described in Chapters 3 and 4, however due to language and logistical difficulties this was not possible. To allow for ease of sampling, delegates attending an 'Official Veterinary' (OV) training course at the University of Bristol Veterinary School were invited to participate in the study once they had completed the AWO and PWO section of the OV training course. The AWO and PWO training syllabus delivered as part of the OV training is identical to that received by those who attended as part of the studies described in Chapter 3 and Chapter 4 (with the exception of local legislation for the training delivered in Spain and Costa Rica).

Semi-structured interviews were chosen as an appropriate form of consultation as they allow for flexibility in the direction of the interview whilst adhering broadly to specific themes. The interviewer (EW) had appropriate background knowledge of the subject and questions had been prepared to stimulate discussion, which was centred on the following themes:

- Background information on the participants
- General thoughts on training
- Effects of training on attitudes towards animal welfare
- Perceived effects of training on welfare in processing plants

Interviews were recorded and later transcribed. To maintain anonymity, the names of the participants were removed from the transcripts and each transcript was randomly assigned a number. Interview length ranged from 20 to 50 minutes.

6.2.1 Analysis

Transcripts were analysed using Framework analysis (Ritchie et al., 2007) which is a systematic approach and includes the following stages:

- Familiarisation of the data
- Identification of recurrent and important themes in order to develop a working analytical framework
- Indexing and pilot charting
- Charting where data is summarized within the finalised analytical framework
- Investigation and interpretation

This approach was chosen as it does not rely on coding and indexing alone, but encourages organisation and management of data through summarisation, resulting in a robust and flexible matrix (Ritchie et al., 2007).

To achieve inter-coder reliability, the analysis was undertaken by the principle researcher (EW) and by a member of the supervisory team with experience in qualitative data analysis.

6.3 **Results**

6.3.1 Participants

Six delegates volunteered to take part in the interviews, which were conducted between the 18th and 22nd May 2019. Four of the delegates were male and two were female. Five were qualified veterinary surgeons, and one was in the final year of the Bachelor of Veterinary Science Degree at the University of Bristol. With the exception of the delegate still in education, all were working in the slaughter industry at the time of the interview, four as meat inspectors and one as a field veterinary officer. Five out of the six delegates were European nationals, using English as a second language. Two had previous experience of AWO/PWO training.

6.3.2 Themes

Four main themes were identified: Change in own attitudes; perceived attitude change of others; motivation for welfare improvement and barriers to welfare improvement. In the quotes below, the number represents the delegate number and italic text represents speech from the interviewer.

6.3.2.1 Change in own attitudes

Reported attitude changes post-training broadly fit into three sub-themes: Development of knowledge; change in affect; no change. (See Table 6.1)

Table 6.1 Example quotes from each sub-theme of: Change in own attitudes.

Theme	**Change in own attitudes**		
Sub-Theme	**1.1 Development of knowledge**	**1.2. Change in affect**	**1.3. No change**
Delegate 1	"I feel I gained more confidence and knowledge"	"I feel I can now stop anthropomorphising animals"	
Delegate 2			
Delegate 3		"Feel more affect for the animals"	
Delegate 4	"Because I have this knowledge"	"Affects the heart, affects the feelings"	
Delegate 5	"I know what should be done right, the course provides me [with] that background"		*"Did the training change how you feel…* No, I'm still, I do like it"
Delegate 6			*"Have your views towards animal welfare changed?..* Umm no, I don't think so"

Three of the six delegates interviewed reported that they acquired new knowledge as a result of the training:

> "Yesterday when we discussed about poultry welfare and that dislocating the neck will only damage the spinal cord well, I am used to seeing my uncle doing it most of the time and I was ok with it… I found out that it's not really ideal.
>
> *Will you say anything about it?*
>
> Absolutely absolutely, yup yup I feel I gained more confidence and the knowledge I have now is definitely better that the one I had before" (1)

Three delegates reported a change in affect resulting from the training:

> "this course affects the heart, affects the feelings, when I watched the videos about the slaughtering of pigs using gas killing, I began to cry a little… I don't think how anybody, how these videos or this course can't affect you in any way" (4)

Both delegate 5 and 6 reported that their attitudes had not changed since attending the AWO/PWO course (Table 6.1). However, it should be noted that both participant 5 and 6 had already attended AWO/PWO training courses which may have influenced their accounts.

6.3.2.2 Perceived attitude change of others

When discussing how the training may affect other (non-veterinary) members of the slaughter industry, two focal sub-themes emerged: Development of knowledge; new perspectives towards welfare (See Table 6.2).

Table 6.2 Example quotes from each sub-theme of: Perceived change in attitudes of others.

Theme	**Perceived change in attitudes of others**	
Sub-Theme	**1.1 Development of knowledge**	**1.2 New perspectives towards welfare**
Delegate 1	"Find out things they didn't know"	
Delegate 2		"Those people not familiar with specifics in welfare, maybe see things in another perspective"
Delegate 3	"Learn more about the welfare of animals"	"Change his mind"
Delegate 4	"Very useful because they…don't have knowledge"	"People would change their minds"
Delegate 5	"Gain knowledge"	
Delegate 6	"Explains everything"	"A welfare perspective"

Nearly all delegates reported that others attending the course would gain new knowledge:

> "I think they would learn more about the welfare of animals, how to handle the animals, information about welfare" (3)

Most also commented that others may change their perspective towards animal welfare at slaughter, for example:

> "it would make you more open to…a welfare perspective. The course goes through saying why we are doing it, it explains why the legislation is what it is, why the recommendations are what they are, and it makes you think through, why is the stun to stick time a certain time, you know, it explains everything from the grassroots up" (6)

6.3.2.3 Motivation to improve welfare

During the interviews there was a strong consensus that economics and meat quality aspects were significant motivators for welfare improvement in processing plants post-training. Perception of the public was also identified as a third sub-theme (Table 6.3).

Table 6.3 Example quotes from each sub-theme of: Motivations for welfare improvement.

Theme	**Motivations for welfare improvement**		
Sub-Theme	**Economic**	**Meat Quality**	**Public perception**
Delegate 1	"If they do this, they are going to get more money"	"Impact on quality of meat"	
Delegate 2	"Improve your benefits"	"Quality is very close related with welfare"	
Delegate 3	"If the animal is stressed, is worse for meat and they will receive less money"	"Worse meat"	
Delegate 4		"Quality of meat will be better"	"Consumer is more interested in this"
Delegate 5	"Keep the client"	"Justify on the quality side"	
Delegate 6	"Incentive for a plant"	"Welfare directly linked to product quality"	"Loss of reputation"

The association between animal welfare and meat quality was reported by every delegate. It was suggested that this link would be a substantial motivator for welfare improvement:

> “If they do care about welfare, it will have a positive impact on the quality of the meat” (1)
>
> “Without stress the quality of the meat will be better…with the information from this course then…they will see an increase in meat quality” (4)

Some delegates specified that an improvement in product quality would result in an increase in financial return to processing plants:

> “you have increased welfare, you are going to have less rejected meat as part of the process, ‘cause you know you can reduce blood splash or bruising to the meat all those types of things… which means better money” (6)
>
> “Welfare equals quality, that’s the thing, that’s the useful thing I can actually use in the abattoir. Because it’s all about money in the end” (1)

Delegate 4 and 6 both suggested that public perception of welfare at slaughter is an important drive to welfare improvement:

> “The most important part will be animal welfare…every month, every year, the consumer is more interested in this” (4)
>
> “I think the biggest driver of welfare would be public perception, rather than the animals, which is a bit bizarre” (6)

6.3.2.4 Barriers to welfare improvement

Economic constraints were also a sub-theme in discussions regarding barriers to welfare improvement (Table 6.4). Lack of support within plant was identified as a second sub-theme.

Table 6.4 Example quotes from each sub-theme of: Barriers to welfare improvement.

Theme	**Barriers to welfare improvement**	
Sub-Theme	**1.1 Economic constraints**	**1.2 Lack of support within plant**
Delegate 1	"Get paid by piece"	"Never see 'slaughterman of the year'"
Delegate 2	"Only care about money"	"Nobody is going to listen to you"
Delegate 3	"Probably money"	
Delegate 4	"Just interested in money"	
Delegate 5	"Money speaks higher than welfare"	"Doesn't have any power to decide"
Delegate 6	"Economic benefit"	"Struggle for support"

All delegates reported that economic factors were a barrier to welfare improvement:

> "[slaughtermen] get paid by piece, it is just stupid 'cause of course they want to kill as many as they can without regards for welfare" (1)

> *"...how would you suggest plants go beyond legislation and improve welfare?*
>
> Umm, well again sometimes, you could say just educating people, but if that's not got an economic benefit, why would they put in the effort?" (6)

Delegates also suggested that lack of support when those who attend a training course return to their role, may hinder welfare improvement:

> "The impact of the market would be higher than providing the training to an individual which as soon as he starts to implement he doesn't have any power to decide, it will always be the senior manager telling them what to do or they will be sacked" (5)
>
> "if someone comes back from the course and is really enthusiastic and tries to bring those into practice but they are not supported through the managerial chain or the OVs turning a blind eye to it then it is not worth going on and people won't see the value of going on it, so I think it needs a huge acceptance across all levels and support once people get back so they don't seem it's like worthless and they can have an effect, you need to be able to empower the people to be able to do what they think is best practice an then, you know positively reinforce that" (6)

6.4 Discussion

The aim of this study was two-fold, to expand on the results of Chapter 2 in assessing any changes in attitudes as a result of attending AWO/PWO training courses, alongside exploring possible explanations for the changes in welfare outcomes described in Chapters 3 and 4.

6.4.1 Change in attitudes

When discussing delegates' own attitudes towards animal welfare at slaughter, there was a contrast between responses. Some reported that their attitudes had changed, and suggested they felt increased empathy towards animals, while others reported no change as a result of training. It is important to consider that those who reported no attitude change had already attended an AWO/PWO course and whether these individuals' attitudes had been influences by their first experience of training was not explored. Results from Chapter 2 indicate that increased empathy is associated with being female, having worked in the industry for longer periods of time and working with mammals but there were no significant associations with previous training experience. There is evidence that empathy may be a predictor of positive attitudes towards animals (Beveridge, 1996; Hemsworth & Coleman, 2011), therefore reports of improved empathy as a direct result of the training are encouraging, and a potential motivator for welfare change.

Four of the six delegates reported that the training would likely alter attitudes of other, non-veterinary members of the slaughter industry (for example those of slaughtermen and processing plant managers). These accounts conflict with results from Chapter 2 which suggested that AWO/PWO training has limited immediate impact on attitudes of slaughter industry personnel.

An individual's level of knowledge is not considered as a specific 'attitude', however attitudes can change with new experiences or information (Ajzen, 1988; Paul & Serpell, 1993) and improved technical knowledge has the potential to directly improve stockmanship (Boivin et al., 2003).

Interviewees commonly reported that attending AWO/PWO training led to improvements in their own, and others, knowledge. Unlike some welfare training courses which specifically focus on targeting attitudes and behaviours of stockpeople that have a direct effect on animal welfare, (Hemsworth, 2003) the AWO/PWO training courses are designed to facilitate 'knowledge transfer' to the industry. This study suggests that the AWO/PWO courses are currently meeting this objective. Whether the addition of cognitive-behavioural intervention techniques would enhance the training, and improve welfare in plant, may be worth exploring. It should be noted that those participating in this study were qualified, or close to qualifying, veterinary surgeons, with a presumed high level of background knowledge on animal welfare. The reported further acquisition of welfare knowledge as a direct result of the training suggests that the AWO/PWO training could be considered an important part of preparing veterinary professionals to work within the slaughter industry.

6.4.2 Motivations and barriers to welfare improvement

It is not surprising that monetary factors were described as both a motivation and barrier to the improvement of welfare within the slaughter industry. When purchasing meat products, price is a major factor that influences consumer choice in the UK (Apostolidis & McLeay, 2016) and with increasingly global meat markets, there is an increase in competition from lower cost economies (Taylor, 2006). Due to often slender profit margins (Hendrix & Dollar, 2017) minimising costs and maximising returns is an important consideration when implementing changes in processing plants. Although welfare training itself cannot directly overcome this systemic, industry wide economic issue, the focus on meat quality throughout both the AWO and PWO training courses attempts to highlight the importance welfare can play in improving economic return; in general, higher welfare conditions are associated with improvements in numerous aspects of meat quality and quantity and thus associated with increased financial returns (see section 1.2.2) (Although results assessing the effects of AWO/PWO training on product quality described in Chapter 3 and 5 were not fully conclusive).

All delegates mentioned ‘improved meat quality’ as a motivation for welfare improvement post-training. However, the practice of not incentivising those members of the industry who may not directly benefit from increased profits i.e. those responsible for the daily handling and slaughtering of animals was also discussed. One delegate summarised this issue:

> "it's up to the managers actually to try and find a way to reward those who are actually are doing things better after the training…
>
> *In your experience, does this happen?*
>
> No"

Incentives can be a very powerful tool for behaviour change in the short term, which can lead to the development of new habits (Whay & Main, 2010). There is evidence that rewarding animal handlers can improve product quality. In the US and British poultry industries, broken wings were reduced from 5% to 1% by paying a bonus to catchers when there were less than 1% of birds with broken wings delivered to the slaughterhouse (Grandin, 2010b). It can be argued that such financial incentives for stockpeople, although effective in improving welfare, still form a part of the overarching theme of monetary factors which play an integral role in slaughterhouse welfare.

The absence of support within the working environment was mentioned as a barrier to welfare improvement. Although small, subtle behaviour changes to improve animal welfare (e.g. using point of balance when moving animals) are relatively straightforward for individuals working in slaughterhouses to implement, more substantial operational or procedural improvements often require support from those at a higher managerial level, who may not be regularly involved in animal handling. These findings reiterate the results of Chapter 2 of the importance of the attitudes of managerial staff towards animal welfare. In a discussion of the psychology of slaughter-plant managers, Grandin (1988) comments that processing plants where managers have an attitude of humaneness towards both animals and employees tend to have better managed and more humane slaughtering operations. The concern of the delegates in this study regarding lack of support was somewhat addressed in the methodology for Chapters 3 and 4 which included training both for managerial staff and those handling live animals working in the same processing plant.

6.4.3 Limitations of the research methodology

Several limitations can be identified in this study. The number of interviews carried out was less than that recommended (Mason, 2010). It can't be known whether the themes and sub-themes would differ had there been more participants. Interviews are a self-reported method and so this study reflects the personal views and experiences of participants. All delegates had extensive veterinary training, and those with experience of the slaughter industry had worked in an enforcement role as a meat inspector, employed by the Food Standards Agency (FSA) in the UK. None had been employed by an FBO or worked outside the UK; thus, their views may not reflect that of those working in different roles, or in different counties with differing legislation, cultures and levels of 'baseline' training. As described in Chapter 2, there are several factors, including role, which can influence views of those working within the slaughter industry. These were not explored in this study. The relative inexperience and the closeness of the interviewer to the project may also have influenced the direction of the discussions.

Framework analysis was chosen for this study as it allows all data to be considered, this was deemed important due to the small sample size, however framework analysis has been criticised for lacking the same theoretical underpinning as other qualitative approaches, such as grounded theory and ethnography (Smith et al., 2011).

6.5 Conclusions

The results from the interviews suggest that the AWO/PWO courses are perceived as effective in transferring knowledge to those in attendance. The effect on other specific attitudes towards animal welfare at slaughter was inconclusive.

Understanding motivators and barriers to change is an important step in recognising why attending welfare training may or may not result in actual welfare improvement. These interviews highlight the importance of economic factors, both as motivators, and barriers, to welfare change in the slaughter industry. The interviews also indicate that the link between animal welfare and product quality is especially significant when considering welfare enhancement. Encouraging those in a range of roles within slaughter-plants, especially those in supervisory positions, to attend welfare training, may drive welfare improvement by encouraging support throughout all managerial levels.

Chapter 7. General Discussion

The aim of this PhD was to evaluate the impact of the AWO/PWO welfare training on the commercial slaughter industry, addressing some current gaps in the literature. This final chapter brings together the project findings, including the new knowledge gained, and highlights some limitations and the scientific and practical relevance of the results.

Animal welfare training aims to directly affect animal welfare (and thus product quality) through the influence of trained people who work with animals. The mixed methods design used during this project allowed for the impact of training to be assessed in regard to personnel, animal welfare and product quality.

7.1 The impact of welfare training on animal welfare and product quality

There is currently limited literature outlining the impact of animal welfare training in the slaughter industry. This thesis provides objective evidence that animal welfare training of personnel has the potential to improve animal welfare measures within commercial beef and poultry slaughter facilities. It was found that the 'better welfare' conditions post-training did not necessarily result in improved product quality measures, likely due to the multifactorial causes of carcass defects.

Unlike previous work which has focused on the impact of training on one aspect of welfare compromise during the cattle slaughter process (e.g. goad use (Grandin, 1998b) or shot positioning (Gallo et al., 2003)), Chapter 3 assessed the impact of training throughout the pre-slaughter, stunning and slaughter process. Consistent significant improvements in welfare were found across all study plants when animals were entering raceways and moving into the stun box. The impact of training was less consistent in other areas, for example in the lairage, at the tagging area and at the bleed rail. There may be several reasons for this:

- Procedural specifications (for example, manually reading ear tags) may prevent aspects of welfare improvement measures being implemented.
- The welfare assessment protocol may not have included appropriate measures to detect welfare change.
- Operators may have already been using ‘better practice’ prior to training (for example all stun-stick intervals in the study slaughterhouses, were at an acceptable level prior to training).
- Training did not have any impact.

Chapter 4 represents the first time that the impact of welfare training has been assessed in commercial poultry slaughtering facilities. The results support the view that welfare training has the potential to positively influence aspects of animal welfare. It was encouraging that in the Costa Rican plant, the majority of bird welfare measures improved post-training. In some countries (outside the UK) the accessibility of comprehensive welfare training is limited. It is hoped that the results of this study will incentivise the slaughter industry in these nations to seek welfare education, and furthermore, promote those currently delivering training courses to the livestock industry to develop appropriate material for the slaughter industry.

Although aspects of animal welfare improved in both the study cattle and poultry plants, this wasn’t consistently mirrored by an improvement in product quality measures. There have been numerous studies that highlight the importance of the direct link between welfare at slaughter and carcass quality. However, other factors, not necessarily associated with the training may have also influenced results. There is evidence that training individuals involved in the pre-slaughter process (however not working in the slaughterhouse) can improve product quality measures, for example poultry catching teams (Pilecco et al., 2013) and cattle truck drivers (Warren et al., 2010). Such individuals did not receive training as part of this project.

Whether including welfare training for those throughout the production chain (farmers, catches, transporters, slaughterhouse personnel) would result in improvements to product quality measures warrants further investigation. Providing evidence that welfare training of personnel throughout the production chain positively impacts product quality (thus having an economic benefit to food business operators) would likely incentivise further industry uptake of the training.

7.2 The impact of welfare training on industry personnel

It was identified in Chapter 2 that slaughter industry personnel believe that training is an important requirement for their role, however almost a third reported they had not received adequate training. The 'capacity building' aspect of the AWO and PWO training courses used throughout this project is primarily through promoting knowledge transfer. Almost all those interviewed in Chapter 6 reported acquisition of new knowledge as a result of this training. When considering welfare training in the livestock industry, Butterworth (2013) stated that the type, depth and intensity of training depends on the needs of those to be trained, very much aligning with the humanist view of educational theory. The AWO/PWO training courses used in this thesis are standardised, meaning that (except for country specific legislation) they are ubiquitous; the content remains the same for a couple of years before they are updated with new scientific findings or technological developments. Humanism argues that education should focus on the needs of the individual learner however this is not wholly possible in such standardised training, where up to 30 people can receive the same training in a classroom scenario. Constructivism educational theories argue that 'learning is not something that can be delivered to students by passively listening to a teacher delivering knowledge.' Much of the AWO/PWO course is in this didactic format and perhaps this is a flaw in its construct. The experienced trainers involved in this study stimulate discussion throughout the training, attempting to include both the 'cognitive constructivism' and 'social constructivism' aspects of successful learning; however the thesis did not explore the success of these techniques.

To address animal welfare problems, there must be a genuine awareness that a problem exists, alongside knowledge about possible solutions (Whay & Main, 2010). This 'new knowledge' gained from the training can translate directly to an improvement in animal welfare measures, for example as described in Chapter 4, where slaughterhouse management made changes to equipment, reducing pre-stun shocks and improving neck cutting of broilers. However, previous work by Grandin (2003) suggests that the slaughter industry are more willing to purchase new equipment than they are to adopt behavioural principles that they have to learn and practice. Grandin's observation is reflected somewhat in the results of this thesis, where welfare improvements post-training were more consistent in the highly automated poultry primary processing plants compared to that in the cattle slaughterhouses, which rely more on human-animal interaction (and therefore behavioural principles) to move, stun and slaughter animals.

Knowledge acquisition alone is generally not sufficient to change the behaviour of stockpeople. Coleman and Hemsworth (2014a) describe three main factors that contribute to a stockperson's work performance:

1. Capacity – includes factors such as skills, ability and knowledge.
2. Willingness – includes factors such as motivation, job satisfaction, attitudes towards animals and work attitudes.
3. Opportunities – which includes factors such as working conditions, actions of co-workers and organisational policies and rules.

Results from this thesis suggest that the AWO/PWO training is providing the 'capacity' required for 'better' stockmanship. Aspects of 'willingness' were also investigated and although gaining new information has the potential to affect an individual's attitude, limited evidence of attitude change as a result of training was reported in the results of Chapter 2 or 7. Other demographic factors and characteristics of employment, for example: gender, species worked with, time working in the industry and employed role, all significantly impacted responses to the questionnaire. Knowledge of the impact of such factors may be beneficial in the tailoring and development of further training courses, for example addressing why stockpeople are more likely to 'get frustrated when working with animals' by ensuring awareness of 'best practice' animal handling techniques and facilitating discussions between those occupying differing roles within the industry.

It can be argued that the final 'factor' described by Coleman and Hemsworth, i.e. 'opportunities', is particularly relevant in the unique environment of the slaughterhouse. Stockpeople, those handling animals, have a direct, day-to-day impact over animal handling and welfare. However, it is the managerial personnel who are often responsible for purchasing new equipment, writing and enforcing standard operating procedures, monitoring the effects of welfare improvement measures and providing on-site training for new staff. The significant influence of management on animal welfare, and their role in monitoring and improving animal welfare is the reasoning for providing these personnel with the comprehensive two-day AWO/PWO course. The positive effect of this training on management, and thus animal welfare was particularly apparent in plant C3 (Chapter 3). As a result of the training, management in this plant changed the standard operating procedures outlining that only 4 animals were to be present in the tagging area at any one time, compared to 5 pre-training. This change resulted in a significant reduction in animal behaviours indicative of poor welfare. The influence of management was also highlighted in Chapter 6, where lack of support from those at a higher managerial level was described as a distinct barrier to welfare improvement in the slaughter industry.

7.3 Motivators and barriers to welfare improvement

It is clear that trainees perceive they gain knowledge through AWO/PWO training (Chapter 6). Understanding potential reasons that the training may or may not actually result in objective welfare change is an important consideration. There is currently little evidence outlining specific motivators or barriers to welfare improvement for those working in the slaughter industry. Wickman (2013) described 'lack of knowledge' of management staff as a potential barrier to welfare improvement in Swedish slaughter-plants, however it can be argued that training provided in this study helps overcome such 'lack of knowledge'. Alongside the role of management in supporting welfare change as mentioned above, Chapter 6 highlighted the importance that economic factors play in facilitating welfare change. Welfare training of slaughterhouse personnel is limited in its impact in directly overcoming commercial barriers, however it may have a role to play in educating those involved in writing retailer specifications and conducting retailer audits. There is a clear economic incentive for slaughterhouses to remain on approved supplier lists. In the experience of the author, if retailers introduce stringent welfare requirements, slaughterhouses invariably instigate significant welfare improvement measures in order to meet such requirements. For example, the UK retailer Marks and Spencer's stipulate that the stun-stick interval for cattle must be within 60 seconds. All slaughterhouses that supply Marks and Spencer's must have a stop clock on the wall of the kill floor to allow slaughtermen to ensure that they stick cattle within the 60s time frame. For slaughter plants to supply the corporate giant McDonalds the Animal Welfare Officer must conduct an internal welfare audit on a weekly basis. It is likely that these commercial incentives are more effective in actively improving welfare than training alone. However, it can be argued that welfare training has an important role to play in ensuring that plant management has the knowledge required in order to meet retailer requirements.

One of the most striking findings from this PhD was that even post-training, both study poultry slaughterhouses were using insufficient currents to 'stun' birds. Unlike most other processes within the poultry slaughterhouse (where advances in welfare are known to correspond to improvements in product quality), increasing current in electrical water bath stunning, whilst improving welfare due to increased likelihood of producing a successful stun, also increases the risk of product downgrading. This conflict between welfare and product quality in electrical water bath stunning was one of the driving forces behind the development of gas killing methods for poultry slaughter. In the UK, gas killing is used in the majority of commercial poultry slaughter operations, at the time of the study, processing plant P2 (Chapter 4 and 5) produced poultry meat for the halal market (which does not permit gas killing in the UK) however, was in the process of building a new plant, which would utilise gas killing to process birds. Although gas killing of poultry is gaining popularity in the UK and the rest of the EU, electrical stunning is still the main stunning method used worldwide in commercial poultry plants (Sirri et al., 2017). Results from Chapter 4 suggest that training does significantly improve stun parameters, however not to an acceptable level. Again, using training to educate retailers may have a role to play in initiating welfare improvement, however further research is warranted into preventing unnecessary suffering in poultry slaughtered using the electrical water bath method.

7.4 CCTV for assessing and improving welfare at slaughter

During this project the Mandatory Use of Closed-Circuit Television in Slaughterhouses (England) Regulations 2018, came into enforcement, resulting in England having one of the most highly regulated slaughter industries within Europe, if not worldwide. Chapter 5 discusses the use the CCTV and Remote Video Auditing (RVA) and its potential to overcome observer bias which may have occurred during the welfare assessments in Chapter 3 and 4. This chapter supports the view of FAWC: that CCTV is only as effective as the viewing or review process employed. If used effectively, the data generated by CCTV and RVA would likely be beneficial to monitoring welfare, and assessing the impact of animal welfare improvement measures, such as training. For the use of these data to be optimised, training users (e.g. food business operators, official veterinarians, remote video auditors) in both animal welfare assessment techniques and efficient use of CCTV/RVA would be advantageous. It is the opinion of the author that those delivering welfare education in the slaughter industry, especially in England where CCTV is mandatory, should consider including content on the effective use of CCTV to monitor and improve welfare.

Although both the CCTV and RVA discussed in this thesis currently rely on individuals to watch and react to footage, within the field of animal welfare science there is increasing interest in the use of CCTV and other technologies to automatically assess welfare. The systematic, repeated processes used in the processing of animals in commercial slaughterhouses may lend itself to automated methods of detecting welfare compromise. This is an interesting area for further research and development.

7.5 Limitations

Many of the limitations of the individual studies in this thesis have been outlined in the corresponding chapters. One overarching limitation is that only two training courses have been used throughout the PhD: The AWO and PWO courses run by the University of Bristol. Other comparable training courses are available and their impact on the industry may differ from the results outlined in this thesis. It should also be noted that it is likely that all the industry personnel involved in the assessments (questionnaire, welfare and product quality assessments and interviews) would have received some level of welfare training prior to participation in the study. This training would have likely ranged from basic ‘in-house’ training of operatives, to previous attendance at University of Bristol two-day AWO and PWO training courses. Therefore the ‘baseline’ pre-training measurements would have included some level of prior welfare education. An overall aim of this thesis was to assess the impact of recognised standardised welfare training on the commercial slaughter industry. As having some level of welfare training is a reflection of common practice in the industry, (and a legislative requirement in some cases), the issue of ‘background’ training was viewed as a limitation to these studies, but it was not a major concern.

There is a potential that the relationship between the author (EW) and those responsible for delivering the training may have influenced results. Although preferable, it was not possible to use a ‘non-biased’ observer (i.e. an individual not associated with the University of Bristol). Therefore, to reduce any potential for bias, the welfare and product quality assessment measures used were chosen to be objective as far as possible.

The design of the studies in Chapter 3 and 4 in which the management personnel received a full two day training course and the operators received on-the-job or role specific training does not allow for the source of welfare impact to be established. As well as the confounding factors mentioned in the chapters and in this discussion, welfare change could have stemmed from operator behavioural change, peer operator influenced behavioural change or company policy behaviour change. Further work would be required in order to pinpoint where best to target training in a slaughter plant environment. This could be achieved by designing a study with plants receiving operator training only be compared with plants who received management training only, plants who received both operator and management training and plants which received no training. In reality this would be difficult to achieve given the role that plant particulars (e.g. culture, design and location) can play on animal welfare and the design of animal welfare assessment protocols.

The impact assessments measures used in the PhD (questionnaire, welfare and product quality assessment) were developed specifically to analyse the impact of personnel training on individuals, animal welfare and product quality. These measures were not exhaustive. There is the possibility that attitudes of the participants may have changed but were not captured by the 20 Likert items included in the questionnaire, or that welfare/product quality changes were not apparent from the results of the assessment protocols.

Improving welfare may not simply be reducing negative experiences, it should also incorporate the promotion of positive experiences (Boissy et al., 2007). It is difficult to associate an animal’s journey through the slaughterhouse with positive experiences, however the assessment protocols used in this thesis, particularly those used to assess welfare in cattle slaughterhouses (Chapter 3) may have benefited from the inclusion of some positive welfare measures (for example the use of quiet talking, or gentle touching which has a positive effect on cattle (Hemsworth et al., 2011)).

Due to logistical and cost constraints only a small number of cattle and poultry slaughterhouses were involved in the studies, and these plants, to a great extent, were selected based on their willingness to participate. Due to these factors, the results cannot be extrapolated to the entire slaughter industry. Similarly, the number of interviews carried out in Chapter 6 was small and were conducted with veterinary surgeons. The results may not be representative of the slaughter industry as a whole and it may be valuable to repeat these interviews with more participants working in a range of roles.

7.6 Further work

Suggestions for potential areas of further research and topics for inclusion in future welfare training courses have been incorporated throughout this chapter and thesis. They are consolidated below:

7.6.1 Areas for further research

- In this thesis cattle and poultry were used as a model species for assessing the impact of welfare training in the slaughterhouse. Evidence of the impact of training personnel on the welfare at slaughter of other species is also limited and should be explored.

- Results from Chapter 2 suggest that stockpeople are more likely to get frustrated when working with animals. The further use of questionnaires, or interviews to investigate the cause of such frustration should be conducted for this potential issue to be addressed by the industry.

- It was observed by the author that the manual reading of ear tags in cattle slaughterhouses often resulted in animals becoming agitated and can lead to an increase in negative human-animal interactions. Restraining animals to allow for ear tags to be read prior to slaughter also has a detrimental effect on product quality (Mpamhanga & Wotton, 2015). Alternatives to the manual reading of ear tags on live animals (e.g. electronic tags such as those currently used in sheep or the reading of ear tags post-slaughter) would be beneficial both for animal welfare, and those stockpeople currently responsible for reading ear tags.

- Chapter 4 reported that even after training, electrical current used in water bath stunning of poultry was still significantly below that required to effectively stun broilers. Work should be carried out exploring the reasons for this, and how barriers to improving stunning in water baths could be overcome. This is especially relevant in countries (outside the EU) where minimum stunning currents are not a legislative requirement.

- The training programmes used in this thesis were delivered to those working within the slaughterhouse, however, there is evidence that training others involved in the pre-slaughter process (e.g. farmers, transporters and poultry catching crews) can also improve welfare and product quality. Repeating the methodology used in this thesis and including training for those throughout the production chain may provide more valuable evidence as to where and how welfare training may be best targeted and developed.

- Producing a cost/benefit analysis for attending AWO/PWO training courses using a range of product quality measures and including both direct and indirect costs may be beneficial understanding impacts of welfare training and in encouraging wider industry uptake.

- It would be interesting to combine welfare training with data from remote video auditing and investigating whether CCTV feedback on the impact of improvement measures would further improve welfare and product quality outcomes.

- Development of automated welfare assessment methods within the slaughterhouse would benefit animal welfare by providing continuous, real-time feedback to management and operators on any potential animal welfare concern. For example, technology designed to recognise signs of consciousness on bleed rails which would feedback to operators to allow for immediate re-stunning.

- Results from this thesis suggest that the AWO/PWO training courses primarily facilitate knowledge transfer to the industry. Other cognitive-behavioural training courses are known to improve welfare at slaughter by targeting stockpeople attitudes. It may be worth exploring whether combining these types of training would enhance welfare and product quality improvement in plant.

7.6.2 Suggestions for future welfare training courses

- Combining ‘knowledge transfer’ aspects of welfare education with elements of cognitive-behavioural training may improve attitudes alongside building the capacities of individuals.

- Including information on efficient and effective use of CCTV to monitor and improve welfare.

- Teaching aspects of ‘positive welfare’ (for example encouraging use of quiet talking and gentle touching in cattle plants).

- Addressing barriers to welfare improvement through facilitating discussions between different members of the industry.

- Provide plant managers with the tools to develop their own self-auditing protocols. This would allow those involved day to day in the industry to continually assess the impact of welfare improvement measures such as ‘in-house’ training programmes.

7.7 Summary

The results obtained from this thesis provides useful evidence as to the impact of animal welfare training on some aspects of the commercial slaughter industry. In doing so it has highlighted several lines of enquiry as to further areas within ‘animal welfare at slaughter’, which warrant further research. Furthermore, the information presented may help develop and improve welfare education for the industry, and encourage industry uptake, ultimately improving welfare for animals at the time of slaughter.

References

Aghwan, Z. A., Bello, A. U., Abubakar, A. A., Imlan, J. C., & Sazili, A. Q. (2016). Efficient halal bleeding, animal handling, and welfare: A holistic approach for meat quality. *Meat Science, 121*, 420-428.

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckman (Eds.), *Action control* (pp. 11-39). Heidelberg, Germany: Springer.

Ajzen, I. (1988). *Attitudes, personality, and behavior.* Chicago Dorsey Press

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211.

Alexandratos, N., & Bruinsma, J. (2012). *World agriculture towards 2030/2050: the 2012 revision* (Vol 12, no.3) FAO, Rome: ESA Working Paper. Retrieved from https://ageconsearch.umn.edu/record/288998/

Alexandrov, A. (2010). Characteristics of single-item measures in Likert scale format. *The Electronic Journal of Business Research Methods, 8*(1), 1-12.

Apostolidis, C., & McLeay, F. (2016). Should we stop meating like this? Reducing meat consumption through substitution. *Food Policy, 65*, 74-89.

Armellino, D., Cifu, K., Wallace, M., Johnson, S., DiCapua, J., Dowling, O., . . . Browning, S. (2018). Implementation of remote video auditing with feedback and compliance for manual-cleaning protocols of endoscopic retrograde cholangiopancreatography endoscopes. *American Journal of Infection Control, 46*(5), 594-596.

Armellino, D., Hussain, E., Schilling, M. E., Senicola, W., Eichorn, A., Dlugacz, Y., & Farber, B. F. (2011). Using High-Technology to Enforce Low-Technology Safety Measures: The Use of Third-party Remote Video Auditing and Real-time Feedback in Healthcare. *Clinical Infectious Diseases, 54*(1), 1-7.

Arrowsight. (2018). Remote Video Auditing in livestock and Poultry Processing Plants Improve Compliance, Performance and Safety. Retrieved from https://s3.amazonaws.com/arrowsight-media-public/AgriMarketing/AgriMarketing/Arrowsight_Food_Processing_Sales_Brochure_2016.pdf

Asif, M. (2009). *The Effects of Pre-stun Shocks in Electrical Waterbath Stunners on Carcass and Meat Quality in Broilers.* (Msc Dissertation), University of Bristol, UK.

Atkinson, S., & Algers, B. (2007). *The development of a stun quality audit for cattle and pigs at slaughter.* Paper presented at the Proceedings International Congress in Animal Hygiene, Tartu, Estonia

Atkinson, S., Velarde, A., & Algers, B. (2013). Assessment of stun quality at commercial slaughter in cattle shot with captive bolt. *Animal welfare, 22*(4), 473-481.

Aubery, K., & Riley, A. (2019). *Understanding and Using Educational Theories* (2nd ed.). London, UK SAGE Publishing.

Baracho, M., Camargo, G., Lima, A., Mentem, J., Moura, D., Moreira, J., & Nääs, I. (2006). Variables impacting poultry meat quality from production to pre-slaughter: a review *Brazilian Journal of Poultry Science, 8*, 201-212.

Baran, B. E., Rogelberg, S. G., & Clausen, T. (2016). Routinized killing of animals: Going beyond dirty work and prestige to understand the well-being of slaughterhouse workers. *Organization, 23*(3), 351-369.

Barker, R. (2006). *The Effect of Waterbath Stunning Current Frequency and Waveform on Carcass and Meat Quality in Broilers.* (Msc Dissertation), University of Bristol, UK.

Barnett, J. L., & Hemsworth, P. H. (1990). The validity of physiological and behavioural measures of animal welfare. *Applied Animal Behaviour Science, 25*(1-2), 177-187.

Ben Sassi, N., Averós, X., & Estevez, I. (2016). Technology and Poultry Welfare. *Animals, 6*(10), 62.

Berg, C., & Raj, M. (2015). A Review of Different Stunning Methods for Poultry—Animal Welfare Aspects (Stunning Methods for Poultry). *Animals, 5*(4), 0407.

Beveridge, L. M. (1996). *Studies on the influence of human characteristics and training on stockperson work performance and farm animal behaviour.* (PhD Thesis), University of Aberdeen, UK.

Bianchi, M., Petracci, M., & Cavani, C. (2005). Effects of transport and lairage on mortality, liveweight loss and carcass quality in broiler chickens. *Italian Journal of Animal Science, 4*, 516-518.

Blömke, L., & Kemper, N. (2017). *Automated assessment of animal welfare indicators in pigs at slaughter.* Paper presented at the Proceedings of the 12th international symposium on the epidemiology and control of biological, chemical and physical hazards in pigs and pork (SafePork) Foz do Iguacu, Brasil.

Bock, B. B., Van Huik, M., Prutzer, M., Eveillard, F. K., & Dockes, A. (2007). Famers' relationship with different animals: the importance of getting close to the animals. Case studies of French, Swedish and Dutch cattle, pig and poultry farmers. *International Journal of Sociology of Agriculture and Food 15*(3), 108-125.

Boissy, A., Manteuffel, G., Jensen, M. B., Moe, R. O., Spruijt, B., Keeling, L. J., . . . Aubert, A. (2007). Assessment of positive emotions in animals to improve their welfare. *Physiology & Behavior, 92*(3), 375-397.

Boivin, X., Lensink, J., Tallet, C., & Veissier, I. (2003). Stockmanship and farm animal welfare. *Animal welfare, 12*(4), 479-492.

Bouissou, M.-F. (1981). Behaviour of domestic cattle under modern management techniques. In H. DE & T. PV (Eds.), *The Problem of Dark-Cutting in Beef* (pp. 141-169). The Hague: Springer.

Bourguet, C., Deiss, V., Tannugi, C. C., & Terlouw, E. M. C. (2011). Behavioural and physiological reactions of cattle in a commercial abattoir: Relationships with organisational aspects of the abattoir and animal characteristics. *Meat Science, 88*(1), 158-168.

Breuer, K., Hemsworth, P. H., Barnett, J., Matthews, L. R., & Coleman, G. (2000). Behavioural response to humans and the productivity of commercial dairy cows. *Applied Animal Behaviour Science, 66*(4), 273-288.

Brouček, J. (2014). Effect of noise on performance, stress, and behaviour of animals. *Slovak journal of animal science, 47*(2), 111-123.

Butterworth, A. (2013). On-farm broiler welfare assessment and associated training *Brazilian Journal of Poultry Science, 15*, 71-77.

Butterworth, A., Whittington, P., & Hammond-Seaman, A. (2012). Applying welfare training in global commercial settings. *Animal welfare, 21*(3), 373-377.

Carstens, E., & Moberg, G. P. (2000). Recognizing pain and distress in laboratory animals. *Ilar j, 41*(2), 62-71.

Ceballos, M. C., Sant'Anna, A. C., Boivin, X., Costa, F. d. O., Carvalhal, M. V. de L., & Paranhos da Costa, M. J. R. (2018). Impact of good practices of handling training on beef cattle welfare and stockpeople attitudes and behaviors. *Livestock Science, 216*, 24-31.

Charlton, C., Rasbash, J., Browne, W., Healy, M., & Cameron, B. (2019). MLwiN Version 3.03. Centre for Multilevel Modelling, University of Bristol

Chimi, C. J., & Russell, D. L. (2009). *The Likert scale: A proposal for improvement using quasi-continuous variables.* . Paper presented at the ISECON, Washington DC.

Chulayo, A. Y., & Muchenje, V. (2015). A balanced perspective on animal welfare for improved meat and meat products. *South African Journal of Animal Science, 45*(5), 452-469.

Cockram, M. S., & Corley, K. T. T. (1991). Effect of pre-slaughter handling on the behaviour and blood composition of beef cattle. *British Veterinary Journal, 147*(5), 444-454.

Cockram, M. S., & Dulal, K. J. (2018). Injury and mortality in broilers during handling and transport to slaughter. *Canadian Journal of Animal Science, 98*(3), 416-432.

Coleman, G., & Hemsworth, P. (2014a). Training to improve stockperson beliefs and behaviour towards livestock enhances welfare and productivity. *Rev. Sci. Tech, 33*, 131-137.

Coleman, G. J. (2004). Personnel management in agricultural systems. In B. E. Rollin & J. Benson (Eds.), *Maximizing well-being and minimizing suffering in farm animals* (pp. 167-181). Ames, USA: Iowa State University Press.

Coleman, G. J., & Hemsworth, P. H. (2014b). Training to improve stockperson beliefs and behaviour towards livestock enhances welfare and productivity. *Rev Sci Tech, 33*(1), 131-137.

Coleman, G. J., Hemsworth, P. H., & Hay, M. (1998). Predicting stockperson behaviour towards pigs from attitudinal and job-related variables and empathy. *Applied Animal Behaviour Science, 58*(1-2), 63-75.

Coleman, G. J., Hemsworth, P. H., Hay, M., & Cox, M. (2000). Modifying stockperson attitudes and behaviour towards pigs at a large commercial farm. *Applied Animal Behaviour Science, 66*(1–2), 11-20.

Coleman, G. J., McGregor, M., Hemsworth, P. H., Boyce, J., & Dowling, S. (2003). The relationship between beliefs, attitudes and observed behaviours of abattoir personnel in the pig industry. *Applied Animal Behaviour Science, 82*(3), 189-200.

Coleman, G. J., Rice, M., & Hemsworth, P. H. (2012). Human-animal relationships at sheep and cattle abattoirs. *Animal welfare, 21*, 15-21.

Costa, L. N. (2009). Short-term stress: the case of transport and slaughter. *Italian Journal of Animal Science, 8*(1), 241-252.

Costa, L. N., Fiego, D. P. L., Tassone, F., & Russo, V. (2006). The relationship between carcass bruising in bulls and behaviour observed during pre-slaughter phases. *Veterinary Research Communications, 30*, 379-381.

Costa, N., Stelletta, C., Cannizzo, C., Gianesella, M., Lo Fiego, P., & Morgante, M. (2007). The use of thermography on the slaughter-line for the assessment of pork and raw ham quality. *Italian Journal of Animal Science, 6*(sup1), 704-706.

Daly, C. C., & Whittington, P. E. (1986). Concussive methods of pre-slaughter stunning in sheep: effects of captive bolt stunning in the poll position on brain function. *Research in Veterinary Science, 41*(3), 353-355.

Daugherty, R., Black, P., Ecclestone, K., James, M., & Newton, P. (2008). Alternative perspectives on learning outcomes: challenges for assessment. *The Curriculum Journal, 19*(4), 243-254.

Dawkins, M. (1980). *Animal Suffering*. London: Chapman & Hall

Dawkins, M. S. (1988). Behavioural deprivation: A central problem in animal welfare. *Applied Animal Behaviour Science, 20*(3-4), 209-225.

Dawkins, M. S., Lee, H.-j., Waitt, C. D., & Roberts, S. J. (2009). Optical flow patterns in broiler chicken flocks as automated measures of behaviour and gait. *Applied Animal Behaviour Science, 119*(3), 203-209.

del Campo, M., Brito, G., Soares de Lima, J., Hernández, P., & Montossi, F. (2010). Finishing diet, temperament and lairage time effects on carcass and meat quality traits in steers. *Meat Science, 86*(4), 908-914.

Derrick, B., & White, P. (2017). Comparing two samples from an individual Likert question. *International Journal of Mathematics and Statistics, 18*(3).

Désiré, L., Veissier, I., Després, G., & Boissy, A. (2004). On the Way to Assess Emotions in Animals: Do Lambs (Ovis aries) Evaluate an Event Through Its Suddenness, Novelty, or Unpredictability? *Journal of Comparative Psychology, 118*(4), 363-374.

Dillard, J. (2008). A slaughterhouse nightmare: Psychological harm suffered by slaughterhouse employees and the possibility of redress through legal reform. *Geo. J. on Poverty L. & Pol'y, 15*, 391.

Dillman, D. A. (2007). *Mail and Internet Surveys: The Tailored Design Method* (2nd ed.). New York: John Wiley & Sons, Inc.

Donaldson, M. J. T. (1993). What is hegemonic masculinity? *Theory and society 22*(5), 643-657.

Dulal, K. J. (2017). *Risk factors affecting wing injuries of broiler chickens at a slaughter plant in New Brunswick, Canada.* (Master of Science Master of Science), University of Prince Edward Island, New Brunswick.

Duncan, I. J. H. (1996). Animal welfare defined in terms of feelings. *Acta Agriculturae Scandinavica Section a-Animal Science*, 29-30.

Duncan, I. J. H. (2005). Science-based assessment of animal welfare: Farm animals. *OIE Revue Scientifique et Technique, 24*(2), 483-492.

Dunn, O. J. J. T. (1964). Multiple comparisons using rank sums. *6*(3), 241-252.

EC. (2009). Council Regulation (EC) No. 1099/2009 of 24 September 2009 on the Protection of Animals at the Time of Killing. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:sa0002

Edwards-Callaway, L. (2017). Human-animal interactions: effects, challenges, and progress. In C. B. Tucker (Ed.), *Advances in Cattle Welfare* (pp. 83). Cambridge, UK Woodhead Publishing.

EFSA. (2004). *Opinion on the welfare aspects of stunning and killing methods.* EFSA Panel on Animal Health and Welfare (AHAW). European Food Safety Authority (EFSA), Parma, Italy. pp 241. Retrieved from

EFSA. (2011). *European Food Saftey Authority* Scientific Opinion concerning the welfare of animals during transport. *9*(1), 1966.

EFSA. (2019). Slaughter of animals: poultry. *EFSA Journal, 17*(11), e05849.

Ellis-Iversen, J., Cook, A. J. C., Watson, E., Nielen, M., Larkin, L., Wooldridge, M., & Hogeveen, H. (2010). Perceptions, circumstances and motivators that influence implementation of zoonotic control programs on cattle farms. *Preventive Veterinary Medicine, 93*(4), 276-285.

English, P., Burgess, G., Segundo, R., & Dunne, J. (1992). *Stockmanship. Improving the care of the pig and other livestock*. Ipswich, UK: Farming Press Books.

Eurostat. (2019). Data on slaughtering in slaughterhouses. Retrieved from http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

FAO. (2018). Meat Market Review. October 2018. Retrieved from http://www.fao.org/3/CA2129EN/ca2129en.pdf

FAWC. (2015). *Opinion on CCTV in slaughterhouses* London, UK. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/400796/Opinion_on_CCTV_in_slaughterhouses.pdf

Ferguson, D. M., & Warner, R. D. (2008). Have we underestimated the impact of pre-slaughter stress on meat quality in ruminants? *Meat Science, 80*(1), 12-19.

Ferreira, G. B., Andrade, C. L., Costa, F., Freitas, M. Q., Silva, T. J. P., & Santos, I. F. (2006). Effects of transport time and rest period on the quality of electrically stimulated male cattle carcasses. *Meat Science, 74*(3), 459-466.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*. Reading, USA.: Addison-Wesley.

Fitzgerald, A. J. (2010). A social history of the slaughterhouse: From inception to contemporary implications. *Human Ecology Review, 17*(1), 58-69.

Fraser, D., Weary, D., Pajor, E., & Milligan, B. (1997). A scientific conception of animal welfare that reflects ethical concerns. *Animal welfare, 6*, 187-205.

Fries, R., Schrohe, K., Lotz, F., & Arndt, G. (2012). Application of captive bolt to cattle stunning - a survey of stunner placement under practical conditions. *Animal, 6*(7), 1124-1128.

Gallo, C., & Huertas, S. (2016). Main animal welfare problems in ruminant livestock during preslaughter operations: A South American view. *Animal, 10*(2), 357-364.

Gallo, C., Tadich, T., Huertas, S., César, D., Da Costa, M. P., Broom, D., & Paulista, E. (2010). *Animal welfare education in Latin America.* Paper presented at the The First International Conference on Animal Welfare Education: Everyone is responsible., Brussels, Belgium.

Gallo, C., Teuber, C., Cartes, M., Uribe, H., & Grandin, T. (2003). Improvements in stunning of cattle with a pneumatic stunner after changes in equipment and employee training. *Archivos De Medicina Veterinaria, 35*(2), 159-170.

Gentle, M. J., & Tilston, V. L. (2000). Nociceptors in the Legs of Poultry: Implications for Potential Pain in Preslaughter Shackling. *Animal welfare, 9*(3), 227-236.

Goldstein, H. (2003). *Multilevel statistical models* (3rd ed.). London, UK: Hodder Arnold.

Gouveia, K. G., Ferreira, P. G., da Costa, J. C. R., Vaz-Pires, P., & da Costa, P. M. (2009). Assessment of the efficiency of captive-bolt stunning in cattle and feasibility of associated behavioural signs. *Animal welfare, 18*(2), 171-175.

Gracey, J., & Collins, D. (1992). *Meat hygiene* (9th ed.). London UK: Baillière Tindall.

Grandin, T. (1978). The effect of social regrouping on the incidence of dark-cutting carcasses in beef steers. *J. Anim. Sci, 47*(Suppl 1), 217.

Grandin, T. (1988). Behavior of slaughter plant and auction employees toward the animals. *Anthrozoös, 1*(4), 205-213.

Grandin, T. (1990). Design of loading facilities and holding pens. *Applied Animal Behaviour Science, 28*(1-2), 187-201.

Grandin, T. (1993). Behavioral agitation during handling of cattle is persistent over time. *Applied Animal Behaviour Science, 36*(1), 1-9.

Grandin, T. (1996). Factors that impede animal movement at slaughter plants. *Journal of the American Veterinary Medical Association, 209*(4), 757-759.

Grandin, T. (1998a). The feasibility of using vocalization scoring as an indicator of poor welfare during cattle slaughter. *Applied Animal Behaviour Science, 56*(2-4), 121-128.

Grandin, T. (1998b). Handling methods and facilities to reduce stress on cattle. *The Veterinary clinics of North America. Food animal practice, 14*(2), 325-341.

Grandin, T. (1998c). Objective scoring of animal handling and stunning practices at slaughter plants. *Journal of the American Veterinary Medical Association, 212*(1), 36-39.

Grandin, T. (1999). *Principles for Low Stress Cattle Handling* Paper presented at the The Range Beef Cow Symposium XVI, Greeley, Colorado

Grandin, T. (2001). Antemortem handling and welfare. In Y. H. Hui, W.-K. Nip, R. W. Rogers, & O. A. Young (Eds.), *Meat science & applications* (pp. 221-254). New York Marcel Dekker Ltd.

Grandin, T. (2002). Return-to-sensibility problems after penetrating captive bolt stunning of cattle in commercial beef slaughter plants. *Journal of the American Veterinary Medical Association, 221*(9), 1258-1261.

Grandin, T. (2003). Transferring results of behavioral research to industry to improve animal welfare on the farm, ranch and the slaughter plant. *Applied Animal Behaviour Science, 81*(3), 215-228.

Grandin, T. (2005). Maintenance of good animal welfare standards in beef slaughter plants by use of auditing programs. *Journal of the American Veterinary Medical Association, 226*(3), 370-373.

Grandin, T. (2006). Progress and challenges in animal handling and slaughter in the U.S. *Applied Animal Behaviour Science, 100*(1–2), 129-139.

Grandin, T. (2010a). Auditing animal welfare at slaughter plants. *Meat Science, 86*(1), 56-65.

Grandin, T. (2010b). *Improving animal welfare : a practical approach*. Wallingford, Oxfordshire, UK: CAB International.

Grandin, T. (2012). Developing measures to audit welfare of cattle and pigs at slaughter. *Animal welfare, 21*(3), 351-356.

Grandin, T. (2015). *Improving animal welfare: a practical approach* (2nd ed.). Wallingford, UK: CABI.

Grandin, T. (2018). Welfare Problems in Cattle, Pigs, and Sheep that Persist Even Though Scientific Research Clearly Shows How to Prevent Them. *Animals, 8*(7), 124.

Gregory, N., Austin, S., & Wilkins, L. (1989). Relationship between wing flapping at shackling and red wingtips in chicken carcases. *Veterinary Record, 124*(3), 62-62.

Gregory, N., & Bell, J. (1987). Duration of wing flapping in chickens shackled before slaughter. *The Veterinary Record, 121*(24), 567-569.

Gregory, N., & Wilkins, L. (1989). Effect of ventricular fibrillation at stunning and ineffective bleeding on carcase quality defects in broiler chickens. *British Poultry Science, 30*(4), 825-829.

Gregory, N. G. (2007). *Animal Welfare and meat production* (2nd ed.). Wallingford, UK CABI Publishing.

Gregory, N. G., Lee, C. J., & Widdicombe, J. P. (2007). Depth of concussion in cattle shot by penetrating captive bolt. *Meat Science, 77*(4), 499-503.

Gregory, N. G., & Wotton, S. B. (1986). Effect of slaughter on the spontaneous and evoked activity of the brain. *British Poultry Science, 27*(2), 195-205.

Grey, M. A. (1999). Immigrants, Migration, and Worker Turnover at the Hog Pride Pork Packing Plant. *Human Organization, 58*(1), 16-27.

Grilli, C., Loschi, A. R., Rea, S., Stocchi, R., Leoni, L., & Conti, F. (2015). Welfare indicators during broiler slaughtering. *British Poultry Science, 56*(1), 1-5.

Grist, A., Lines, J. A., Bock, R., Knowles, T. G., & Wotton, S. (2019). An Examination of the Performance of Blank Cartridges Used in Captive Bolt Devices for the Pre-Slaughter Stunning and Euthanasia of Animals. *Animals, 9*(8), 552.

Groom, G. (1990). Factors affecting poultry meat quality. In B. Sauveur (Ed.), *L'aviculture en Méditerranée* (pp. 205-210). Montpellier: CIHEAM.

Hamdy, M. K., May, K. N., Flanagan, W. P., & Powers, J. J. (1961). Determination of the Age of Bruises in Chicken Broilers. *Poultry Science, 40*(3), 787-789.

Hamilton, L., & McCabe, D. (2016). "It's just a job': Understanding emotion work, de-animalization and the compartmentalization of organized animal slaughter. *Organization, 23*(3), 330-350.

Hampton, C. (2002). Teaching practical skills. *Perspectives on distance education: Skills development through distance education*, 83-91.

Hartnack, S., Springer, S., Pittavino, M., & Grimm, H. (2016). Attitudes of Austrian veterinarians towards euthanasia in small animal practice: impacts of age and gender on views on euthanasia. *BMC veterinary research, 12*(1), 26.

Hemsworth, P., Coleman, G., & Barnett, J. (1994). Improving the attitude and behaviour of stockpersons towards pigs and the consequences on the behaviour and reproductive performance of commercial pigs. *Applied Animal Behaviour Science, 39*(3-4), 349-362.

Hemsworth, P. H. (2003). Human–animal interactions in livestock production. *Applied Animal Behaviour Science, 81*(3), 185-198.

Hemsworth, P. H., & Coleman, G. J. (2011). *Human-Livestock Interactions: The Stockperson and the Productivity and Welfare of Intensivley Farmed Animals* (2nd Edition ed.). Oxford UK: CAB International

Hemsworth, P. H., Coleman, G. J., Barnett, J. L., Borg, S., & Dowling, S. (2002). The effects of cognitive behavioral intervention on the attitude and behavior of stockpersons and the behavior and productivity of commercial dairy cows. *Journal of Animal Science, 80*(1), 68-78.

Hemsworth, P. H., Rice, M., Karlen, M. G., Calleja, L., Barnett, J. L., Nash, J., & Coleman, G. J. (2011). Human-animal interactions at abattoirs: Relationships between handling and animal stress in sheep and cattle. *Applied Animal Behaviour Science, 135*(1-2), 24-33.

Hendrix, J. A., & Dollar, C. B. (2017). American Slaughterhouses and the Need for Speed: An Examination of the Meatpacking-Methamphetamine Hypothesis. *Organization & Environment, 31*(2), 133-151.

Herzog, H. A., Betchart, N. S., & Pittman, R. B. (1991). Gender, Sex Role Orientation, and Attitudes toward Animals. *Anthrozoös, 4*(3), 184-191.

Hindle, V., Lambooij, E., Reimert, H., Workel, L., & Gerritzen, M. (2010). Animal welfare concerns during the use of the water bath for stunning broilers, hens, and ducks. *Poultry Science, 89*(3), 401-412.

Hoffman, L. C., & Lühl, J. (2012). Causes of cattle bruising during handling and transport in Namibia. *Meat Science, 92*(2), 115-124.

Holdstock, J., Aalhus, J., Uttaro, B., López-Campos, Ó., Larsen, I., & Bruce, H. (2014). The impact of ultimate pH on muscle characteristics and sensory attributes of the longissimus thoracis within the dark cutting (Canada B4) beef carcass grade. *Meat Science, 98*(4), 842-849.

Hötzel, M. J., Mota, S. M., Ludtke, C. B., & Poletto, R. (2018). Knowledge and attitudes of official inspectors at slaughterhouses in southern Brazil regarding animal welfare. *Revista Brasileira de Zootecnia, 47*.

Huertas, S., Gil, A., Piaggio, J., & Van Eerdenburg, F. (2010). Transportation of beef cattle to slaughterhouses and how this relates to animal welfare and carcase bruising in an extensive production system. *Animal welfare, 19*(3), 281-285.

Huertas, S., van Eerdenburg, F., Gil, A., & Piaggio, J. (2015). Prevalence of carcass bruises as an indicator of welfare in beef cattle and the relation to the economic impact. *Veterinary Medicine and Science, 1*(1), 9-15.

Hultgren, J., Wiberg, S., Berg, C., Cvek, K., & Kolstrup, C. L. (2014). Cattle behaviours and stockperson actions related to impaired animal welfare at Swedish slaughter plants. *Applied Animal Behaviour Science, 152*, 23-37.

Jacobs, L., Delezie, E., Duchateau, L., Goethals, K., & Tuyttens, F. A. M. (2017). Impact of the separate pre-slaughter stages on broiler chicken welfare. *Poultry Science, 96*(2), 266-273.

Jarvis, A. M., Selkirk, L., & Cockram, M. S. (1995). The influence of source, sex class and pre-slaughter handling on the bruising of cattle at two slaughterhouses. *Livestock Production Science, 43*(3), 215-224.

Johns, R. (2010). Likert items and scales. Survey Question Bank Retrieved from https://www.sheffield.ac.uk/polopoly_fs/1.597637!/file/likertfactsheet.pdf

Jones, B. (2011). *Cattle behaviour: methods for improving the movement of cattle in-to a stunning pen and the implications for the use of electrical goad.* (MSc Dissertation), University of Bristol, UK.

Jones, R. B., Satterlee, D. G., & Cadd, G. G. (1998). Struggling responses of broiler chickens shackled in groups on a moving line: effects of light intensity, hoods, and `curtains'. *Applied Animal Behaviour Science, 58*(3), 341-352.

Kannan, G., Heath, J., Wabeck, C., Souza, M., Howe, J., & Mench, J. (1997a). Effects of crating and transport on stress and meat quality characteristics in broilers. *Poultry Science, 76*(3), 523-529.

Kannan, G., Heath, J. L., Wabeck, C. J., & Mench, J. A. (1997b). Shackling of broilers: Effects on stress responses and breast meat quality. *British Poultry Science, 38*(4), 323-332.

Kellert, S. R., & Berry, J. K. (1987). Attitudes, knowledge, and behaviors toward wildlife as affected by gender. *Wildlife Society Bulletin, 15*(3), 363-371.

Kenny, F., & Tarrant, P. (1987). The behaviour of young Friesian bulls during social re-grouping at an abattoir. Influence of an overhead electrified wire grid. *Applied Animal Behaviour Science, 18*(3-4), 233-246.

Khaneghahi Abyaneh, H., Dabaghian, A., Rezaeigolestani, M., & Amanollahi, D. (2019). Compliance with OIE animal welfare standards in slaughterhouses in Tehran Province, Iran: An introductory survey. *Journal of Applied Animal Welfare Science*, 1-8.

Kittelsen, K. E., Granquist, E. G., Vasdal, G., Tolo, E., & Moe, R. O. (2015). Effects of catching and transportation versus pre-slaughter handling at the abattoir on the prevalence of wing fractures in broilers. *Animal welfare, 24*(4), 387-389.

Koknaroglu, H., & Akunal, T. (2013). Animal welfare: An animal science approach. *Meat Science, 95*(4), 821-827.

Kranen, R., Veerkamp, C., Lambooy, E., Van Kuppevelt, T., & Veerkamp, J. (1996). Hemorrhages in muscles of broiler chickens: The relationships among blood variables at various rearing temperature regimens. *Poultry Science, 75*(4), 570-576.

La Gaceta. (2013). Reglamento Sanitario y de Inspección Veterinaria de Establecimientos de Sacrificio y Procesadores de Aves. Retrieved from http://www.gaceta.go.cr/pub/2013/03/06/ALCA43_06_03_2013.pdf

Lacourt, A., & Tarrant, P. V. (1985). Glycogen depletion patterns in myofibres of cattle during stress. *Meat Science, 15*(2), 85-100.

Lambooij, E., Pieterse, C., Hillebrand, S., & Dijksterhuis, G. J. P. S. (1999). The effects of captive bolt and electrical stunning, and restraining methods on broiler meat quality. *Poultry Science, 78*(4), 600-607.

Lambooij, E., Reimert, H., & Hindle, V. (2010). Evaluation of head-only electrical stunning for practical application: Assessment of neural and meat quality parameters. *Poultry Science, 89*(12), 2551-2558.

Leach, K. A., Whay, H. R., Maggs, C. M., Barker, Z. E., Paul, E. S., Bell, A. K., & Main, D. C. J. (2010). Working towards a reduction in cattle lameness: 1. Understanding barriers to lameness control on dairy farms. *Research in Veterinary Science, 89*(2), 311-317.

Lee, T. L., Reinhardt, C. D., Bartle, S. J., Vahl, C. I., Siemens, M., & Thomson, D. U. (2017). Assessment of risk factors contributing to carcass bruising in fed cattle at commercial slaughter facilities. *Translational Animal Science, 1*(4), 489-497.

Lensink, J., Boissy, A., & Veissier, I. (2000). *The relationship between farmers' attitude and behaviour towards calves, and productivity of veal units.* Paper presented at the Annales de Zootechnie, Paris, France.

Lerner, H. (2008). *The Concepts of Health, Well-being and Welfare as Applied to Animals: A Philosophical Analysis of the Concepts with the Regard to the Differences Between Animals.* (PhD Thesis), Linköping Univeristy, Linköping. Retrieved from http://www.diva-portal.org/smash/get/diva2:18162/FULLTEXT01.pdf

Lines, J., Wotton, S., Barker, R., Spence, J., Wilkins, L., & Knowles, T. (2011). Broiler carcass quality using head-only electrical stunning in a waterbath. *British Poultry Science, 52*(4), 439-445.

Lloyd, D. H. (1975). Effective staff management. In B. M. Freeman & K. N. Boorman (Eds.), *Economic factors affecting egg production* (pp. 221-231). Edinburgh British Poultry Science.

Losada-Espinosa, N., Villarroel, M., María, G. A., & Miranda-de la Lama, G. C. (2018). Pre-slaughter cattle welfare indicators for use in commercial abattoirs with voluntary monitoring systems: A systematic review. *Meat Science, 138*, 34-48.

MacKay, J. R., Haskell, M. J., Deag, J. M., & van Reenen, K. (2014). Fear responses to novelty in testing environments are related to day-to-day activity in the home environment in dairy cattle. *Applied Animal Behaviour Science, 152*, 7-16.

Mahmood, S., Basarab, J. A., Dixon, W. T., & Bruce, H. L. (2016). Can potential for dark cutting be predicted by phenotype? Relationship between sex, carcass characteristics, and the incidence of dark cutting beef. *Canadian Journal of Animal Science, 96*(1), 19-31.

Mahmood, S., Roy, B. C., Larsen, I. L., Aalhus, J. L., Dixon, W. T., & Bruce, H. L. (2017). Understanding the quality of typical and atypical dark cutting beef from heifers and steers. *Meat Science, 133*, 75-85.

Main, D., & Mullan, S. (2017). A new era of UK leadership in farm animal welfare. *Veterinary Record, 181*(2), 49-50.

MAL. (2014). Dark cutting in livestock. Retrieved from http://www.mla.com.au/Research-and-development/Search-RD-reports/RD-report-details/Eating-Quality/Dark-cutting-in-livestock/2616

Manteca, X. V., A., & Jones, B. (2009). Animal welfare components. In F. Smulders & B. Algers (Eds.), *Welfare of production animals: assessment and management of risks* (Vol. 2009, pp. 61-77). The Netherlands: Wageningen Academic Publishers.

María, G. A., Villarroel, M., Chacón, G., & Gebresenbet, G. (2004). Scoring system for evaluating the stress to cattle of commercial loading and unloadind. *The Veterinary Record, 154*(26), 818-821.

Markus, H., & Zajonc, R. B. (1985). The Cognitive Perspective in Social Psychology. In G. Lindzey & E. Aronson (Eds.), *Handbook of Social Psychology* (3rd ed., pp. 137-229). New York: Random House.

Mason, M. (2010). Sample size and saturation in PhD studies using qualitative interviews. *Forum qualitative Sozialforschung/Forum: qualitative social research, 11*(3).

Mayes, F. J. (1980). The incidence of bruising in broiler flocks. *British Poultry Science, 21*(6), 505-509.

McGilchrist, P., Pethick, D. W., Bonny, S. P. F., Greenwood, P. L., & Gardner, G. E. (2011). Beef cattle selected for increased muscularity have a reduced muscle response and increased adipose tissue response to adrenaline. *Animal, 5*(6), 875-884.

McLoughlin, E. (2018). Knowing cows: Transformative mobilizations of human and non-human bodies in an emotionography of the slaughterhouse. *Gender, Work & Organization, 1*(21).

McManus, C., Tanure, C. B., Peripolli, V., Seixas, L., Fischer, V., Gabbi, A. M., . . . Costa, J. B. G. (2016). Infrared thermography in animal production: An overview. *Computers and Electronics in Agriculture, 123*, 10-16.

McNally, P. W., & Warriss, P. D. (1996). Recent bruising in cattle at abattoirs. *Veterinary Record, 138*(6), 126-128.

Mellor, D. J., & Littin, K. E. (2004). Using science to support ethical decisions promoting humane livestock slaughter and vertebrate pest control. *Animal welfare, 13*(1), 127-132.

Mench, J. A. (2008). Farm animal welfare in the U.S.A.: Farming practices, research, education, regulation, and assurance programs. *Applied Animal Behaviour Science, 113*(4), 298-312.

Miller, M. (2007). *Dark, firm and dry beef* National Cattlemen's Beef Association, on behalf of The Beef Checkoff Program. U.S.A. Centennial, CO. Retrieved from https://buffalo.extension.wisc.edu/files/2010/06/Dark-Firm-and-Dry-Beef.pdf

Mir, N. A., Rafiq, A., Kumar, F., Singh, V., & Shukla, V. (2017). Determinants of broiler chicken meat quality and factors affecting them: a review. *Journal of Food Science and Technology, 54*(10), 2997-3009.

Miranda-de la Lama, G. C., Leyva, I. G., Barreras-Serrano, A., Pérez-Linares, C., Sánchez-López, E., María, G. A., & Figueroa-Saavedra, F. (2012). Assessment of cattle welfare at a commercial slaughter plant in the northwest of Mexico. *Tropical animal health and production, 44*(3), 497-504.

Moberg, G. P. (2000). Biological response to stress: implications for animal welfare. In G. P. Moberg & J. A. Mench (Eds.), *The biology of animal stress* (pp. 1-21). New York USA: CABI Publishing.

Mpamhanga, C. J., & Wotton, S. B. (2015). The effects of pre-slaughter restraint (for the purpose of cattle identification) on post-slaughter responses and carcass quality following the electrical stun/killing of cattle in a Jarvis Beef stunner. *Meat Science, 107*, 104-108.

Nasirahmadi, A., Edwards, S. A., Matheson, S. M., & Sturm, B. (2017). Using automated image analysis in pig behavioural research: Assessment of the influence of enrichment substrate provision on lying behaviour. *Applied Animal Behaviour Science, 196*, 30-35.

Neethirajan, S. (2017). Recent advances in wearable sensors for animal health management. *Sensing and Bio-Sensing Research, 12*, 15-29.

Neethirajan, S., Tuteja, S. K., Huang, S.-T., & Kelton, D. (2017). Recent advancement in biosensors technology for animal and livestock health management. *Biosensors and Bioelectronics, 98*, 398-407.

Nesbitt, C. I., Phillips, A. W., Searle, R. F., & Stansby, G. (2015). Randomized Trial to Assess the Effect of Supervised and Unsupervised Video Feedback on Teaching Practical Skills. *Journal of Surgical Education, 72*(4), 697-703.

Nijdam, E., Arens, P., Lambooij, E., Decuypere, E., & Stegeman, J. A. (2004). Factors influencing bruises and mortality of broilers during catching, transport, and lairage. *Poultry Science, 83*(9), 1610-1615.

Paranhos da Costa, M. J. R., Huertas, S. M., Gallo, C., & Dalla Costa, O. A. (2012). Strategies to promote farm animal welfare in Latin America and their effects on carcass and meat quality traits. *Meat Science, 92*(3), 221-226.

Paul, E., & Serpell, J. (1993). Childhood pet keeping and humane attitudes in young adulthood. *Animal welfare, 2*(4), 321-337.

Peabody, D. (1962). Two components in bipolar scales: Direction and extremeness. *Psychological Review, 69*(2), 65.

Pedersen, A., Getty Ritter, E., Beaton, M., & Gibbons, D. J. A. j. (2017). Remote video auditing in the surgical setting. *AORN journal, 105*(2), 159-169.

Peeters, G. (1971). The positive-negative asymmetry: On cognitive consistency and positivity bias. *European Journal of Social Psychology, 1*(4), 455-474.

Peeters, G., & Czapinski, J. (1990). Positive-negative asymmetry in evaluations: The distinction between affective and informational negativity effects. *European review of social psychology, 1*(1), 33-60.

Petracci, M., Bianchi, M., & Cavani, C. (2010). Pre-slaughter handling and slaughtering factors influencing poultry product quality. *World's poultry science journal, 66*(1), 17-26.

Pilecco, M., Almeida Paz, I., Tabaldi, L., Nääs, I., Garcia, R., Caldara, F., & Francisco, N. (2013). Training of catching teams and reduction of back scratches in broilers *Brazilian Journal of Poultry Science, 15*, 283-286.

Pinillos, R. G. (2018). We need to make more use of technology in the slaughter industry to improve welfare. *Veterinary Record, 183*(6), 198.

Pompe, V., & Ruis, M. A. W. (2015, September 2015). *Participative monitoring of the welfare of veal calves.* Paper presented at the 66th annual meeting of the European Association for Animal Production (EAAP), Warsaw, Poland.

Ponnampalam, E. N., Hopkins, D. L., Bruce, H., Li, D., Baldi, G., & Bekhit, A. E.-d. (2017). Causes and Contributing Factors to “Dark Cutting” Meat: Current Trends and Future Directions: A Review. *Comprehensive Reviews in Food Science and Food Safety, 16*(3), 400-430.

Porcher, J. (2008). Ouvrière en production porcine industrielle: le prix de la reconnaissance. Retrieved from http://www.ethnographiques.org/2008/Porcher

Porcher, J. (2011). The relationship between workers and animals in the pork industry: A shared suffering. *Journal of Agricultural and Environmental Ethics, 24*(1), 3-17.

Porcher, J., Cousson-Gélie, F., & Dantzer, R. (2004). Affective components of the human-animal relationship in animal husbandry: development and validation of a questionnaire. *Psychological reports, 95*(1), 275-290.

Poursaberi, A., Bahr, C., Pluk, A., Van Nuffel, A., & Berckmans, D. (2010). Real-time automatic lameness detection based on back posture extraction in dairy cattle: Shape analysis of cow with image processing techniques. *Computers and Electronics in Agriculture, 74*(1), 110-119.

Quinn, A. D., Kettlewell, P. J., Mitchell, M. A., & Knowles, T. (1998). Air movement and the thermal microclimates observed in poultry lairages. *British Poultry Science, 39*(4), 469-476.

Raj, A. (2004). Stunning and Slaughter of Poultry In G. Mead (Ed.), *Poultry Meat Processing and Quality*. New York. NY: CRC Press.

Raj, A. B. M., O'Callaghan, M., & Knowles, T. G. (2006). The effects of amount and frequency of alternating current used in water bath stunning and of slaughter methods on electroencephalograms in broilers. *Animal welfare, 15*(1), 7-18.

Rao, M. A., Knowles, T. G., & Wotton, S. B. (2013). The effect of pre-stun shocks in electrical water-bath stunners on carcase and meat quality in broilers. *Animal welfare, 22*(1), 79-84.

Richards, E., Signal, T., & Taylor, N. (2013). A Different Cut? Comparing Attitudes toward Animals and Propensity for Aggression within Two Primary Industry Cohorts—Farmers and Meatworkers. *Society & Animals, 21*(4), 395-413.

Ritchie, J., Spencer, L., & O'Connor, W. (2007). Carrying out qualitative analysis. . In J. Ritchie & J. Lewis (Eds.), *Qualitative Research Practice* (pp. 219-262). London UK: Sage Publications.

Rocha, L. M., Devillers, N., Maldague, X., Kabemba, F. Z., Fleuret, J., Guay, F., & Faucitano, L. (2019). Validation of Anatomical Sites for the Measurement of Infrared Body Surface Temperature Variation in Response to Handling and Transport. *Animals, 9*(7), 425.

Rollin, B. E. (1993). Animal welfare, science, and value. *Journal of Agricultural and Environmental Ethics 6*(Suppliment 2), 44-50.

Romero, M. H., Gutierrez, C., & Sanchez, J. A. (2012). Evaluation of bruises as an animal welfare indicator during pre-slaughter of beef cattle. *Revista Colombiana De Ciencias Pecuarias, 25*(2), 267-275.

Rozin, P., & Royzman, E. B. (2001). Negativity bias, negativity dominance, and contagion. *Personality and social psychology review, 5*(4), 296-320.

RSPCA. (2010). Record-breaking demand for freedom food. Retrieved from https://www.rspca.org.uk/whatwedo/latest/news

Ruis, M. A. W., Coleman, G. J., Waiblinger, S., Windschnurer, I., & Boivin, X. (2010). A multimedia-based cognitive-behavioural intervention program improves attitudes and handling behaviours of stockpeople in livestock farming. *Advances in Animal Biosciences, 1*(1), 175.

Rushen, J., Chapinal, N., & De Passille, A. (2012). Automated monitoring of behavioural-based animal welfare indicators. *Animal Welfare-The UFAW Journal, 21*(3), 339.

Sarid, A. (2018). A theory of education. *Cambridge Journal of Education, 48*(4), 479-494.

Schuman, H., & Presser, S. (1981). *Questions and Answers in Attitude Surveys*. New York: Academic Press.

Schwartzkopf-Genswein, K. S., Faucitano, L., Dadgar, S., Shand, P., González, L. A., & Crowe, T. G. (2012). Road transport of cattle, swine and poultry in North America and its impact on animal welfare, carcass and meat quality: A review. *Meat Science, 92*(3), 227-243.

Seabrook, M. (2001). *The effect of the operational environment and operating protocols on the attitudes and behaviour of employed stockpersons.* Paper presented at the Human-animal relationship: stockmanship and housing in organic livestock systems. Proceedings of the 3rd NAHWOA Workshop, Clermont-Ferrand, France,.

Shields, S. J., & Raj, A. B. M. (2010). A Critical Review of Electrical Water-Bath Stun Systems for Poultry Slaughter and Recent Developments in Alternative Technologies. *Journal of Applied Animal Welfare Science, 13*(4), 281-299.

Sirri, F., Petracci, M., Zampiga, M., & Meluzzi, A. (2017). Effect of EU electrical stunning conditions on breast meat quality of broiler chickens. *Poultry Science, 96*(8), 3000-3004.

Smith, G. C., Savell, J. W., Dolezal, H. G., Field, T. G., Gill, D. R., Griffin, D. B., . . . Tatum, J. D. (1995). The final report of the national beef quality audit. Colorado State Univeristy, Fort Collins

Smith, H. W. (1975). *Strategies of Social Research: methodological imagination.* London: Prentice Hall International.

Smith, J., Bekker, H., & Cheater, F. (2011). Theoretical versus pragmatic design in qualitative research. *Nurse Res, 18*(2), 39-51.

Solomon, M., Laack, R., & Eastridge, J. (1998). Biophysical basis of pale, soft, exudative (PSE) pork and poultry muscle: A review. *Journal of Muscle Foods, 9*(1), 1-11.

Sparrey, J., & Kettlewell, P. (1994). Shackling of poultry: is it a welfare problem? *World's Poultry Science Journal, 50*(2), 167-176.

Special Eurobarometer. (2016). Attitudes of EU citizens towards Animal Welfare. 442. Retrieved from http://ec.europa.eu/COMMFrontOffice/publicopinion/index.cfm/Survey/getSurveyDetail/instruments/SPECIAL/surveyKy/2096

Spoolder, H., & Ruis, M. A. W. (2015, 23-26 Oct 2015). *Improving Farm Animal Productivity and Welfare, by Increasing Skills and Knowledge of Stock People.* Paper presented at the Int. Symp. on Animal Environ. & Welfare, Chongqing, China.

Strappini, A. C., Metz, J. H. M., Gallo, C., Frankena, K., Vargas, R., de Freslon, I., & Kemp, B. (2013). Bruises in culled cows: when, where and how are they inflicted? *Animal, 7*(3), 485-491.

Strappini, A. C., Metz, J. H. M., Gallo, C. B., & Kemp, B. (2009). Origin and assessment of bruises in beef cattle at slaughter. *Animal, 3*(5), 728-736.

Tarrant, P. (1989). Animal behaviour and environment in the dark-cutting condition in beef-a review. *Irish Journal of Food Science and Technology*, 1-21.

Taylor, D. H. (2006). Strategic considerations in the development of lean agri-food supply chains: a case study of the UK pork sector. *Supply Chain Management: An International Journal, 11*(3), 271-280.

Taylor, G. B. (1972). One man's philosophy of welfare. *The Veterinary record, 91*(18), 426-428.

Teague, C., & Green, L. (2012). Using CCTV footage as a communication training and safety Resource.

Terlouw, E. M. C., Arnould, C., Auperin, B., Berri, C., Le Bihan-Duval, E., Deiss, V., . . . Mounier, L. (2008). Pre-slaughter conditions, animal stress and welfare: current status and possible future research. *Animal, 2*(10), 1501-1517.

Terlouw, E. M. C., Porcher, J., & Fernandez, X. (2005). Repeated handling of pigs during rearing. II. Effect of reactivity to humans on aggression during mixing and on meat quality. *Journal of Animal Science, 83*(7), 1664-1672.

Tucker, C. B., Coetzee, J. F., Stookey, J. M., Thomson, D. U., Grandin, T., & Schwartzkopf-Genswein, K. S. (2015). Beef cattle welfare in the USA: identification of priorities for future research. *Animal Health Research Reviews, 16*(02), 107-124.

Tulloh, N. (1961). Behaviour of cattle in yards. II. A study of temperament. *Animal behaviour, 9*(1-2), 25-30.

USDA. (1996). Livestock Slaughter Annual Summary 1995. Retrieved from http://usda.mannlib.cornell.edu/usda/nass/LiveSlauSu//1990s/1996/LiveSlauSu-03-14-1996.pdf

Valeeva, N. I., Lam, T. J. G. M., & Hogeveen, H. (2007). Motivation of Dairy Farmers to Improve Mastitis Management. *Journal of Dairy Science, 90*(9), 4466-4477.

Vanderhasselt, R. F., Sprenger, M., Duchateau, L., & Tuyttens, F. A. M. (2013). Automated assessment of footpad dermatitis in broiler chickens at the slaughter-line: Evaluation and correspondence with human expert scores. *Poultry Science, 92*(1), 12-18.

Vaughan, K., & Cameron, M. (2009). *Assessment of learning in the workplace: A background paper*: Industry Training Federation Wellington.

Velarde, A., & Dalmau, A. (2012). Animal welfare assessment at slaughter in Europe: Moving from inputs to outputs. *Meat Science, 92*(3), 244-251.

Villarroel, M., María, G. A., Sierra, I., Sañudo, C., Garćia-Belenguer, S., & Gebresenbet, G. (2001). Critical points in the transport of cattle to slaughter in Spain that may compromise the animals' welfare. *Veterinary Record, 149*(6), 173-176.

Vinco, L. J., Archetti, I. L., Giacomelli, S., & Lombardi, G. (2016). Influence of crate height on the welfare of broilers during transport. *Journal of Veterinary Behavior, 14*, 28-33.

Waiblinger, S., Boivin, X., Pedersen, V., Tosi, M.-V., Janczak, A. M., Visser, E. K., & Jones, R. B. (2006). Assessing the human - animal relationship in farmed species: A critical review. *Applied Animal Behaviour Science, 101*(3), 185-242.

Wallace, S. (2008). *A Dictionary of Education* Oxford, UK: OUP.

Wambui, J., Lamuka, P., Karuri, E., & Matofari, J. (2018). Animal Welfare Knowledge, Attitudes, and Practices of Stockpersons in Kenya. *Anthrozoös, 31*(4), 397-410.

Warner, R. D., Ferguson, D. M., Cottrell, J. J., & Knee, B. W. (2007). Acute stress induced by the preslaughter use of electric prodders causes tougher beef meat. *Australian Journal of Experimental Agriculture, 47*(7), 782-788.

Warren, L. A., Mandell, I. B., & Bateman, K. G. (2010). Road transport conditions of slaughter cattle: Effects on the prevalence of dark, firm and dry beef. *Canadian Journal of Animal Science, 90*(4), 471-482.

Warriss, P., Knowles, T., Brown, S., Edwards, J., Kettlewell, P., Mitchell, M., & Baxter, C. (1999). Effects of lairage time on body temperature and glycogen reserves of broiler chickens held in transport modules. *The Veterinary Record 145*(8), 218.

Warriss, P. D. (1990). The handling of cattle pre-slaughter and its effects on carcass and meat quality. *Applied Animal Behaviour Science, 28*(1), 171-186.

WATOK, The Welfare of Animals at the Time of Killing (England) Regulations 2015, **Statutory Instruments No. 1782** (2015).

Waynert, D., Stookey, J., Schwartzkopf-Genswein, K., Watts, J., & Waltz, C. (1999). The response of beef cattle to noise during handling. *Applied Animal Behaviour Science, 62*(1), 27-42.

Weeks, C. (2008). A review of welfare in cattle, sheep and pig lairages, with emphasis on stocking rates, ventilation and noise. *Animal welfare, 17*(3), 275-284.

Weeks, C., McNally, P., & Warriss, P. (2002). Influence of the design of facilities at auction markets and animal handling procedures on bruising in cattle. *Veterinary Record, 150*(24), 743-748.

Weschenfelder, A. V., Saucier, L., Maldague, X., Rocha, L. M., Schaefer, A. L., & Faucitano, L. (2013). Use of infrared ocular thermography to assess physiological conditions of pigs prior to slaughter and predict pork quality variation. *Meat Science, 95*(3), 616-620.

Whay, H. R. (2007). The journey to animal welfare improvement. *Animal welfare, 16*(2), 117.

Whay, H. R., & Main, D. C. (2010). Improving animal welfare: practical approaches for achieving change. In T. Grandin (Ed.), *Improving Animal Welfare* (pp. 227-251). Wallingford, Oxfordshire, UK: CAB International

Wickman, M. (2013). *Knowledge and attitudes among staff handling livestock at Swedish slaughterhouses.* SLU, Uppsala. Retrieved from https://stud.epsilon.slu.se/5206/

Wigham, E. E., Butterworth, A., & Wotton, S. (2018). Assessing cattle welfare at slaughter – Why is it important and what challenges are faced? *Meat Science, 145*, 171-177.

Wilkins, L., Gregory, N., Wotton, S., & Parkman, I. (1998). Effectiveness of electrical stunning applied using a variety of waveform-frequencycombinations and consequences for carcase quality in broiler chickens. *British Poultry Science, 39*(4), 511-518.

Wilkins, L., Wotton, S., Parkman, I., Kettlewell, P., & Griffiths, P. (1999). Constant current stunning effects on bird welfare and carcass quality. *Journal of Applied Poultry Research, 8*(4), 465-471.

Willits, F. K., Theodori, G. L., & Luloff, A. (2016). Another look at Likert scales. *Journal of Rural Social Sciences, 31*(3), 126.

Wotton, S. B., Gregory, N. G., Whittington, P. E., & Parkman, I. D. (2000). Electrical stunning of cattle. *Veterinary Record, 147*(24), 681-684.

Wotton, S. B., & Whittington, P. E. (1997, August 24-29). *The use of multi-media in training; the Animal Welfare Officer training course.* Paper presented at the World Congree on Food Hygiene The Hague - The Netherlands.

Zegwaard, K., Coll, R. K., & Hodges, D. (2003). Assessment of workplace learning: A framework. *International Journal of Work-Integrated Learning, 4*(1), 9.

List of Abbreviations

6mpost-T	6 months post-training visit
AC	Alternating Current
ANOVA	Analysis of Variance
AW	Animal Welfare
AWO	Animal Welfare Officer
C1, C2, C3	Cattle Plant 1, 2, 3
CCTV	Closed-Circuit Television
CI	Confidence Interval
CoC	Certificate of Competence
Coef.	Coefficient
DCB	Dark Cutting Beef
DEFRA	Department for Environment, Food and Rural Affairs
DVR	Digital Video Recorder
EC	European Commission
EU	European Union
EW	Ellie Wigham
FAWC	Farm Animal Welfare Committee
FBO	Food Business Operator
FSA	Food Standards Agency
GLM	General Linear Model
HAI	Human-animal interaction
HQ	Headquarters
IRR	Incidence Rate Ratio
MQL	Marginal Quasi-likelihood
NAMI	North American Meat Institute

NGO	Non-Governmental Organisation
OR	Odds ratio
OV	Official Veterinarian
P1, P2, P3	Poultry Plant 1, 2, 3,
PAACO	Professional Animal Auditor Certification Organisation
PQL	Predictive quasi-likelihood
PO	Potential Occurrence
post-T	Immediately post-training visit
PPE	Personal Protective Equipment
Pre-T	Pre-training visit
PSM	Poultry Stun Meter
PSS	Pre-stun Shocks
PWO	Poultry Welfare Officer
QA	Quality Assurance
Ref	Reference
RMS	Root Mean Squared
RVA	Remote Video Auditing
SD	Standard Deviation
SE	Standard Error
SOP	Standard Operating Procedure
UoB	University of Bristol
USDA	United States Department of Agriculture
Var	Variance
WATOK	Welfare of Animals at the Time of Killing

Appendices

Appendix 1: Full Questionnaire

Questionnaire

By completing and returning this questionnaire I fully and freely consent to my participation in this study. I agree to the University of Bristol keeping and processing the data I have provided during the course of the study. I understand that the data will only be used for the purpose set out in the information sheet and that my anonymised data may be publicly available through a repository.

For each of the questions below, circle the response that best characterises how you feel about the statement, where 1=Strongly Disagree, 2=Disagree, 3=Neither Agree nor Disagree, 4=Agree, 5=Strongly agree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I enjoy working with animals	1	2	3	4	5
Welfare at slaughter is as good as it's going to get	1	2	3	4	5
Up to now I feel I have not received enough welfare training	1	2	3	4	5
Working in the slaughter industry is a stressful job	1	2	3	4	5
Current animal welfare legislation is too lenient	1	2	3	4	5
I am willing to spend more money on welfare friendly food products	1	2	3	4	5

Livestock animals are all individuals and each have their own personalities	1	2	3	4	5
Time constraints mean that stock handlers do not have time to correctly handle livestock	1	2	3	4	5
It is important to me that animals have 'a life worth living'	1	2	3	4	5
Working in the slaughter industry gives me a feeling of accomplishment.	1	2	3	4	5
I get upset when I see someone mistreat an animal	1	2	3	4	5
All abattoir staff handling animals should receive welfare training	1	2	3	4	5
I feel that in the slaughter industry 'Production is everything'	1	2	3	4	5

Animals feel pain just like humans do.	1	2	3	4	5
Public concern about the welfare of animals is exaggerated	1	2	3	4	5
I try to emotionally detach from my day to day job.	1	2	3	4	5
I get easily frustrated when working with animals.	1	2	3	4	5
Stressing an animal at an abattoir doesn't matter – they are going to be slaughtered anyway.	1	2	3	4	5
I am very concerned about the pain and suffering of animals	1	2	3	4	5
CCTV is an effective way to improve animal welfare at slaughter	1	2	3	4	5

Further Questions

1. ***Gender (please circle):***

Male Female Prefer not to say

2. ***Nationality:***

3. ***Time working in slaughter industry (in years/months):***

4. ***Species involved with (please circle all that apply):***

Cattle Pigs Sheep Poultry Deer Horses Game Other

5. ***Do you currently hold any Certificate of competencies (please circle)***

Yes No

6. ***Previously attended a University of Bristol AWO/PWO training course? (please circle)***

Yes No

7. ***Current Role – other than AWO/PWO (please circle main role)***

Stockperson – based in the lairage	Stockperson -restraining animals or shackling live birds	Slaughterman – involved in stunning/sticking/shackling
Supervisor – based in the lairage/on the slaughterfloor	Supervisor – office based	Technical/Quality manager
Other manager – slaughterhouse	Other – abattoir based	Veterinarian
Meat inspector	Non-abattoir based (please state role)	Non-slaughter industry based (please state role)

Appendix 2: Cattle Welfare assessment.

Lairage Pen

Pen number: **Time**

Behaviour	Count
Mounting	
Butting	
Slips	
Banging into object/structure	

Entering Raceway/ Tagging area

Time: **End**

	Movement							**Human Animal Interaction**					
Animal	Slip	Fall	Running	Turn around	Jump	Bang	Move backwards	Sound	HG	HH	OG	OH	Goad
1													
2													
3													
4													
5													
6													
7													
8													
9													

10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													

26													
27													
28													
29													
30													
31													
32													
33													
34													
35													
36													
37													
38													
39													
40													
41													

42													
43													
44													
45													
46													
47													
48													
49													
50													

Entering Stun Pen

Time:

Animal	Time into box	Movement Score	Slip	Banging into object/structure	Coercion Score
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					

25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
41					
42					
43					
44					
45					
46					
47					
48					
49					
50					

Movement score 0-3

- 0. Animal begins to move into stun box without the need for coercion.
- 1. Animal moves into the stun box once coercion is used.

- 2. Animal enters the stun box, then baulks and backs up.
- 3. Animal refuses to move – a lot of coercion required.

Coercion score 0-2

- 0. No coercion.
- 1. Use of hand or object.
- 2. Use of electric goad.

Stunning (box)

Time:

Animal	Time door close -> shot fired/cut	Struggle	Banging into object/structure	Shots administered
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				

Bleeding

Time:

Animal	Stun to stick/stick to stun interval (s)	Fixed glazed expression Y/N	Lack of rhythmic breathing Y/N	Second shot administer ed? Y/N
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				

23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				

<u>Assessment protocol</u>

The protocol outlined below aims to collect data from 250 animals/carcasses at 6 main observation points over a period of five days. (Modification may be required due to low kill numbers/short days etc.)

Assessment point	Monday	Tuesday	Wednesday	Thursday	Friday
<u>Lairage pens</u> – 3 pens observed for 10 minutes each after a 2min ‘settle’ period.	Pre-production	Pre-production	Pre-production	Pre-production	Pre-production
<u>Race entry</u> – 50 animals from entering raceway	1	2	3	4	5
<u>Raceway –</u> In race if halal, corner of race if conventional	5	1	2	3	4
<u>Stun box –</u>50 animals	4	5	1	2	3
<u>Bleed-</u> 50 animals	3	4	5	1	2
<u>Line –</u> 50 carcasses bruising assessment	2	3	4	5	1

Appendix 3 A full list of topics covered in the AWO course

AWO			
Day one		**Day two**	
Subject	**Topics covered**	**Subject**	**Topics covered**
Introduction to the course and legislation	• Course history • Introductions • European and national legislation • The UK slaughter industry – production figures • EC NO 1099/2009 • SOPs	What do I understand by electricity?	• Understand how electricity is generated • Understand AC and DC current, • Understand Frequency • Understand Voltage • Understand Current • Understand Resistance • Understand relationship between Voltage, Current and Resistance.
What is animal welfare?	• Anthropomorphism • The five freedoms • Definition of welfare • Does size matter? • Abattoir perspective • Welfare drivers in the abattoir	How does electricity stun?	• Effect of voltage • Criteria for immediate stun • Important factors to control • Epilepsy • Phases of the stun • Time to recovery • Stun assurance monitor • Electrode position • Automatic stunning • Signs of unconsciousness

			• Carcass quality • Equipment – factors to control
Animal behaviour and movement	• Understanding cattle behaviour • Flight zones • Factors that effect animal movement • Understanding sheep behaviour • Understanding pig behaviour • Types of race • Stockmanship	Electrical head to body stunning	• The problem with head only stunning • Phases of epilepsy after 'cardiac arrest stunning' • Correct electrode position. • Physical criteria for effective stun/kill • Period of unconsciousness produced • Effect on meat quality • Automated systems
Meat and quality	• What is quality? • Muscle to meat • Dark cutting beef • Dark firm dry pork • Skin damage in pigs • Recovery • Pale soft exudative meat • Identifying meat quality • Effect of pre-slaughter stress on flavour • EASy PEAsy	Electrical stun/killing of cattle	• Jarvis beef stunner • Minimum current requirement • Recognising an effective stun • The death process
Animal transport	• Stress of transport • Fit to transport?	Gas killing of pigs	• Stockmanship • Legislative requirements

	• Assessing fitness for transport • Unloading		• Controlled atmospheres (CA) • Effect of CA on neural tissue • Experiments on students and pigs • Operation of the chamber • Recognising effective killing • Back-up
Lairaging and stockmanship	• Stockmanship • Lighting • The lairage environment • Stocking density • Lairage design • Electric goads • Coercion • Lairaging of sheep	Slaughter	• Definition • Meant industry myths • Blood loss • Effect of cardiac arrest on blood loss • Blood loss in sheep • Blood loss in cattle • Blood loss in pigs • Difference between species
Restraint	• Cattle restraint • Sheep restraint • Pig restraint	Auditing stunning	• Numerical scoring • Prohibited practices • CCTV • Key welfare indicators
Introduction to stunning	• Definitions • Brain death • Why use rhythmic breathing? • What is stunning?	Religious slaughter	• Shechita • Halal • Overview • Three questions • Is restraint stressful?

			• Is the cut painful? • How long do they take to die? • What is the difference between the species? • Blood loss at slaughter • Dialrel
		<u>Casualty slaughter</u>	• What is a casualty? • Casualty slaughter of cattle

<u>Appendix 4:</u> Full Negative binomial models for BEHSCORE and HAISCORE which were used to calculate IRR

C1 ENTERING RACEWAY

Predictor	BEHSCORE				HAISCORE			
	Coef.	SE	z-ratio	*p*	Coef.	SE	z-ratio	*p*
Constant	-1.63	0.246	-6.634	<0.0001	-0.654	0.191	-3.427	0.001
Visit								
1	*(ref)*				*(ref)*			
2	-0.801	0.382	-2.098	0.036	-4.37	0.278	-1.573	0.116
3	-1.059	0.39	-2.654	0.008	0.238	0.267	0.893	0.372
Random effects	Var	SE			Var	SE		
Day	0.06	0.14			0.15	0.07		

C1 TAGGING

Predictor		BEHSCORE				HAISCORE			
		Coef.	SE	z-ratio	*p*	Coef.	SE	z-ratio	*p*
Constant		0.79	0.155	5.108	<0.0001	0	0.199	0	1
Visit	1	*(ref)*				*(ref)*			
	2	0.449	0.217	2.065	0.039	0.365	0.279	1.306	0.192
	3	0.358	0.218	1.645	0.1	-0.075	0.282	-0.265	0.791
Random effects		Var	SE			Var	SE		
Day		0.08	0.04			0.13	0.07		

C2 ENTERING RACEWAY

Predictor	BEHSCORE				HAISCORE			
	Coef.	SE	z-ratio	*p*	Coef.	SE	z-ratio	*p*
Constant	-1.139	0.177	-6.426	<0.0001	-0.440	0.181	-2.433	0.015
Visit								
1	*(ref)*				*(ref)*			
2	-0.553	0.269	-2.061	0.039	0.06	0.255	0.236	0.813
3	-0.532	0.268	-1.987	0.047	-0.319	0.26	-1.226	0.22
Random effects	Var	SE			Var	SE		
Day	0.013	0.068			0.125	0.061		

C2 TAGGING

Predictor		BEHSCORE				HAISCORE			
		Coef.	SE	z-ratio	*p*	Coef.	SE	z-ratio	*p*
Constant		0.659	0.138	4.776	<0.0001	0.117	0.143	0.815	0.415
Visit	1	*(ref)*				*(ref)*			
	2	-0.049	0.195	-0.25	0.803	-0.166	0.206	-0.813	0.416
	3	-0.216	0.196	-1.103	0.27	-0.074	0.203	-0.363	0.717
Random effects		Var	SE			Var	SE		
Day		0.04	0.04			0.05	0.04		

C3 ENTERING RACEWAY

Predictor		BEHSCORE				HAISCORE			
		Coef.	SE	z-ratio	*p*	Coef.	SE	z-ratio	*p*
Constant		-1.347	0.477	-2.821	0.005	0.235	0.099	2.373	0.018
Visit	1	*(ref)*				*(ref)*			
	2	-1.553	0.726	-2.1.8	0.032	-0.352	0.146	-2.41	0.016
	3	-1.754	0.74	-2.37	0.018	-0.225	0.144	-1.568	0.117
Random effects		Var	SE			Var	SE		
Day		0.69	0.45			0.03	0.02		

C3 TAGGING

Predictor		BEHSCORE				HAISCORE			
		Coef.	SE	z-ratio	*p*	Coef.	SE	z-ratio	*p*
Constant		1.051	0.159	6.611	<0.0001	0.703	0.076	0.555-0.852	<0.0001
Visit	1	*(ref)*				*(ref)*			
	2	-0.299	0.226	-1.013	0.311	-0.187	0.109	-1.711	0.087
	3	-0.414	0.227	-1.827	0.068	-0.085	0.108	-0.788	0.431
Random effects		Var	SE			Var	SE		
Day		0.08	0.04			0.003	0.01		

<u>Appendix 5</u>: Full Negative binomial models of behaviours when animals were entering and within the stun box for each plant. These were used to calculate the IRR.

C1

Predictor		Slip				Bang				Struggle			
		Coef.	SE	z-ratio	*p*	Coef.	SE	z-ratio	*p*	Coef.	SE	z-ratio	*p*
Constant		-0.978	0.21	-4.6	<0.0001	-0.93	0.21	-4.43	<0.0001	-1.09	0.21	-5.26	<0.0001
Visit	1	*(ref)*				*(ref)*				*(ref)*			
	2	-0.59	0.315	-1.88	0.06	-0.16	0.3	-0.55	0.58	0.18	0.29	0.64	0.525
	3	--4.54	1.06	-4.37	<0.0001	-3.9	0.76	-5.14	<0.0001	-1.39	0.35	-3.97	<0.0001
Random Effect		Var	SE			Var	SE			Var	SE		
Day		0.17	0.11			0.18	0.1			0.12	0.09		

C2

Predictor		Slip				Bang				Struggle			
		Coef.	SE	z-ratio	*p*	Coef.	SE	z-ratio	*p*	Coef.	SE	z-ratio	*p*
Constant		-2.48	0.328	-7.55	<0.0001	-1.81	0.262	-6.89	<0.0001	-1.76	0.17	-10.58	<0.0001
Visit	1	*(ref)*				*(ref)*				*(ref)*			
	2	-0.34	0.484	-0.7	0.487	-0.42	0.39	-1.08	0.28	-1.12	0.32	-3.49	<0.0001
	3	-0.65	0.51	-1.27	0.2	-1.41	0.46	-3.06	0.002	-0.93	0.3	-3.08	0.002
Random Effect		Var	SE			Var	SE			Var	SE		
Day		0.31	0.23			0.23	0.16			0.04	0.08		

C3

Predictor		Slip				Bang				Struggle			
		Coef.	SE	z-ratio	*p*	Coef.	SE	z-ratio	*p*	Coef.	SE	z-ratio	*p*
Constant		-3.03	0.46	-6.59	<0.0001	-1.07	0.11	-9.81	<0.0001	-0.77	0.13	-5.76	<0.0001
Visit	1	*(ref)*				*(ref)*				*(ref)*			
	2	-0.09	0.62	-0.15	0.89	-0.76	0.2	-3.85	<0.0001	-0.91	0.22	-4.22	<0.0001
	3	0.38	0.6	0.64	0.53	-0.28	0.17	-1.68	0.094	-1.02	0.23	-4.44	<0.0001
Random effect		Var	SE			Var	SE			Var	SE		
Day		0.31	0.23			0.23	0.16			0.04	0.06		

Appendix 6: Poultry welfare and product quality assessment

Date	
Time	
Temperature	
RH	

LAIRAGE

Crate	Position (B/M/T)	Birds Panting Y/N	Comment
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			

18			
19			
20			

HANG-ON

100 birds watched per operator.

Position	Both Legs Y/N	Flapping Y/N	Comments

Entering Stun Bath

Water Bath parameters

Voltage	Current	Frequency	Birds in bath

Number of birds observed=500

Score = 0	Score = 1	Score = 2	Score = 3	Comments

- Score 0 = an uninterrupted entry into the water bath where only a single contraction of the skeletal muscles occurred
- Score 1 = two to four separate contractions in response to electrical stimulation
- Score 2 = the bird flies the first stage of the water bath for ≥ 4s

Neck cutting

Observe 500 birds

Birds missing 1st slitter	Birds missing 2nd slitter

Take 25 birds off the line post cutting

Bird	*0 carotids cut*	*1 carotid cut*	*2 carotids cut*
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

Carcass Quality

Measure =

1	26	51	76	101	126	151	176
2	27	52	77	102	127	152	177
3	28	53	78	103	128	153	178
4	29	54	79	104	129	154	179
5	30	55	80	105	130	155	180
6	31	56	81	106	131	156	181
7	32	57	82	107	132	157	182
8	33	58	83	108	133	158	183
9	34	59	84	109	134	159	184
10	35	60	85	110	135	160	185
11	36	61	86	111	136	161	186
12	37	62	87	112	137	162	187
13	38	63	88	113	138	163	188
14	39	64	89	114	139	164	189
15	40	65	90	115	140	165	190
16	41	66	91	116	141	166	191
17	42	67	92	117	142	167	192
18	43	68	93	118	143	168	193
19	44	69	94	119	144	169	194
20	45	70	95	120	145	170	195
21	46	71	96	121	146	171	196
22	47	72	97	122	147	172	197
23	48	73	98	123	148	173	198
24	49	74	99	124	149	174	199
25	50	75	100	125	150	175	200

Measures -see photographic standards.

Dislocated femur: 0 = none 1= single hip 2= both hips

Red wing tips = 0, 1, 2, 3

Shoulder haemorrhaging: 0,1,2,3,

Broken/Dislocated wings

Wing haemorrhaging: 0,1,2,3

Red Pygostyles : 0,1,2

Appendix 7 A full list of topics covered in the PWO course

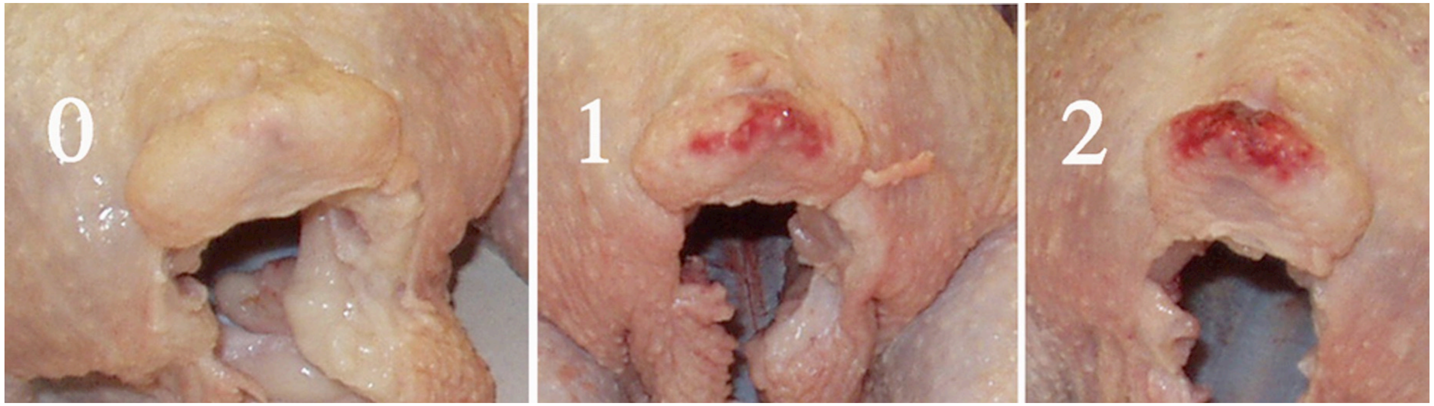
PWO			
Day one		Day two	
Subject	Topics covered	Subject	Topics covered
Introduction to the course and legislation	• Course history • Introductions • European and national legislation • The UK poultry industry – production figures • EU NO 1099/2009 • The white meat cycle • The effects of processing on welfare and quality • Consequences of poor welfare	What do I understand by electricity?	• Understand how electricity is generated • Understand AC and DC current, • Understand Frequency • Understand Voltage • Understand Current • Understand Resistance • Understand relationship between Voltage, Current and Resistance.
Catching poultry	• Preparing for depopulation • Feed withdrawal • Stockmanship • Manual catching of broilers • Flight zones • Whole bird catching • Spent hens • Mechanical catching • Catching turkeys	Poultry electrical water bath stunning	• Prevention of pre-stun shocks • The birds head is fully immersed • The variation in resistance in a multibird water bath stunner • The range in bird impedance • The variation in impedance produced by the leg/shackle interface • The variation in impedance produced by the addition of salt to the water bath • Position of electrodes

			• Recommended minimum currents to stun.
Transport	• Transport selection • Fit for purpose • Maintenance • Effect of transport • Thermal stress • Ventilation • Temp/humidity monitoring • Module/drawers • Practical consideration	Checking for effective water bath stunning	• Legislative requirement • How is stunning achieved • Current waveforms • Stunning – laboratory assessment • New criteria • Research recommendations • Stunning -practical assessment
Lairage	• Reception • Dead on arrival • Thermal stress • Thermal comfort zone • Temp. + Relative Humidity control • Ante mortem inspection • The lairage environment • Welfare of the individual • Hygiene and welfare • Are they treated as a commodity? • Staffing concerns	Head only stunning	• The American stunning knife • Dutch vision head only stunning • Head-only electrical stunning of poultry using a water bath?
Hang-on to stun	• What the job requires • Wet shackles • The effect of line speed • Lighting levels	Effect of water bath stunning on quality	• The effect of current magnitude on quality at 50 Hz AC • The effect of processing on broken bones in broilers • The effect of stunning on meat quality

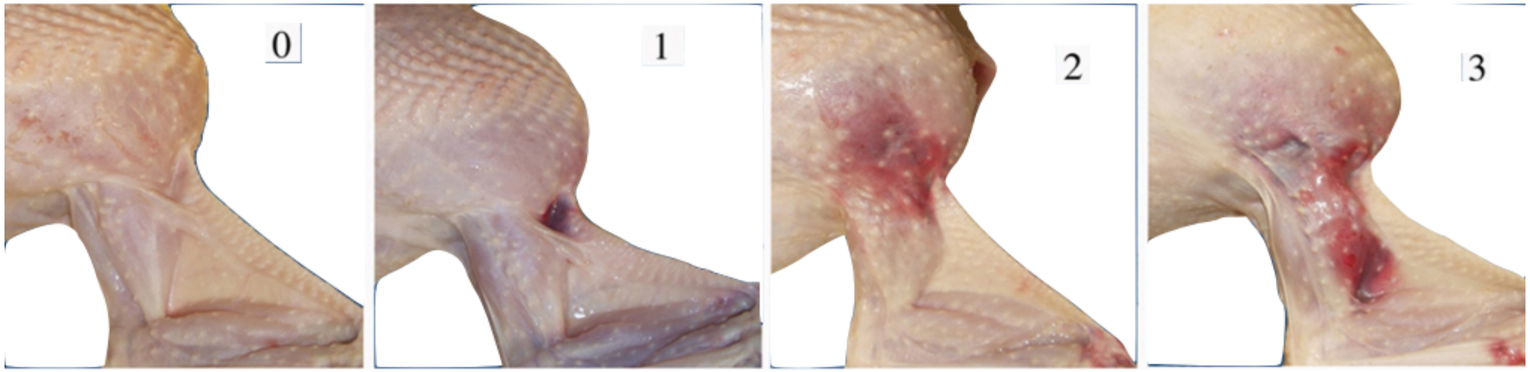
	• Inversion & shackling • Downgrading at hang-on • Severed feet • Ante mortem wing flapping • Bird size • Breast comforters • Obstruction/disturbance/access • Time to settle • Line design		• The effect of stunning current on quality in turkeys and ducks • The effect of increased stunning frequency on carcass and meat quality • The effect of welfare recommendations for stunning on quality
		Poultry slaughter	• Legislative requirement • Bird anatomy • How is slaughter achieved? • Commercial neck cutting • Assessment in the laboratory • Stun-to-kill • Stun-to-stun • How the measure the rate of blood loss The effect of blood loss on meat quality.
		Casualty slaughter of birds	• What is a casualty? • Legislation • Neck dislocation • Decapitation • Mechanical systems • Had-only electrical stunning – chickens • Head-only electrical stunning – turkeys

<u>Appendix 8:</u> Photo standards used to score carcasses in Chapter 5

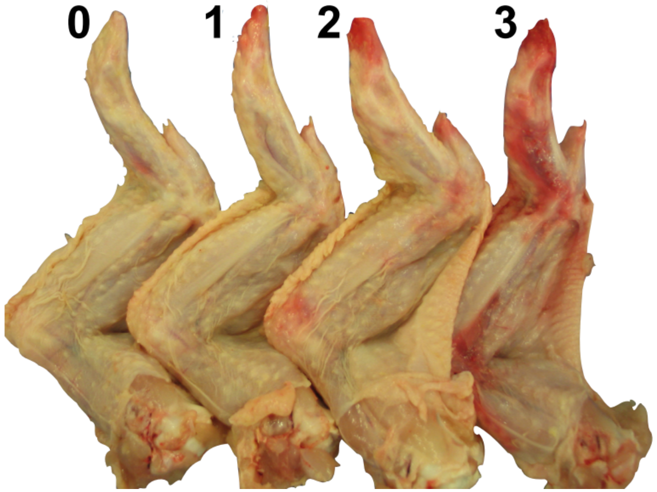
Red pygostyles



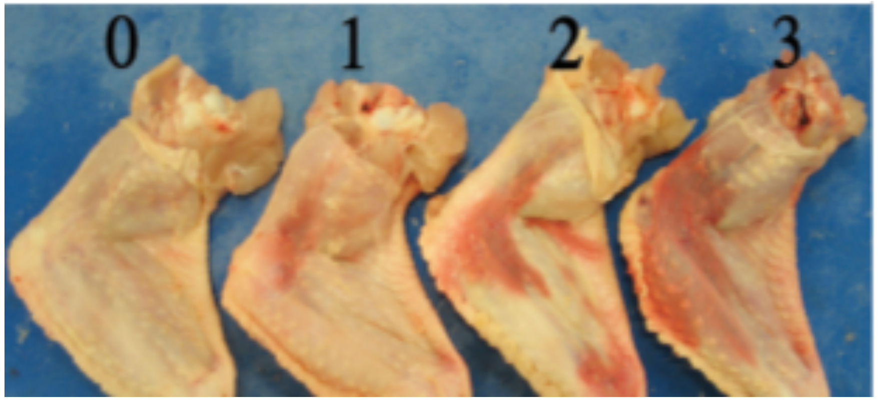
Shoulder Haemorrhage



Red wing tips



Wing Haemorrhage



Broken Wings

Bruised legs