final report

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Assessing and addressing on-farm sheep welfare

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Executive summary

The core aim of this research project was to understand the relationships between producer attitudes and the welfare of their ewes.

Six animal-based measures were evaluated for use as ewe welfare indicators: body condition score, fleece condition, skin lesions, tail length, dag score and lameness. Over the course of this study, the main welfare issues were poor nutrition (under and over feeding), mortality, lameness, ecto-parasites (flystrike) and mastitis. All of these issues can arise from, and be treated by, management practices. Along with management strategies, reproductive stage, breed and region all affected animal welfare, but farm size did not.

Farmers had very positive views on the importance of the welfare of their ewes. It was clear that our farmers had a strong concern and appreciation for animal welfare and attitudinal beliefs that their actions influenced ewe welfare. In some cases, however, there was a disconnect between their behaviours and welfare outcomes of the ewes under their care.

Attitude and perceived behavioural control were the two key drivers behind the behaviour of sheep farmers. Strategies to encourage behaviour change that target these drivers to be developed and tested. Benchmarking welfare and production would be one valuable way to engage farmers and encourage change. In the short term improving data collection and record keeping would be a simple activity to benefit welfare.

Providing farmers with easily accessible and practical solutions to common welfare issues could help increase the frequency with which animals needing further care are treated. Methods would need to be applied when ewes are in the yards, or implement relatively easily in the paddock.

Industry-wide welfare risks were tail length, lameness and recording accurate data on mortalities. Targeting these issues would have substantial benefit to a large number of animals. Cost-benefit analyses indicate modest financial gains on farm with improved welfare. These include reduced losses from short docked tails and gains from improved body condition management through more effective pasture allocations. Across all study farms, the average annual ewe mortality rate was 4.9%. A 1% reduction in the annual ewe mortality rate would increase the gross income of the Australian sheep flock by $53,516,000. Economic modelling did not include the industry identified risk animal welfare poses the biggest single risk to maintaining market access over the next 15 years.

Research recommendations focus on benchmarking welfare between different classes of stock, farms and over time, understanding incidents and causes of lameness and mastitis further, and evaluating the impact of activities targeting attitude and perceived behavioural control. Extension recommendations involve providing practical solutions to common welfare issues identified on farm, and tools to identify issues early.

Acknowledgements

Over 300 farmers contributed to this project. This contribution was a voluntary one that was based on their motivations to improve the welfare of their animals, their businesses and the industry. We're especially appreciative of the 32 farmers that opened their gates to us and shared their insights. Without their commitment, there would be no project.

Eight technical staff supported Carolina and Rebecca with the data collection for the project. We also received support from the Mackinnon project, Agriculture Victoria and industry experts.

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1 List of outputs to date

1.1 Scientific outputs

Scientific papers published

1. Munoz, C.; Campbell, A.; Barber, S; Hemsworth, P.; Doyle, R. (2018). Using Longitudinal Assessment on Extensively Managed Ewes to Quantify Welfare Compromise and Risks. *Animals*. 8: 8

2. Munoz, C.; Campbell, A.; Hemsworth, P.; Doyle, R. (2017). Animal-Based Measures to Assess the Welfare of Extensively Managed Ewes. *Animals*. 8: 2

3. Doughty AK, Coleman GJ, Hinch GN and Doyle R. E. (2017). Stakeholder perceptions of welfare issues and indicators for extensively managed sheep. *Animals*. 7:28

Scientific papers under review

1. Carolina A. Munoz and Rebecca E. Doyle (in preparation) The welfare of extensively managed ewes.

Conference presentations

2. Carolina A. Munoz, Angus J. D. Campbell, Paul H. Hemsworth and Rebecca E. Doyle. On-farm ewe welfare and its relationship with farmer management styles. International Conference on the Assessment of Animal Welfare at Farm and Group Level, Wageningen, September, 2017.
3. Munoz, C. A., Coleman, G. J., Campbell, A. J. D., Hemsworth, P. H., Doyle, R. E. 'Reliability and feasibility of animal-based indicators to assess the welfare of extensively managed ewes.' Australian Society for Animal Production, Adelaide, Australia, July 2016
4. Munoz, C. A., Coleman, G. J., Campbell, A. J. D., Hemsworth, P. H., Doyle, R. E. 'Assessment of human-animal relationship in extensively managed ewes'. International Society of Applied Ethology, Edinburgh, Scotland, July 2016
5. Munoz, C. A., Coleman, G. J., Campbell, A. J. D., Hemsworth, P. H., Doyle, R. E. 'Farmers' opinions about sheep management and welfare'. International Society of Applied Ethology, Edinburgh, Scotland, July 2016
6. Doughty A. K., Coleman G. J., Hinch G. N. and Doyle R. E. 'The welfare of extensively managed sheep: a survey identifying issues and indicators'. International Society of Applied Ethology, Edinburgh, Scotland, July 2016
7. Carolina A. Munoz, Angus J. D. Campbell, Paul H. Hemsworth and Rebecca E. Doyle. 'Indicators to examine sheep welfare'. The International Society for Applied Ethology regional meeting, Auckland, New Zealand, October 2016

Academic seminars

8. Munoz, C. A. 'Towards a sustainable sheep production, Australian and Chilean context'. The V Chilean Graduate Conference, Sydney, October 2017.

9. Munoz, C. A. ‘Assessing and addressing the welfare of extensively managed ewes’: Seminar for Scotland's Rural College, Edinburgh, Scotland, September 2017
10. Munoz, C. A. ‘Assessing and addressing the welfare of extensively managed ewes’: Seminar for the Institut für Tierhaltung und Tierschutz der Vetmeduni, Vienna, Austria, September 2017
11. Munoz, C. A. ‘Assessing and addressing the welfare of extensively managed ewes’: Faculty of Veterinary and Agricultural Science (FVAS) Symposium, Melbourne, December 2016
12. Munoz, C. A. ‘Assessing sheep welfare in Australia and opportunities to apply welfare assessments in Chile’. The IV Chilean Graduate Conference, Brisbane, October 2016
13. Munoz, C. A. ‘Identifying sheep welfare measures’. Faculty of Veterinary and Agricultural Science (FVAS) Symposium, Melbourne, November 2015

1.2 Industry outputs

1. Doyle, R. E. ‘Scientific insights: A survey of public and farmer attitudes to sheep welfare’. Presentation to the DEDJTR Livestock Industry Consultative Committee (LICC). July, 2015, Attwood

2. Doyle, R. E. ‘Assessing and addressing the welfare of extensively managed ewes’. Barwon Prime Lamb Producer Group presentation. May, 2015, Winchelsea, Victoria

3. Munoz, C. and Doyle, R. E. ‘On farm welfare assessment and farmer attitudes’. Goorambat Producer Group presentation. May, 2017, Goorambat, Victoria

2 Background

2.1 Significance of sheep welfare to the industry

According to the 2020 Meat Industry Strategic Plan, animal welfare poses the biggest single risk to maintaining market access over the next 15 years. Consumers are increasingly demanding assurances about animal welfare when they buy livestock products, and so understanding the welfare of sheep in Australian production systems is critical if consumer confidence in the sheep meat industry is to be maintained.

The main on-farm issues considered to negatively impact sheep welfare include nutrition (under and over-feeding), ecto- and endoparasites, lameness (and associated foot diseases), mastitis, dystocia, and subsequent mortality (Phillips & Phillips 2010; Phythian et al 2011; Ferguson et al 2014). All of these issues pose economic risks to producers as well.

For both reasons, good sheep welfare critical to individual farmers and the industry as a whole.

2.2 Welfare of extensively managed sheep

The extensive nature of the sheep production creates a general perception of high welfare, as it provides sheep with more freedom to move, explore and socialize (Webster 1995; Dwyer & Lawrence 2008; Dwyer 2009). As a result of these positive perceptions, sheep production has been the subject of less scrutiny compared to other livestock productions such as pigs, poultry and dairy cattle (Stubsjøen et al 2009). This suggests that consumer perception for sheep welfare is positive, and retaining this is critical for maintained market access.

While behaviour is not restricted, other possible welfare issues exist (Dwyer 2009). Extensive sheep production systems are characterized by infrequent inspection and intervention at a close proximity, impeding detection and treatment of disease and illness, and climatic variability of nutritional, thermal and physical comfort resources. In reality, the behavioural freedom ewes experience in extensive settings create an almost polar opposite set of welfare issues that are seen in intensive, or behaviourally restrictive, production settings.

On-farm welfare assessments of animals can be a useful way to demonstrate compliance with national and international legal welfare standards; demonstrate compliance with farm assurance schemes; and for immediate or ongoing on-farm monitoring and benchmarking by farmers and veterinarians (Phythian et al., 2013). For on-farm welfare assessments to be effective and acceptable by all key stakeholders (i.e. industry, scientists, consumers and society), they must incorporate welfare indicators that are valid (meaningful with respect to animal welfare), reliable (provide repeatable outcomes when applied by different observers), and feasible (practical under farm conditions) (Knierim and Winckler, 2009; Phythian et al., 2013).

A valid, reliable and feasible animal-based welfare assessment protocol for the Australian sheep industry has not been clearly defined, making the process of identification and justification of on-farm welfare standards difficult.

2.3 Farmer attitudes and animals

Farmer behaviour is determined by three 'key beliefs': (1) farmer attitudes towards working with the farm animal in question, (2) subjective norms (farmer beliefs about other people's expectations of them), and (3) perceived behavioural control (farmer beliefs about the extent to which they have control to appropriately interact with the animal in question) (Hemsworth and Coleman, 2011). Farmer behaviour can also be influenced by educational level, work experience, willingness to learn, job motivation, and financial returns (Coleman et al., 2003; Kiliç and Bozkurt 2013; Coleman and Hemsworth, 2014).

Previous research has clearly shown that farmer behaviour towards working with animals influences animal behaviour, welfare and productivity (Hemsworth et al., 1989; 1993b; Hemsworth and Coleman, 2011); however, how farmer characteristics relate to management and on-farm welfare in extensively managed ewes is limited. Examples do exist however; Wassink and Green (2015) found that farmers that perceived footrot as a highly important problem reported less sheep affected with footrot compare with farmers that perceived this disease as a small importance problem. Similarly, Kiliç and Bozkurt (2013) found that farmers with high welfare perception provided their sheep with good shelter conditions and had better trained personnel when compared with farmers with lower welfare perception.

As shown in other livestock industries, understanding the underlying beliefs that underpin farmer behaviour can provide the opportunity, through targeted education, training and policy, to improve the key human-animal interactions and thus improve the human-animal relationship and subsequent animal welfare.

2.4 Project aims and outcomes

This project aimed to study the relationship between farmer characteristics and the welfare of sheep. We chose to focus on ewes as they are the main group of sheep on all farms and are considered to be the most reliable indicator of welfare.

In order to do this, a welfare assessment protocol for extensively managed ewes, an attitude questionnaire for farmers were developed, and a survey of key stakeholder perspectives on sheep welfare was conducted.

This study gives a detailed evaluation of the welfare of ewes in Australia and how farmers function. These results can be used to encourage future welfare and production improvements of the Australian sheep industry.

3 Project objectives

1. Produce a review document of sheep mortalities and sheep welfare to MLA including existing unpublished reports.

2. Understand the relationships between producer attitudes to animal welfare and other job-related characteristics (e.g. knowledge, work motivation, job satisfaction, perceived 'barriers' to best practice, and sources of advice and trust) and how these relate to management and on-farm sheep mortality and welfare

3. Using results from Objective 2, develop and trial an intervention strategy to address producer attitudes, other job-related characteristics and behaviour where necessary

4. Conduct a detailed assessment of the production, financial and welfare changes seen in response to changes in farmer characteristics and practice change, including a cost-benefit analysis of the intervention

5. Train a PhD graduate with practical extension skills and robust research skills

A summary of the research activities undertaken to achieve these objectives are in Table 3.1.

Table 3.1: Research activities and corresponding project objectives

Objective	Research activities
1	Literature reviews 1. Assessing and addressing on farm sheep welfare, Rebecca Doyle 2. The welfare of extensively managed ewes, Carolina Munoz and Rebecca Doyle
2	Stakeholder survey[1] Development and validation of the farmer attitude questionnaire Development and validation ewe welfare indicators On-farm welfare assessment and farmer interviews
3	Immediate feedback on farm Feedback post-visit Benchmarking report Post-project interviews
4	Cost-benefit analyses Case studies
5	PhD student Carolina Munoz was recruited in April 2015. Carolina's research work forms the majority of objectives 2 and 3. Her thesis is due for submission in April 2018, giving her the predicted graduation date of July 2018.

[1]Conducted in conjunction with the sheep CRC.

4 Literature review

Rationale

Compared to the welfare of other production species, the welfare of extensively managed sheep has been largely under-reported. In order to gather a comprehensive understanding of existing material and identify subsequent gaps, a large literature review was conducted. Relevant material will be published to address the knowledge gap in the scientific literature.

Aim

1. To review existing published and unpublished information on sheep production, mortality and welfare.
2. To review published evidence of the relationship between farmer attitudes and animal welfare.
3. To review published evidence on the welfare of extensively managed ewes.

Methods

Literature from MLA final reports were obtained from the website and following recommendations from project manager Jim Rothwell. Colleagues from the Sheep CRC, DEDJTR and The University of Melbourne were also contacted to obtain any unpublished reports. Literature searches for relevant material were conducted in both Google Scholar and Web of Science. Combinations of the following keywords were used in literature searches: Animal welfare; Animal-based indicators; Extensive management; Farmer attitude; Merino; Mortality; On-farm welfare assessment; Productivity; Shearing; Sheep

The first literature review is presented in the appendix.

5 Stakeholder survey

Rationale

This research activity was conducted in collaboration with the Sheep CRC. This survey was designed as the first step in the development of a welfare assessment framework that would facilitate the goals of the current project and the Sheep CRC. This helped to fill the existing gaps around public and producer perspectives about sheep welfare, as well as identify welfare risks and indicators that would be used to assess sheep welfare on farm. Full details on the survey are presented in the appendix.

Aim

1. To identify stakeholder perceptions of sheep welfare (goal of both studies)
2. To identify acceptable indicators for sheep in extensive Australian sheep production systems (MLA B.AWW.0237 goal)
3. To identify potential causes of welfare compromise (Sheep CRC goal)

5.1 Methods

The final format of the survey was determined through extensive consultation with an advisory group of 10 that comprised experienced animal welfare scientists (*n* = 3), industry advisors (2), sheep extension officers (2) and sheep producers (3). The survey was conducted online and was developed using the online survey platform Survey Monkey (Survey Monkey Inc. 2014). Once participants had read through the introduction, they selected which stakeholder category best described them: sheep farmer (producer), sheep industry service provider or advisor (service provider), sheep focused scientist/researcher (scientist), general public, or other. While all stakeholders answered a set of 11 common questions, some requiring multiple responses, participants also answered additional questions tailored specifically for that stakeholder group category. Questions covered perceived welfare issues, perceptions of welfare indicators and self-rated knowledge, along with basic demographic questions. The question formats varied with the question and involved: (1) respondents selecting a single choice from the range provided; (2) selecting the most appropriate response on a Likert scale; and (3) replying freely to an open-ended question (Table 1). Likert scales were 1–5 for all questions except for the question “What is your belief about animal welfare?”, which had a scale of 1–4.

5.2 Results

A total of 1535 people responded to the survey during the month it was open, and 956 of these completed the survey in its entirety. Of these, 15 were under 18 years of age. While the survey was voluntary, the ethics application only covered participants 18 years or over, and so these 15 were removed from the results. The breakdown of the 941 valid participants according to stakeholders was: General public = 499 (53.0%), Producer = 260 (27.6%), Scientist = 95 (10.1%), and Service provider = 87 (9.2%). The genders of the respondents were skewed towards women (61.2% overall), and a difference within each stakeholder category existed; the percentages of women represented in each group were: 27% for producers, 45% scientists, 25% service providers and 88% general public. The majority (70%) of survey respondents were tertiary educated, (a higher proportion than the 44% of Australians in the general population(Australian Bureau of Statistics 2016)) with others being trained

at a technical institute (19.0%) or high school (11%). Participants age ranged from 18 years old to 82 years old, with both an average age and median age of 47 (1967) and the mode was 58 (1956).

All of Australia's states and territories were represented, with the largest portion coming from New South Wales (30.8%) and then Victoria (27.6%), South Australia (15.3%), Western Australia (10.8%), Queensland (9.9%), Tasmania (3.3%), the Australian Capital Territory (1.5%) and the Northern Territory (0.8%); with these proportions being roughly equitable with the overall distribution of the population. The general public, sheep industry service providers and sheep-specific scientists were asked to select their current residential location, with producers all being classified as rural and not included below. The majority of respondents were suburban (27.2%) and 14.2% were rural, followed by urban (11.4%), country town (9.5%), regional city (7.0%), peri-urban (3.5%) and remote (0.3%); which was again roughly equitable with the overall distribution of the population, except for rural respondents, which was higher and reflective of the agricultural focus of this survey.

Animal welfare was considered to be important by all participating groups in this survey (average score of 3.78/4). Respondents felt the welfare of grazing sheep was generally adequate but improvement was desired (2.98/5), with female members of the public rating sheep welfare significantly worse than other respondents ($p < 0.05$). Environmental issues were considered to pose the greatest risk to welfare (3.87/5), followed by heat stress (3.79), lameness (3.57) and husbandry practices (3.37). Key indicators recognised by all respondents were those associated with pain and fear (3.98/5), nutrition (4.23), mortality/management (4.27), food on offer (4.41) and number of illness/injures in a flock (4.33). There were gender and stakeholder differences in the perceived importance of both welfare issues and indicators with women and the public consistently rating issues (all $p < 0.01$) and indicators (all $p < 0.05$) to be of greater significance than other respondents.

5.3 Discussion

The importance of sheep welfare was endorsed by all stakeholders with all believing it to be of importance, and that there was the capacity for it to be compromised. There was a stakeholder × gender interaction in regard to the respondents' perception of the welfare of grazing sheep with females from the general public stakeholder category believing welfare to be in more need of improvement than other groups.

When assessing risks to sheep welfare, some commonalities were evident with respondents' answers to the specified and open-ended questions. Of the specified issues, flystrike, nutrition and predation were considered most likely to compromise a sheep's welfare, and all of these contribute to the PCA component named "environmental issues".

There was also one very prominent response to the open-ended question, with issues around live export being identified as the single most significant issue facing sheep welfare. Examples of welfare compromise in live-exported sheep have been prominent in the last few years in Australia and have received a significant amount of media coverage. This likely influenced the views of the general public, who offered all responses on live export.

Sheep welfare was an important consideration to all stakeholders in this survey, and all issues were perceived to cause some degree of welfare compromise. Welfare issues of key importance to the stakeholders were those relating to environmental issues, heat stress, lameness and husbandry

practices. The welfare indicators perceived to be of key importance were those related to nutrition, pain and fear, mortality and management, feed on offer and the number of illness/injuries occurring within a flock. Both gender and stakeholder differences were clear, the most notable were women's greater concern for welfare and the general public's concern for off-farm issues. These results highlight the importance of including all stakeholders and an even balance of genders when developing a welfare framework that can address both practical and societal concerns.

This work was published in 2017 and presented at ISAE 2016

Doughty, A.K., Coleman, G.J., Hinch, G.N. and Doyle, R.E., 2017. Stakeholder Perceptions of Welfare Issues and Indicators for Extensively Managed Sheep in Australia. *Animals*, *7*(4), p.28

Doughty A. K., Coleman G. J., Hinch G. N. and Doyle R. E. 'The welfare of extensively managed sheep: a survey identifying issues and indicators'. International Society of Applied Ethology, Edinburgh, Scotland, July 2016.

6 Development of on-farm components: Farmer attitude questionnaire

Rationale

Objective two was to understand the attitudes, knowledge, work motivation, job satisfaction, perceived 'barriers' to best practice, and sources of advice and trust sheep farmers use. This research activity refined and validated the questionnaire before it was used for on-farm data collection. A draft questionnaire was developed based on the literature. Two focus groups were then run to refine the draft questionnaire.

Aim

1. Gather qualitative information on the opinion and concerns of sheep farmers about sheep management and welfare with the purpose of identifying the underlying beliefs that influence farmers' animal management and behaviour.
2. Trial and refine the draft questionnaire for sheep farmers.

6.1 Methodology

This study was approved by the Veterinary and Agricultural Sciences Human Ethics Advisory Group of The University of Melbourne (Ethics Application 1545238.1).

Two focus groups were conducted at Boort and Kyneton, Victoria. The focus groups comprised eight and seven farmers respectively, from 35 to 65 years of age. In the focus group discussions, farmers were encouraged to discuss their opinions in an informal manner in a confidential setting. During the discussions, the researchers asked a series of questions using a structured protocol pertaining to the farmers' work e.g. sheep management, work motivation, job satisfaction, sheep health and welfare.

The focus group discussions ran for approximately 60 minutes, were audio-recorded and written notes were taken during the discussions. Data were analysed qualitatively. In the last 30 minutes of the second focus group session, the draft questionnaire was handed out and completed by the farmers from whom feedback was gathered. The focus group findings and feedback on the draft questionnaire were used to refine the content and format of the questionnaire.

6.2 Results

6.2.1 Welfare indicators and assessment

Monitoring was usually performed visually, without approaching the mob; all farmers agreed that behaviour and body condition are main indicators of sheep health and welfare, but none of the participants used numerical scoring to assess body condition. Pasture quality and availability were also mentioned as important indicators and they were mainly assessed visually.

Overall, farmers agreed that frequency of monitoring depends on the circumstances, the year and location, as there are important geographical differences within Victoria. In terms of general management practices, the majority of the participants scan for pregnancy annually, and they widely stated that scanning for twins and singles and separating pregnant from dry ewes is an important management strategy that helps them make better management decisions, and in turn, improve their

productivity. However, they also commented that, in terms of productive parameters, ‘what is acceptable for the industry and what you get are two different things’.

Overall, the majority of farmers did not maintain accurate records in their farms. Perceived barriers to more frequent/detailed management included time and labour availabilities. Beside this, it was also mentioned that picking dead animals to maintain accurate mortality records was ‘too depressing’.

6.2.2 Behaviour and attitudes

In general, there was a strong acknowledgement that behaviour and attitudes towards moving sheep dictated a farmer’s success, with direct quotes including ‘if you say sheep are stupid and you are getting angry at them, it is probably because you are doing something wrong’, and ‘the worst you can do it is to set a time… do not put a time on it, do not rush and everybody would be happy’.

Farmers also acknowledged that is hard to assess if a sheep is in pain, but they perceived some husbandry procedures as painful, such as marking and mulesing. They also believed that the use of pain relief makes a ‘huge difference’ in how the sheep recover. Veterinary intervention was rare, reserved mainly to assess rams before mating.

There was a strong acknowledgment that there are a number of farmers that do not take appropriate care of their stock, and do not participate in industry workshops and related activities. By contrast, participants in these focus groups actively participated in training courses to improve their management strategies. They commented that this was not common in the industry, and that they represent about 10- 20% of the farmers in their area.

SECTION A: General questions about sheep welfare and management

Table 2: Welfare indicators farmers use for their mob

Positive welfare indicators	Negative welfare indicators
• Performing normal behaviours (e.g. grazing, ruminating) • Normal feeding patters (e.g. in summer they eat later in the day) • Good body condition	• Isolated from the rest of the mob • Lying down apart from the rest of the mob • Fat body condition

Table 3: Reflections on common management practices

Body condition scoring	Pregnancy scan	Pasture availability	Mortality records	Veterinarian services
• It is a good guide • It is mainly done visually but no actual numeric scoring • Not done in a race • Animals with BCS of 2 are a worry	• Majority of farmers in the group do scan for pregnancy	• It is mainly done visually • Every time you check the paddocks	• In general, farmers do not keep mortality records	• Not regularly • To check the rams before joining • Only for particular diseases

Table 4: Perceived advantages and disadvantages on how to move the mob

Ways of moving sheep	Advantages	Disadvantages
• **Dog**	• They have a natural ability to move sheep • They do not force the mob too much • A dog in the mob creates a herd instinct	• A lack of knowledge and time to train a dog • Need to find the right dog with the right temperament • Very few dogs are capable of working properly in a paddock and a yard • May be stressful if sheep had a bad past experience with dogs
• **Motorbikes**	• Very useful in the paddock • Sheep get used to the motorbike	• May be stressful for sheep if you are going too fast with the motorbike

Associated quotes
'The worst you can do it is to set a time, for example: I am going to have the mob in the yards by 9 am. Do not put a time on it, do not rush and everybody would be happy'.

Table 5: Common productivity statistics, the issues preventing improvement and management practices that can lead to improvements

Productivity percentages	Main concerns	Management considerations
Joining • 3% dry ewes (according to industry) • Depends on the circumstances • 20% dry ewes in bad years	• With Merinos, you expect a high return rate. • Body condition	• Pregnancy scan • Separate dry and wet ewes and twins and singles • Pasture management • Nutritional management
Lambing-Marking • Merinos 90% • Cross-breeds 130% • If every pregnant ewe raises a lamb and a fleece, I find that acceptable	• Good body condition (not under or over feeding) • Cold weather • Mismothering • Lamb mortality • Pasture quality and availability	• Recently shorn ewes are kept in the shed in case of bad weather. • Sheep are kept in most protected paddocks at lambing • Pick up dead lambs
Weaning • 1% losses • Depends on the circumstances and the year • 12% in bad years • In general, not many losses between Marking and Weaning	• Dry dams • Malnutrition (small lambs) • Flystrike	• Prevention measures (e.g. crutching earlier) • Increasing monitoring for flystrike.

Associated quotes
'What is acceptable for the industry and what you get are two different things'.
Overall, about 90% of farmers do scan for pregnancy. 'You can't afford to run a non-productive ewe in this environment. Having dry ewes is like having a wether, you can't have non-productive animals'
'Probably what I learned most about this group is that scanning for twins and singles, and making sure that your singles are not having monster lambs is essential. I notice that knowing that, is a lot better management tool'

SECTION B: Farmer attitudes about working with sheep

Table 6: Farmers' beliefs about sheep

Are they smart?	Are they sensitive to pain?	Easy to train to a routine?	Frustrating to work with?
• Not as stupid as people might think • They have different personalities • Good memory	• Hard to know • Some husbandry procedures may be painful (e.g. mulesing, marking) • The use of pain relief makes a huge difference, animals heal better • Some diseases may be painful (e.g. foot abscess, eye damages)	• They are creatures of habits • If you identify the leader the rest will follow • Depends on the design of your yards	• Sometimes when they do not go through gates • Usually there are one or two that are difficult to work with

Associated quotes
'If you say sheep are stupid and you are getting angry at them, it is probably because you are doing something wrong'.
'Depends on your attitude and how you are handling the stock'
'Once a shearer gets tired and gets frustrated they start handling the sheep wrong'
'The use of anaesthetics for mulesing and castration is very effective'

SECTION C: Subjective norms

Table 7: Farmers general belief about other farmers

Are there farmers that do not do the right thing for their sheep?
• Yes (general opinion) • We could be good in a couple of things and we might be terrible in others. • There are plenty of people who do not care about their stock • The ones who really need to be in these courses aren't • In bad years better farmers will manage their stock better, whereas others will sell them all

Do you attend training sessions?

- Yes, six times a year
- Not very common in the industry
- We represent about 10- 20% of the farmers in our area
- Knowledge is power

Associated quotes
‘Our group has not grown. No matter how many farmers you talk to, they always have an excuse’
‘Any welfare aspect that we can improve in our sheep will have a production outcome.’
‘Happy sheep are performing sheep.’

SECTION D: Perceived behavioural control

Table 8: Frequency of monitoring

Frequency of monitoring	Things monitored	Main concerns	Main barrier for monitoring
Joining • Daily during summer • Three or Two times a week when they are hand fed • Once a week when they are not hand fed • Depends on the year, the circumstances (e.g. rain in summer)	• Drinking troughs • Pasture availability • Feed quality (e.g. grass seeds) • Presence of flies	• Water and food availability • Not much can be wrong at joining	• Time • Labour • Busy with other things • Laziness
Lambing • Twice a day at the start • Once a day at the end of lambing • Depends on the circumstances (e.g. Three times a day if ewes are too fat)	• Ewes that cannot lamb • Good udder and teats shape • If the lamb is feeding	• Fat ewes and big lambs • Mismothering • Lamb and ewe mortality	• Same as above • Picking dead lambs is depressing
Weaning • Once a day or every two days • Same as joining time	• Pasture availability	• Food availability for summer	• Same as above

Monitoring is usually performed visually, without approaching the mob too much. Overall, frequency of monitoring depends on the circumstances, the years and location (geographical differences).

Table 9: Sentiments surrounding seasons

How is this season going to be?
• Most people will have less feed than what they normally would hope. • We are probably optimistic that we are going to get a reasonable pasture growth • We had a tough year last year, so we are hoping for a better year • Last year was shocking, terrible. • There is so much variability across the area

6.3 Discussion

This qualitative study will be used to refine the draft questionnaire with regard to content and format. When assessing the feedback from the farmers, important points around flock management and farmer performance were identified.

Farmer attitudes to sheep were positive and welfare was expressed as an important consideration. However, the extensive farming conditions and a perceived lack of behavioural control are likely barriers to welfare monitoring and improvement. For example, the need for monitoring the flock was seen to depend on the quality of the season and other environmental factors, including where the farm was located.

When it came to monitoring the animals, farmers believed that doing this visually was suitable. Similarly, the welfare indicators farmers described were behavioural; being isolated from the mob and laying down as indicators of poor welfare, and performing normal behavioural and feeding patters as indicators of good welfare. This approach allows farmers to identify a variety of animals with significant welfare compromise. Animals identifiable by these methods would include those that are so severely undernourished it may be visible from a distance, and individuals that have severe lameness, illness/disease or injury and cannot keep up with the mob. This method risks missing animals that may experience health and welfare issues, and also makes health and welfare issues more difficult to treat. Less obvious but severe issues including major injuries under the fleece, developing fly strike, eye wounds and animals of low body condition but in fleece are likely not identifiable from a distance. Because animals that are identifiable are likely severely compromised, it could limit treatment options or makes time until recovery long. Visual observation using these indicators makes make early identification and intervention difficult. The extent to which these welfare issues are present on farm is not known however. Further information on the health and welfare of ewes needs to be collected to determine the prevalence of severe, moderate and minor issues.

An important comment was that these farmers believed they represented the top 10-20% of the industry. If they are indeed ahead of the curve, it means that the management practices, welfare issues and productivity statistics they report are likely to be poorer on the majority of sheep farms. While anecdotal in nature, these comments are important to consider, as farmers would have a reasonable sense of what others in their districts are doing. Being able to verify if the assumptions of the farmers in this study are legitimate is an important step.

The results from the focus groups were presented at ISAE 2016:
Munoz, C. A., Coleman, G. J., Campbell, A. J. D., Hemsworth, P. H., Doyle, R. E. ‘Farmers’ opinions about sheep management and welfare’. International Society of Applied Ethology, Edinburgh, Scotland, July 2016

7 Development of on-farm components: Ewe welfare indicators

Rationale

Currently, there is not a specific welfare protocol for extensively managed sheep. Therefore, a series of animal-based welfare indicators for sheep needed to be identified. The validity (meaningful with respect to animal welfare), reliability (repeatable outcomes when applied by different observers) and feasibility (practical under farm conditions) of a number of indicators were tested. Indicators were taken from Larsen et al. (1994), Turner and Dwyer (2007), Kondinin (2009), Kaler et al., (2010), Phythian et al. (2011), Stubsjøen et al. (2011); Phythian et al. (2013) and the AWIN welfare protocol for sheep (2015).

Aim

1. The aim of the present study was to identify if 17 animal-based indicators were both reliable and feasible, and therefore appropriate for inclusion in the welfare assessment protocol.

7.1 Methods

A longitudinal study was performed at the The University of Melbourne's Dookie Farm between July and December 2015. Seventeen animal-based indicators were identified and examined in a total of 100 Merino ewes (2-4 years old) during three key stages of the production cycle of sheep; late-pregnancy (LP) (July), mid-lactation (ML) (November) and weaning (WN) (December). The ewes were managed under extensive conditions, in a year-round outdoor system, grazing annual pastures, and managed under commercial conditions. The indicators were assessed in all animals individually, and the assessment was performed in a pen and raceway.

At mid-lactation and weaning, mastitis was scored in the ewes. This was a collaborative research activity with Dr. Stuart Barber's MLA-funded project 'Importance and epidemiology of mastitis in the Australian sheep flock (B.AHE.0013).

7.2 Results

Inter- and intra- observer agreement at mid-pregnancy

At mid-pregnancy, there was 'almost perfect' overall observer agreement for fleece cleanliness and fleece condition, 'moderate' agreement was found for BCS, skin lesions, foot-wall integrity and hoof overgrowth, and 'poor' agreement for rumen fill, and tail length (Table 7.1). In the same way, pair agreement was higher for fleece cleanliness and fleece condition, while BCS, rumen fill and tail length presented the lowest. Overall, the TSO and observer 2, the most experienced observer, had better percentage of pair-agreement for most of the measures compared to the results obtained by the TSO against observer 3 and 4, the less experienced observers. Results for intra-observer agreement are presented in Table 7.2. Overall, fleece cleanliness and fleece condition were the most repeatable measures. Dag score, foot wall-integrity and hoof overgrowth had moderate

repeatability, while BCS and skin lesions had the lowest. Lameness was not assessed for intra-observer agreement because all the observers assisted with the identification of lame animals, but showed moderate intra-assessment agreement W= 0.53. In addition, observer 1 and 2 showed the highest levels of repeatability for most of the measures compared with the other observers as determined by W and k values. In terms of practicality, the assessment at this stage took 4-5 min per ewe and rumen fill was the least feasible measures followed by foot-wall integrity and hoof overgrowth according to the observers. Based on this, rumen fill was not included in the subsequent visits and therefore intra- observer agreement was not assessed.

Table 7.1: Overall observer agreement (OA), percentage of agreement (%) and pair agreement at mid-pregnancy.

Measures	OA (*W*)	Pair agreement				
		Observer identity	%	Kendall's (*W*)	Weighted Kappa (95% CI)	**Interpretation (W/Kw)**
BCS	0.60	2	30	0.78	0.38 (0.28-0.54)	Substantial/poor
		3	24	0.74	0.30 (0.16-0.38)	Substantial/poor
		4	23	0.71	0.25 (0.09-0.33)	Substantial/poor
Rumen fill	0.14*	2	73	n/a	0.12** (-0.11-0.32)	Poor
		3	70	n/a	0.13** (-0.08-0.34)	Poor
		4	75	n/a	0.31** (0.09-0.47)	Poor
Fleece cleanliness	1.00	2	100	1.00	1.00 (1.00-1.00)	Perfect agreement
		3	100	1.00	1.00 (1.00-1.00)	Perfect agreement
		4	100	1.00	1.00 (1.00-1.00)	Perfect agreement
Fleece condition	1.00	2	100	1.00	1.00 (1.00-1.00)	Perfect agreement
		3	100	1.00	1.00 (1.00-1.00)	Perfect agreement
		4	100	1.00	1.00 (1.00-1.00)	Perfect agreement
Skin lesions	0.41	2	98	0.50	0.66 (0.65-0.67)	Moderate
		3	99	0.83	0.66 (0.04-1.00)	Substantial/moderate
		4	99	0.69	0.39 (-0.17-0.93)	Moderate/poor
Tail length	0.35*	2	86	n/a	0.38** (0.14-0.64)	Poor
		3	77	n/a	0.28** (0.10-0.45)	Poor
		4	71	n/a	0.28** (0.10-0.45)	Poor
Dag score	0.70	2	77	0.81	0.59 (0.43-0.72)	Substantial/moderate
		3	76	0.77	0.52 (0.37-0.66)	Substantial/moderate
		4	74	0.83	0.62 (0.48-0.76)	Substantial/moderate
Foot-wall integrity	0.44	2	90	0.68	0.47 (-0.15-1.00)	Moderate
		3	97	0.50	0.21 (-0.15-0.57)	Moderate/poor
		4	95	0.57	0.55 (0.20-0.90)	Moderate
Hoof overgrowth	0.65	2	91	0.84	0.66 (0.51-0.80)	Substantial/moderate
		3	79	0.75	0.50 (0.33-0.68)	Substantial/moderate
		4	66	0.63	0.43 (0.27-0.60)	Moderate

* Inter-observer agreement for nominal measures determined by Fleiss's Kappa (k). **Pair-agreement with the test standard observer for nominal measures determined by Cohen's Kappa (k).

Table 7.2: Intra-observer agreement at mid-pregnancy.

Measures	Observer Identity	W	Kw	Interpretation (W/Kw)
BCS	1	0.68	0.22	Moderate/poor
	2	0.80	0.31	Substantial/poor
	3	0.61	0.10	Moderate/poor
	4	0.68	0.20	Moderate/poor
Fleece cleanliness	1	1.00	1.00	Perfect agreement
	2	1.00	1.00	Perfect agreement
	3	1.00	1.00	Perfect agreement
	4	1.00	1.00	Perfect agreement
Fleece condition	1	1.00	1.00	Perfect agreement
	2	1.00	1.00	Perfect agreement
	3	1.00	1.00	Perfect agreement
	4	1.00	1.00	Perfect agreement
Skin lesions	1	0.49	0.48	Moderate
	2	1.00	1.00**	Perfect agreement
	3	0.49	-0.01**	Moderate/poor
	4	0.48	0.56**	Moderate
Dag score	1	0.63	0.37	Moderate/poor
	2	0.64	0.39	Moderate/poor
	3	0.63	0.43	Moderate
	4	0.6	0.45	Moderate
Foot-wall integrity	1	0.64	0.37	Moderate/poor
	2	0.58	0.39	Moderate/poor
	3	0.50	0.43	Moderate
	4	0.59	0.45	Moderate
Hoof overgrowth	1	0.79	0.57	Substantial/moderate
	2	0.78	0.50	Substantial/moderate
	3	0.83	0.59	Substantial/moderate
	4	0.72	0.44	Substantial/moderate

**Pair-agreement for nominal measures determined by Cohen's Kappa (k). Intra-observer agreement was done within a 15-day period.

Inter- and intra- observer agreement at mid-lactation

At mid-lactation, 'substantial' to 'almost perfect' overall agreement was found for fleece cleanliness, fleece condition, BCS, skin lesions. 'Moderate' overall agreement was found for dag score, foot-wall integrity and hoof overgrowth, while tail length showed the lowest agreement (Table 7.3). Similarly, pair agreement was higher for fleece cleanliness, fleece condition and skin lesions. 'Moderate' to 'substantial' pair agreement was obtained for BCS and dag score while tail length, foot-wall integrity and hoof overgrowth presented the lowest showing from 'poor' to 'substantial' pair agreement. The results of the intra- observer agreement are present in Table 7.4. Overall, fleece cleanliness, fleece condition, skin lesions and dag score were the most repeatable measures followed by BCS and tail length, while foot-wall integrity and hoof overgrowth presented the lowest levels of repeatability. The intra-assessment agreement of lameness increased to 'substantial' W= 0.79. In addition, the TSO showed the highest levels of repeatability for most the measures, and her repeatability increased significantly at mid-lactation when compared to mid-pregnancy, particularly for the

measures BCS and dag score that increased from 'moderate/poor' to 'substantial/moderate' agreement.

Table 7.3: Overall observer agreement (OA), percentage of agreement (%) and pair agreement at mid-lactation.

Measures	OA (*W*)	**Pair agreement**				
		Observer identity	%	Kendall's (*W*)	Weighted Kappa (95% CI)	**Interpretation (W/Kw)**
BCS	0.74	2	48	0.85	0.55 (0.53-0.76)	Substantial/moderate
		5	23	0.83	0.41 (0.29-0.50)	Substantial/moderate
		6	26	0.85	0.45 (0.36-0.55)	Substantial/moderate
Fleece cleanliness	1.00	2	100	1.00	1.00 (1.00-1.00)	Perfect agreement
		5	100	1.00	1.00 (1.00-1.00)	Perfect agreement
		6	100	1.00	1.00 (1.00-1.00)	Perfect agreement
Fleece condition	0.75	2	98	0.83	0.66 (0.04-1.00)	Substantial
		5	100	1.00	1.00 (1.00-1.00)	Perfect agreement
		6	100	1.00	1.00 (1.00-1.00)	Perfect agreement
Skin lesions	0.99	2	100	1.00	1.00 (1.00-1.00)	Perfect agreement
		5	100	1.00	1.00 (1.00-1.00)	Perfect agreement
		6	100	1.00	1.00 (1.00-1.00)	Perfect agreement
Tail length	0.18*	2	97	n/a	-0.01** (-0.03-0.00)	Poor
		5	97	n/a	-0.01** (-0.03-0.01)	Poor
		6	97	n/a	-0.01** (-0.03-0.01)	Poor
Dag score	0.69	2	65	0.87	0.62 (0.49-0.76)	Substantial
		5	64	0.85	0.47 (0.34-0.61)	Substantial/moderate
		6	63	0.77	0.40 (0.24-0.55)	Substantial/poor
Foot-wall integrity	0.45	2	96	0.65	0.75 (0.44-1.00)	Moderate/substantial
		5	86	0.60	0.32 (-0.18-0.81)	Moderate/poor
		6	94	0.47	0.53 (-0.02-1.00)	Moderate
Hoof overgrowth	0.56	2	66	0.80	0.48 (0.31-0.64)	Substantial/moderate
		5	66	0.75	0.30 (0.22-0.48)	Substantial/poor
		6	40	0.79	0.27 (0.10-0.36)	Substantial/poor

* Inter-observer agreement for nominal measures determined by Fleiss's Kappa (k). **Pair-agreement with the test standard observer for nominal measures determined by Cohen's Kappa (k).

Table 7.4: Intra-observer agreement at mid-lactation.

Measures	Observer Identity	W	Kw	Interpretation (W/Kw)
BCS	1	0.87	0.57	Substantial/moderate
	2	0.79	0.49	Substantial/moderate
	5	0.76	0.37	Substantial/poor
	6	0.62	0.22	Moderate/poor
Fleece cleanliness	1	1.00	1.00	Perfect agreement
	2	1.00	1.00	Perfect agreement
	5	1.00	1.00	Perfect agreement
	6	1.00	1.00	Perfect agreement
Fleece condition	1	1.00	1.00	Perfect agreement
	2	0.83	0.89	Substantial
	5	1.00	1.00	Perfect agreement
	6	0.75	0.78	Substantial
Skin lesions	1	0.83	0.66**	Substantial
	2	0.75	0.49**	Substantial/moderate
	5	0.83	0.66**	Substantial
	6	0.69	0.49**	Moderate
Tail length	1	n/a	0.58**	Moderate
	2	n/a	1.00**	Perfect agreement
	5	n/a	0.50**	Moderate
	6	n/a	0.02**	Poor
Dag score	1	0.87	0.60	Substantial/moderate
	2	0.85	0.61	Substantial
	5	0.90	0.67	Substantial
	6	0.70	0.32	Substantial/poor
Foot-wall integrity	1	0.73	0.65	Substantial
	2	0.62	0.31	Moderate/poor
	5	0.54	0.21	Moderate/poor
	6	0.48	0.30	Moderate/poor
Hoof overgrowth	1	0.77	0.49	Substantial/moderate
	2	0.74	0.39	Substantial/poor
	5	0.79	0.55	Substantial/moderate
	6	0.60	0.13	Moderate/poor

**Pair-agreement for nominal measures determined by Cohen's Kappa (k). Intra-observer agreement was done within a 24h period.

Inter- and intra- observer agreement at weaning

At weaning, most of the welfare measures presented from 'moderate' to 'almost perfect' overall agreement (Table 7.5). 'Almost perfect' pair agreement was obtained for fleece cleanliness, fleece condition and skin lesions. Body condition score, dag score and hoof overgrowth ranged from 'poor-moderate' to 'almost perfect' pair agreement. Foot-wall integrity and tail length had the lowest pair agreement, however k values for tail length ranged from 0.22 ('poor') to 1.00 ('almost perfect'). The intra-observer agreement results are presented in Table 7.6. The most repeatable measures at weaning were fleece cleanliness, fleece condition, skin lesion and BCS followed by dag score and tail length. The least repeatable measure were foot-wall integrity and hoof overgrowth. The intra-assessment agreement of lameness also increased significantly at weaning showing substantial

levels of repeatability W= 0.86. Furthermore, the TSO showed the highest levels of repeatability, and her repeatability increased significantly, particularly for BCS, dag score and tail length which increased from 'substantial/moderate' at mid-lactation to 'substantial/almost perfect' at weaning. The time spend assessing the ewes at this stage was about 2-3 min per ewe.

Table 7.5: Overall observer agreement (OA), percentage of agreement (%) and pair agreement at weaning.

		Pair agreement				
Measures	OA (*W*)	Observer identity	%	Kendall's (*W*)	Weighted Kappa (95% CI)	**Interpretation (W/Kw)**
BCS	0.80	7	38	0.90	0.63 (0.54-0.72)	Almost perfect/substantial
		8	39	0.88	0.59 (0.48-0.70)	Substantial/moderate
		9	31	0.86	0.39 (0.27-0.50)	Substantial/poor
Fleece cleanliness	1.00	7	100	1.00	1.00 (1.00-1.00)	Perfect agreement
		8	100	1.00	1.00 (1.00-1.00)	Perfect agreement
		9	100	1.00	1.00 (1.00-1.00)	Perfect agreement
Fleece condition	0.93	7	90	0.88	0.60 (0.41-0.80)	Substantial/moderate
		8	99	0.96	0.88 (0.73-1.00)	Almost perfect
		9	99	0.92	0.88 (0.71-1.00)	Almost perfect
Skin lesions	0.96	7	99	0.96	0.92 (0.76-1.00)	Almost perfect
		8	100	1.00	1.00 (1.00-1.00)	Perfect agreement
		9	99	0.96	0.92 (0.76-1.00)	Almost perfect
Tail length	0.49*	7	97	n/a	0.65** (0.29-1.00)	Substantial
		8	100	n/a	1.00** (1.00-1.00)	Perfect agreement
		9	94	n/a	0.22** (-0.19-0.62)	Poor
Dag score	0.68	7	79	0.75	0.35 (0.22-0.48)	Substantial/poor
		8	90	0.83	0.53 (0.40-0.65)	Substantial/moderate
		9	87	0.83	0.52 (0.39-0.64)	Substantial/moderate
Foot-wall integrity	0.52	7	92	0.63	0.43 (0.07-0.79)	Substantial/moderate
		8	92	0.83	0.64 (0.36-0.93)	Substantial
		9	93	0.68	0.37 (-0.03-0.76)	Substantial/poor
Hoof overgrowth	0.61	7	76	0.70	0.52 (0.37-0.67)	Substantial/moderate
		8	75	0.71	0.51 (0.36-0.65)	Substantial/moderate
		9	73	0.77	0.48 (0.32-0.64)	Substantial/moderate

*Inter-observer agreement for nominal measures determined by Fleiss's Kappa (k). **Pair-agreement with the test standard observer for nominal measures determined by Cohen's Kappa (k).

Table 7.6: Intra-observer agreement at weaning.

Measures	Observer Identity	W	Kw	Interpretation (W/Kw)
BCS	1	0.90	0.64	Almost perfect/substantial
	7	0.87	0.56	Substantial/moderate
	8	0.87	0.58	Substantial/moderate
	9	0.85	0.59	Substantial/moderate
Fleece cleanliness	1	1.00	1.00	Perfect agreement
	7	1.00	1.00	Perfect agreement
	8	1.00	1.00	Perfect agreement
	9	1.00	1.00	Perfect agreement
Fleece condition	1	0.92	0.88	Almost perfect
	7	0.91	0.65	Almost perfect/substantial
	8	0.86	0.74	Substantial
	9	0.77	0.69	Substantial
Skin lesions	1	0.86	0.82	Substantial/almost perfect
	7	0.95	0.90	Almost perfect
	8	0.86	0.71	Substantial
	9	0.90	0.65	Almost perfect/substantial
Tail length	1	n/a	0.80**	Substantial
	7	n/a	0.54**	Moderate
	8	n/a	0.80**	Substantial
	9	n/a	0.18**	Poor
Dag score	1	0.79	0.61	Substantial
	7	0.70	0.37	Substantial/poor
	8	0.65	0.41	Substantial/moderate
	9	0.76	0.48	Substantial/moderate
Foot-wall integrity	1	0.79	0.58	Substantial/moderate
	7	0.48	0.23	Moderate/poor
	8	0.66	0.48	Moderate
	9	0.70	0.34	Substantial/poor
Hoof overgrowth	1	0.77	0.54	Substantial/moderate
	7	0.75	0.49	Substantial/moderate
	8	0.62	0.32	Moderate/poor
	9	0.63	0.33	Moderate/poor

**Pair-agreement for nominal measures determined by Cohen's Kappa (k). Intra-observer agreement was done within a 24h period.

4. Discussion

The aim of this study was to assess the reliability and feasibility of 10 animal-based welfare measures for extensively managed ewes, which were derived from the scientific literature, previous welfare protocols and through consultation with veterinarians and animal welfare scientists. Body condition score, fleece condition, skin lesions, tail length, dag score and lameness are proposed for on-farm use in welfare assessments of extensive sheep production systems. These six valid measures address the main welfare concerns for ewes, and they are reliable and feasible. When combined, they provide an overview of the nutritional, health and welfare state of the ewes as well as evidencing previous or potential welfare concerns.

Reliability of the animal-based welfare measures

High inter- and intra- observer agreements, from 'substantial/moderate' to 'substantial/almost perfect' agreements, were found for BCS, fleece cleanliness, fleece condition, skin lesions, tail length, dag score and lameness. Furthermore, the inter-observer agreement and the intra-agreement of the TSO increased significantly from mid-pregnancy through to weaning. In the present study, BCS was the measure that increased the most, increasing from 'moderate' at mid-pregnancy to 'almost perfect' at weaning. Body condition is widely accepted as a valid and important welfare measure that reflects the nutritional state of sheep [19,20]. Results in the present study suggests that a quarter-point scale is reliable, but that operators require sufficient training and experience to achieve high agreement in this measurement. In this study, the experienced observers (TSO, observer 2 and 7) showed the highest agreement and repeatability for this measure. The increased training sessions and the clarification of the descriptive terms used may have help to achieved 'almost perfect' inter- and intra- observer agreement at the end of the study. Although individual differences, observer expertise and differences in intervals of reassessment (15-day period at MP vs 24h at ML and WN) may have influenced in the levels of agreement obtained, there is evidence that the level of observer agreement increases significantly when sufficient training is provided [14,19].

Rumen fill, foot-wall integrity and hoof overgrowth were the measures with lower agreement in this study. This is likely the result of difficulties associated with assessing these measures, e.g. presence of fleece and the fact that ewes often moved backwards and forwards along the race, which particularly affected how easily foot-wall integrity could be assessed. In addition, the scoring scales and the descriptive terms used for foot-wall integrity may have affected the levels of observer agreement. Simplifications of the scoring scales as well as clarification of the description terms may provide higher agreement and may be more useful for future on-farm assessments.

Evaluation of reliability

The performance of each welfare measure was evaluated in agreement with previous reliability studies [2,14,19,31]. Percentage of agreement was used as it provides an easy illustration of observer agreement. However, as this method does not estimate the amount of agreement that could occur by chance, Kendall's coefficient of concordance (W) and Kappa (k) were selected to statistically assess the inter and intra-observer agreement of ordinal and binominal measures. Care is needed however when interpreting k values, because they are affected by the prevalence of the

condition under consideration. Populations with few animals presenting the condition of interest will provide very low values of k that may not necessarily reflect low levels of observer agreement [38]. In the present study, the length of the tail was a simple binominal scale and presented high percentage of agreement across the three-time points examined (MP: 71 - 86 %; ML: 85 - 97 %; WN: 96 - 100 %). However, k values were consistently low; from 0.28 to 0.39 at MP, from -0.01 to 0.56 at ML and from 0.37 to 1.00 at WN. Discrepancies between the percentage of agreement and k values may be a consequence of the low number of animals that had adequate tail length in this study (n= 8, as determined by the TSO), and may not necessarily mean low inter- observer agreement. It is possible that higher k values would have been achieved if more animals in this study had adequate tail length. Similar difficulties in the interpretation of k values have been reported in previous studies [2,12,38].

Overall, there is wide variation in the scientific literature on how reliability of welfare measures is assessed. Currently, there is no agreement on the number of animals, number of observers or the methodology that should be used. For instance, a reliability study in lambs used four observers to assess 966 lambs [2], a study of welfare assessment for adult sheep used two observers and 360 ewes [15], and studies assessing reliability on locomotion scoring in various species have used five observers and 83 cows [39], three observers and 30 video clips of sheep [40], and three observers and 80 photographs and videos of footrot lesions in sheep [31]. The sample size selected in the present study was based on a power calculation and recommendations by the AWIN sheep protocol [16], and the fact that the performance of the measures was tested under farm conditions during key periods of the sheep production cycle further supports their reliability and applicability under farm conditions.

Feasibility of the animal-based welfare measures

Welfare measures need to be practical if they are to be valuable. Sheep farms in Australia can commonly have 12,000 animals, and they are usually managed by a single person [17,41]. This, highlights the need for feasible measures that can be taken in short periods of time with low need of resources and personnel as time and labour force are limited in extensive sheep systems. When assessing the feasibility of the measures of this study a variety of factors were considered such as time taken to perform the assessment, resources required and the ability to collect these measurements across different farms. Generally, the measures tested proved to be feasible, requiring 2 to 3 min to assess an individual ewe. This was assessed for feasibility for a third party to perform, not a farmer. The most feasible measures were found to be BCS, fleece cleanliness, fleece condition, skin lesions, tail length, dag score and lameness. Clear advantages of these measures in terms of practicality are that no measures required specialised equipment; the only infrastructure required is a raceway, which is a common facility on sheep farms, and other than the labour required to bring the sheep into the yards, they do not interrupt farm management practices. It should also be considered that most farmers visually monitor their sheep in the paddock, rather than gathering them into the yards. In this context, it has been shown that some of these measures, e.g. thin body condition, lameness and dags can be examined from the distance during key stages of the production cycle with minimal interference with farm work, and thus, may be considered more acceptable by producers [42,43]. Foot-wall integrity and hoof overgrowth on the other hand, were

found less practical as they were time-consuming and they were not easy to assess as ewes often moved backwards and forwards. Additionally, they should be assessed in races that do not have covered walls alongside, which may limit their implementation across farms.

Recommended measures for on-farm welfare assessment of extensively managed ewes

The validity of these measures reported in Munoz et al. [24], plus their reliability and feasibility examined in this study indicate that these six animal- based measures; BCS, fleece condition, skin lesions, tail length, dag score and lameness are appropriate/recommended to include in welfare protocols for ewes managed extensively, particularly in Australia. When combined, these measures reflect previous welfare issues; they provide a snapshot of the current welfare status of ewes, as well as providing evidence of potential welfare risks. Combining a decline in BCS, poor fleece condition and high dag score helps to identify that the welfare of that animal is compromised, while also facilitates the identification of the problem and the appropriate treatment. These measures can be cross-referenced with multiple broad principles of animal welfare (Five freedoms, Five domains, Welfare Quality protocols), and also address important welfare issues identified by producers, industry, specialist and general public [10,12,16].

Fleece cleanliness, although repeatable and feasible, might not be meaningful for extensive systems. Fleece cleanliness has previously been proposed as an important welfare measure for sheep, as it can provide information about the quality of the environment [2,14–16,23]. However, this measure is more valuable for intensive indoor lambing systems where is important to assess the cleanliness of the floor/bedding and how the animal is coping with this environment. Rumen fill, foot-wall integrity and hoof overgrowth were discarded based on poor reliability and feasibility. The assessment of rumen fill was difficult because of the presence of the fleece, which may have affected the levels of agreement in this study. The validity and reliability of rumen fill as a welfare measure has only been explored in young lambs, and has obtained 'moderate' inter- observer agreement in a previous study [2]. In addition, rumen fill only provides short-term information of food access; and therefore, the nutritional state of sheep could be provided more reliably by assessing body condition. In view of the difficulties of assessing rumen fill in ewes that are not in short wool and its limitations in assessing sheep welfare, the measure was excluded from subsequent visits in this study. Foot-wall integrity and hoof overgrowth showed poor repeatability and feasibility to be implemented across different farms. In addition, the assessment of foot-wall integrity and hoof overgrowth may be less valuable than the assessment of broader measures, such as lameness, that provide a more integrative welfare assessment.

Besides the importance of discriminating which welfare measures would be more suitable for extensive conditions, it is also important to identify alternatives that could be used to measure on-farm welfare in sheep. For instance, limited research has been done to develop practical assessments of fear of humans in sheep, and studies on this topic vary in methodology and performance [48]. The majority of this research has been focused on intensively managed sheep [13,15,49,50], and usually under experimental conditions [41,49,51]. Further work is needed to validate a practical on-farm assessment of fear of humans that could be applied to extensive systems. Additionally, limited work has been done to develop practical on-farm assessments for

clinical and sub-clinical mastitis [16]. Udder examination and collection of milk samples to perform an on-farm test (e.g. California mastitis test) is time-consuming and labour intensive, which make these assessments less appealing for on-farm use. Further studies in the development of practical welfare assessments should consider the incorporation of new technologies for practical assessment of mastitis and to track grazing behaviour and sheep movement to detect sick/lame animals. Finally, it should also be considered that extensive systems are characterised by seasonal variation in both, climate and food availability, which results in seasonal variation in the welfare status of sheep [14]. Welfare measures therefore must be able to detect variation in the welfare status of ewes over main risk periods of the production cycle [14], as well as be sensible to identify differences between farms. Further research into the development of welfare assessment for extensive systems should assess both seasonal variation of the measures selected and their ability to detect differences between farms as only one property was examined in the present study.

5. Conclusions

The results obtained in the present study suggest that BCS, fleece condition, skin lesions, tail length, dag score and lameness are valid, reliable and feasible measures that can be included in welfare protocols for extensive sheep production systems. The high levels of inter- and intra- agreement found for these measures also suggests that the scoring scales and the descriptive terms used are reliable. When combined, these broad measures provide a snapshot of the current welfare status of ewes, as well as evidencing previous or potential welfare issues. When these measures are used in combination with resource-based and management-based measures they can be utilized to address welfare compromise. Further research examining the ability of these measures to detect seasonal variation and between-farm differences will provide further evidence of their effectiveness in assessing the welfare condition of ewes managed extensively.

These results have been written into two research papers and three conference abstracts. They are presented in the Appendix.

Carolina A. Munoz, Angus J.D. Campbell, Paul H. Hemsworth and Rebecca E. Doyle (for submission October 2017) Reliability and feasibility of animal-based measures to assess the welfare of extensively managed ewes. *Animals*.

Carolina A. Munoz, Angus J.D. Campbell, Stuart Barber, Paul H. Hemsworth and Rebecca E. Doyle (for submission October 2017) Seasonal variation in on-farm welfare of extensively managed ewes and potential welfare risks. *Animals*.

Munoz, C. A., Coleman, G. J., Campbell, A. J. D., Hemsworth, P. H., Doyle, R. E. 'Reliability and feasibility of animal-based indicators to assess the welfare of extensively managed ewes.' Australian Society for Animal Production, Adelaide, Australia, July 2016

Munoz, C. A., Coleman, G. J., Campbell, A. J. D., Hemsworth, P. H., Doyle, R. E. 'Assessment of human-animal relationship in extensively managed ewes'. International Society of Applied Ethology, Edinburgh, Scotland, July 2016

Carolina A. Munoz, Angus J. D. Campbell, Paul H. Hemsworth and Rebecca E. Doyle. ‘Assessing reliability, feasibility and seasonal variation in animal-based indicators in extensively managed ewes’. The International Society for Applied Ethology regional meeting, Auckland, New Zealand, October 2016

8 Farmer attitudes, management practices and the welfare of extensively managed ewes

Rationale

This was the major data collection component of the research project. In order to determine the relationships between farmer attitudes and ewe welfare, data on both had to be collected. In order to do this, farmers had to be recruited, questionnaires conducted and two visits for welfare assessment needed to be conducted. Recruitment commenced in February, 2016 and data collection was completed in July, 2017.

Aim

1. Understand the attitudes and management practices of Australian sheep producers
2. Quantify the welfare of extensively managed ewes

8.1 Methods

8.1.1 Farmer recruitment

A target of 30 commercial sheep farms around Victoria was set for the study. This was based on power analyses conducted following the focus group study (Section 6). Farmers were recruited through advertisements in the Mackinnon Newsletter, by engaging with lifetime ewe management facilitators and their groups, by advertising at a stand at the Best Wool Best Lamb Conference 2016, and through word of mouth. Eligible farms had to be from either Western district or North-West regions of Victoria, have a self-replacing ewe flock and spring lambing, and a minimum of 600 breeding ewes.

8.1.2 Farmer questionnaire

A series of attitude and management questions was asked to each farmer using the validated questionnaire. The questionnaire was conducted in an interview-style, where the researcher and the farmer talked through the questions. This allowed the farmer to clarify anything he/she was uncertain of, and for the researcher to follow up with any questions for clarification.

Questionnaires took anywhere between 45 min and 2 hours to complete, depending on the level of discussion that occurred. Along with the quantitative details collected in the questionnaire, qualitative data were also collected by recording the comments farmers made around the questions. At the same time as the questionnaire, a stock tally form was given to the farmer to complete and return at a later date.

The stock tally data were subjectively assessed for validity using the following four criteria: no rounded numbers; details within class (rather than just totals); limited discrepancies in totals; and self-reported record keeping in the questionnaire. From this, a score was assigned to each farm's stock tally data. The maximum possible score was 4.

The full questionnaire is presented in the appendix.

8.1.3 Ewe welfare assessment

A total of 100 randomly selected ewes (2-4 years old) were assessed according to the welfare protocol validated in section 7. Two visits to each farm, at mid pregnancy and at weaning, were conducted within a one year period. These periods were selected because they are known to be important times in the concerns for sheep welfare (Phythian, 2011, Stubsjøen al., 2011).

The on-farm welfare assessment lasted approximately 4 hours and was performed in the yards and raceway of each farm. Wherever possible, visits coincided with scanning (mid-pregnancy visit) or weaning.

The welfare assessment protocol consisted of three parts:

1. Behaviour observations (10 minutes per a group)
2. Response to human approach (5 minutes per group)
3. Individual welfare assessment (2 min per ewe)

Behavioural observations

In a group of 25, ewes were moved into a pen close to the race. Once in the pen, ewes were observed for 10 min. Sheep were continuously observed for a variety of social behaviours (Table 8.1).

After 10 min, the human approach tests and individual welfare assessments were performed. After one group of 25 was complete, behavioural observations started for the next group.

Table 8.1: Ethogram of observable behaviours

Behaviour	Definition
Displacement	The number of times a ewe was seen to move or step away from a position due to the force imposed by another ewe
Social withdrawal	The number of sheep that voluntarily created a distance of more than 3m from the group
Excessive itching	The number of sheep that persistently scratched for bouts exceeding 20 seconds
Stereotypies	The number of sheep displaying abnormal behaviours that were performed repeatedly with no apparent goal; including bar-biting or wool-pulling
Lameness	The number of animals that limped, had difficulty walking or total lack of weight-bearing on a limb

Response to human approach

A ewe's response to an unfamiliar human was assessed with the assumption that the behavioural response of sheep to an individual will reflect the way in which they would respond to the farmer and/or external contractors and veterinarians, reflecting the process of stimulus generalization [18]. This information may provide a further insight of the quality of the human-animal relationships. Flight distance (FD) was used to measure this.

In order to test FD, a single observer, always the same person, quietly entered the pen holding a group of 25 ewes, walked around the perimeter and stood again at the entry point. From here, the observer waited for a ewe to be orientated towards her before approaching the animal. The ewe was approached by the observer in a standardised way (e.g. taking one step per second, maintaining the right arm in an angle of 45◦ in front of the body and the palm pointing towards the floor) [12, 17]. The test ended when the ewe withdrew, defined as stepping away from the observer. Flight distance was estimated by counting the steps between the observers' hand and the ewes' head at the moment of withdrawal.

The behaviour of the ewe when approached by the observer was scored by using a 4-point score system as follow: a score of (0) if behaved calmly when approached, a score of (1) if there is some avoidance, a score of (2) if there is marked avoidance and struggling to escape; and a score of (3) if the ewe attempt to escape by jumping out of the pen (Stubsjøen *et al.* 2011). Flight distance was measured in 5 ewes randomly selected from each of the 4 groups of 25 ewes, and was repeated at each reproductive stage, giving a total of 20 ewes assessed, per visit, per farm.

The pen used on each farm varied. The effects of this on the FD of the ewes is not known. An honours research project is underway to understand the influence of pen size on ewe flight distance. A summary of the project is presented in the appendix.

Individual welfare assessment

Ewes were moved into the race for individual welfare assessment. To assess lameness, ewes were released from the race into a yard to observe their movement. The body condition, fleece condition, skin lesions, tail length, dag score and lameness of each ewe was assessed according to the criteria presented in Table 8.2. General physical condition, any other observable issues and notes about the assessment measures were also recorded.

After welfare assessment, ewes that were determined to be in need of further care were reported to the farmer. Reasons for further care included: any injury that was > 5 cm and fresh/bleeding or infected; moderate or severe lameness (scores 2 or 3); active mastitis defined as a clearly distended udder, then hot to touch and/or caused ewe to move with discomfort; another sign of significant and current disease/injury (including pink eye). If the farmer was aware of the issue already and it had been treated, it was not classified as needing further care.

Table 8.2. Animal-based welfare measures used to assess the welfare of extensively managed ewes.

Welfare measure	Assessment criteria
Body condition score	Scored on a 5-point scale from 1 (thin) to 5 (obese), using a quarter-unit precision. Sheep were assessed by palpation of the backbone, muscle and short ribs (Russel *et al.* 1969; Calavas *et al.* 1998)
Fleece condition	Scored on a 3-point scale: (0) good fleece condition, when parted, the fleece has no lumpiness or signs of ectoparasites (1) some fleece loss, small shed or bald patches of no more than 10 cm diameter. When parted, the fleece may have some lumpiness or scurf, little evidence of ectoparasites, and (2) significant fleece loss with bald patches of greater than 10 cm in diameter, clear evidence of ectoparasites (Dwyer *et al.* 2015a).
Skin lesions	Assessed by recording number, location and severity of the skin lesions. Lesions were classified as cuts, open wounds, old wounds or scars and abscesses.
Tail length	Scored on a 2-point scale: (0) the tip of the vulva is covered by the tail when held down (1) the tail is over-shortened or almost not present, or if the vulva and anus cannot be covered (T Munro 2009 ; Dwyer *et al.* 2015a)
Dag score	Scored on a 6-point scale: (0) no evidence of faecal soiling, (1) very light soiling on the breech area, (2) Moderate dag on the breech area extending ventrally (3) Severe dag predominantly on the breech area, extending ventrally and dorsally over the tail some soiling and dag around anus, (4) excessive dag on the breech area and on the hind legs (5) Very severe dag on the breech area and on the hind legs or below the level of the hocks (Larsen *et al.* 1994)
Lameness	Scored on a 4-point scale: (0) not lame, (1) clear shortening of stride with obvious head nodding or flicking as the affected limb touches the floor, (2) clear shortening of stride with obvious head nodding and not weight-bearing on affected limb whilst moving, (3) reluctant to stand or move (Dwyer *et al.* 2015a).

8.1.4 Relationships between farmer characteristics and ewe welfare

Two steps have been undertaken so far to examine the relationship between ewe welfare and management practices of the farmers.

Firstly, farmers were classified as being either ‘faster’ or ‘slower’ adopters of management styles. Farmers who do not measure the body condition of their ewes, do not maintain mortality records and do not scan for pregnancy, or scan but do not manage single and multiple ewes differently were classified as slow adopters.

Secondly, based on the farmers’ responses to a set of management questions, farmers were given a score that ranged between 0 to 9, and if a farmer performed all these practices, they obtained the maximum score of 9. The questions were:

1. Regularly body condition score their ewes

2.Regularly monitor the ewe flock during the year
3.Check pasture availability/quality
4.Pregnancy scan annually
5.Records of the number of animals at key points
6.Test before drench
7.Records of diseases
8.Records of mortality
9.Regularly assistance to workshop sessions

Statistical relationships between the farmer scores and ewe welfare on their farms were then assessed. This is a preliminary analysis. A more comprehensive analysis that examine relationships between management practices, farmer attitudes, ewe welfare and farm profitability will be performed as a part of Carolina Munoz's PhD thesis (due for submission April, 2018).

8.1.5 Statistical analyses

Findings were compared according to farming systems. Generally, data were split according to breed, so farms were classified as either Merinos or meat breed ewe flocks, location (sheep-wheat vs. high rainfall zones), and visit (mid-pregnancy vs. weaning). We split the data this way, rather than by primary enterprise, because the management, health and welfare status of ewes may be different for breed and region, rather than what the main source of sheep-related income was.

For farmer management practices, Fisher's exact tests were used to compare differences between ewe breeds and locations. For farmer attitude responses, meat-breed and merino ewe flocks were compared. To do this, t-tests were performed for any question that had more than 0.5 points difference in scores between the two groups.

To assess ewe welfare, generalised linear mixed models were conducted to investigate the effects of time of assessment (mid-pregnancy and weaning), ewe breed and location on welfare outcomes, with all three and their interactions as fixed factors. For dag score, tail length was also included as a fixed factor. In all instances, farm was set as a random factor to account for specific variations in management between farms.

Relationships between farmer characteristics and ewe welfare were analysed in two different ways. The impact of faster vs. slower adopters on the number of ewes in adequate body condition score and the number of ewes requiring further care was analysed using a generalised linear model with a binomial distribution. The relationship between farmer score (0-9) and the number of ewes in adequate body condition, fleece condition, injuries, dag score, lameness and those needing further care were analysed using Spearman's Correlations.

8.2 Results

8.2.1 Farm and farmer characteristics

A total of 32 farmers from Victoria, Australia were recruited for the study. A distribution of farm locations is displayed in Figure 1 and the type of enterprise and breed represented is presented in Table 8.3. From the 32 farms in the study, the majority of farmers/managers were male (n = 30). The average age was 51, and there was a wide spread of ages to achieve this average (25-87). The average years working with sheep 26.7 years (2 – 67 years).

Figure 1: Location of farms involved in this study; orange shaded circles indicate farm locations, size of the circles indicates the number of farms visited within that location

Table 8.3: Farm demographics according to primary enterprise, location and breed; the number of farms where sheep were not the overall primary enterprise are presented in parentheses

Primary enterprise	**Farms**	**High rainfall**	**Sheep-wheat**	**Breed**
Meat	13 (1)	10	3	Composite, Highlander, Corriedale, Poll Dorset
Meat-wool	12 (3)	5	7	Composite, Dohne, Merino
Wool	7	4	3	Merino

Land used for sheep averaged 77 hectares (20-100 ha), with these numbers near identical for meat and Merino ewe flocks (77.5 and 76.7 ha respectively) and high rainfall and wheat-sheep regions (75.9 and 79.0 ha respectively). There was a range in the number of breeding ewes across the 32

farms (431 – 9,400). The average ewe flock size was 2,770, with there being more ewes on farms with meat breed ewes (3,289), compared to Merino breed ewes (2,313). There were significantly more ewes on farms in the high rainfall zone compared to the wheat sheep, where the ewe flocks averaged 3,555 and 1,624 respectively ($t = 2.86$, $P = 0.008$). On-farm labour units averaged 1.7 FTE (range: 0.5 to 3.5), but this may reflect a large number of part-time employees.

Industry engagement in the recruited group was high. Membership to industry groups was common amongst the study's farmers (n = 22, 69%), and it was even more common for farmers to attend workshops (n = 26, 81%). Eight farmers said they attended Lifetime Ewe Management courses, and 15 attended Best Wool Best Lamb groups or information sessions (most attended both). Other examples included non-specific information days/sessions on lamb survival, foot rot and sheep genetics. The most common industry group membership was to Best Wool Best Lamb (n = 16, but not all necessarily active currently). Other groups included independent prime-lamb groups or pasture systems groups, the Mackinnon Project group, Landcare, Victorian Famers Federation and the Grassland Society.

8.2.2 Farm management practices

When surveyed about farm management practices, we focused on the ewes, with some questions that applied to other stock classes. Where relevant, these results are presented based on the breed of ewe (merino vs. meat-breed), location (wheat-sheep vs. high rainfall zones), or the type of enterprise (meat, wool-meat, wool).

Monitoring animals and record keeping

Twice-weekly monitoring of the pregnant or dry ewe flock was common practice (21/32 farms); followed by weekly monitoring (4 merino flocks and 1 meat-breed flock) and every second day (2 merino, 2 meat-breed). Daily and weekly monitoring were performed by only one farmer respectively. The frequency of monitoring increased significantly at lambing, with 87.5% of flocks being monitored twice daily (n = 20) or daily (n = 8). Two merino farmers did not monitor their flocks during lambing. Every farmer described monitoring as being done visually and from a distance. All farmers did this while driving around the paddock, and/or when feeding or moving sheep.

Body condition scoring was commonly performed on meat-breed flocks, but not merino flocks (Table 8.4; $p = 0.02$), and on farms in high rainfall, but not wheat-sheep zones ($P = 0.03$). Ten farmers out of the 23 (43%) that did BCS either always or sometimes did so by physically touching the ewes when they were in the race, another 10 only did so visually. Three farmers mentioned that they take weights of the ewes, or draft the skinny ones to weigh, rather than BCS. A lack of time or not enough labour were cited as the most common reasons farmers may not BCS their ewes. Other descriptive

reasons included farmers not wanting to do it, not appreciating the value of it, not being trained to do it/not having confidence in their techniques, or simply not caring.

Pregnancy scanning was more common than BCS, and the consistency differed between flock type (Table 8.4; p = 0.01) and location (P = 0.03). Cost was cited as the most common reason farmers may not pregnancy scan their ewes. Other reasons given included poor facilities, farmers not appreciating the benefits/being too traditional, it not being a priority, and "indolence".

Keeping records of marking percentages were common, but weaning records were less common (Table 8.4). Neither were influenced by flock type, but farmers in high rainfall zones were more likely to keep records at marking (P = 0.02). A lack of time was the most common reason farmers may not keep records, and descriptive reasons included a lack of interest/motivation, that it's "not something that is going to impact your industry", it's "just another thing to do", and "most people hate paperwork".

Table 8.4: Frequency of common farm management practices according to the breed of ewe

		Frequency		
Measure	Farm type	Always	Sometimes	Never
Body condition scoring	Meat breed	8	6	1
	Merino	3	6	8
	High rainfall zone	10	5	4
	Wheat-sheep zone	1	7	5
Scanning for pregnancy	Meat breed	11	2	2
	Merino	5	10	2
	High rainfall zone	14	4	1
	Wheat-sheep zone	2	8	3
Keeping marking records	Meat breed	10	4	1
	Merino	6	8	3
	High rainfall zone	13	4	2
	Wheat-sheep zone	3	8	2
Keeping weaning records	Meat breed	8	7	0
	Merino	6	7	4
	High rainfall zone	10	6	3
	Wheat-sheep zone	4	8	1
Keeping mortality records	Meat breed	9	1	5

	Merino	3	4	10
	High rainfall zone	6	3	10
	Wheat-sheep zone	6	2	5

Only five meat sheep and one merino farm had a written health plan. Seven meat sheep and 11 merino farms never recorded incidents or types of diseases. Of those that did, they recorded diseases at certain times, like when animals were in the yards (scanning, marking), if they were a part of an assurance program or other research program (e.g. the Mackinnon LANDI project), or in the cases "if we have something".

At lambing time, 13 (86%) meat-breed farmers reported intervening if ewes were experiencing lambing difficulties, and 65% (n=11) merino farmers did. Four merino farmers and one meat-breed farmer reported never intervening in these dystocia cases.

When it came to providing pain relief from husbandry practices, 13 of the 16 merino farms mulesed their animals (81%), and of those 13 farms, 10 provided pain relief to the lambs. By comparison, only two farms provided pain relief at castration.

Mortality and culling

Mortality records were frequently kept for ewes on meat-breed farms, and it was common for merino farms to not keep any mortality records (Table 8.4; tendency towards a statistically significant difference $p = 0.06$). When asked how mortality records were kept, responses included doing tallies at key times, that it was calculated rather than an actual figure, and that they're "trying… but it doesn't always work".

The most commonly reported reason for not keeping mortality records was lack of time (n = 7). When asked to elaborate, farmers reported 25 other reasons or comments about mortality record keeping. Some reasons indicated that farmers would have a good idea of their mortality rates, but wouldn't necessarily record them: "most farmers would have an idea of how many ewes they have lost". Other reasons focused on the difficulty of measuring rates, including statements like "it's difficult to keep accurate records", "it's difficult to work in the office when you are tired from working sheep", "from stock tally, but sometimes is not very accurate". Out of the 25 comments, 15 focused on farmers either not wanting to know what the mortality rates were, or not seeing the value in knowing mortalities. Statements included focusing on not wanting to know the answers included being "scared of the answer" and "you don't want to keep remembering how much you have lost". Statements around not recognising the value of knowing mortalities included "the

information doesn't change my operation", "because it doesn't help to prevent no deaths", and "(you) can't make a dead sheep alive".

The most common cause of mortality was reported to be related to nutritional issues or disease (both n = 5), followed by flystrike (n=3). Other reported issues included ewes being too heavy or too light around lambing and associated issues (n = 14), with lambing difficulties or dystocia being reported eight times. Old ewes, clostridial disease, adverse weather after shearing and worms were also reported to be common causes of mortality.

Age was the most common reason for culling ewes (n = 18), followed by reproductive failure (n = 6) and fly strike (n = 4). Bad conformation (n = 3) and wool quality issues (n = 2) were other key reasons for culling.

Stock tally form

A total of 26 (81%) farmers provided their stock tally data. Five farmers scored the maximum of 4, indicating that their stock tally data was considered to be entirely reliable and accurate (Table 8.5). The average score was 2.4 and two stock tally records scored the minimum of 0. Two farms scored 1, 10 scored 2 and 8 scored 3.

Table 8.5: Number of farms meeting the subjective assessment of the stock tally data; percentage presented in parentheses (out of 26 farms)

Criteria	**Number of farms**
No rounded numbers	19 (73)
Mortality details provided within class	21 (81)
No discrepancies in totals	15 (58)
Reported mortality record keeping in the questionnaire	11 (42)

Farmers estimated their annual ewe mortalities as a part of the questionnaire. The average estimate was 2.7%, with a minimum estimate of 1% and maximum of 5%. The average estimated mortality rates were comparable between zone and breed type: high rainfall = 2.6%, wheat-sheep = 2.9%, meat breed = 2.5%, Merino = 3.0%.

According to the stock tally data, the average annual ewe mortality rate was 4.7%, with a minimum of 0.2% and a maximum of 14.4%. These two farms both had a subjective stock tally score of 3, suggesting that the stock tally data was likely accurate. The average stock tally mortality rates were comparable between zone and breed type as well: high rainfall = 5.3%, wheat-sheep = 3.8%, meat breed = 4.6%, Merino = 4.7%.

Compared to their stock tally records, six farmers overestimated their mortalities, six were near accurate (<0.5%) and 16 underestimated their mortality rates.

Monitoring feed on offer

Pasture monitoring was somewhat common. The majority of farmers monitored pasture availability sometimes (17 farms; 56%), and 8 farmers never monitored pasture (25%). When measuring availability, farmers also measured quality (always: n=7, 22%, sometimes: n=16; 50%). These practices were common between merino and meat breed farmers, and did not differ across regions.

Twenty farmers reported assessing pastures visually. While much less common, more technical approaches to measuring pasture availability and quality were used. Two farmers used cages, lifetime wool sheets and agronomists. Three farmers said they used pasture rulers/sticks, while another farmer indicated that he uses the rule 'sometimes', but found it too difficult. Two farmers that did not monitor pasture had completed courses in how to do it. When asked about why farmers may not monitor pasture, the most common response was lack of time. Other reasons given included it being too complicated to perform, not a valuable activity, lack of skills or that they like to farm traditionally.

8.2.3 Farmer attitudes

Results of the attitude questionnaire are presented as an overall mean for the group, and were also split according to breed type.

Attitudes towards and knowledge of sheep management and husbandry

Attitudes towards frequent checking dry ewes were different to pregnant ewes and those with lambs, with it being rated as less important, and this attitude extended to body condition score as well (Table 8.6). Pasture availability was considered important to manage from all farmers. Pregnancy scanning was seen to be less important for Merino ewe flocks than meat-breeds, but was still scored as important (4.6 vs. 3.9, with a score of 5 = very important). Assisting ewes with dystocia was considered an important activity by both groups.

Both groups of farmers considered veterinary checks to be low priority, but meat-breed farmers considered this to be more important than Merino farmers. This difference between farms extended to health plans, with meat-breed farmers considering written health plans to be somewhat important, and Merino farmers considering this to be of low importance. When it came to

calculating annual disease rates, mortality and culling, farmers all considered to this be somewhat important to important.

There was a significant difference between farmers on the importance of mulesing as a tool to manage flystrike, with Merino farmers considering it to be important (mean score 4.1) and meat-sheep farmers considering it to be somewhat important (mean score 2.8).

Table 8.6: Attitudes towards and knowledge of sheep management and husbandry; the minimum score of 1 indicated the statement was 'not at all important' and the maximum score of 5 indicated 'very important', * indicated a statistically significant difference between the two types of breeds ($p < 0.05$)

	Overall mean	**Meat breed**	**Merino**
How important is it to check these stock classes daily:			
Dry ewes	1.6	1.8	1.4
Pregnant ewes	3.4	3.9	3.1
Ewes with lambs at foot	3.0	2.8	3.1
How important is monthly body condition scoring for:			
Dry ewes	2.6	2.7	2.6
Pregnant ewes	3.9	4.2	3.7
Ewes with lambs at foot	3.6	4.2	3.3
How important is it to measure pasture availability?	4.1	4.1	4.2
How important is it to measure pasture quality?	3.7	3.5	3.8
How important is it to allocate pregnant ewes in different groups according to their nutritional needs?	4.5	4.7	4.4
How important is it to perform pregnancy scans annually? *	4.2	4.6	3.9
How important is it to assist ewes with of dystocia?	4.2	4.2	4.1
How important is it to provide ewes with shelter during winter?	4.3	4.4	4.2
How important is it to provide ewes with shelter during summer?	4.0	3.8	4.2
How important is it to have the ewes annually checked by a veterinarian? *	1.4	1.8	1.1
How important is it to have a written health plan in the farm? *	2.7	3.3	2.3
How important is it to treat ewes for parasites?	4.5	4.4	4.6
How important is it to test ewes for parasites before drenching sheep?	3.9	4.1	3.7
How important do you think mulesing is to prevent fly strike?*	3.5	2.8	4.1
How important is it to provide local anaesthesia or pain relief at mulesing?	3.8	4.0	3.6
How important is it to calculate annual disease rates in your farm?	3.2	3.5	3.0
How important is it to calculate annual mortality rate in your farm?	3.7	3.8	3.5
How important is it to calculate annual culling rate in your farm?	3.4	3.8	3.1

Attitudes towards ewes

When considering the welfare and behaviour of ewes, farmers responded positively and had a positive attitude towards them (Table 8.7). Farmers all considered themselves to be very responsible for the welfare of their animals, and that their animals have the capacity to experience affective states, including pain. Ewes were considered to be intelligent and not somewhat stubborn. Farmers clearly recognised that how people handle ewes will affect their fearfulness. These findings were all consistent across farms, regardless of the breed of animal farmers managed.

Table 8.7: Attitudes towards the behaviour and welfare of ewes; the minimum score of 1 indicated 'strong disagreement' and the maximum score of 5 indicated 'strong agreement'

	Overall mean	Meat breed	Merino
I'm responsible for the welfare of my animals	4.9	4.9	4.8
Farm animals have feelings like people have feelings	3.9	4.0	3.8
Farm animals experience physical pain as humans do	4.1	4.2	3.9
Farm animals generally aren't affected by the way they are treated	1.7	1.7	1.8
Ewes are intelligent	3.9	4.0	3.9
The way how people handle ewes will impact ewes' fearfulness	4.3	4.5	4.2
Ewes are stubborn animals	2.9	2.7	3.2
Ewes have a gentle nature	3.5	3.7	3.4
Ewes are frustrating to work with	2.5	2.2	2.8
Ewes are easy to train to a routine	3.8	3.9	3.8
Moving sheep is an easy task	4.2	4.4	4.2
The best way to move sheep is by not rushing them	4.5	4.6	4.4
Using sheepdogs is the best way to move the ewes	3.6	3.0	3.9
Using trained sheepdogs is not stressful for ewes	3.5	3.4	3.4
Ewes are easy to handle	3.6	3.8	3.4
Ewes do not require a great deal of care	2.2	2.0	2.2
Mulesing is not painful for sheep	1.8	1.5	1.9
I think ewes can be annoying	2.8	2.5	3.1
Shearing is not stressful for ewes	2.5	2.7	2.3

Attitudes towards work and work motivation

Farmers had good job satisfaction and perceived themselves to be very competent in in their jobs, with mean scores of 4 ('agree') or higher for positive statements, or 2 ('disagree') or lower for

negative statements, for 10 of the 15 statements posed in this part of the survey (Table 8.8). This was regardless of the breed managed.

Farmers tended to agree that they had limited control over the survival of ewes, with an average score of 3.9.

Table 8.8: Attitudes towards work and work motivation; the minimum score of 1 indicated 'strong disagreement' and the maximum score of 5 indicated 'strong agreement'

	Overall mean	Meat breed	Merino
I really like being a sheep farmer	4.4	4.6	4.3
I look forward to the days I have to work sheep in the yards.	3.7	3.7	3.6
I am good at handling sheep	4.0	3.9	4.1
If someone is roughly handling my sheep, I would intervene	4.3	4.5	4.3
It is really important for me to try hard at work.	4.3	4.3	4.2
I am the type of person who gets over-involved with my job.	3.5	3.4	3.7
It is important to me that I do a good job.	4.4	4.4	4.4
I get bored easily in my job.	1.9	1.9	2.0
I do not like having a lot of responsibility at work.	1.7	1.5	1.8
I feel respected for the work I do.	3.7	3.7	3.7
I'm able to do things that don't go against my morals	4.0	4.1	3.9
I do not have the chance to do something that makes use of my abilities	2.0	2.1	1.9
I feel rewarded from this job	4.2	4.3	4.0
No matter how hard I try, a constant number of ewes will always die	3.8	3.6	3.9
Weather will influence lamb survival more than any management decisions I make	3.2	3.2	3.1

Sources of advice

Farmers sought advice from a variety of sources, but Merino farmers tended to seek veterinary advice less than meat breed farmers (Table 8.9). Farmers also reported using other sources of advice including consultants (n = 3), online resources including MLA and State Government (n = 2), and Best Wool Best Lamb groups (n = 2). One farmer reported that they did not seek advice from others.

Table 8.9: Sources of advice or guidance; the minimum score of 1 indicated 'advice never sought' and the maximum score of 5 indicated 'advice always sought', * indicated a statistically significant difference between the two types of breeds ($p < 0.05$)

	Overall mean	Meat breed	Merino
Veterinarians*	3.4	3.8	3.2
More experienced farmers	3.3	3.2	3.3
Closest family members (e.g. spouse, parents, siblings, etc.)	3.2	3.1	3.5
Friends	2.8	2.7	2.9

Perceived 'barriers' to best practice

There was a low perceived difficulty for all management practices, with the average score for all 22 statements given to be less than 2.5 (score 2 = slightly difficult; Table 8.10). Measuring pasture availability, parasite management and quantifying culling rates were all scored as being not difficult (mean score 1.5, 1.6 and 1.6 respectively).

Meat-breed farmers indicated that annual veterinary checks of the mob were not difficult (mean score 1.6), whereas Merino farmers perceived this to be difficult (mean score 3.1; T test =, P = X).

Table 8.10: Perceived 'barriers' to best practice; the minimum score of 1 indicated 'not at all difficult'' and the maximum score of 5 indicated 'very difficult', * indicated a statistically significant difference between the two types of breeds ($p < 0.05$)

How difficult is it for you to perform daily checking of:	Overall mean	Meat breed	Merino
Dry ewes	2.4	2.2	2.4
Pregnant ewes	2.2	1.7	2.3
Ewes with lambs at foot	2.3	1.9	2.5
How difficult is it for you to monthly check body condition of:			
Dry ewes	1.9	2.1	1.9
Pregnant ewes	2.0	1.8	2.1
Ewes with lambs at foot	2.7	3.0	2.7
How difficult is it for you to measure pasture availability?	1.5	1.4	1.7
How difficult is it for you to measure pasture quality?	2.2	2.0	2.3
How difficult is it for you to allocate pregnant ewes in different groups according to their nutritional needs?	1.8	1.5	1.9
How difficult is it for you to perform pregnancy scan annually?	1.7	1.8	1.8
How difficult is it for you to assist ewes in case of dystocia?	2.2	1.6	2.4
How difficult is it for you to provide ewes with a form of shelter during winter?	2.2	2.4	2.1
How difficult is it for you to provide ewes with a form of shelter during summer?	2.0	2.2	1.9
How difficult is it for you to have the ewes annually checked by a veterinarian?*	2.4	1.6	3.1
How difficult is it for you to have a written health plan in the farm?	2.0	1.6	2.2

How difficult is it for you to test ewes for parasites before drenching?	1.6	1.7	1.5
How difficult is it for you to annually treat ewes for parasites?	1.6	1.7	1.7
How difficult is it for you to provide any form of local anaesthesia or pain relief at mulesing?	1.7	1.9	1.6
How difficult is it for you to calculate annual disease rates	2.2	1.9	2.5
How difficult is it for you to calculate annual mortality rate	1.8	1.6	2.0
How difficult is it for you to calculate annual culling rate?	1.6	1.6	1.5
How difficult is it for you to be prepared for a bad season?	2.4	2.4	2.6

8.2.4 Ewe welfare assessment

Of the 32 farms recruited for the study, 30 were visited twice (mid-pregnancy and weaning), and two once (both at weaning). Mid-pregnancy visits were not conducted because one farmer sold all his sheep after the first visit. The second farmer was unavailable for the second visit until the ewes were in late pregnancy, which would have influenced comparisons. In total, the welfare of 6,200 ewes were assessed.

Body condition score

In mid-pregnancy, 49.9% of meat-breed ewes and 48.1% of merinos were within the recommended BCS (Figure 2), and this increased to 61.1% and 55.2% respectively at weaning (Figure 3). When comparing the number of ewes in adequate body condition, there was a statistically significant interaction between Breed type, Visit and Location ($F = 4.38$, $p < 0.001$). Meat-breed ewes in the wheat-sheep zone were more often in inadequate body condition at weaning compared to all other groups, other than Merinos of the same category. More Merino ewes in the wheat-sheep zone were also in inadequate body condition at weaning compared to mid-pregnancy. In summary, ewes in the wheat-sheep zone had inadequate body condition more often than any other group.

Extending the range to 0.25 above and below the recommended targets substantially. A total of 83.4% of meat-breed ewes and 84.4% of merino ewes were within the BCS range of 2.5 and 3.25 at mid-pregnancy. At weaning, 83.3% and 81.4% of meat-breed and merino ewes were within the range of 2.25 and 3.25 respectively. This suggests that while up to 50% of ewes were outside the recommended range, extreme condition scores were limited. There were nine ewes in total that were BCS 1.5 at weaning, and 10 at pregnancy.

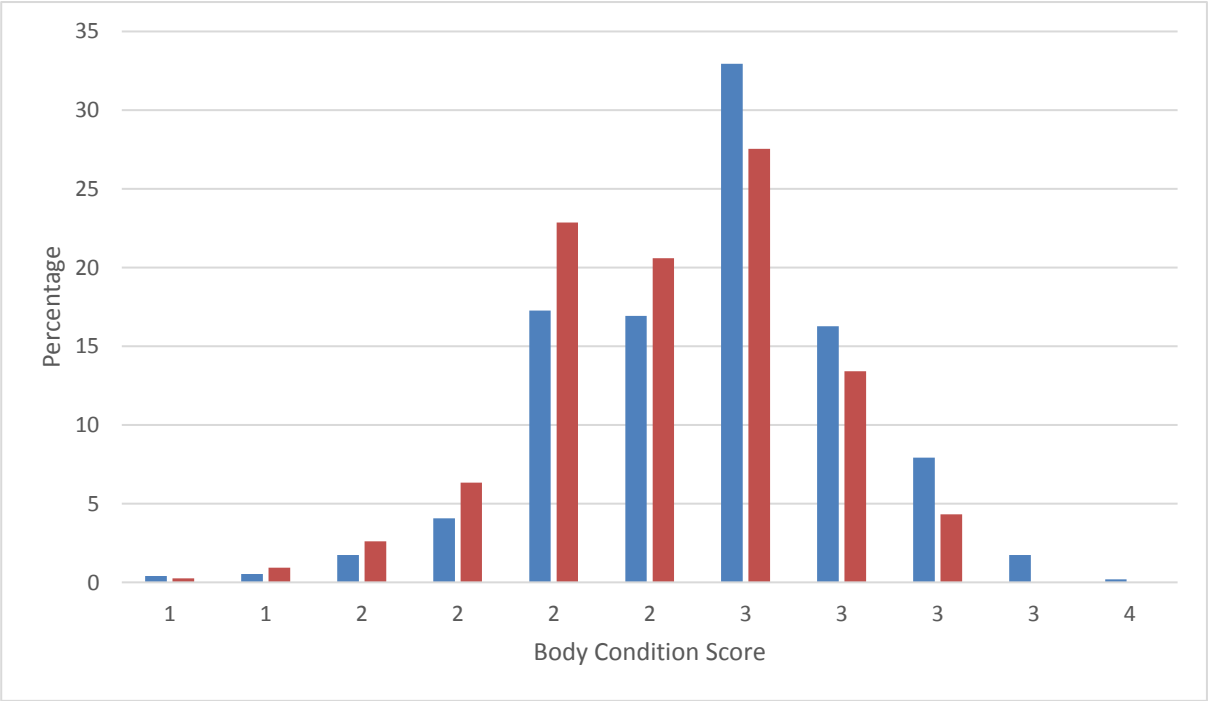

Figure 2: Body Condition Score at mid-pregnancy; blue bars represent meat-breed, red bars represent merino ewes; recommended BCS is 2.75 to 3 for this stage of reproduction.

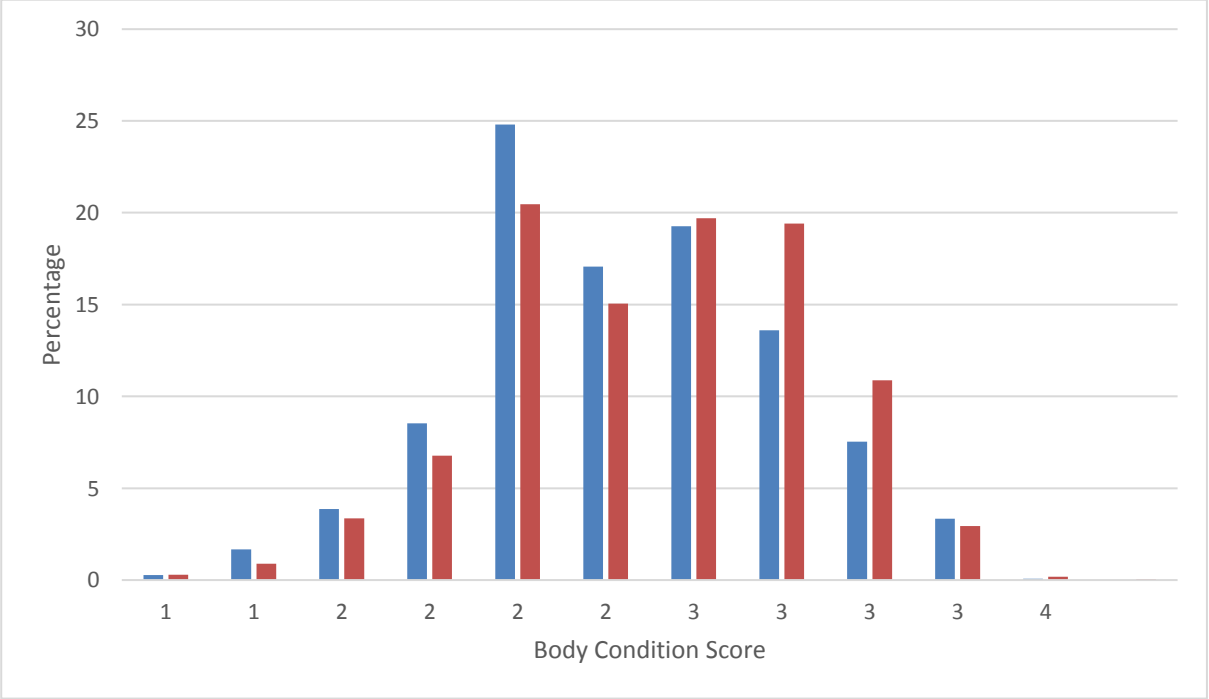

Figure 3: Body Condition Score at weaning; blue bars represent meat-breed, red bars represent merino ewes; recommended BCS recommended BCS is 2.5 to 3 for this stage of reproduction

Fleece condition

Fleece issues were more common in meat-breed ewes than they were in merinos (F = 5.67, P = 0.02; Table 8.11), and were more common at weaning than in mid-pregnancy (F = 5.50, P = 0.19). Incidents were under 5% in merinos, but up to 15% in meat ewes at weaning. The common issues observed were fleece rot (n = 508), lumpy wool (n = 32) and broken wool (n = 21).

Table 8.11: Number of ewes with adequate and inadequate fleece condition according to breed and time of assessment; percentages presented in parentheses

	Meat		Merino	
Score	Mid-pregnancy	Weaning	Mid-pregnancy	Weaning
Adequate	1320 (88)	1274 (84.9)	1428 (95.2)	1617 (95.1)
Inadequate	180 (12)	226 (15.1)	72 (4.8)	83 (4.9)

Injuries

The rate of injuries was higher at weaning (0.5 injuries per ewe; F = 200.46, P < 0.001) than pregnancy (0.29 injuries per ewe). The greatest number of ewes presenting were Merinos mid-pregnancy (Table 8.12), and Merinos at weaning presented with the greatest number of injuries. Out of the 1915 ewes that were recorded with injuries, only a limited number were deemed to be severe enough to be referred to the farmers for further care. A high total number of minor injuries were not reported as needing further care.

Table 8.12: Injuries observed and their incidents according to breed and time of assessment; percentages presented in parentheses

	Meat		Merino	
	Mid-pregnancy	Weaning	Mid-pregnancy	Weaning
Ewes with injuries	369 (24.6)	446 (29.7)	535 (35.7)	565 (33.2)
Number injuries per ewe	1.2	1.3	2.3	3.6
Total number of injuries observed	428	594	1209	2030
Head/neck	22 (6)	66 (14.8)	155 (29)	442 (78.2)
Ear	311 (84.3)	328 (73.5)	277 (51.8)	311 (55)
Eye	13 (3.5)	4 (0.9)	6 (1.1)	4 (0.7)
Body	5 (1.4)	79 (17.7)	288 (53.8)	694 (122.8)
Rear	76 (20.6)	94 (21.1)	412 (77)	414 (73.3)
Legs	1 (0.3)	23 (5.2)	71 (13.3)	165 (29.2)

Eye injuries

Other than the incidents listed in Table 8.12, eye injuries were considered to pose the most significant risk to welfare. Twenty-six ewes in total (0.7%) were recorded with eye injuries. Nine of these were active pink eye, and a maximum rate recorded of the disease on farm was 2%. The

remaining 17 cases ranged from minor cuts around the eye area to ingrown horns in both eyes and grass-seed induced blindness.

Shearing related injuries

Of the 62 farm visits, five merino flocks were visited following shearing or crutching. Of the 500 ewes assessed, 434 (86.8%) had at least one injury to their body, legs, rear, ears or head (Table 8.13). The average number of injuries per ewe was 5.4 (range 0 to 26) and the majority of these were to the body. Shearing significantly affected the number of injuries observed per ewe ($F = 1128.7$, $P < 0.001$).

Table 8.13: Locations of injuries seen within two weeks of shearing or crutching

Injuries	Total number (%)
Total number of injuries observed	2360
Head/neck	484 (20.5)
Ear	86 (3.6)
Body	902 (38.2)
Rear	676 (28.6)
Legs	212 (9)

Tail length and dag score

A total of 84% of ewes in this study had tails that were too short, with 2334 (77.8%) of meat-breed and 2896 (90.5%) of merino ewes having short tails.

Dag score according to time of assessment and tail length are presented in table 8.14. Ewes with very high dag scores (score 4 and 5) were found on 17 out of the 32 farms. Ewes in the wheat-sheep zone presented with very high dag scores more frequently at weaning than they did mid pregnancy ($F = 29.19$, $P < 0.001$). The frequency of these groups was comparable to ewes in the high rainfall areas.

At mid-pregnancy, less ewes with short tails presented with very high dag scores, but tail length did not affect dag scores otherwise (Table 8.14 and 8.15; $F = 29.19$, $P < 0.001$). Docking tails short is often given as a reason to reduce dags, but there was no relationship between heavy dags and tail length at the higher risk times (weaning, when high dag scores were more common).

Table 8.14: Frequencies of scores according to time of assessment; percentages presented in parentheses

	Meat		Merino	
Score	Mid-pregnancy	Weaning	Mid-pregnancy	Weaning
0	892 (59.5)	967 (64.5)	829 (55.3)	1009 (59.4)
1	268 (17.9)	254 (16.9)	318 (21.2)	261 (15.4)
2	229 (15.3)	178 (11.9)	250 (16.7)	191 (11.2)
3	101 (6.7)	72 (4.8)	80 (5.3)	122 (7.2)
4	8 (0.5)	27 (1.8)	20 (1.3)	84 (4.9)

5	2 (0.1)	2 (0.1)	3 (0.2)	33 (1.9)

Table 8.15: Frequencies of very high dag score sheep (scores 4 and 5) according to tail length and time of visit; percentages presented in parentheses

	Mid-pregnancy	Weaning
Short	25 (1.0)	118 (4.4)
Adequate	8 (1.8)	28 (5.3)

Lameness

Lame ewes were found on all 32 farms, and 68.2% of all observed lameness cases were mild (score 1; Table 8.16). Lameness was affected by visit and location (F = 5.87, P = 0.014), with ewes in the wheat-sheep zone having lower incidents of lameness at mid-pregnancy compared to weaning. Ewes in the high rainfall zone were intermediate.

Table 8.16: number and severity of lameness according to time of assessment

	Meat		Merino	
Score	Mid-pregnancy	Weaning	Mid-pregnancy	Weaning
0	1438	1433	1434	1599
1	40	48	48	66
2	22	19	18	34
3	0	0	0	1
% lame	4.1	4.5	4.4	5.9
% severely lame	1.5	1.3	1.2	2.1

Further care

A total of 185 ewes were reported to farmers for further care. There was at least one ewe reported for further care on each farm, but for two farms at mid-pregnancy and one farm at weaning, no ewes required further care. The highest number of ewes requiring further care on a farm was 14 (7%), and 11 of these cases were at weaning. Despite this example, there was no influence of breed type or visit on the number of ewes needing further care.

Location significantly influenced the number of ewes that required further care (F = 1.87, P < 0.001). Ewes on wheat-sheep farms were more commonly in need of further care than ewes in high rainfall areas (n = 97 vs. n = 88). Reasons for further care included moderate or severe lameness, BCS of 1.5, flystrike, and injury classified as ‘major’.

Response to human approach

Data from the human approach test are still being analysed. The honours research project by Samantha Cramer identified that pen shape did have a significant effect on the flight distance of ewes. We then calculated the maximum distance between the observer and the sheep using Pythagoras' theorem. This was used to adjust the flight distance of the same group of ewe in different shaped pens and was effective at making their flight distances between pens comparable. The results from the current study will be adjusted in the same way so results between farms can be compared.

A summary of the honours project is presented in the appendix.

8.2.5 Relationships between farmer characteristics and ewe welfare

In a preliminary analysis 56% (n=14) of farmers were classified as 'slower' adopters and 44% (n=11) were classified as 'faster' adopters. Looking at weaning data alone, no differences were found in the average BCS of slower (2.9 ± 0.25) or faster flocks (2.8 ± 0.19). Farmers classed as slower adopters did have more ewes in inadequate BCS (too thin or too fat according to industry recommendations) (P=0.004), and more ewes needed further care in passive flocks (due to flystrike, severe lameness, etc.) compared to proactive flocks (P=0.017), indicating that farmers with passive management style have more ewes at risk of welfare compromise.

There was also a significant, positive correlation between the number of management practices farmers performed and the number of animals that were in adequate BCS (Table 8.17). The number of management practices farmers performed had a strong negative correlation between the number of animals needing further care, and a moderate negative correlation between number of lameness. There was a tendency (P = 0.052) towards a negative correlation between farmer management and the number of injuries observed.

More comprehensive analyses will be undertaken as a part of Carolina's PhD. This includes expanding the statistical methods used, the data included in the modelling, and increasing the analyses to include all 32 farms across mid-pregnancy as well as weaning. While there are other factors that need to be investigated, a weak, negative correlation between total flock size and the number of animals requiring further care indicates that scale may be one contributing factor, with smaller farmers having more animals in need of additional care ($r = -0.38$, $p = 0.03$).

Table 8.17: Spearman's correlations between Farmer management practices and ewe welfare indicators.

Ewe welfare indicators	R	*P*
Adequate BCS*	0.52	0.002
Fleece condition	-0.02	0.903
Skin injuries	*-0.35*	*0.052*
Short tail length	0.05	0.758
Dag score	0.32	0.066
Lameness*	-0.39	0.026
Further Care*	-0.64	0.003

These preliminary results were presented in the appendix.

8.3 Discussion

To our knowledge, this study constitutes the largest, and most comprehensive, independent evaluation of the welfare of sheep in Australia.

Are farmers in this study representative of all Australian sheep farmers?
Considering we used a voluntary process to recruit farmers, there was an even representation of enterprise type and location for our study. Over the course of the 7-12 months farmers were involved in the study, we only had two drop out, giving a retention rate of 93%. This is likely the result of the voluntary recruitment process and the participatory activities.

The recruitment method also becomes the limitation of this study however, with farmers that are engaged with industry groups, or more active in the industry being the ones to volunteer. This makes it hard to know if the farmers in our study represent the regional, state or national profile accurately. The majority of farmers in this study attended industry education sessions and over half were associated with farmer groups or organisations. Considering the focus group participants in section 6 described themselves as being the top 20% of the industry for these reasons, it suggests that the population of farmers in this study are above the industry norm. We had 15/32 farmers (47%) attending Best Wool Best Lamb (BWBL) groups or workshops. An AWI report states that 1,700 wool producers in Vic attend BWBL groups (AWI No Date), and 2015-16 farm data states that Victoria has 12,124 sheep and lamb producers (data 2017). That suggests 14% of the industry in Victoria have participated in BWBL, whereas representation in our study was 47%. Further analysis of how representative our farmers were is continuing.

Farmers had a very high rate of job satisfaction, which may be associated with how they sought out industry education and groups, and why so many of them were committed to the duration of the study. If these farmers do not accurately represent the broader population, understanding the influence of job satisfaction on farming practices would be important.

Without cold-calling farmers from an industry wide-data base, it's difficult to solve this issue. Even then, the likelihood of engaging with these farmers may be lower. One possible activity would be to have a nation-wide survey that collects attitude and demographic data from a wide variety of farmers. This would not guarantee results were not skewed, as farmers would still have to participate, but it would broaden the reach and increase the likelihood of a more accurate representation.

Assessment and data recording needs improving and could increase risk to ewe welfare

Consistent with the focus group, the majority of farmers in this study monitored their ewes visually from a distance. Reliance on visual assessment for pasture availability and quality was even greater. Body condition scoring was done through 'hands-on' assessment on one third of farms (10 out of 32), and this was the most frequent physical monitoring performed. Record keeping in general, particularly around incidents of disease, and a written health plan were generally done on an 'as needs' basis. A potential problem with this approach is that it's hard to know when you need a health plan, or veterinary intervention, if you are not recording data consistently, and not monitoring your stock frequently.

The accuracy with which farmers could estimate issues on farm was low, with stock tally data commonly not corresponding with the estimated ewe mortality rates provided by the farmer, and mortality rates were frequently underestimated. It is hard to tell if the farmer's estimates are inaccurate however, because the accuracy of the stock tally records was also variable. The accuracy of these records was generally low, with 54% of records having an accuracy score of 2 out of 4 or lower, and another 6 farms not providing any information at all. Stock tally data is the basic of data collected and required for farm taxation purposes. It may well be the case that the forms were difficult to complete, or farmers did not want to share this information with us. Regardless, it was clear that the accuracy of these records needs to be understood further. This low accuracy could also be related to unwillingness to know, or not understanding the value of this information.

Farmers sought advice from a variety of sources, but much of this happened on an as-needs basis according to the health and veterinary check plans. This may be why there was a low level of importance placed on veterinary and health care plans. This could be a reasonable approach, but becomes complicated when the data on the state of the flock is somewhat limited though low rates of recording and more subjective data collection methods. As described above, these methods risk missing ewes that may experience less obvious but severe issues, and it makes health and welfare issues more difficult to treat because early intervention is not feasible.

In combination, the reliance on visual monitoring, the finding of low levels of record keeping and inaccuracies in the stock tally data suggests that more detailed and accurate recording would be valuable.

The welfare of the ewe flock was good, but welfare compromise to the individual animal can be significant

In total, the health and welfare of 6,200 ewes were recorded in this research activity. To our knowledge, this makes our study the largest welfare assessment of ewes ever conducted in Australia. The findings provide a valuable insight into the status of ewe flocks and will act as a sound basis for future ewe research and welfare benchmarking.

There were cases of ewes needing further care on each farm. In all instances, ewes requiring further care were experiencing significantly compromised welfare and, in some cases, an extremely heightened risk of mortality. None of these had been identified by the farmer, highlighting difficulty of identifying welfare compromise from a distance. While the number of ewes needing further care was infrequent, with the lowest being 0.5%, percentages reached 14% in one farm. With an average of 3% of ewes needing further care, and an average flock size of 2,770 ewes across this study, 83 ewes would be experiencing significant compromise to their biological functioning and requiring further care at any one time on farm.

The welfare of ewes was largely positive; however, this was a robust study population. Age and mortality in sheep has a parabolic relationship, with risk being higher in younger and older animals. We specifically selected the easiest to manage and most economically valuable group of sheep on farm: ewes 2 to 4-year-old, single bearing (if known). As a result, we suggest that the level of welfare compromise reflected on here may be the lowest it would be across each farm. The 2015-16 season in Victoria was a good year in terms of food and rain. Farmers were happy, which probably aided the recruitment process, and sheep may have been in better condition than in less favourable years. Ewes were also brought into the yards by the farmers so welfare assessment could be conducted. This process, or the drafting process itself, may favour healthier animals. Those compromised ewes (weak, lame) may miss selection, and so assessment, more frequently because they are less able to move. The key point is that since this has not been recorded before, we do not know. Maintaining the positive welfare image of the Australian sheep industry makes understanding and improving welfare important.

We conservatively conclude that the welfare of the ewe flock is positive, but those ewes that experience welfare compromise are at risk of reduced welfare for a protracted period before detection, and sheep that experience compromised welfare could be higher in different groups of sheep or different seasons. As this is the first comprehensive study of ewe welfare, it acts as a benchmark for future comparison, but this makes it difficult to know how ‘common’ these results were. Further research to validate these welfare results would be valuable if welfare assessments were to be conducted on farm.

Welfare assessment identifies current welfare compromise, previous experience and future risk

Up to 50% of the ewe flock was outside the targeted body condition range, but the majority of these outliers were just outside the range. While the risk of welfare and fertility of these ewes and the survival of their offspring is increased, it is not significant and easily correctable. While high body condition score ewes are at risk in late pregnancy and in parturition, low condition score ewes face more immediate risks to welfare generally; 261 ewes across all farms fell into this category. Their risk of mortality was classed as being significant.

Lame ewes were found across all farms and there were 93 cases of moderate lameness. Lameness is considered to be substantially painful to sheep. Pain associated with lameness affects how easily ewes can move within a paddock, reducing mobility, feed intake and weight gain, and decreasing body condition and wool production. This makes lameness both a welfare and production issue.

Mastitis was identified in a few ewes. Mastitis cases in this study were not identified clinically, so all cases seen were extremely severe and had reached the stage of hard, hot, visibly affected udders. As mastitis is known to cause pain and discomfort, body condition loss, lameness and mismothering of lambs, it can be a significant welfare and production issue clinically and sub clinically. With Merino ewes having rates of 1 to 2% clinical and 7% subclinical mastitis during lactation, welfare compromise experience by extensively managed ewes from mastitis may be much higher than currently identified. More details on this are given in the appendix.

With 84% of the ewes in this study having tails that were too short, tail docking presents a risk to welfare. Tail docking is used to prevent dags and flystrike, but short docked tails has been linked to bacterial arthritis, rectal prolapse and vulva cancer While there was no association between dags and tail length in this study, short tails can cause an increased risk of dags and therefore flystrike Short tails are also evidence of previous welfare compromise, as lambs with short-docked tails experience poorer healing and more pain and discomfort at the time of docking. While infrequent, adequate tail lengths were present across 30 of the 32 farms assessed, indicating that this was variation in tail length on farm, rather than a difference in management between farms. As tail length is a common husbandry practice on all farms, other classes of stock may experience this and the associated welfare issues.

The number of injuries recorded was significantly higher following shearing. While only very large and open cuts were referred to the farmers, there were many instances where cuts were >5 cm in length, but healed. Shearing is a stressful procedure for sheep, and injuries sustained during wool removal contributes significantly to this. Hargreaves and Hutson (1990) demonstrated that the more frequent and severe injuries sustained during shearing were, the more significant the physiological stress response was. It also creates a risk of infection and other diseases. Nowhere in the literature could we find frequency and numbers of shearing injuries reported. This could be the first time it has been quantified. What is not known is the impact, if any, that shearing injuries have on the production and welfare of sheep beyond this shorter-term stress response.

The majority of welfare indicators used in this study assessed the biological functioning of ewes. The welfare of the ewes as assessed by their affective state, is still being analysed. The flight distance scores, how these differ across farms, and how their associated with farmer management practices and attitudes will give more information on the affective state of ewes. This is a core component to welfare assessment, especially around handling and could affect day to day management. Relationships between welfare indicators will also be analysed.

Perceived behavioural control and attitude were associated with management practices

Farmers clearly made associations between body condition, nutrition and mortality, however, this did not always translate to management practices. Comments made in the questionnaire that focused around some practices not being able to influence the outcome, or not having enough time to perform them, indicated attitude and perceived behavioural control are the major drivers behind why farmers don't perform practices, or why they believe other farmers do not. According to the questions around barriers to best practice, farmers did not see any of the management practices as being difficult to perform, supporting the questionnaire comments that indicated management practices either were not valuable to perform, or time was the major restriction.

While more comprehensive analyses of these results are required, this is consistent with the literature for livestock workers, with both of these factors, rather than subjective norms, being the key drivers behind intention and behaviour. These preliminary analyses suggest education is not the only key limitation to improving farm management practices. Strategies targeted at attitudinal change and increasing farmers awareness of how they could control their farm performance despite time and other limitations, may well be valuable ways to generate sustained practice change.

Breed and regional differences in management practices and attitudes

The breed of ewe and the location of the farm were influential in some instances. Scanning was less common in the wheat-sheep zone and in merino flocks compared to meat-breed, as was measuring body condition. Merinos are less likely to carry twins, so this has been given importance in the past. Merino flocks can also generate alternative income due to the greater economic value from wool than what meat breeds have, so there may be less incentive for farmers to monitor and manage them more closely. It was more common for meat-breed flocks to have veterinary records and health plans, which adds some weight to this point. Economically, there are clear benefits to effectively managing the carrying capacity and condition of mature ewes for reproductive gains. These benefits apply to both prime lamb and merino ewe enterprises, so justification on this from an economical perspective is inaccurate.

Attitudes to welfare were positive

Farmers consistently displayed positive attitudes to the welfare of their sheep and had a good understanding that their behaviour and management would directly affect the welfare of their animals. This is a critical component to guaranteeing good welfare, but it does not necessarily translate into practice. Farmers have a positive attitude to welfare, but do not check ewes frequently and they monitor them from a distance, which the welfare assessment demonstrate leads to some ewes with compromised go unnoticed. These results suggest a disassociation between these specific management practices and the impact they can have on animal welfare. Further analysis of the existing data set is required to give clarity on this. There also may be a perception that the welfare

of ewes is largely positive, and if they have key resources and behavioural freedom their welfare is fine. This sentiment is supported in the online survey and the broad perception of the welfare of sheep described in the literature review.

9 Feedback and interventions

Rationale

While the concept of welfare is not unfamiliar to farmers or the industry, welfare assessment is in its infancy in the sheep industry. Targeted intervention to deliver welfare change has not been tested before. This was the initial goal of Objective Three. After the literature review, survey and focus groups, it was apparent that there were no clear common welfare issues that could be targeted for intervention. As a result, a step-wise passive intervention was performed for each farm in the study instead. This came in the form of giving feedback immediately and by benchmarking.

There were a wide variety of attitudes and issues observed in our initial farm visits and surveys, but we did identify common issues that could be targeted in future intervention studies. This is a valuable first step to identifying common welfare and productivity issues that could be addressed in the future.

Aim

1. To understand how farmers respond to information about their mob and if it increased awareness and/or stimulated intention to improve welfare

9.1 Methods

9.1.1 Immediate feedback

Following assessment, any ewes that required further care were identified and reported to the farmer. Criteria for further care included: (1) major injury, (2) active mastitis, (3) a lameness score 2 or higher, and/or (4) another sign of significant and current disease/injury (e.g. pink eye, fly strike). The course of action, or intended course of action, taken by the farmer was recorded.

A body condition report was provided to each farmer within a week of each visit. This provided the farmer with immediate feedback on the condition of the flock, and how many were within the recommended range for that point of the reproductive cycle. This could provide the opportunity to manage their nutrition if needed.

9.1.2 Benchmarking report

After the completion of all of the on-farm assessments, a benchmarking report was developed for each farm. The farmer could identify their farm in the report, but all other farms were anonymous. The report contained details on record keeping and ewe mortality, body condition score, animals needing further care and lameness data. Quick facts, details on common practices from other

participants, and further recommendations were all presented in the document. These were chosen because record keeping is a critical first step if improvements are to be tracked; BCS is something that farmers are familiar with and place value on; and lameness and animals needing further care were common to all farms in one instance or another. Experts from the Mackinnon Project provided feedback before it was sent out. Reports were then express posted to farmers, so all received a hard copy of the report. Examples of the benchmarking report are provided as a part of the cost-benefit case studies in Section 10.

After the benchmarking report was sent out, farmers were called to hear their reflections on the report. Data on this is still being collected and will be a component of Carolina Munoz's thesis.

9.2 Results

9.2.1 Immediate feedback

Farmers took action in 37 of the 185 cases of ewes needing further care (20%). Action taken involved drafting the ewes to check later (n = 29), or immediately addressing the issue. Immediate actions taken were hoof trimming (n = 3), draining abscesses (n = 2), treating for flystrike (n = 2), removing horns (n = 1). Issues where no action was taken include low condition score ewes, injuries, pink eye and mastitis.

Farmer responses varied and on 21 farms, no immediate action was taken; all animals requiring further care were treated on two farms, and on nine farms there was mix of responses. The numbers of cases varied between farms, and in the case of four visits where no immediate action was taken, farmers were not on farm during the assessment.

There were no relationships between the provision of first BCS report and the number of animals in 'adequate' body condition on the second visit. The majority of visits occurred at weaning initially, and influence of reproductive stage on body condition was clear, so the impact that providing this feedback to farmers was not known. A controlled trial of intervention strategies would be one way to measure this, now that this study has established possible strategies and attitudes to target.

In these cases further action was not taken may be opportunistic, and we do not know if actions were taken after we reported them.

9.3 Discussion

While the number of ewes requiring further care were low, actions taken to care for ewes in immediate need was infrequent. Qualitative review of the actions suggest that farmers took

immediate action if the method of treatment was simple to apply. The response of farmers is likely multifactorial however. Possible reasons for not providing immediate treatment could include: that the course of action was not immediately clear to the farmer; that the treatment required was difficult to implement; farmers were not present at the time of the visit, and so limiting their course of action; and/or the issue was not deemed to be significant to the farmer. Value of the individual animal and disconnect between practices, ewe welfare, and the survival and production outcomes may also be contributing factors as to why farmers did not intervene. Investigating the attitude and perceived behavioural control profiles of the farmers will give us more insight into this.

For farms that did not want those ewes drafted from the mob, we cannot assume the outcome of these ewes, as farmers may have managed them at a later date. Similarly, we classified action being taken as drafting the ewes to inspect later, which does not guarantee that corrective action was taken. We do not know if ewes recovered quickly, experienced protracted welfare compromise, compromised reproductive performance, or mortality as a result of these issues. The longitudinal study in Section 7 tracked the same 100 ewes across their reproductive cycle. This research indicates that some ewes that were identified as having compromised welfare, or precursors to compromised welfare, deteriorated over the course of the study and in some cases died as a result of these issues.

There were a variety of issues identified within the mobs we studied. The extensive nature of these farming systems makes management options for these ewes complicated. The methods of identification are difficult in the first place. Treatment options are available but often require animal-specific and repeated interactions, with opportunities to follow up limited by the extensive system. Farmers perceived low levels of behavioural control when it comes to implementing management practices, in these instances, these perceptions are closely tied to reality. Identification and management of issues while they are sub-clinical, or even better preventative, is the key way to assuring welfare of the mob. Importantly, making farmers aware of the issues that were immediately treatable often led to interventions to improve welfare.

10 Cost-benefit analyses

10.1 Farm case studies

Case studies of three farms were used to contextualise the details collected on farm and how they related to individual farm management. These case studies were sent to farmers and are part of the feedback and intervention strategies being analysed (Section 9). The first case study presents the complete benchmarking report. The remaining two present the differential components for that farm.

10.1.1 Case study 1

The farmer in case study 1 had 19 years of experience working with sheep and managed a meat-breed flock in the wheat-sheep zone. Based on his answers to the questionnaire, he was classified as being a slower adopter and was ascribed a management score of 5/9 (0 = no management activities, 9 = performs all management activities regularly; see section 8 for more details).

With an approximate flock size of 1,000 ewes (specific details removed for anonymity), he checked the flock weekly to twice weekly in non-lambing periods when he was feeding ewes. Monitoring increased during lambing time to every second day, which was done by distance using binoculars. Similarly, he rated daily checking of dry ewes as being not important at all, and monthly condition scoring as being slightly important. He body condition-scored his ewes by sampling ~80 ewes when they were in the race around pre-joining and mid-pregnancy. At mid-pregnancy, 40% of his ewes were in recommended body condition, and this increased to 47% at weaning. When looking at the spread of his ewes in mid-pregnancy, most of them were slightly below condition.

Lamb mortality rates were not known because the farmer didn't scan for pregnancy, but commented that dystocia was not a major issue for the flock. Despite this, he rated annual pregnancy scanning and meeting the nutritional needs of different ewes as being important. He classed nutritional management of ewes as being slightly difficult, but classed annual pregnancy scanning as being difficult (the second highest score). When asked about why farmers may not scan for pregnancy, the farmer replied that it wasn't important to farmers in the area and that they were changing their focus away from sheep farming.

He estimated the rate of mortality to be ~2%, but according to the stock tally numbers it could be 3.3%. His estimated culling rate was 5% and this was mainly due to lambing related issues, but further details on this were not clear. He had participated in lifetime ewe management and was a member of a prime lamb group. Pasture availability was assessed visually, despite the farmer having attended courses on quantification methods.

The farmer viewed animal welfare positively. He strongly agreed that he was responsible for the welfare of his animals and that how people handled ewes impacted their fearfulness, and agreed that they had the capacity to experience feelings. Job satisfaction scores were also high. He greatly enjoys being a sheep farmer, and agreed that trying hard at work and doing a good job was important. He felt rewarded in his job and believed he had a good amount of control of the welfare outcomes of the flock.

Assessing extensively managed ewes

Benchmarking Report

Dear ,

Thank you very much for your participation with us. We really appreciated your time and involvement in this research.

Over 12 months, 32 commercial sheep farms were involved in this project. Two visits were conducted to the majority of the properties (one visit at weaning and one at mid-pregnancy). At each study visit, 100 breeding ewes were examined.

In this confidential report, we provide you with further information about the body condition of your flock, the percentage of ewes that needed further care at each visit, how you compare to other participants in the study and ewe mortality.

The outcomes of this project will be used to identify common strengths and weaknesses around ewe management, and improve the approach of future extension programs targeting health and productivity.

If you have further questions, please give me a call [0424634321]

Report developed by:
Carolina Munoz MV MSc | PhD student. Faculty of Veterinary and Agricultural Sciences. The University of Melbourne.
Dr. Rebecca Doyle. Senior lecturer. Faculty of Veterinary and agricultural science. The University of Melbourne.
Dr. Angus Campbell. Senior Veterinary Consultant and Lecturer in Ruminant Medicine & Production with the Mackinnon Project, Faculty of Veterinary Science. The University of Melbourne

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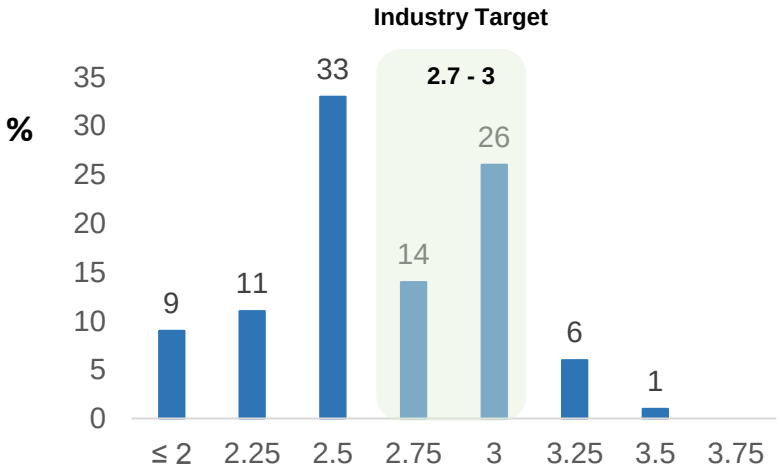
X Farm

Owner/Manager:
Main farming enterprise: Prime lamb
Location:

Mid-pregnancy BCS

Day of the visit: xx/xx/xx
Mob assessed: Mixed age, not scanned

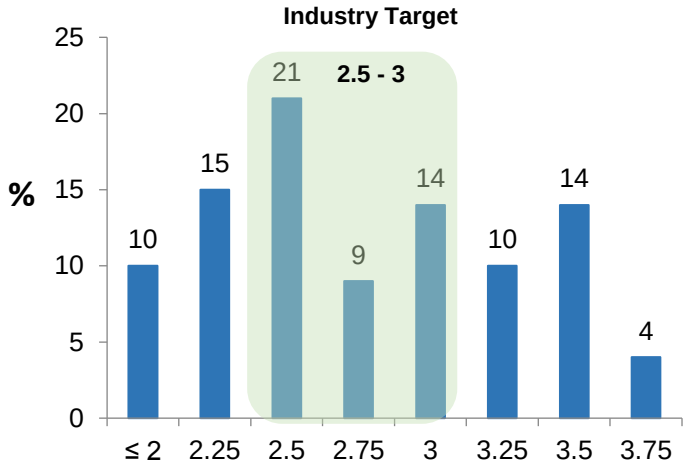


Your BCS average: 2.6

Fig 1. Percentage of ewes allocated in each BCS category.

Weaning BCS

Day of the visit: xx/xx/xx
Mob assessed: Mixed aged (2-4), weaned 7 days before.



Your BCS average: 2.74

Fig 2. Percentage of ewes allocated in each BCS category.

Body condition score

X Farm versus other participants

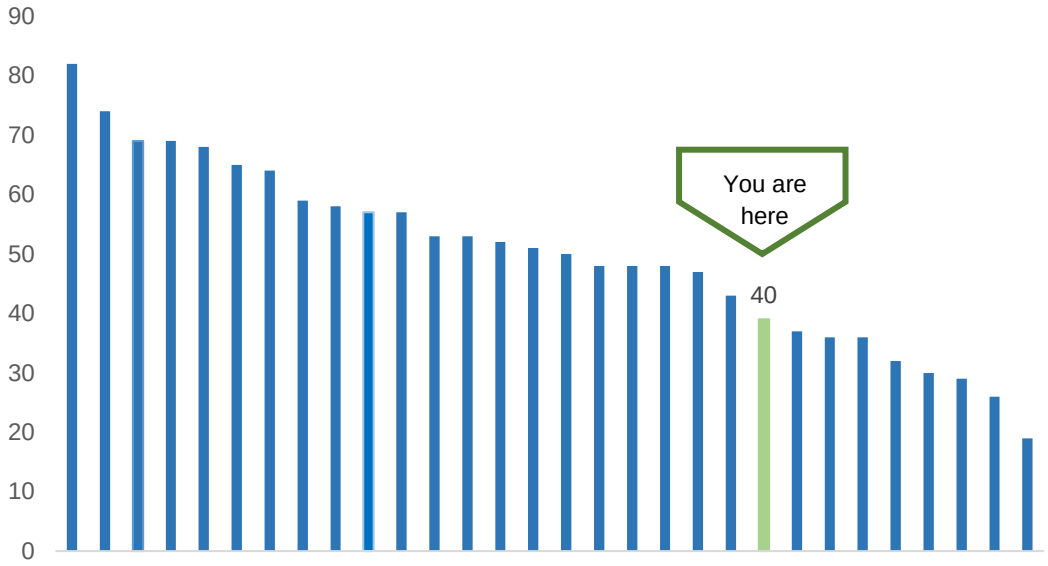


Fig 3. Percentage of ewes within recommended body condition at mid-pregnancy

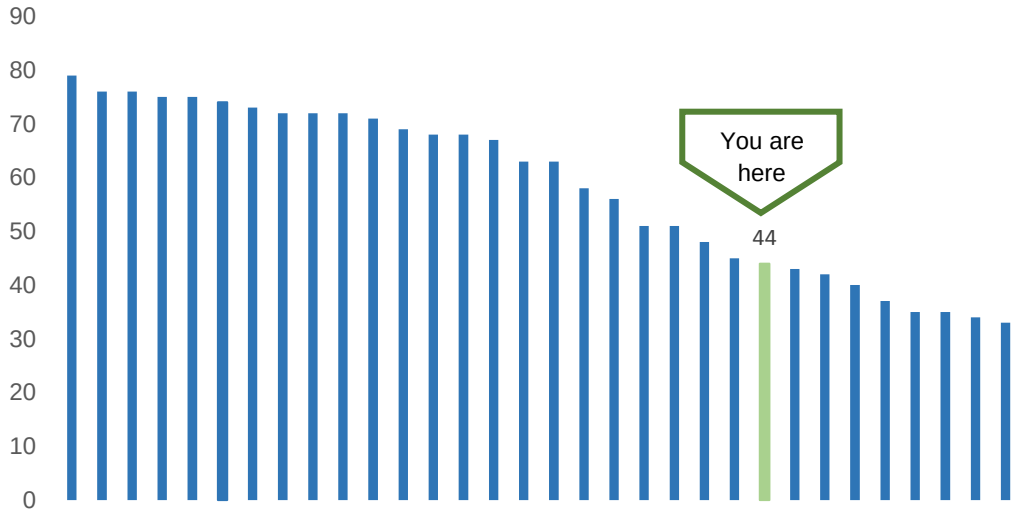


Fig 4. Percentage of ewes within recommended body condition at weaning.

Quick facts from the study:

- 34% of the farmers regularly body condition score or weigh their ewe flock at key points.
- 56% of the farmers pregnancy scan annually, while 31% scan only in particular years, and 13% have not scanned yet.
- 81% of the farmers that pregnancy scan, maintain single and multiple bearing ewes in different mobs.

What producers with most ewes in recommended BCS are doing?

Common traits among these farmers were that they:

- Regularly body condition score or weigh the ewes at key points.
- Pregnancy scan annually.
- Allocate dry, single and multiple bearing ewes in different mobs.

Some quotes from participants…

'Checking body condition is not something that you can do in the paddock, the eye is inaccurate and you may only pick up extremes, you need to put a hand on ewes and BCS them'

'You have to scan your ewe flock. You can't afford to run a non-productive ewe in this environment. Having dry ewes is like having a wether, you can't have non-productive animals'

'You are wasting resources by running ewes as one mob. You are overfeeding ewes that already reach optimum, and underfeeding your end tail ewes'.

'Scanning for twins and singles, and making sure that your singles are not having big lambs is essential. I notice that knowing that, is one of my best management tools'

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Ewes needing further care

X Farm versus other participants

The ewes were classified as 'Needing further care' if they presented at least one of the followings:
- Evident lameness (not weight bearing the affected limb)
- Injuries/diseases
- Very low body condition (score 1.5).

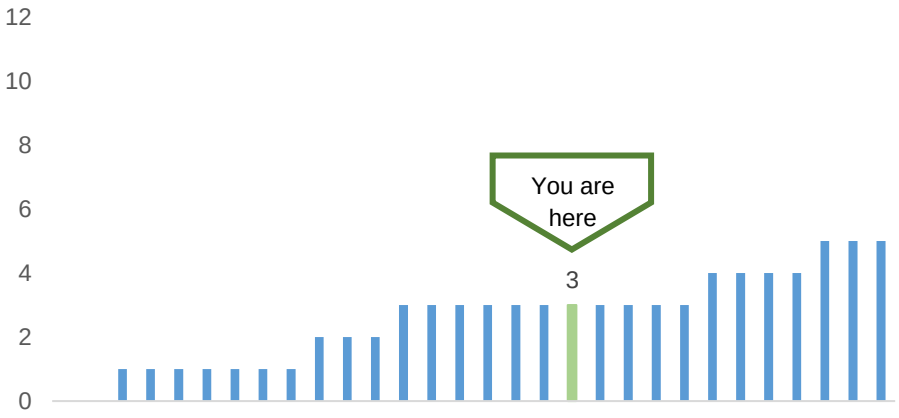


Fig 7. Percentage of ewes needing further care at pregnancy

Further details: Two ewes had low BCS (1.5), one also with a lameness score of 2, and one had pink eye.

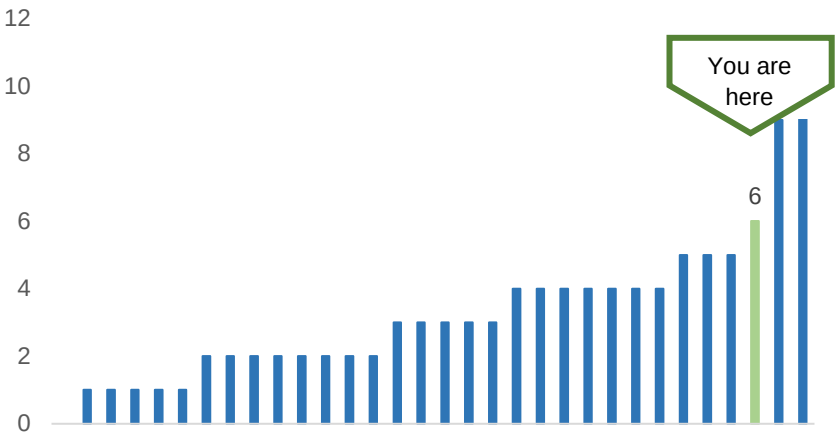


Fig 8. Percentage of ewes needing further care at weaning.

Further details: Six ewes needed further care after the assessment at weaning. 3 ewes were lame (score 2), two had lumpy wool, one had lumpy wool and low condition (1.5).

Quick facts from the study:

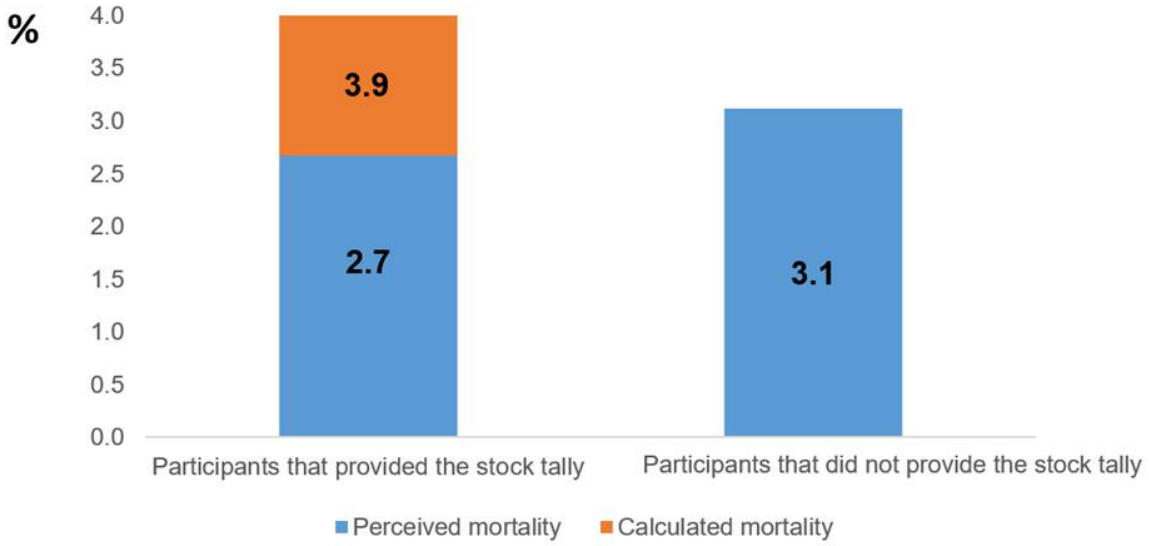
- 16% of the farmers monitor their ewe flock every second day during the non-lambing period, and 63% monitor the flock daily during lambing time.
- 34% of the farmers continuously maintain productivity records of the farm.
- The most common cause of ewes needing further care was evident lameness, accounting for 55% of the cases at weaning.

What farmers with less animals needing further care are doing?

- Top performers monitor their ewe flock regularly throughout the year.
- Keep long-term productivity records of the farm.

Ewe Mortality

The average 'perceived mortality' was obtained based on participants' responses to the on-farm questionnaire and the average 'calculated mortality' was obtained from the stock tallies**.**



Quick facts from the study:

- 81% of the participants completed the stock tally form.
- Only 23% of the participants kept detailed records of mortality.
- The average ewe mortality calculated from the stock tallies was 3.9%.
- Our results suggest that ewe mortality is higher than what is currently perceived by farmers.

Why Body Condition Score ewes?

Condition scoring sheep is a practical and accurate method of estimating the 'nutritional well-being' of your sheep flock. Condition scoring a mob at key times throughout the year gives producers key information to make management decisions to reach condition score targets for joining and lambing.

How we measure Body Condition?

Body condition is assessed by placing the hand between the sheep's backbone and short ribs (see photo for reference). The cover of fat and tissue is examined by assessing the fullness of the muscle in between the backbone and ends of the short ribs.

Source: https://www.agric.wa.gov.au

Score 1

No fat very little muscle

Score 2

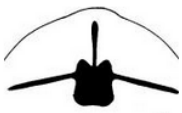
Small amount of muscle along the backbone but no fat

Score 3

Good level of fat and muscle with rounded ends of ribs and top of

Score 4

Over-round across backbone-lots of muscle and fat



Score 5

Can't feel the backbone or ribs. Over-fat

Useful resources:

http://www.lifetimewool.com.au/conditionscore.aspx
https://www.agric.wa.gov.au/management-reproduction/condition-scoring-sheep
http://www.makingmorefromsheep.com.au/wean-more-lambs/tool_10.1.htm

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The importance of monitoring your ewe flock

Ewes are the most productive unit in the farm, and therefore maintaining ewes in good health has the largest effect on farm welfare and productivity. Ewes' health relates closely to both lamb and weaner survival, with healthy ewes producing strong offspring, and these offspring being at a lower health risk throughout their lives.

- Sick/injured ewes are suffering pain, discomfort and distress.
- This not only compromises their welfare but also reduces their likelihood/speed of recovery, increases the risk of disease spreading and reduces productivity.
- Frequent monitoring is especially important at times of drought, or at the change of season when paddock condition can change rapidly.

Useful resources:

https://www.agric.wa.gov.au/management-reproduction/key-monitoring-times-ewe-flock
http://www.assurewel.org/sheep/sheepneedingfurthercare

The importance of keeping mortality records

Record keeping is an important tool in sheep management. Records help producers to follow up the performance of the farm and assists in making decisions based on concrete facts.

Tips from Mackinnon experts:

- Try to record your sheep numbers when possible, keep records at key times, for example at shearing, marking, weaning and selling.

- Balance your stock tally against class: e.g. hoggets in July 1st 2015 become ewes in June 30th 2016.

- Be consistent, try to keep records and calculate your farm mortality each year.

10.2 Case study 2

The property manager in case study 2 had 9 years of experience working with sheep and managed a meat-breed flock in the high rainfall zone. Based on his answers to the questionnaire, he was classified as being a faster adopter and was ascribed a management score of 0/9 (indicating he performs all management activities regularly).

With an approximate flock size of 3,900 ewes, he checked the flock approximately every second day in non-lambing periods, and did so visually and when moving them from one paddock to another. He used the same approach during lambing time, trying not to check very often, but checking twins more frequently than singles. He rated daily checking of dry ewes as being not important at all, but rated monthly condition scoring as being important. He attributed frequent checking at lambing to mis-mothering at lambing, and believed it not to be necessary at other times.

Body condition-scoring was done in the yards on ~10% of the flock. His management approach was one of the most effective with 70% of ewes being in the target condition score mid-pregnancy and 77% in recommended condition at weaning.

He estimated lamb mortality rates to be very low and didn't have any issues with dystocia. Attitudes to pregnancy scanning and meeting the nutritional needs of different ewes corresponded with management practices and were rated as very important and not at all difficult to do. When asked about why farmers may not scan for pregnancy, the farmer replied that these types of farmers were old fashioned, not educated about the benefits of the practices, or had fear to change.

He estimated the rate of mortality to be 1.2%, but according to the stock tally numbers it could be 2.4%. He didn't report his culling rate, but reported that they culled on age, indicating that this would be a relatively consistent number every year. He had participated in lifetime ewe management and more lambs for less, but was not a member of an industry group. Pasture availability was assessed in a variety of different ways, including visually, using feed tests and a pasture cage.

The farmer viewed animal welfare positively. He strongly agreed that he was responsible for the welfare of his animals and that how people handled ewes impacted their fearfulness, but strongly that they had the capacity to experience feelings in the same way we do. Job satisfaction scores were also very high. He strongly agreed that he enjoys being a sheep farmer, and that he was highly motivated at work. He felt rewarded in his job and believed he had a good amount of control of the welfare outcomes of the flock.

X Farm

Owner/Manager:
Main farming enterprise: Prime lamb.
Location:

Mid-pregnancy BCS

Day of the visit: xx/xx/xx
Mob assessed: Single- bearing ewes, mixed age, scanned

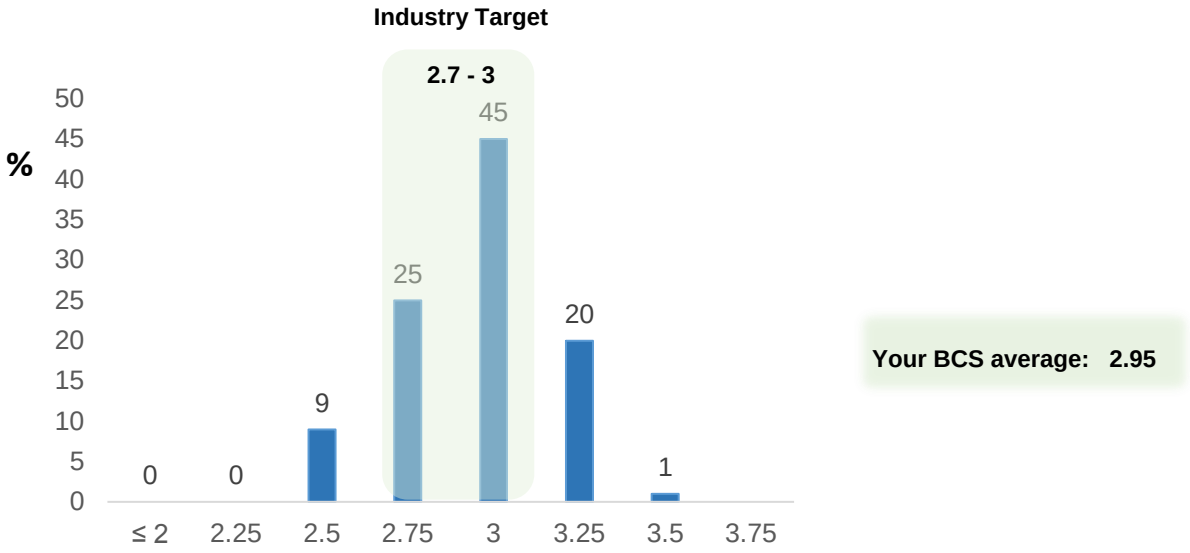


Fig 1. Percentage of ewes allocated in each BCS category.

Weaning BCS

Day of the visit: xx/xx/xx
Mob assessed: Twin and single- bearing ewes, mixed aged (2-4), weaned one week before.

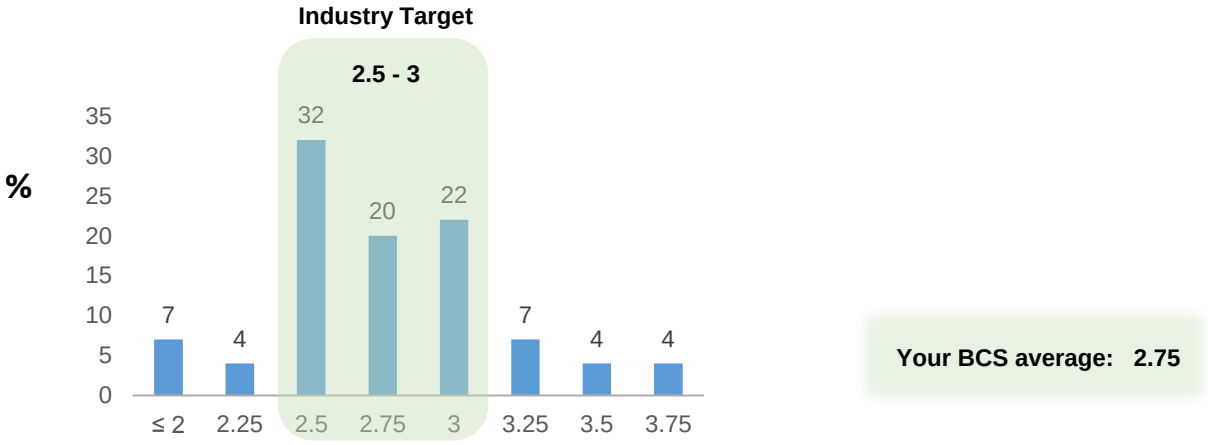


Fig 2. Percentage of ewes allocated in each BCS category.

Body condition score

X Farm versus other participants

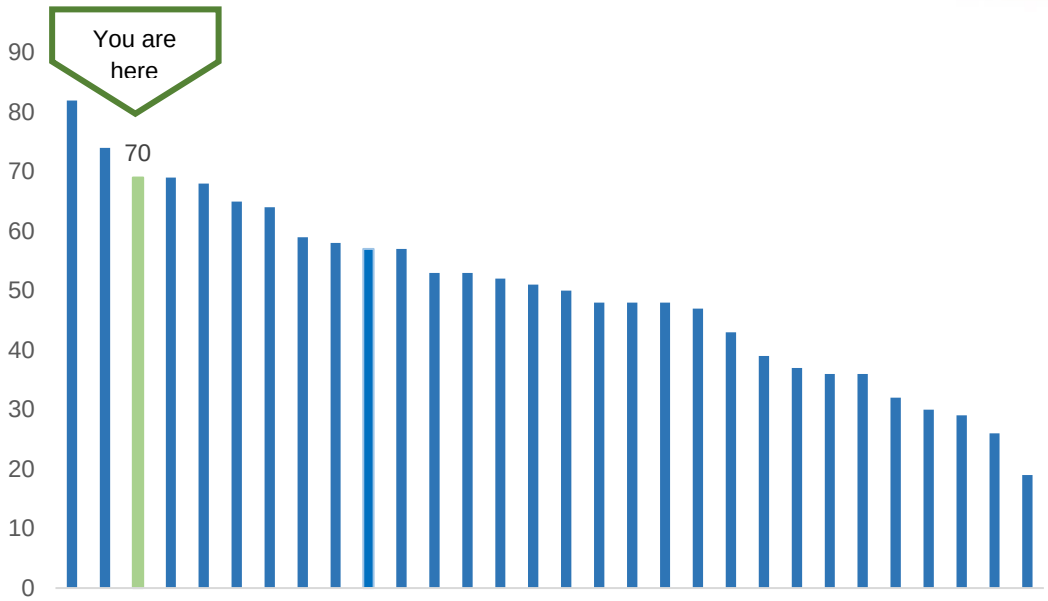


Fig 3. Percentage of ewes within recommended body condition at mid-pregnancy

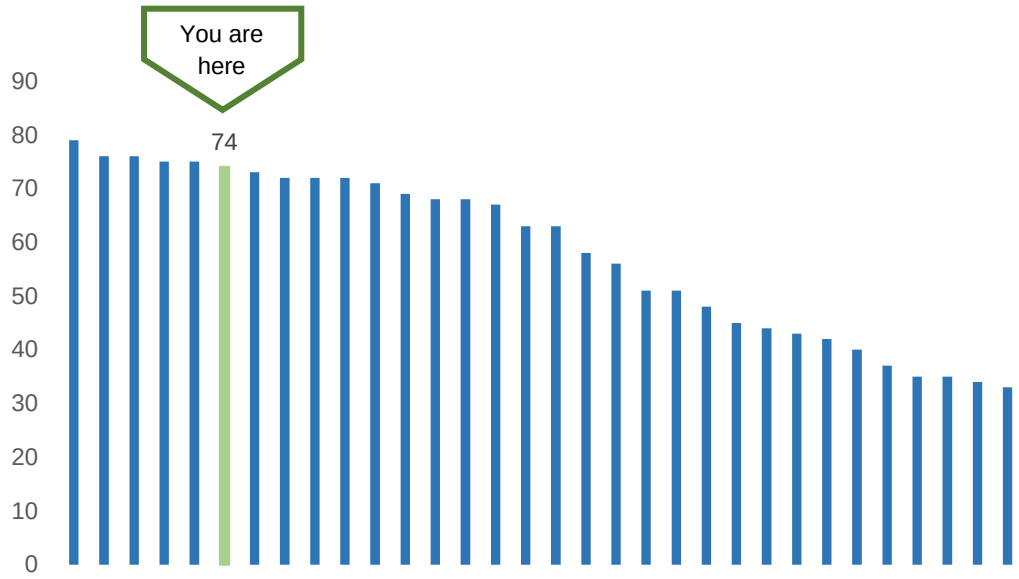


Fig 4. Percentage of ewes within recommended body condition at weaning.

Ewes needing further care

X Farm versus other participants

The ewes were classified as 'Needing further care' if they presented at least one of the followings:
- Evident lameness (not weight bearing the affected limb)
- Injuries/diseases
- Very low body condition (score 1.5).

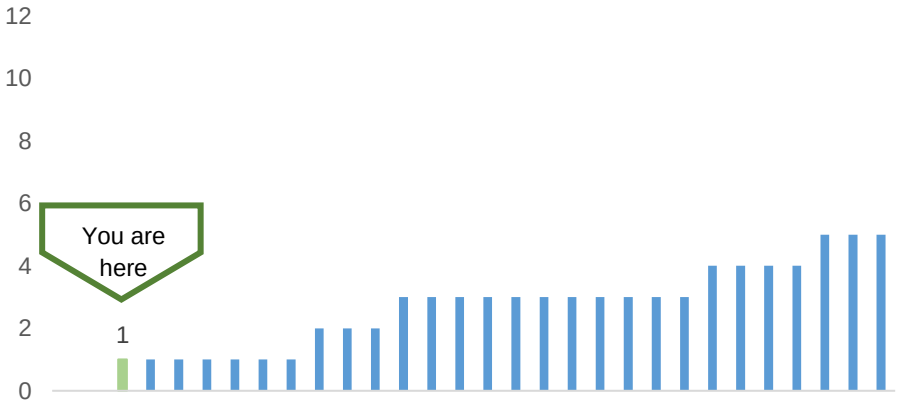


Fig 7. Percentage of ewes needing further care at pregnancy

Further details: One ewe with a lameness score of 2.

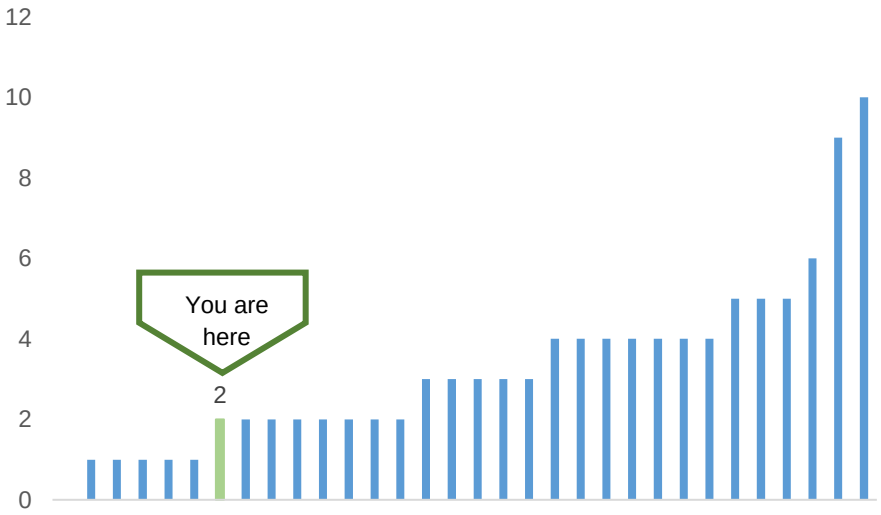


Fig 8. Percentage of ewes needing further care at weaning.

Further details: Two ewes with a lameness score of 2, due to foot abscess

10.3 Case study 3

The property manager in case study 3 had 20 years of experience working with sheep and managed a meat-breed flock in the high rainfall zone. Based on his answers to the questionnaire, he was classified as being a slower adopter and was ascribed a management score of 2.5/9 (indicating he does not perform many management activities and is not consistent in what he does perform).

With an approximate flock size of 2,500 ewes, he checked the flock weekly in non-lambing periods, and did visually, from the distance, when driving around the paddock. He checked lambing ewes every second day on motorbike. Checking dry ewes daily was considered by the farmer to be slightly important, and monthly condition scoring was of moderate importance. Body condition scoring was done visually at shearing, and explained that 'farmers know the BCS of their ewes, it is their second nature'. At mid-pregnancy, 47% of ewes were in the target condition score, and 69% in recommended condition at weaning.

He estimated lamb marking to be 110%, but did not scan annually and only kept records sometimes. The farmer deemed pregnancy scanning and meeting the nutritional needs of different ewes to be important and slightly difficult to do. He estimated the rate of mortality to be 3%, but could not provide stock tally numbers. The farmer considered that he only needed to assess pasture availability visually because 'we know which are our best paddocks'.

The farmer viewed animal welfare positively, strongly agreeing that he was responsible for the welfare of his animals, and agreeing that they could experience pain and that how people handled ewes impacted their fearfulness. Job satisfaction scores were also high, but he believed that he had only some control over the welfare outcomes of the flock.

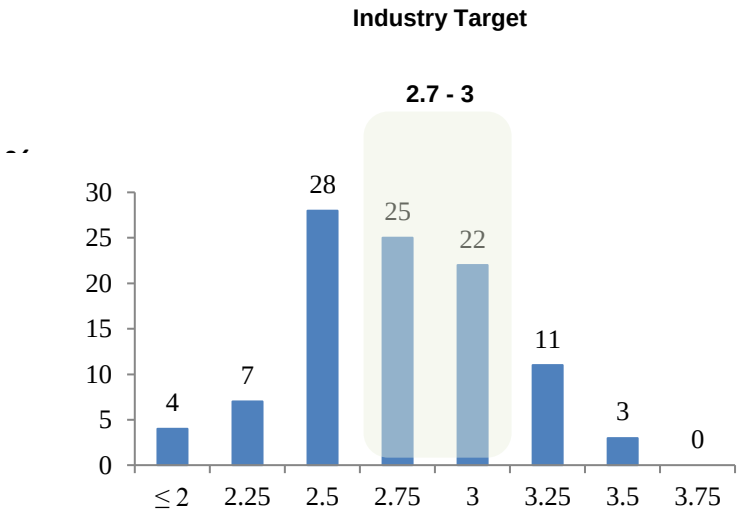
X Farm

Manager:
Main farming enterprise: Mixed farming, Sheep and Cattle.
Location:

Mid-pregnancy BCS

Day of the visit: xx/xx/xx

Mob assessed: Single- bearing ewes, mixed age, scanned on



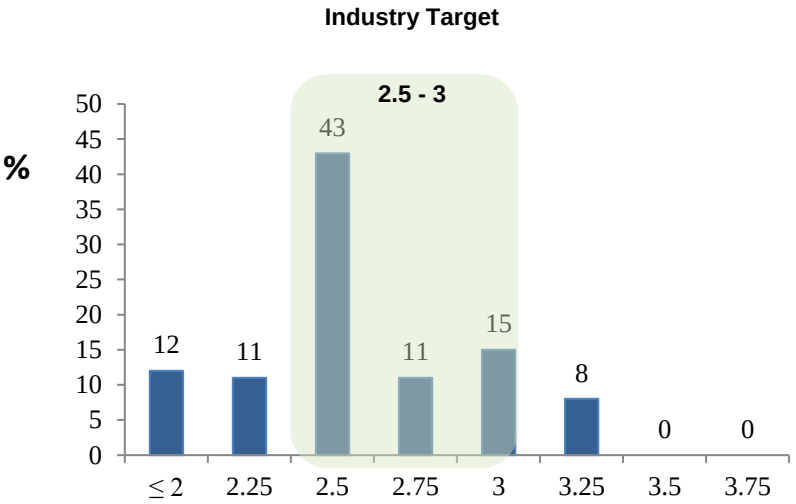
Your BCS average: 2.74

Fig 1. Percentage of ewes allocated in each BCS category.

Weaning BCS

Day of the visit: xx/xx/xx

Mob assessed: Single and twin-bearing ewes, mixed age, weaned 9 days earlier



Your BCS average: 2.55

Fig 2. Percentage of ewes allocated in each BCS category.

Body condition score

X Farm versus other participants

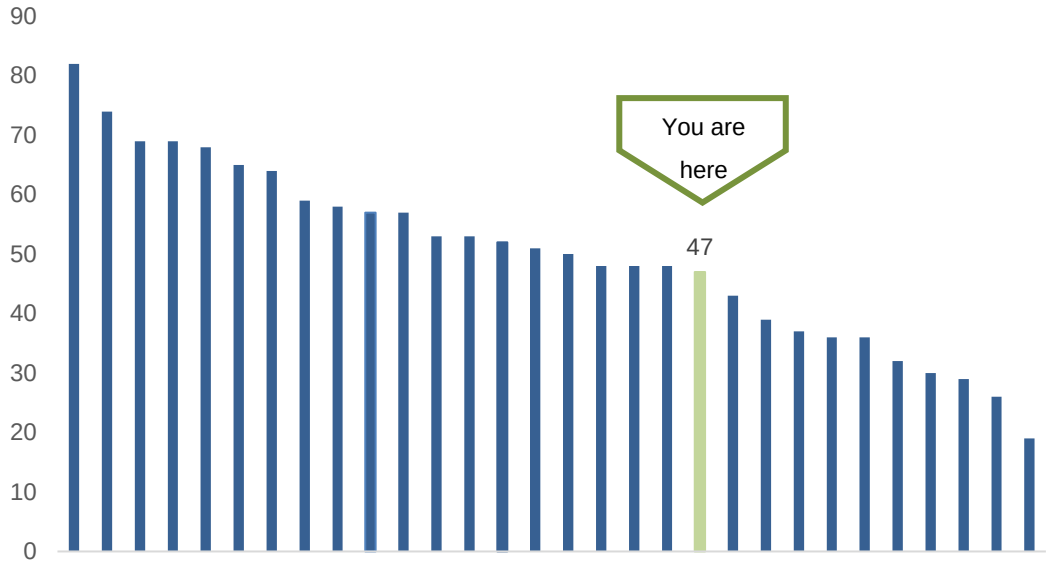


Fig 3. Percentage of ewes within recommended body condition at mid-pregnancy

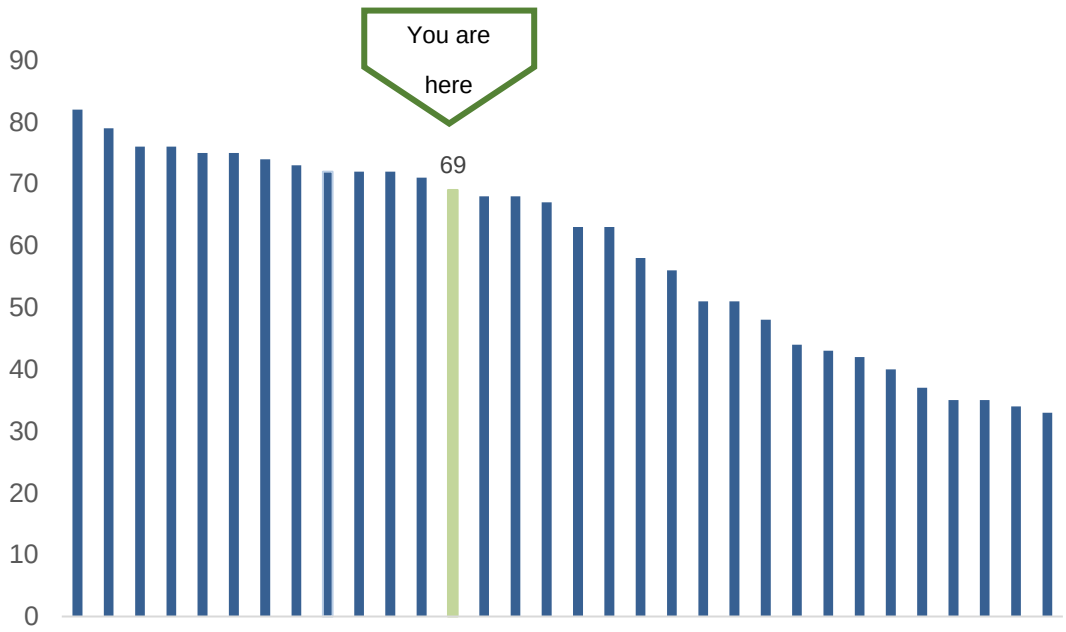


Fig 4. Percentage of ewes within recommended body condition at weaning.

Ewes needing further care

X Farm versus other participants

The ewes were classified as ‘Needing further care’ if they presented at least one of the followings:

- Evident lameness (not weight bearing the affected limb)
- Injuries/diseases
- Very low body condition (score 1.5).

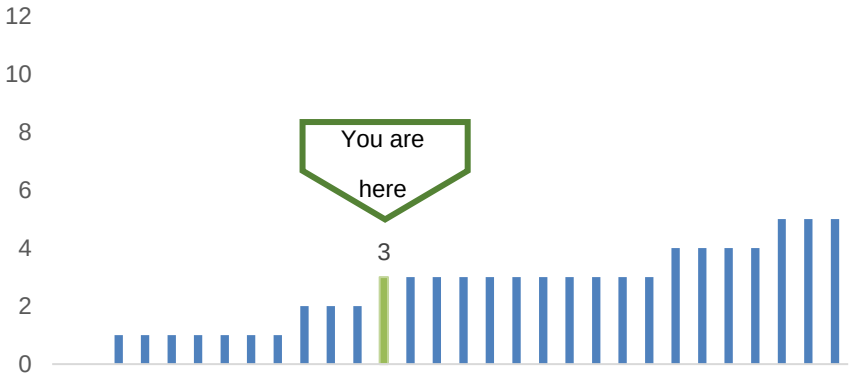


Fig 7. Percentage of ewes needing further care at pregnancy

Further details: Three ewes had a lameness score of 2.

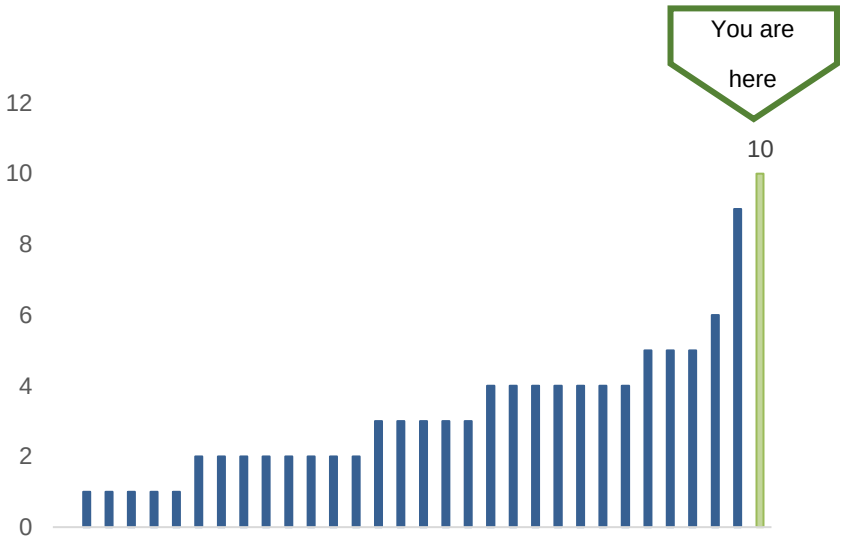


Fig 8. Percentage of ewes needing further care at weaning.

Further details: Ten ewes needed further care after the assessment at weaning. Two had broken wool and injuries (flystrike), two had open wounds (with flies), one has a lameness score of 2, two had pink eye and three had low condition (1.5).

10.4 Cost benefit analyses

10.4.1 The benefit of docking tails at the correct tail length

There are a number of important benefits of docking lambs at the correct tail length. Lambs should be docked at the 3rd palpable joint leaving 3 coccygeal vertebrae, approximately at the tip of vulva or equivalent in wethers.

There are several important reasons that lambs should be docks at the correct tail length.

1. Evidence indicates that docking at the correct tail length reduces the risk of breech strike in both mulesed and unmulesed sheep.
2. The risk of arthritis in lambs is 1.5 time higher in lambs docked with a short tail length
3. There is a higher risk of rectal prolapse in lambs docked with a short tail length
4. There is a higher likelihood of vulval cancer in older ewes that where docked with a short tail as a lamb

1. Risk of breech strike with docking short tails:

Incorrect tail length is major risk factors for breech strike, even in mulesed sheep. This is shown by the summary of a 1978 study in Table 1 where there is a huge benefit of medium tail length over short tail length in mulesed ewes.

Table 1. Effect of tail length and mulesing on breech strike in ewes (Watts & Luff, AVJ 1978 54: 356-357).

Tail length	Mulesed
Butted	15.8%
Medium	2.2%

It is apparent that some producers that are not mulesing merino lambs are docking them with very short tails in the belief that they will be easier to crutch. Table 2 shows the benefit of tail length to reduce the risk of breech strike in unmulesed ewe and wether weaners.

The benefit of tail length in unmulesed ewe was not as clear (Table 2) but tail length is likely to be still important but clearly unmulesed wether weaners which were docked with short tails (butted) had double the rate of breed strike compared with unmulesed wether weaners that had a medium tail length. The reason for the small difference in ewes is uncertain but could be due to the small number of ewes in the medium tail length group or that more prolonged wetting of ewes occurred due not only to scouring but urine staining.

Table 2 Incidence of breech strike in unmulesed merino weaners with short and medium length tails with scouring

Tail length	Butted	Medium
Ewe weaners	85%	82%
Wether weaners	62%	33%

In another trial conducted in the 1940's more compelling results were reported (table 3)

Table 3 incidence of breech strike in unmulesed merino lambs

Tail length	Short (Above vulva)	Medium (Vulval orifice)	Long (just below tip of vulva)	Very long (1 ¼ cm below bare area margin)
Weaners 5 month after marking	42%	31%	17%	11%

2. Risk of Arthritis with docking short tails

A recent abattoir study found a correlation between short-docked tails (fewer than three coccygeal vertebrae remaining) and bacterial arthritis in lambs. (Lloyd et al Small Ruminant research 2016 144:17-22). Tail length had a significant effect on the prevalence of arthritis in the lambs as determined by government-accredited meat inspectors ($P < 0.001$), with shorter tails (one or two coccygeal vertebrae) (2.2% of carcases with arthritis) having a higher risk than longer tails (1.5 % of carcases with arthritis). Presumably the higher risk of arthritis in lambs docked with one or two coccygeal vertebrae was due to haematogenous spread of bacteria with wounds that take longer to heal or tracking up the spinal cord.

3. Risk of Rectal Prolapse with docking short tails

For the prime lamb producers, tail butted lambs are at much greater risk of developing rectal prolapse. This syndrome commonly occurs in prime lambs in feedlots and is an important cause of death and wastage in lamb feedlots. Thomas DL et al J. Anim. Sci. 2003. 81:2725–2732, in a study over six sites found that the incidence of rectal prolapse was greater ($P < 0.05$) for Short-docked lambs (7.81%) than for either Medium (3.97%) or Long-docked (1.85%) lambs (Table 2), but the difference between the Medium and Long-docked groups was not statistically significant. Using a Medium dock length instead of a Short dock length decreased the incidence of rectal prolapse by 49.2%, and using a Long dock length instead of a Short dock length decreased the incidence of rectal prolapse by 76.3%. In this study short and medium docked lambs were docked with less than three coccygeal vertebrae. Docking lambs at the site where the caudal folds on the underside of the tail attach to the tail significantly decreases the incidence of rectal prolapse to negligible levels.

4. There is a higher likelihood of vulval cancer in older ewes that where docked with a short tail as a lamb

Swan et al AVJ 1984 61:146-151 reported a study examining the epidemiology of squamous cell carcinoma in the perineal region of sheep and found that the prevalence of squamous cell carcinoma was significantly higher ($p<0.001$) in sheep with tails docked shorter than the anus compared with longer tailed sheep. In this study, all cases of squamous cell carcinoma occurred in sheep docked at one cm below the anus or shorter. The incidence of squamous cell carcinoma increased from 0.43% in 5 year old ewes to 5.14% and 41.19% in six and seven year old merino ewes respectively.

The financial benefit of docking to the correct tail length

The benefit of docking at the correct length will depend on a number of factors including flystrike risk and management, relative risk of arthritis, management of lambs where feedlotting increases the risk of rectal prolapse and the age that ewes are retained to as older ewes are at higher risk of squamous cell carcinoma of the vulva. For example, whilst the risk if flystrike will be greatest in unmulesed ewes that have tails docked very short, if they are jetted over the breech for the entire fly season, losses due to flystrike will only be associated with chemical and labour costs rather than wool and body weight losses and potential deaths. Likewise, the financial impact of rectal prolapse in tail butted sheep is much more likely to occur in weaner sheep in a feedlot rather than in an extensive paddock situation. Squamous cell carcinoma of the vulva is more likely to be a serious issue in flocks where ewes are retained for more than five years of age.

Table 3 below summarises the possible financial penalty ($/dse) of ewes from mulesed and unmulesed flocks with tails docked shorter than the third coccygeal vertebrae.

	Mulesed		Unmulesed	
	Merino	Crossbred	Merino	Crossbred
Flystrike	$0.34	$0.18	$0.05	$0.03
Arthritis	$0.44	$0.62	$0.44	$0.62
Rectal Prolapse	$0.00	$0.00	$0.00	$0.00
Vulval cancer	$0.06	$0.08	$0.06	$0.08
Total	$0.84	$0.88	$0.55	$0.73

Assumptions:

Commodity price used: wool and meat 10 year median real prices

Flystrike: base assumptions taken from Lane et al 2015 MLA report B.AHE.0010 Priority list of endemic diseases for the red meat industries.

In mulesed sheep 0.5% ewes with breech strike with correct tail length and 1.8% breech strike with short tail length. Sheep with breech strike have 8% reduced fleece weight, 9% discount on wool value due to reduced staple strength, cost of treatment of affected sheep $5.05/head,10% mortality rate of affected sheep. In unmulesed sheep only 0.2% difference in strike rate due to additional application of chemical prevention required due to higher risk of flystrike.

Arthritis: cost of short tail length due to higher mortality rate of lambs due to arthritis hence higher depreciation of ewes. Now production losses associated with chronic arthritis of adult ewes as they are assumed to be culled

Rectal Prolapse: No cost attributed as ewes assumed not to run or grow up in feedlot

Vulval cancer: 0.43% mortality/cull rate of 5 year old ewes due to vulval cancer with ewes with short tail length.

Potential cost of vulval cancer on case study farms

Case study 1
Merino ewes
Unmulesed
5% ewes correct tail length, 95% ewes short tail length
Annual cost per 100 ewes:

- $0.55/dse cost of short tail length
- $0.52/dse per DSE in flock with 95% short tail length @1.5 DSE/ewe = $0.78/ewe
- $78/100 ewes per annum or $1,950/2,500 ewes on farm

Case study 2
Composite ewes
Unmulesed
67% ewes correct tail length, 33% ewes short tail length
Annual cost per 100 ewes:

- $0.73/dse cost of short tail length
- $0.24/dse per DSE in flock with 33% short tail length @2.2 DSE/ewe = $0.53/ewe
- $53/100 ewes per annum or $2,067/3,900 ewes on farm

Case study 3
Merino X Border Leicester ewes
Unmulesed
51% ewes correct tail length, 49% ewes short tail length
Annual cost per 100 ewes:

- $0.73/dse cost of short tail length
- $0.36/dse per DSE in flock with 49% short tail length @2.2 DSE/ewe = $0.79/ewe
- $79/100 ewes per annum or $849/1,075 ewes on farm

Conclusions

The various risks associated with short-docked tails on the three case study farms did not lead to significant losses on each farm. However, there is no additional cost from docking tails at the appropriate length. We hypothesise that the consistency of short-docked tails across all ewes and all farms in this study could be generalised to lambs, so the 7.81% risk of rectal prolapse in any feedlotted lambs is legitimate.

10.4.2 The financial impact of ewe mortalities in sheep flocks

The main factors determining the cost of ewe mortality is the time of year when deaths occur, ewe replacement cost or in the case where ewes are not replaced, the impact of lower stocking rates. The timing of deaths has a strong effect on the overall cost of ewe mortality. Non-pregnant ewes that have weaned their lambs and are recently off-shears are the least costly deaths, although they must still be replaced in the mob. By contrast, the death of a ewe with a mid-length or long fleece and pregnant with, or suckling, twin lambs costs far more. The potential value of her two lambs and fleece are lost, along with the cost of replacement and any genetic loss. The price of replacement is the obvious cost associated with ewe mortality. In self-replacing enterprises, additional ewes retained to replace losses cannot be sold as breeders or for slaughter. For enterprises that buy replacement ewes in, more ewes must be bought and managed. Current high ewe prices make this cost even greater.

GrassGro was used to calculate the financial impact of mortalities using current commodity prices (2017) and long-term commodity prices adjusted for inflation (10 year median prices) for wool, mutton and lamb. The financial impact was calculated in both a self replacing merino flock and a prime lamb flock (First cross ewes). Costs were based on the average of the south west Victorian farm monitor project.

Figure 1 below summarised the impact of ewe mortality on the gross margin $/dse of a self replacing merino flock and a prime lamb flock (First cross ewes).

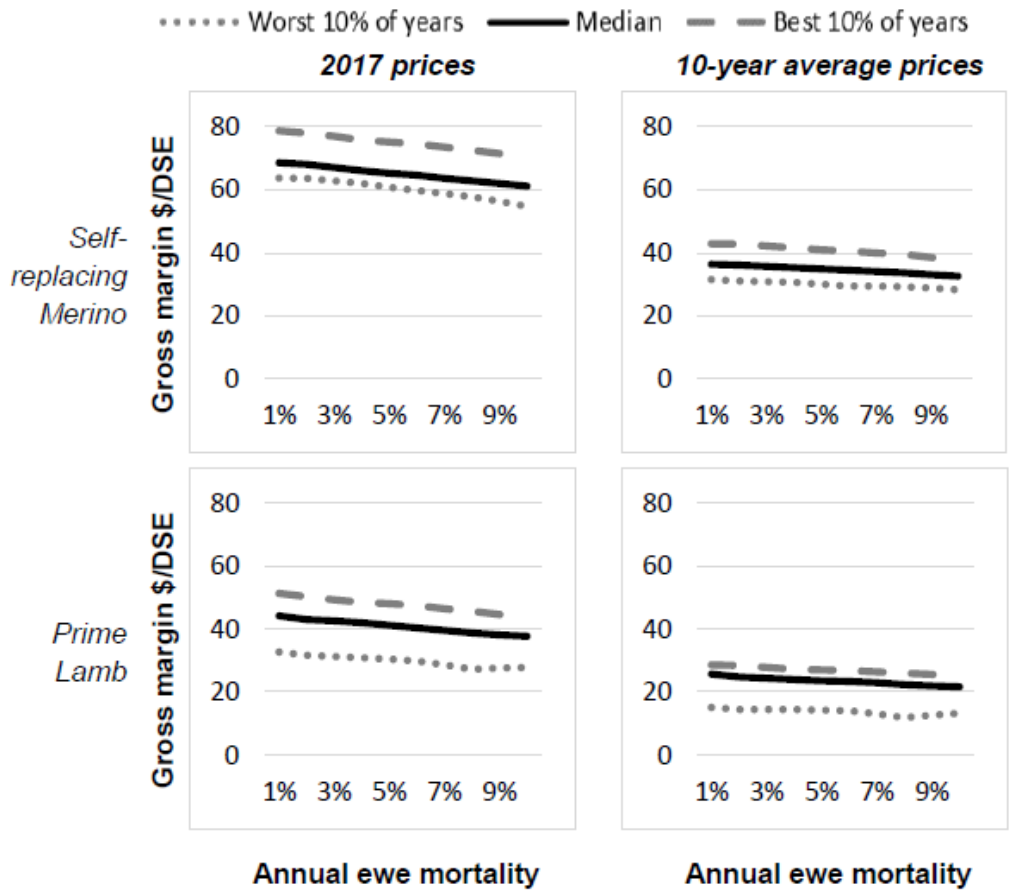


Figure 1 the impact of ewe mortality on gross margins $/dse (from Pfeiffer C Mackinnon Project Newsletter 2017)

The improvement in gross margin chiefly depended on the change in ewe mortality, not what the starting ewe mortality figure was. In other words, reducing mortality from 8% to 7% had similar benefit to reducing mortality from 4% to 3%. Overall, in an average year, the gross margin ($/DSE) in all scenarios increased by about 1.5% for every one percentage point decrease in ewe mortality.

In a self-replacing flock, reducing annual ewe mortality by 1% resulted in an average benefit of $812 per 1000 DSE under current commodity prices, and $403 per 1000 DSE with 10 year median prices. Similarly, in the prime lamb enterprise, when ewe mortality decreased by 1%, on average gross margin increased by $815 per 1000 DSE under current prices, and $397 per 1000 DSE with 10 year median prices. The cost of changing management to reduce ewe mortality will determine the net economic benefit.

Using data from the farms reported in the project, annual ewe mortality rates varied from 0.2% to 14.4% with an average of 4.9% per annum. Some of the data is likely to be an under-estimate of the true mortality rate however, as a large number of the stock tally data did not balance and several estimates of stock deaths were round numbers (for example 100), which is unlikely. Even so, using current commodity prices the annual benefit of reducing mortalities to 4% for ewes would range from $0 (where ewe mortalities were already below 4%) to $8.32/dse where mortalities reduced

from 14.4% to 4% at current commodity prices and $4.14/dse at long term commodity prices for both wool and prime lamb flocks.

From an industry perspective, recent estimates of sheep numbers were 39,350,000 million ewes (ABS Agricultural Commodities 2014-15). A 1% reduction in the annual ewe mortality rate would increase the gross income of the Australian sheep flock by $53,516,000 at current commodity prices, or $26,758,000 with long term commodity prices.

Assumptions: (39,350,000 ewes X average 1.7 DSE/ewe = 66,895,000 DSE X $0.80DSE benefit of reducing 1% mortality rate with current commodity prices or $0.40/DSE benefit of reducing 1% mortality rate at long term commodity prices)

Conclusions

The financial benefits of improved survival are significant. When considering the welfare of ewes, this improvement represents reduced suffering that would be experienced before death. One of the most significant points to note is that the data on which these calculations may be somewhat unreliable. As we suggest, our farmers could be above the industry average, and so national data recording is not likely to be better. Individual electronic identification should be able to give more reliable information, and so mortality costs could shift significantly in the coming years.

These models do not include the industry identified risk that mortality and poor welfare represent to the industry as a whole, and should be considered when industry wide improvements to welfare are being considered.

10.4.3 The potential benefit of managing condition score of ewes on case study farms

Managing the condition score of ewes is an important determinant of profitability of ewes (www.lifetimewool.com.au). The quantity and quality of what sheep eat controls their body condition, which in turn directly affects a number of production factors including lamb survival and the wool production of both the ewe and her progeny. In addition, factors such as worm control and other health issues can be important at determining the body condition of ewes over the year.

As a general guide, ewes in high rainfall regions should be managed to be in condition score 3 at joining and condition score 3 at lambing. Ewes can lose some condition (0.3 of a condition score) over early pregnancy, however, they must regain all condition lost in early pregnancy by lambing. Generally, the cost of grain feeding is too high to increase ewe condition score in late pregnancy. Therefore, gaining condition must be done with green feed. If green feed is not likely to be available in late pregnancy then it is advisable to maintain ewe body condition during pregnancy. Given pasture availability will be dependent on climatic conditions, particularly rainfall, for most producers, maintaining ewe body condition over pregnancy is the safest strategy, particularly early lambing flocks where pasture availability is more likely to be limiting. Late lambing flocks (after August) or flocks that are conservatively stocked are more likely to have adequate feed for ewes to

gain liveweight in late pregnancy. Tactical use of nitrogen and Gibberellic Acid can reduce feed shortages over late pregnancy in winter as a potentially cheaper source of supplementary feeding

During lactation, ewe body condition normally declines, particularly in early lactation. A critical management strategy is to ensure ewes gain body condition after weaning to be condition score 3 by joining. Management strategies include not delaying weaning so ewes do not lose excessive weight and draft ewes on body condition at weaning to ensure that ewes less than condition score 3 are allocated the best feed.

There are likely to be substantial benefits of managing ewe body condition on case study farms, although it is difficult to determine the likely benefit as not all information on available pasture across case study farms is available. The table below summarises the opportunity that exist comparing actual condition score of ewes during pregnancy and at weaning compared with industry benchmarks.

Table 4 Ewe condition score during pregnancy and weaning on case study farms

	Farm 1		Farm 2		Farm 3	
visit	pregnancy	weaning	pregnancy	weaning	pregnancy	weaning
date	15/6/17	19/12/16	18/4/17	21/10/16	24/4/17	17/11/16
Average CS	2.74	2.55	2.95	2.75	2.63	2.74
% <CS2.5	11%	23%	0%	11%	20%	25%
% <CS2.75	39%	68%	9%	43%	53%	46%
% <CS3	64%	77%	34%	63%	57%	55%
average < CS2.5	2.14	2.02	na	2.02	2.08	2.10
average < CS2.7	2.40	2.33	2.50	2.38	2.34	2.09
average < CS3	2.54	2.39	2.68	2.50	2.42	2.34

Assuming ewe condition score in an average year should not fall below condition score 3, during pregnancy 64%, 34% and 57% of ewes were below condition score 3 during the pregnancy visit on case study farms 1, 2 and 3 respectively. The average body condition score of ewes less than condition score 3 was 2.54, 2.68 and 2.42 during the pregnancy visit on farm 1, 2 and 3 respectively. Assuming an average condition score of merino ewes is 8 kg on farm 1 and 10 kg for the composite and first cross ewes on farm 2 and 3, 64% below condition score 3 of ewes on farm 1 were on average 3.7 kg below ideal weight. On farm 2, 34% of ewes below condition score 3 averaged 3.2 kg below ideal weight and on farm 3, 57% of ewes below condition score 3 averaged 5.8 kg below ideal weight.

The potential financial penalty for the proportion of ewes below ideal body condition during pregnancy to lambing includes:

- lower lamb survival
- lower progeny wool production and value
- higher ewe mortality
- lower ewe wool production

For every 1 kg lower liveweight between mid pregnancy and lambing lambs will have 0.045 kg lower lamb birth weight. With lower lamb birth weight the risk of exposure and mortality increases. Models predict that for a 45-kg ewe at joining the survival of twin lambs increases by up to 1.2% per kg change in liveweight to Day 100 of pregnancy and 1.7% per kg change in liveweight during late pregnancy. (Oldham CM et al 2011 Animal Production Science 51:776-783). Thompson AN et al (2011 Animal Production Science 51:794-804) demonstrated that ewes that were 1 condition score heavier during pregnancy produced progeny that produced 0.3 kg clean extra wool that was 0.1 micron finer over a four year period. Mortality rates in ewes depend on body condition score at lambing. Mortality rates are higher in ewes of condition score 2.5 at joining compared with ewes that are condition score 3 by about 0.5-2.1% depending on whether ewes gain or lose weight to lambing (http://www.lifetimewool.com.au/pdf/highrainfallzreport.pdf). Ewe wool production is also dependent on nutrition during the year.

There is also a strong relationship between ewe clean fleece weight and fibre diameter and ewe liveweight and liveweight change over joining, pregnancy and lactation. Likewise there is a consistent relationship between joining weight of ewes and reproductive rate (about 2 extra foetuses per 100 ewes per kg liveweight). (Ferguson MB et al 2011 Animal Production Science 51:763-775). There is likely to be a relationship between weaning body condition score and joining body condition score that will depend on individual flock management with allocation of pasture for ewes after weaning to joining will have an important impact on ewe conception rates at joining.

To evaluate the financial impact of having ewes in lower condition at during pregnancy and at weaning compared with ewes in condition score 3, GrassGro (Ver3.3.4) was used to simulate the financial performance of flocks with ewes managed with a minimum condition score of 2.5 compared to ewes condition score 3 using long term commodity prices (10 year real prices) for a self replacing merino and prime lamb flock in central Victoria using the finding from lifetime wool for reproduction, wool and survival factors.

The table below summarises the simulations using a self replacing merino and terminal prime lamb flock for flocks managed to maintain condition score profiles of condition score 2.5 and 3. The analysis shows that using supplementary feed to maintain a minimum condition score of 3 compared to 2.5 in a flock generates slightly more income from wool (due to life time wool benefits and extra production due to better nutrition and stock sales due to higher reproductive performance and lower mortalities). However, the benefit of virtually all the extra income is negated by higher supplementary feed costs to maintain the higher nutritional status. In prime lamb flocks lower depreciation of ewes is achieved in flocks with the higher body condition profile due to lower mortalities.

The results clearly show that to achieve the full financial benefit of maintaining the higher condition score profile it is critical to use available pasture rather than relying of supplementary feed to achieve the targets.

Table 5 GrassGro results of merino and prime lamb flocks managed for a minimum condition score of 2.5 and 3

	Merino CS2.5	Merino CS3	Prime lamb CS2.5	Prime lamb CS3
Financial performance $/ha				
Wool adults	$221	$227	$106	$101
Wool young	$183	$194	$36	$36
Stock young	$228	$234	$736	$770
Stock CFA	$73	$75	$88	$92
Gross income	$706	$731	$968	$999
Feed costs	$78	$105	$126	$149
Total costs	$269	$298	$582	$606
Gross Margin	$437	$433	$383	$393
SR DSE/ha	12.4	12.6	13.5	13.8
Main flock grain Kg/ha	287	405	550	657

In the case study flocks, there will be very little benefit of maintaining a higher condition score profile if the higher condition score profile is maintained by supplementary feeding. If however, the higher condition score profile is maintained by allocation of better feed to lighter ewes, there is a 4.4% benefit of maintaining ewes in higher body condition (merino flocks farm 1) and a 6.4% benefit of maintaining ewes in higher body condition (prime lamb flocks Farms 2 and 3). The benefit is largest in Flocks 1 and 3 that had a high proportion of ewes below the condition score targets whereas in Flock 2 the benefit is small as most ewes were close to the condition score target. This is likely to be due to the fact that this flock is already managing light ewes to the appropriate condition score profile.

Conclusions

Increasing ewe condition should only be done using green feed. It is rarely economic to feed grain to increase condition. Ewes should only be managed to lose condition over autumn that can be regained using green feed before lambing. In good seasons, if ewes start at a higher condition score they should be managed to maintain a similar condition score profile through the season.

Reductions in mortality, particularly lamb mortality, that are described in this study are directly linked with reduced reputational risk to the sheep industry. This benefit is significant and has not been accounted for here.

Lameness management decision tree

Lameness is an important issue in sheep flocks in southern Australia with a number of important diseases potentially causing lameness and production losses. In the flocks examined lameness was

present in all flocks. There was an average of 4.2% of sheep lame at the pregnancy visit and 5.2% of sheep lame at the weaning visit which is consistent with the normal pattern of lameness affecting sheep mostly over the winter and spring months when environmental conditions have more moisture, though lameness is often present in late pregnancy associated with foot abscess in heavily pregnant ewes. The average lameness score of lame sheep where lame sheep were scored between 1 (Mild) – 3 (severe) on the properties inspected was 1.28 at the pregnancy inspection and 1.30 at the weaning inspection.

Whilst the cause of the lameness was not specified most conditions could be diagnosed based on clinical expression and treatment and prevention based on welfare, cost benefit and specific management requirements

The decision tree below outlines the process to investigate the cause and management of lameness.

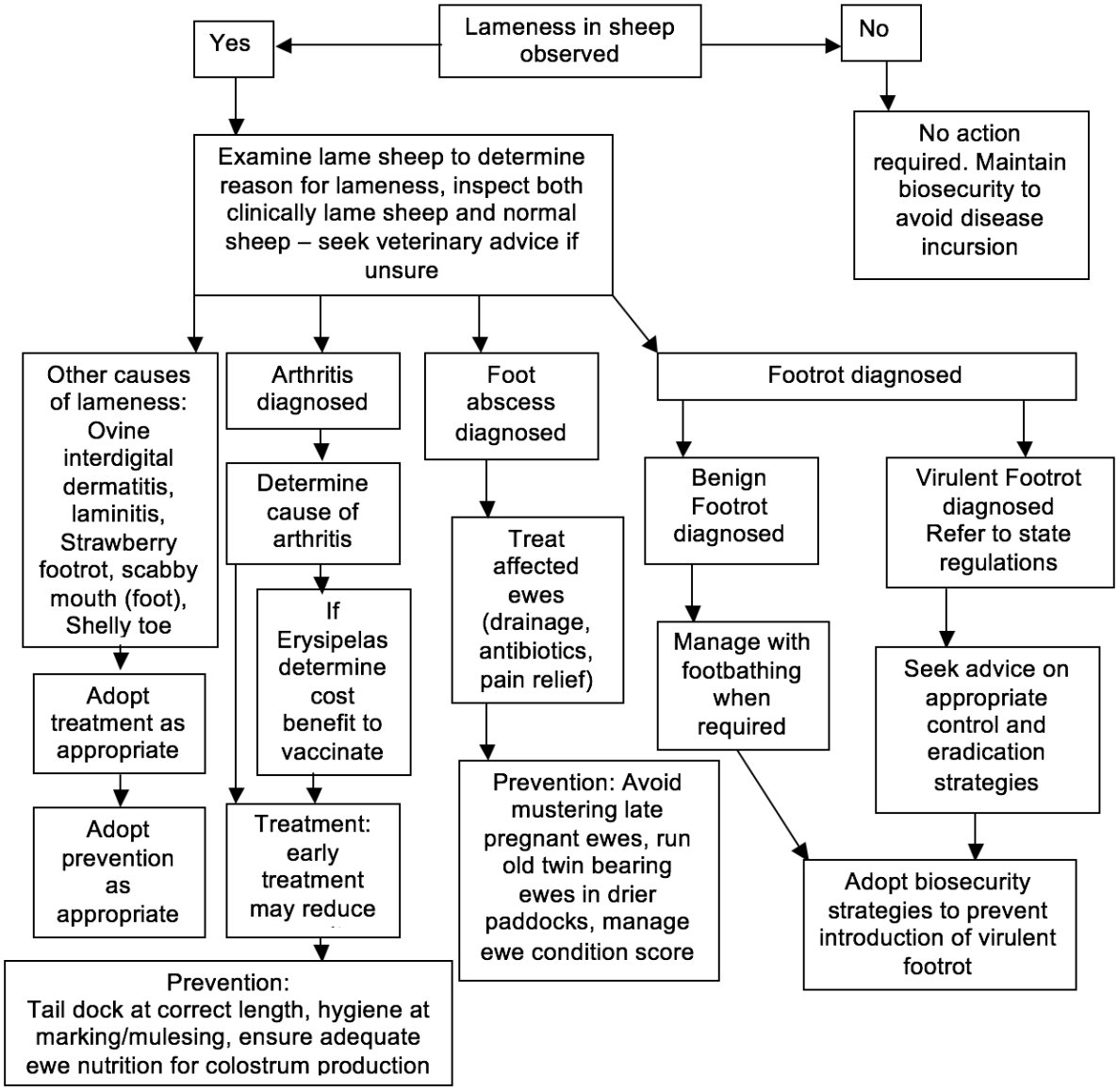


Fig: Decision making tree for lameness events on farm

11 General Discussion

As outlined in Section 3, a series of research activities were undertaken to achieve the objectives of this project. Analysis and interpretation of each of these research activities are presented in the corresponding sections above. This section is the synthesis of the common findings across all of the research activities, what impact they could have for both sheep producers and the welfare of their animals, and what future activities need to occur to make this happen.

11.1 Advancement of our knowledge on the welfare of extensively managed sheep

11.1.1 A valid, reliable and feasible welfare assessment protocol

In order to deliver on the main objectives of this grant, a welfare assessment protocol needed to be developed because a protocol that suited the extensive Australian environment was not available. The protocol scored 100 ewes visit, and conducted two visits per farm. The most economically valuable animal – 2-4-year-old ewes – were chosen for welfare assessment. This class of stock are common to most sheep farming systems, and will generally remain on the same farm year-round and for several years, so they might be considered to be the most reliable indicator of on farm.

Six animal-based measures were used in the final protocol: body condition score (BCS), fleece condition, skin lesions, tail length, dag score and lameness. These measures were deemed to be valid after consulting with farmers and sheep industry experts as a part of a broad national survey and focus groups. Consultation with the general public to ensure the measures had societal validity and the literature to confirm international scientific validity. We measured the reliability and feasibility of these measures, and this was repeatedly tested to assess how the measures captured seasonal variability at welfare- and production-critical time points, which provided evidence of the effectiveness of these measures in assessing the welfare condition of extensively managed ewes. A test for the on-farm assessment of the human-animal relationship was also used. A complementary study to this project improved the application of this test, and the study demonstrated that it can identify variation in the human-animal relationship in ewes. Further validation of the test is required however to determine if it can reliably identify differences between groups of ewes. This may partly come from the analysis of the on-farm study.

When combined, these six measures provide a snapshot of the current welfare status of ewes, as well as evidence of previous welfare issues and future risk. Combining these measures with management and resource-based welfare indicators would be particularly useful to predict risk.

Some of these have been incorporated into the risk assessment tool being developed by the Sheep CRC (ASKBILL), which looks valuable, but a more comprehensive animal-based evaluation and risk profile is needed to address ewe welfare specifically.

11.1.2 Factors affecting ewe welfare

Management strategies, not farm size, are the key cause and solution to welfare

The main welfare issues identified were poor nutrition (under and over feeding), mortality, lameness, ecto-parasites (flystrike) and mastitis. All of these issues can arise from, and be treated by, management practices. Relationships between the incidents of these issues and specific management and attitudes are still being analysed, but it was clear from preliminary work that these relationships were strong.

Stockperson to animal ratio is a common argument given against large-scale extensive farming. "Smaller flocks cared for by more shepherds means better supervision of the animals' health and welfare" – Compassion in World Farming. Preliminary analysis of our data dispels this myth, and indicated that there was a positive relationship between improved ewe welfare and increased flock size. It is likely a case that large farms have more resources, and this will be investigated in further analyses. This highlights the need for the incorporation of management-based measures in the assessment.

Reproductive and seasonality stage

Management practices clearly influenced welfare outcomes, but there were other significant contributing factors. In the longitudinal study on the same population of ewes, ewes had poorer health at mid-lactation and weaning compared to mid-pregnancy. In the large on farm study, ewes in mid-pregnancy were less likely to experience lameness, fleece issues or heavy dags than ewes at weaning; yet the body condition of ewes at weaning was generally better. These results indicate that the reproductive stage affects the welfare of ewes by creating different challenges at different times. We incorporated a few specific measures for points in the reproductive cycle, like clinical mastitis testig and physical udder palpation to help understand this.

Welfare issues may also be exacerbated by the season. Analyzing the environmental risks of these issues would allow for risks to be predicted, but incidents of welfare compromise need to be managed regardless. The same farm was used in Section 7 and 8 and yielded different welfare issues with different frequencies. As this is the first comprehensive study of ewe welfare, it acts as a benchmark for future comparison, but this makes it difficult to know how 'common' these results were. These issues are comprehensively analysed in the two draft manuscripts in the appendix.

Other sources of variation

The breed of ewe and the location of the farm were influential in some instances on welfare scores. What is not known is how much of this is the result of breed-specific or location-specific differences, or management practices that differ across these locations. Further analyses of these factors will be conducted in Carolina's PhD thesis. This variation is an important factor when conducting on-farm welfare assessments, particularly if there was to be an auditing process. Without understanding these sources of variation, and how much variation occurs on farm, it is hard to understand the prevalence of welfare issues and then determine what should be acceptable thresholds and industry targets.

11.2 On-farm welfare assessment has challenges

The protocol required 2 to 3 min to assess an individual ewe. It was designed to not require specialised equipment; the only infrastructure required are a pen and raceway, both of which are common on sheep farms. We designed the protocol so the only farm labour required was to bring the sheep into the yards, and this was done at times to minimise interferences and not interrupt farm management practices. The time taken to perform the assessment averaged 3.5 to 4 hours per farm to assess 100 ewes.

This was assessed for feasibility for a third party to perform, not a farmer. In the focus groups and the main study, the majority of farmers monitored their ewes visually. The accuracy with which farmers could estimate issues on farm varied and their response to animals needing further care was infrequent. As we demonstrated, close physical assessment of ewes is important if welfare issues are to be addressed. Bridging the gap between behaviours needed for welfare improvement and current practices may require culture change. As we evaluate the relationships between farmer attitudes, management practices, farm profitability and ewe welfare (the core focus of the PhD thesis), we will be able to understand this further.

11.3 Common issues and simple targets for industry-wide welfare improvement

Several common issues were identified that could be targeted to improve sheep welfare. Cost-benefit analyses of modifying all three of these issues are underway.

1. Tail length

As 84% of the ewes were identified as having too short tails. This impacts sheep across stock classes in a variety of ways, including increased pain and prolonged recovery at the time of docking, risk of bacterial arthritis, rectal prolapse and vulva cancer. A simple approach to improving this would be

valuable. Appropriate tail length (not too long either) has welfare benefits. Industry-themed messages on this should include facts to dispel the myth that the shorter tail, the better.

2. Lameness

Lameness was observed on all farms, and was an important, standalone welfare issue in the online survey. Minor lameness causes pain and can progress to more serious lameness. The long-term risk to a ewe's welfare from lameness depends on the cause of lameness. We were not able to identify any clear causes of lameness in this study, but the common nature indicates that it needs further investigation and targeting. A practical decision-making tool on the causes and management recommendations for lameness would be valuable.

3. Mortality data

The comprehensive assessments done in this study provided valuable insight, but initial industry improvements could be made by simply encouraging improved data collection. Accurately recording animal numbers, by class, at critical time points like scanning, shearing and drenching would allow farmers to identify stock losses and start the process of welfare and productivity improvements. Streamlining processes, providing simple and easily accessible examples, and providing tips are all ways this could be encouraged for farmers. Helping them understand the value of record keeping is also important. Some examples of this were used in the benchmarking report to farmers and will be evaluated in time.

11.4 Encouraging on farm improvements

11.4.1 Targeting farmer attitudes and behaviours to modify practices

The management practices of farmers have a clear impact on the welfare of ewes. Many of the management strategies are associated with productivity and profitability. Providing this information to farmers could encourage practice change. While financial drivers could be valuable, it was clear that there were attitudinal and perceived behavioural control components behind actions. In other studies, these have been shown to be the dominant forces behind management practices (Elliott 2012). Attitude modification has been used to improve animal welfare in more intensive industries.

Attitudes towards animal may be beneficial in improving productivity too. In studies by Elliot, targeting welfare may well be an effective strategy to improve productivity as well. Elliot (2012) identified that past behaviour and anticipation emotions have the greatest influence on intentions for pregnancy scanning ewes, and suggested that by clearly targeting this emotional component that relates to animal welfare, attitude-driven farmers may be more likely to adopt pregnancy scanning. It was clear that our farmers had a strong concern and appreciation for animal welfare

and attitudinal beliefs that their actions influenced ewe welfare, but there was a disconnect between their behaviours and actual welfare outcomes.

It is not clear how representative our farmers are of the broader population. Demographics and perceptions were similar in the large farm survey and the focus groups. As discussed in Section 8, this needs to be understood further. Focus group participants rated themselves as being the better performers in the industry, and so it is possible that these results could be an 'iceberg scenario' where the frequency and/or severity of the issues increases with farmers that are less 'active' than our farmers. Additional analyses of the current data set are being undertaken to investigate how representative our farmers are of the Victorian and Australian industries.

11.4.2 Benchmarking to encourage practice change

The international welfare assessment program AssureWel is conducted by a third party, but in conjunction with the farmer. This allows for immediate feedback and discussion, but an independent welfare assessment that can then be compared with other farms. This method has had success at reducing welfare issues in a variety of production systems. Benchmarking is a valuable way to generate change on farm. Our preliminary results show that farmers appreciated the feedback and were engaged with the process. Farmers also anecdotally had a keenness to receive feedback about how their animals performed post-farm gate. For example, compared to beef producers, sheep producers receive little to no feedback on the quality of their livestock at the abattoir. In order to then create welfare and productivity improvements, it may be valuable to have an advisor perform the welfare assessment, as they can then give specific suggestions on how to risk-manage and provide practical further care. This could be a good action for a supply chain looking to improve welfare.

11.4.3 Simple ways to start the process

1. Providing practical solutions

While the attitude and availability of farmers influenced whether or not they took further care of compromised ewes, ewes that experienced easy to treat issues were more likely to receive treatment. Providing farmers with easily accessible and practical solutions to common welfare issues could help increase the frequency with which animals needing further care are treated. Methods would need to be applied when ewes are in the yards, or implement relatively easily in the paddock. Tools like decision trees and checklists that are simple to follow and readily available could be effective ways to communicate this, with the fit to load guide being one example.

2. Identification and management of issues early

Identifying issues when they are sub-clinical, or even better to prevent issues from arising, is the key way to assuring welfare of the mob. Better ways to monitor and keep records are essential. Education to do this would be valuable, and it would at least reach the farmers we spend time with as the majority attended info sessions and training. The adoption of sheep Electronic Identification (EID) systems, which is now compulsory in Victoria, may be a useful way to do this without significant input or the requirement of technology to be developed. In our discussions, farmers often said found this technology difficult to implement however, and many were not using it. For now, simple information and tips on the value of accurate record keeping, and how this can be done, may be a first step to improving this. This was one of the features presented in the Benchmarking Report provided to farmers in this study. Data on the value of the benchmarking report are being collected currently.

11.5 Research recommendations

A number of extension and knowledge sharing actions are outlined in sections 12.3 and 12.4.3. We have identified two key areas that require specific research below.

11.5.1 Benchmarking ewe welfare

As this is the first comprehensive study of ewe welfare, it is difficult to know how 'common' these results were. What this study does do is act as a benchmark for future comparison. Independent, objective evaluation of ewe welfare over the course of time and using different breeds is needed to elucidate how common welfare issues are. Examining welfare issues in other classes of stock, particularly weaners/hoggets and older ewes, is important as well. Data on these animals is particularly sparse. Understanding the prevalence of welfare issues is the first step to determining acceptable thresholds.

Further research on specific welfare issues are:

1. Lameness causes and prevalence

Lameness was observed on all farms, but clear causes were not identifiable. As a part of understanding the prevalence and solutions of this, we need to be able to identify the causes as well. Data on this do not exist.

2. Practical mastitis assessment – more welfare issues

Dr. Stuart Barber's MLA-funded project B.AHE.0013 identified that mastitis was more prevalent in ewe flocks than previously expected. We also identified it as being more prevalent on-farm when we used a diagnostic test, rather than udder palpation. Subclinical mastitis compromises welfare and productivity in both ewes and their lambs. Developing a more sensitive but practical test that could be used on farm for welfare and production studies would be valuable.

3. Impact of shearing injuries

Shearing related injuries were common. The impact of these on the welfare and short and long-term productivity of sheep warrants further investigation.

11.5.2 Can practice change be encouraged through activities targeting attitude and perceived behavioural control?

Understanding the relationships between producer characteristics, including attitudes and behaviour towards the welfare and mortality of sheep and welfare and mortality on farm will be utilised to develop and evaluate an intervention strategy to improve animal handling and management with the aim of improving animal welfare, reducing mortalities and improving farm production and profitability. A controlled trial of intervention strategies would be one way to measure this, now that this study has established possible strategies and attitudes to target. Ideally, this would be most valuable if done across a wider group of farmers representative of the industry.

12 Conclusions/recommendations

This research determined that the welfare of the ewe flock was good, but welfare compromise to the individual animal can be significant. Six animal-based measures were evaluated for use as ewe welfare indicators: body condition score, fleece condition, skin lesions, tail length, dag score and lameness. Over the course of this study, the main welfare issues were poor nutrition (under and over feeding), mortality, lameness, ecto-parasites (flystrike) and mastitis. All of these issues can arise from, and be treated by, management practices. Along with management strategies, reproductive stage, breed and region all affected animal welfare, but farm size did not.

Farmers had very positive views on the importance of the welfare of their ewes. It was clear that our farmers had a strong concern and appreciation for animal welfare and attitudinal beliefs that their actions influenced ewe welfare. In some cases, however, there was a disconnect between their behaviours and welfare outcomes of the ewes under their care.

Attitude and perceived behavioural control were the two key drivers behind the behaviour of sheep farmers. Strategies to encourage behaviour change that target these drivers to be developed and tested. Benchmarking welfare and production would be one valuable way to engage farmers and encourage change. In the short term improving data collection and record keeping would be a simple activity to benefit welfare.

Providing farmers with easily accessible and practical solutions to common welfare issues could help increase the frequency with which animals needing further care are treated. Methods would need to be applied when ewes are in the yards, or implement relatively easily in the paddock.

13 Key messages

1. Six animal-based measures were identified to form the basis of a welfare assessment protocol: body condition score, fleece condition, skin lesions, tail length, dag score and lameness.

2. The main welfare issues on farm were poor nutrition (under and over feeding), mortality, lameness, ecto-parasites (flystrike) and mastitis. Industry-wide welfare risks were overly short tails, lameness and inaccurate recording of mortality data. Research recommendations focus on benchmarking welfare between different classes of stock, farms and over time, understanding incidents and causes of lameness and mastitis further.

3. Attitude and perceived behavioural control were the two key drivers behind the behaviour of sheep farmers. Strategies to encourage behaviour change that target these drivers to be developed and tested. Benchmarking welfare and production may be a valuable way to engage farmers and encourage change.

4. Improving data collection and record keeping would be a simple activity to benefit welfare. Other extension recommendations to reduce welfare issues are providing practical solutions and the identification and management of issues early.

14 Bibliography

Reference lists for the scientific outputs are in the appendix.

15 Appendix

15.1 Literature review – Assessing and addressing on farm sheep welfare

Abstract

The MLA funded project entitled 'Assessing and addressing on-farm sheep welfare' (B.AWW.0237) examines the relationships between farmer attitudes, other job-related characteristics, farm management, profits and animal welfare in extensive sheep farming, with the aim of improving animal handling and management and thus in turn improving animal welfare, reducing mortalities and improving farm production and profitability in extensive sheep production. At the commencement of this study a review of existing literature, including several unpublished industry final reports, was conducted to ensure that the project was utilising the latest relevant information on sheep welfare problems and mortality and in particularly, their prevalence, casual factors and associated farmer characteristics. This will be utilised in the detailed planning of the experimental component of B.AWW.0237. The current review therefore focuses on the extensive Australian environment and draws on examples from extensive sheep production internationally as required. Chronic welfare compromise and mortality have been reviewed here in combination because since sheep display only subtle signs of chronic stress, such stress is commonly identified in terms of production and survival outcomes. Furthermore, with sufficient time, chronic welfare compromise will lead to mortality. The topics covered include the perceptions of sheep production and welfare, risks to sheep welfare and mortality and the influence of producer attitudes and behaviour on sheep welfare and mortality. The review highlights that the scale and welfare issues surrounding weaner and ewe mortality are significant, and these chronic welfare issues significantly impact the profitability of farms. Understanding the relationships between producer characteristics, including attitudes and behaviour towards the welfare and mortality of sheep and welfare and mortality on farm will be utilised to develop and evaluate an intervention strategy to improve animal handling and management with the aim of improving animal welfare, reducing mortalities and improving farm production and profitability.

Assumptions of the review

The current review focuses on the welfare of extensively managed sheep. This focus has been driven by aims and objectives of the current project (B.AWW.0237). As a result, the review concentrates

on welfare issues associated with mortality and management that are under significant to moderate control of the farmer.

While not focused on in the current review, the following issues are considered to have a significant impact on sheep welfare: abuse and mistreatment; extreme weather events (flood, drought fire); predation; thermal stress; poisonous plant consumption; specific diseases including footrot and associated lameness; handling and management including mustering and yarding, shearing/crutching and painful husbandry practices; invasive reproductive techniques; confinement ('shedded sheep' and feedlotting); transport (road and sea); and slaughter (on-farm and off-farm). Aspects of these issues have been reviewed by Hutson and colleagues (2001) and Hemsworth and colleagues (Hemsworth et al., n.d.).

1. Perceptions of extensively managed sheep

The general public seem to have a low level of understanding about animal production (Coleman et al., 2014). They also trust livestock workers to care for the welfare of their animals, with the level of trust being highest for farmers (Coleman et al., 2014). The general public also strongly believe that confinement leads to poor welfare (Hemsworth et al., 2010). It is assumed then that the public feel the welfare of sheep in extensive settings is high. In order to ensure this level of trust is maintained (or grown), it is important that the perceptions of animal welfare are met or exceeded.

In the scientific literature a duality exists with how sheep welfare in extensive settings is perceived by producers and experts. Superficially, the welfare of extensively managed sheep is perceived to be high; it is also a common perception that as the scale of the enterprise increases, the welfare of the sheep decreases. The perception is that extensive management is good for welfare, as long as it's not too extensive. It is also likely that the welfare of extensively managed sheep is poorer than currently perceived. The risk to welfare does not necessarily increase however with the size of the enterprise.

1.1 Extensive management of sheep can compromise their welfare

The welfare of extensively managed sheep is considered to be high (Dwyer and Lawrence, 2008). This is largely due to sheep being able to express natural behaviours in the farm setting. Three other drivers are also attributed to this perception: (1) the general public assumes that extensive

conditions equal positive welfare; (2) issues faced in extensive production are perceived by producers as being 'natural' and therefore are not easily addressed, or important to address; and (3) the belief that sheep have evolved in these extensive conditions, and so are well adapted to the environment we manage them in (Turner and Dwyer, 2007).

As a result, in extensive conditions one of the Five Freedoms, which are considered to guide animal welfare (FAWC, 2007), is being met. This is the freedom to express natural behaviour. The other four freedoms are (1) the freedom from hunger and thirst; (2) the freedom from disease, injury and pain; (3) the freedom from discomfort; and (4) the freedom from fear and distress. It is likely that welfare compromise around these four remaining freedoms exists in extensive production (Stott et al., 2012). For example, the sheer size of extensive sheep farming in Australia makes feeding, protection from predation and prevention/treatment of disease and injury more difficult to monitor and address.

A review by Hutson and colleagues (2001) supports this idea, suggesting that neglect and the inability of farmers to provide individual care in extensive systems is a welfare issue, quoting that "mortalities from single pregnancies rose from 7% to 17% when labour was reduced by 70%" and that "clearly there is a conflict between welfare and extensive production". Extensive management also reduces the opportunity for positive human-animal interactions (Boivin, 2003), and thus increase the likelihood of sheep experiencing fear and distress during close contact and handling at least. Indeed, one comprehensive study that gauged the opinions of sheep experts (Phythian et al., 2011) identified 193 welfare issues for sheep in extensive UK settings. Of these 193 issues, 57 issues were applicable across all age groups (lamb, weaner and adult). These were grouped according to the 5 freedoms: freedom from hunger and thirst = 14 issues; freedom from discomfort = 14; freedom from pain/injury/disease = 11; freedom to express normal behaviour = 8; freedom from fear and distress = 10. With this in mind, it is likely that the welfare of sheep farmed extensively is poorer than currently identified.

1.2 Welfare compromise does not necessarily increase with size of production

In opposition to the above view, it is assumed that as the scale of extensive systems increases, the welfare risk to the animals also increases. This is based on the perception that smaller flocks have a lower shepherd to sheep ratio, and so the welfare of individual sheep is more likely to be identified and monitored. Additionally, individual animals in smaller flocks contribute to a greater proportion

of the total flock value, and so will likely be more likely to get treated for individual issues (e.g. dystocia) (Stafford, 2014). The issue underpinning this is that as enterprises increases in size, labour will reduce and with that, care for the individual animal will reduce (Waterhouse, 1996).

The issue of care for individual animals is presented in international animal welfare guidelines. The European Convention on the Protection of Animals kept for Farming Purposes (on November 1992) state that the stockperson must be reasonably able to safeguard the welfare of each individual animal within the flock, regardless of the size (Boivin, 2003), and the Council of Europe regulation states that the stockperson must guarantee the welfare of each individual animal (Council of Europe, 1976). This same safeguard is presented in the recently reviewed Australian standards and guidelines for sheep welfare, where "a person must take reasonable actions to ensure the welfare of sheep under their care" (Animal Health Australia, 2014).

Despite the focus on the handler's responsibility to animal welfare, the literature rarely covers extensive management and associated human-animal relationships (Boivin, 2003), and so the reduction in welfare as a result of increased stockperson to animal ratio is based on assumption rather than being supported by evidence. These assumptions surrounding the welfare and scale of extensive management of sheep are widespread, with these ideas being reported by both sheep welfare experts and farmers (Goddard et al., 2006; Morgan-Davies et al., 2006; Phythian et al., 2011). It has been indicated that producers themselves feel that labour restrictions, which usually result from financial restraints, prevent them from addressing sheep welfare effectively. In one study, 50% of extensive sheep farmers felt that they did not have enough labour to devote to ectoparasite control, and so this suggests that profits and extensive environments may be associated with compromised health and welfare (Morgan-Davies et al., 2006).

Financial modelling and producer sentiments highlight this conflict. When farmers assessed how important certain attributes were to extensively managed sheep welfare, without giving concern to cost and practicality, they scored active flock monitoring at a moderate frequency (gathering the sheep 6 times per year for treatment and sorting) and having a low producer to sheep ratio (1:400) as being the best welfare outcome for the sheep (Stott et al., 2005). In the study's associated financial model, the highest shepherd to sheep ratio (1:2000) and least frequent active monitoring (sorting/treatment 3 times per year) were the cheapest model attributes. This result suggests that farmers have different perceptions of what will lead to a good welfare outcome, compared to what is financially viable. While this is a subjective assessment of welfare benefit, the conflict between

welfare outcomes and financial costs detailed in this study are likely to affect farmer attitudes about their ability to control/improve sheep welfare.

Despite these perceptions, whether or not lower shepherd to sheep ratios and increased scale of production translate into welfare compromise is yet to be validated. Larger farms have the ability to access resources more readily, as husbandry and monitoring tends not to be scale neutral (Phillips and Phillips, 2010). Industry benchmarking supports this, with the top 20% of enterprises producing more lamb using less labour than the bottom 20% of producers welfare (Holmes Sackett & Associates Pty. Ltd., 2005). While the volume of lamb produced cannot be tied to sheep welfare, correlations between productivity and welfare are seen (Stott et al., 2012). Similarly, a survey of sheep producers indicated that farms of a large size (>5,000 head) were more likely to have formal training than smaller farms (<1,000 head) (Sloane and Wentworth, 2010). As it is recognised that stockperson training is likely tied to better welfare (Animal Health Australia, 2014), this again supports the point that welfare is not necessarily compromised as scale increases.

1.3 A balance between perceptions

While the handling and management of animals in very extensive environments increase the risk of poor welfare, this may not be the case for all extensively-managed farms. Research supports this with a large variation in welfare scores being identified on farms with similar income levels (Stott et al., 2005). This suggests that welfare can be improved within the context of viable farm management by careful choice between strategies for individual farms. Having stockpeople adept at handling and managing animals should solve this problem regardless of flock size. It is anticipated that this debate around scale of production will receive more focus in the near future, with the perceptions of increase scale associated with reduced welfare needing to be quantified before it can be reasonably challenged (Hötzel and Appleby, 2014). In summation, the welfare of extensively managed sheep is likely to be poorer than currently perceived. This needs to be addressed. The size or scale of production, however, does not increase the risk of welfare compromise. As a result, it is expected that specific changes targeted at improving welfare will be effective, regardless of the size of the enterprise.

2. Welfare issues in extensively managed sheep

2.1 Internationally identified issues

Most of the international research on extensive sheep welfare has been conducted in the UK. The main issues identified by sheep industry experts were feeding issues (over- and under-nutrition),

lameness (and associated foot diseases), parasitic disease, neonatal disease and mortality, and dystocia as being significant (Goddard, 2003). Stockperson responsibility was also a fundamental issue. This included optimising husbandry, recognising problems at an early stage, knowing when to call in further expertise and exercise good judgement from a welfare cost/benefit analysis (Goddard, 2003). In a producer-focused study, lameness, ectoparasite burdens and nutrition were identified as common health/welfare issues (Morgan-Davies et al., 2006).

2.2 Nationally identified issues

While some of the issues identified internationally are likely to be relevant to the Australian sheep industry, the unique nature of sheep production in Australia will result in distinctive welfare issues as well. A review of the welfare priorities of the Australian sheep industry in 2002 by stakeholders identified five "extremely important" priority areas: land transport of sheep, live animal exports, mortality, mulesing and stockpersonship (described as knowledge, skills, motivations and handling) (Cronin et al., 2002). Welfare concerns of Australian sheep producers focused on practical, production-based issues, with poor nutrition considered to be the most significant sheep welfare challenge on farm (Phillips and Phillips, 2010), with "flies", "intestinal parasites" and "water" also being listed as common concerns. In the same study, farmers identified public opposition to mulesing was the largest welfare issue for the industry; nutrition, intestinal parasites and long distance transport also ranked highly. This perception was supported by a study investigating welfare issues for feedlotting lambs, where producers identified health and resource issues (shade, water, feed) to be the primary welfare concerns (Hemsworth et al., 2010).

The most recent domestic assessment of sheep welfare issues was a workshop attended by industry stakeholders and experts facilitated by the Animal Welfare Science Centre in July of this year (AWSC, 2014; Appendix 1). The top priorities are summarised in Table 1. Compared to UK studies, animal welfare issues between producers and industry experts differed significantly.

Table 1: A comparison of recently identified sheep welfare issues with previously identified issues

Domestic welfare research issues[1]	*Nationally important (stakeholders)*[2]	*Nationally important (producer)*[3]	*Internationally important*[4]
Attitudes of farmers and livestock contractors	✓	×	✓
Alternatives to painful husbandry practices	✓	✓	✓
On-farm welfare assessment	×	×	×
Mortalities and morbidity	✓	×	✓

Product quality and welfare*	×	×	×
Identifying international and national standards of best practice sheep welfare	×	×	×

References used for the table: [1] AWSC (2014); [2] Cronin et al. (2002); [3] Phillips and Phillips (2010); [4] Goddard (2003). * Not considered to be relevant to the current review.

Table 1 also shows how the scientific priorities for sheep welfare in Australia may have changed in the current years. It is unclear whether or not this is because of differences between scientific and on-farm priorities, that the previously identified issues have been addressed, or if there is a shift in priority based on changed industry issues and public focus. It is likely to be a combination of these factors. A broader workshop aimed at identifying industry welfare issues is scheduled to be undertaken by the Sheep CRC in 2015. The current MLA project will also identify these issues from a producer perspective.

2.3 Chronic welfare issues in extensive sheep production

Aside from painful husbandry practices, all of the welfare issues associated with sheep welfare, both nationally and internationally, are considered to be causes of chronic welfare compromise. Many of the issues identified above act as risk factors to mortality. While the welfare of sheep is not measurable by mortality alone, the link between the two is evident. In conjunction with this, sheep display only subtle signs of chronic stress, and so this is more commonly identified in terms of production and survival outcomes (Dwyer and Bornett, 2004). Chronic welfare compromise and mortality have been reviewed in combination below.

3. Mortality and chronic welfare

Mortality has been an identifiable issue in sheep production for decades, and significant improvements have been made (Langlands et al., 1984), and this was supported by industry identified issues outlined above. Despite this, mortality was not identified as a nationally important issue by Australian producers (Phillips and Phillips, 2010). A detailed review on the topic by McGregor (2007) proposes that sheep mortality is double what is commonly presented in reference material, and farmers agree that there is a disconnection between perceived and actual sheep mortalities. It was proposed that this erroneous reporting of mortality gives the impression that sheep mortality levels as they are currently are acceptable and/or little can be done to improve them (McGregor, 2007).

Sheep mortality embodies many aspects of a 'wicked problem', with it being difficult to solve and multifactorial. Accurately recording sheep mortality is also difficult in itself. It is likely that the complex nature of the issue has led to the acceptance of mortality as something that cannot be changed, and so receives little focus in the literature. Despite the complexities, addressing on farm mortalities will be tied to increased profitability and welfare. The scale of lamb, weaner and ewe mortality in extensive production and associated compromises to welfare are outlined below. Each subsection evaluates the scale of mortality, common causes of mortality, producer sentiments and welfare implications.

3.1 Lamb mortality and welfare

Perinatal lamb mortality is not often recognised as a welfare issue by producers or the general public (Hutson et al., 2001). However, an MLA-commissioned review identified lamb mortality rates of 20-30% in commercial Merino flocks and declared this to be unacceptable (Walker et al., 2002). Many of the factors that cause lamb mortality, which include hypothermia, maternal underfeeding, mismothering, infection and injury/predation, are all closely tied to welfare issues experienced by lambs in early life (Mellor and Stafford, 2004). These factors are also confounded. For example, an ill or injured lamb may be unable to suckle, and a lamb that is unable to suckle is likely to succumb to hypothermia (Dwyer, 2008). Neonates experiencing one or more of these factors are likely to suffer from hunger, sickness and/or pain at some point, thus compromising their welfare (Dwyer, 2008).

Despite this, the duration of this suffering may not be prolonged. A dulling of consciousness, driven by hypothermia as a secondary outcome of underfeeding, mismothering and infection or as a primary cause of mortality, is likely to occur in neonatal lambs prior to death (Mellor and Stafford, 2004). From this point of view, the review by Mellor and Stafford (2004) suggests that the welfare of the neonatal lamb may not be as compromised as it is perceived. Importantly though, the authors noted that this may not always be the case. Higher ambient temperatures, for example, would likely prolong suffering by delaying the onset of hypothermia. Secondly, more research about the capacity for these animals to suffer is needed before statements can be conclusive. It is therefore noted that the level of mortality for neonatal lambs is unacceptable, but the degree of suffering an individual lamb experiences prior to death is unknown.

While Phillips and Phillips (2010) reported that only 12% of farmers identified lamb mortality as a welfare concern, Campbell et al. (1986) found that lamb mortalities were of "high concern" to 54% of producers. The study by Campbell et al. (1986) indicated that farmers rarely intervened when lambs have been mismothered (foster lambs: 21%, hand-raise lambs: 9%), and so despite the concern, care for mismothered lambs was not conducted. Farmers were then asked about their feelings towards twin lambs, and were effectively divided between viewing twin lambs as being an important part of achieving production targets and being a "bonus when they survive" (Campbell et al., 1986). It could be hypothesised that those farmers that valued twins highly may be proactive with ewe management prior to and during lambing and/or view mortality as of high concern.

While the duration of suffering associated with mortality in the neonate lamb may not be prolonged, the Australian community's attitude towards and acceptance of a neonate lamb mortality of 20-30% are unknown (this is under investigation by Kubeil and colleagues in the project 'Informing future sheep extension strategies to improve reproduction and related welfare outcomes'). It is also likely that ewe welfare may be compromised as the result of a lamb's death. It could be reasonably expected that the ewe could experience pain if parturition was difficult (which is a risk factor to lamb survival), or from a full udder without a suckling lamb. A ewe may also experience frustration or anxiety as her natural maternal behaviour is thwarted, or distress if separation from her lamb is rapid (Dwyer, 2008).

The common denominators between ewe nutrition and management on lamb survival has led to the suggestion of lamb survival being a useful welfare assessment tool (Waterhouse, 1996). In a survey by Campbell et al. (1986), producers that estimated lamb mortality tended to have higher reported mortalities than those that did more accurate counts. Further to this, all producer-reported lamb mortalities significantly lower than those reported in the scientific literature. Current data further suggest that lamb mortality is still not well known (Walker et al., 2002). This is supported by Trompf and colleagues (2011) who identified that only 12% of farmers quantified lamb mortality rates prior to engagement in the Lifetime Ewe Management program (LTEM). If lamb survival is in fact a suitable measure of sheep welfare, this suggests that extensive sheep welfare may be a larger issue than it is currently thought to be.

Recommendations of the review by Walker and colleagues (2002) included facilitating educational and investigative programs in areas of high mortality, as well as further understanding of the roles of maternal and offspring behaviour, the role of ewe nutrition early in the pregnancy and scanning

and preferential management of twin bearing ewes. Industry programs, the most noted being LTEM, have tried to address these issues and have achieved success amongst participants (Trompf et al., 2011).

3.2 Weaner mortality and welfare

Industry targets for mortality rates are less than 4% (Campbell, 2010), yet reported levels of mortalities differ markedly. One study falls below these targeted mortality rates, with producers reported weaner mortality averaging of 1% (range from 0-8%) (Campbell et al., 1986), yet more recently data report an issue much higher than this. Hatcher et al. (2008) identified NSW weaner losses of 14.6% in the NSW region of Yass and 5% in the NSW central tablelands. Along with being above the industry targets, the range recorded highlights a significant issue, with the highest reported percentage of losses being 25% (Hatcher et al., 2008). A recently published survey of sheep producers reported weaner mortalities of 4.6%, but the authors note that this is likely a conservative estimate if anything (Campbell et al., 2014). Another study by the same author identified weaning mortality rate of 14.3% on closely monitored farms and it was acknowledged that this would likely reflect a realistic representation of weaner mortalities on farm (Campbell et al., 2009). When evaluated in combination, the issue of weaner mortality is an expensive one, and it is estimated to cost the industry AU$89 million annually (Sackett et al., 2006). As identified by Hatcher et al. (2008), this estimate is based on mortality rates of 8-10%, and so this may still be conservative.

The root cause of high weaner mortalities is ill-thrift, which is considered to be a multifactorial issue with nutrition and husbandry issues leading to poor growth, poor production and an increased susceptibility to disease and mortality (Campbell et al., 2014). Of all of these issues, body weight has been identified as the most significant risk factor (Campbell et al., 2009). Producers seem to be aware of this risk. Older studies indicated 22% of producers identified poor nutrition as a main factor contributing to weaner mortality, yet 30% acknowledged that parasite burden as a main factor and 48% indicated “other” reasons for weaner deaths (Campbell et al., 1986). Positively, more recent work indicated that 85% of producers identified nutrition as being the major cause of weaner mortality (Hatcher et al., 2008). This broad knowledge of the issue does not seem to translate into practice, with only 15% of farmers reporting that they gave preferential treatment to weaners of poorer weight (Hatcher et al., 2008). Similarly, flock management by body weight only occurred at 16% of farms in another weaner-focused study (Campbell et al., 2014). The study by Campbell et al. (2014) did identify that weight-based management was more common for crossbred enterprises, which have a higher value on growth in the short-term. While this may well indicate that financial

benefits need to be clear in order for welfare-related outcomes to be pursued on farm, the low proportion of farmers engaging in this sort of management suggests that other factors are involved.

The focus of weaner sheep research has been on mortalities and associated risk factors (as described above), or the management of painful husbandry practices (e.g. Colditz et al., 2009; Levot et al., 2009). Animals suffering from ill-thrift may be in a chronic state of welfare compromise with undernutrition and parasite burden associated with chronic stress to sheep (Dwyer and Bornett, 2004). Those animals that do survive ill-thrift are likely to be physiologically compromised, and so will experience a greater risk of further negative welfare states in the future. Common risks to the welfare of sheep including external parasites and fly strike and lameness would also apply to weaners. Furthermore, weaning itself is a strong psychological stressor that is accompanied by dietary, social and possible environmental changes. Weaning is recognised as a chronic stress that leaves animals susceptible to physiological challenge (Dwyer and Bornett, 2004; Weary et al., 2008), although research in sheep suggests that the physiological responses tend to be minor, and weaning has been ranked as less stressful that isolation/restraint (Mears and Brown, 1997). Finally, their exposure to handling at this time is likely to be negative, with handing to this point in time being associated with painful husbandry practices and separation from the dam. At this stage of development, the human-animal relationship is likely to malleable, but common husbandry practices are strongly associated with negative outcomes, and so perpetuates a negative association with humans (Dwyer and Bornett, 2004).

It is likely that the welfare of the weaner is at a particularly high risk of compromise, and that this is the case for both animals that succumb to mortality and those that survive. Furthermore, there is a high opportunity cost associated with mortality at this age (Hatcher et al., 2008) and risks of poor production into adulthood. These factors combined suggest that a targeted approach to improving weaner survival will have significant production and welfare benefits as effective management of weaner health and welfare is likely to result in improved profits from maiden ewes being more fertile at first joining, to meat sheep being in an appropriate body condition at the point of sale.

3.3 Ewe mortality and welfare

Ewe mortality has been estimated at an average of 2.4% (Campbell et al., 1986), but more recent studies estimate it as being considerably higher. A thorough review of ewe wastage and mortality conducted by McGregor (2007) identified ewe mortality rates of 5 – 6% (range 2 – 25%). This

percentage is supported by ABARE statistics, where farmers reported mortalities were 6.5% nationally (2006). Also in line with McGregor, another study reported annual mortality rates averaged 4.9% (Trompf et al., 2011). Most recently, a study of ewe mortality identified losses of 10% in the Northern Tablelands of New South Wales over a two-year period (Kelly et al., 2014), which the author interpret as in line with the annual rates mentioned above. This study involved individual identification of ewes four times per year, and so is likely to provide an accurate record of ewe mortality. Similarly to weaner mortality statistics, it has been suggested that reported levels of ewe mortality may be conservative (McGregor, 2007).

Causal components of ewe mortality (and wastage) fall into three categories: (1) host effects, which include age, breed, sex and parturition; (2) environmental effects, which include management, nutrition, climate and famer characteristics; (3) agent effects or infectious diseases. Agent effects have the ability to be manipulated, for the most part, if effective vaccination and management practices are employed on farm. Host effects will change over time and may be at least partly modified by selective management and breeding. For environmental factors influencing ewe mortality, nutrition is regularly reported as central to this issue, with risk factors to mortality including pregnancy toxaemia, dystocia, body condition score (BCS) and various mineral deficiencies, all of which are underpinned by nutritional management (McGregor, 2007). Other more acute causes of mortality are also associated with nutrition, with body weight being strongly predictive of death following shearing (Campbell, 2006; Hutchinson, 1965). Appropriate nutrition is under the influence of the stockperson, along with a large number of other risks to welfare, including, monitoring and intervention, stocking density and times of joining and shearing.

Financially, ewe wastage has a major cost and impact on the profitability of enterprises, and reducing adult ewe mortality has the largest effect on the income of a farm because the proportion of the flock in the most productive unit is retained (McGregor, 2007). While it is financially significant, ewe mortality has previously been viewed as of minor concern to farmers, with 63% of farmers describing the issue in this way (Campbell et al., 1986). To the author's knowledge, no recent studies have reported the level of concern producers have towards ewe mortalities. While attitude to ewe mortality remains unknown, a broad survey identified that less than half of producers (47%) either separated their ewes into different mobs according to their nutritional needs, or would be willing to do so; only 32% did or were willing to measure the condition of their ewes (Jones et al., 2011).

Increasing the information available to aid decision making by sheep producers on these issues is heavily focused on in Australia via extension programs. The application of technical knowledge on farm in Australia has been recorded as low, with only marginal improvement of many sheep practices, despite the advancement of knowledge and its dissemination (Robertson and Wimalasuriya, 2004). The implementation of the LTEM program addresses this critical issue of ewe nutrition in a straightforward way. Evaluation of the program indicates its success with participants in LTEM reporting a decrease in their annual mortality rate from 4.9% to 2.8% (Trompf et al., 2011). Similarly, participation in the LTEM sister program, Lifetime Wool, were more likely to change their practices surrounding flock (Jones et al., 2011). While engagement with this program is well executed, how long these behaviours are maintained and what are the barriers to engagement with the program in the first place remain unknown. Prior to involvement in the LTEM program, 42% of farmers quantified ewe mortality rates (increasing to 81% Trompf et al., 2011). In the UK, it is a legal requirement that ewe mortalities are recorded, with levels of mortality above 3% being considered a health and welfare problem (Phythian et al., 2014). It is proposed that presenting accurate data on the issue of ewe mortality would be an important first step in engaging producers that currently do not evaluate ewe condition and nutrition. Understanding mortality links in well with basic improvements to sheep welfare. Ewe mortality relates closely to both lamb and weaner survival, with healthy ewes in a good welfare state producing strong offspring, and these offspring being at a lower risk of chronic welfare compromise throughout their lives.

Similarly to the chronic welfare issues outlined for weaner sheep, ewes are likely to experience compromised welfare in other forms than those leading to mortality. Separation from lambs is a strong psychological stressor, particularly leading to lamb mortality. It is also likely that weaning is a stressful event to the ewe as well, although evidence to date has focused on the weaned lamb. Both exo- and endoparasitic burdens and sub-optimal nutrition are chronic stressors for ewes (Dwyer and Bornett, 2004). Lameness and chronic disease issues such as Ovine Johne's Disease would also compromise ewe welfare. Complications during lambing have the potential to compromise ewe welfare. Assisting ewes with dystocia is commonly associated with mismothering of other ewes and lambs in the same paddock, and is perceived as having no economic benefit (Mellor and Stafford, 2004), so in many cases assistance is not provided. While this may not have a significant welfare compromise to the lamb (as reviewed in section 4.1), the ewe is likely to experience distress and potentially short to long-term pain as a result; however, this has not been quantified.

3.4 Conclusions on sheep mortality and chronic welfare

Mortality rates of weaners and particularly adult ewes are less than neonate lambs; however, suffering associated death may be more prolonged in weaners and ewes. Furthermore, weaning is a stage in which welfare is at a particularly high risk of compromise, and thus those weaners and indeed neonates that survive ill-thrift are likely to be physiologically compromised, and so are likely to experience a greater risk of further negative welfare states in the future. As with weaners, ewes are likely to experience compromised welfare in other forms than those leading to mortality. The loss of neonatal lambs and separation from lambs at weaning are strong psychological stressors, and dystocia is also likely to be painful. Both exo- and endoparasitic burdens and sub-optimal nutrition are also chronic stressors for ewes. Based on these issues, there is a need for a focus on mortality, not only because mortality in itself is likely to involve suffering, but some of the conditions leading to mortality also lead to welfare compromise even for the survivors.

This review has demonstrated that understanding mortalities may closely reflect the welfare of the mob, and so accurately recording mortalities is an important step in welfare assessment. While this is a rudimentary way to assess welfare, it provides opportunity for preventive measures to be taken for the mob, even if this is not the case for the individual. With this in mind, mortality rates should be used in conjunction with other key measures to assess the welfare of extensively managed sheep. It is proposed that by starting to identify mortality rates and possible causes, welfare can be evaluated and improved upon.

4. Welfare assessment

There is a strong focus on the assessment of farm animal welfare. A review by Martin and Blache (n.d.) suggests that a welfare assurance scheme may be a valuable step for the red meat industry. Another recent review from an Australian context proposed a Unified Field Index for welfare assessment (Colditz et al., 2014), and it was suggested the assessment of assesses animal, resource and management areas to quantify welfare.

On-farm welfare assessment of extensively-managed sheep may be difficult because of infrequent observation. The mob's fear of humans makes *in situ* observation difficult. The size of flocks and paddocks, along with attempts to minimise labour costs, means that frequent direct health and welfare observations difficult (Goddard, 2003). For many sheep producers even accurately estimating mortalities is difficult (Turner and Dwyer, 2007; and as outlined throughout section 4). While this is the case, a variety of potential indicators have been presented by Turner and Dwyer

(2007), of which there is a strong focus on the stockperson, including their attitude, frequency of flock inspection, handling methods and skills/training, and their knowledge of sheep health (Table 2).

Table 2: Welfare assessment criteria for extensively managed sheep as proposed by Turner and Dwyer (2007)

Criteria	Secondary criteria	Specific indicator
Environment	Handling facilities	Suitability of flooring
		Existence of protrusions
		Gradient of slopes
	Winter housing	*Not applicable to Australian conditions*
Contingencies	Health	Presence of a health plan
		Availability of medicine
		Specific health knowledge
	Extreme weather	Availability of supplementary feed, water, shelter or shade and labour at short notice*
Stockpersonship	Handling	Use of aversive handling techniques
		Skills and training
	Inspection	Frequency and quality of inspections
	Attitude	Empathy with animals

Those measures proposed in Table 2 are valuable to extensive settings and would allow for assessment to take place without frequent sheep handling; however, they are all resourced based, and the most direct welfare assessment indicators are animal-based measures (Hubbard and Scott, 2011). A large number of potential indicators, including animal-based measures, were identified by Phythian et al. (2011) following a workshop of industry experts. These have been reproduced in Table 3. Other indicators that may be worthwhile considering could include: reactivity to humans, wool blindness, the existence of a bushfire plan, pain-alleviation during surgical husbandry procedures, and sedation for rams during shearing.

As a part of the current Sheep CRC, these issues with welfare indicators in extensive environments are being addressed. This includes a review of potential indicators of extensive sheep welfare and the assessment of remote measures of welfare in an effort to improve individual animal assessment in extensive settings. The experience in developing indicators in Sheep CRC project will be utilised in the current project to identify valid indicators to assess sheep welfare at the study farms. A variety of these measures will be used in the current project to identify the welfare of sheep on farm. The usefulness and perceived validity of these measures from a producer perspective will also be evaluated in work done in collaboration with the current project and that of the Sheep CRC.

Table 3: Potential animal-, resource- and management-based indicators of sheep welfare as proposed by Phythian et al. (2011)

Indicators in italics are not relevant to extensive Australian production systems

Animal-based indicators	Resource-based indicators	Management-based indicators
Alertness to approach in the field	Castration and tail- docking policy	Abattoir feedback
Atypical behaviours	*Flooring type*	Assessment of handling skills
Biochemical measures	Good fencing and farm boundaries	Current flock health plan
Body condition	*Presence of a lie back area*	Disease records
Body injuries and wounds		
Cleanliness (rear and belly)	*Presence of an isolation area*	Ear tagging policy and quality
Ear integrity (tagging injuries)	Presence of handling facilities	Faecal egg count records
Eye condition	*Provision and quality of bedding*	Farmer self-assessment
Fleece condition and wool cover	Provision of shelter and shade	Growth rate records
Gait/lameness	Quality and quantity of food	Judgement of appropriate on-farm action
General demeanour	*Space allowance in housing*	Medicine records
Live weight	Stocking density at grazing	Mixing of different ages and sizes
Nasal discharge	Sward height	Mixing of horned and un-horned sheep
Panting	Trough space	Mortality and culling records
Play behaviours	Water provision, access and quality	Movement records
Presence of in-growing horns		
Qualitative behavioural assessment		Observation of daily farmer tasks
Rumen fill		Observation of specific management procedures (tagging, castration)
Ruminatory behaviour		Policy for hypothermia management
Separation from the flock		Presence of carcasses with live sheep
Skin condition		Reproductive management and policy
Tail length		Scanning records
Thriving lamb assessment		
Time spent standing		Stockperson awareness of on-farm disease
Time to stand and suck		
Urolithiasis		

5. Producer attitudes

Economic drivers significantly impact adoption of practices on farm, and so many extension programs around practice change on farm focus around this; however, this is not the only factor that needs to be considered. Factors influencing decision making and behaviour are complex. For farmers, decision making is partly influenced by financial returns and partly influenced by other psychological and social factors (Ajzen, 1991; Edwards-Jones, 2006). Behaviour is driven by attitudes, subjective norms and perceived behavioural control, as well as financial outcomes (Hemsworth and Coleman, 2011). Attitudes have been defined as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour" (Eagly and Chaiken, 1993). Thus attitudes are: (1) directed towards something; (2) are based on a disposition; and (3) culminate in a positive or negative evaluation (Hemsworth and Coleman, 2011). Importantly, attitudes are learned, and so are able to be modified (Hemsworth and Coleman, 2011).

Psychologists have generally defined three components to attitude: cognition, affect and conation (Hemsworth and Coleman, 2011). Cognition refers to the thoughts that people have about some object; they are beliefs or subjective facts, things which people believe to be true about a person or object. Therefore, if a farmer may believe that sheep are very difficult to handle and require a lot of effort, which would reflect an underlying negative attitude towards working with sheep. Affect refers to the emotional response that a person has towards some other person or object. The extent to which a person likes or dislikes an object is an example of affective response. As such, a farmer that expresses a dislike of sheep, or finds them frustrating to work with, reflects an underlying negative attitude. Finally, conation refers to a tendency to behave in a particular way. A farmer's intention to avoid contact with sheep or to finish work with sheep as quickly as possible, are examples of conation and may also reflect an underlying negative attitude towards sheep. Albarracín and colleagues' (2014) view that the three components are expressions of attitude rather than components of attitude is probably the most reasonable way to conceptualize attitudes in that the three components are outcomes rather than the underlying disposition as such. These three components are all correlated with each other and all contribute to an understanding of the underlying evaluative attitude dimension. This means that measuring any one of the components will provide some indication of a person's attitude.

A major development in the conceptualization of the relationship between attitudes and behaviour came with Fishbein and Ajzen's Theory of Reasoned Action (Ajzen and Fishbein, 1980). This theory was developed to deal with behaviours which were under the person's control, in other words, volitional behaviours and Hemsworth and Coleman (2011) have described the rationale and development of this theory as follows: the three components of attitude (affect, belief and conation)

can better be considered as three response tendencies which represent a sequence in the development of behavioural outcomes. More specifically, the beliefs that people hold, when combined with their evaluations of those beliefs lead to the formation of attitudes. Intentions and actions then follow from these attitudes (Figure 1). A comprehensive picture of a later revision of the model can be seen in Figure 1 (Ajzen and Fishbein, 1980). From this figure, it can be seen that the immediate cause of a person's behaviour is intention. So long as there are no impediments to intention being translated into behaviour, the theory is useful for predicting behaviour. In other words, if there are no physical constraints, such as inability to perform a behaviour or lack of access to the behavioural situation, then a person is likely to do what he or she intends.

The immediate cause of intended behaviour is a person's attitude toward the behaviour in combination with the person's subjective norms with respect to the behaviour. A person's subjective norms refer to the extent to which a person believes that relevant other people would approve of the behaviour and the extent to which the person feels willing to comply with other people's expectations. One important feature of this part of the theory is that the object of the attitude is not some general person (or animal), but a behaviour. The Theory of Reasoned Action relies on attitudes towards specific behaviours rather than objects for prediction of acts. Attitudes are, in turn, determined by a combination of beliefs about the outcomes which are likely to occur following a particular behaviour and an evaluation of those outcomes.

One of the limitations of this theory is that intentions do not always translate into behaviour. This can arise because the beliefs associated with the relevant attitudes are unrealistic and do not accord with the actual behavioural situation. One way in which this can occur arises when the person feels that it is not possible to engage in the relevant behaviour. An example of this that is relevant to livestock production arises when stockpeople at abattoirs think that they cannot engage in best practice in handling animals pre-slaughter because they believe that it is inconsistent with the demands of management that they keep up with the speed demand of the processing facility. To address this, Ajzen and Fishbein (1980) introduced perceived behavioural control as a further factor in predicting behaviour (Figure 1).

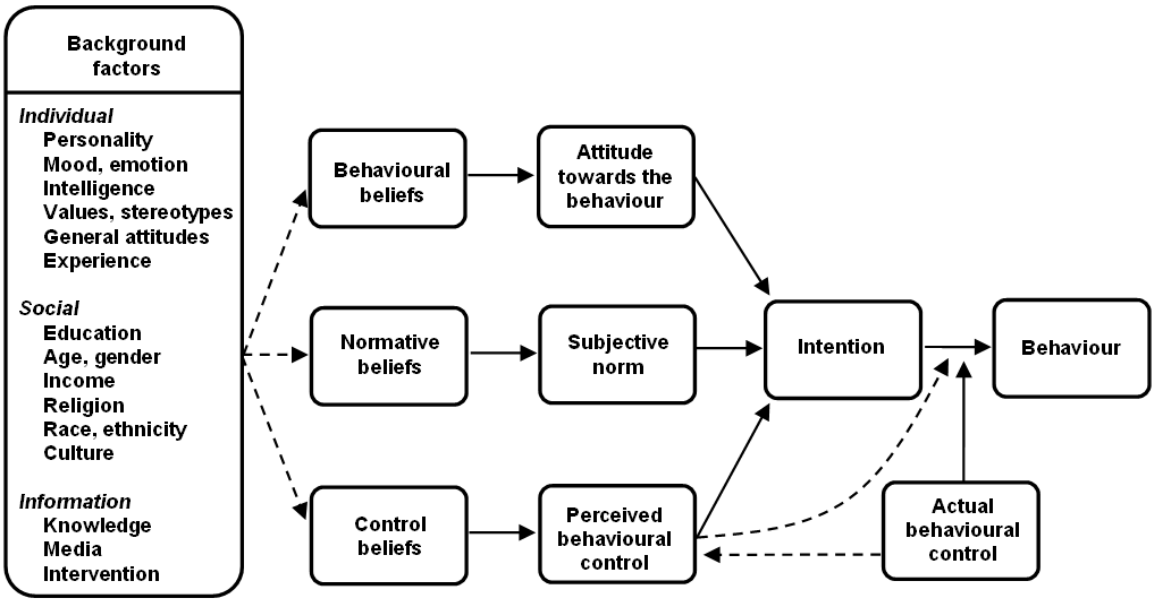


Figure 1: A model of the theories of reasoned action and planned behaviour (adapted by Hemsworth and Coleman, 2011 from Albarrcian et al. (2014)

The antecedents of beliefs, evaluations and motivations are many and varied. As can be seen in Figure 1, demographic variables, past experiences, various general attitudes and personality traits indirectly affect behaviour through their influence on beliefs, evaluations and motivations. It is important to recognize that the Theory of Reasoned Action proposes that the important dispositional factor in predicting behaviour is attitude and other dispositional factors, including personality, operate indirectly through attitudes.

There is a generally consistent attitude-behaviour correlations in the dairy, pig and egg industries (Hemsworth and Coleman, 2011), which indicates that the stockperson's attitude towards interacting with his/her farm animals may affect his/her behaviour towards these animals. These results demonstrate that one of the antecedents of stockperson behaviour appears to be the attitudes that the stockperson holds towards specific behaviour.

Information on sheep farmer attitudes and practices are somewhat limited. In the past years several international studies have focused on farmer perceptions of sheep welfare. When compared to the literature measuring the sheep's response to these situations, discrepancies can be identified. For

example, when scoring the impact handling would have on sheep welfare, farmers identified mustering sheep with the use of dogs as having the lowest impact on welfare (Dwyer, 2009). Despite the perception of farmers, this activity is likely to be distressing to sheep, particularly when raised extensively (Goddard, 2003), and the use of dogs is particularly stressful to sheep (Beausoleil et al., 2005). Farmers also rated their own stress levels during handling as being higher than those of the sheep during the process. In the same study, farmers rated shearing as being low to moderately stressful (Dwyer, 2009); whereas physiological data suggests that this is significantly stressful to sheep (Hargreaves and Hutson, 1990a, 1990b; Sanger et al., 2011). In a recently conducted study, producers scored moderately to severely lame sheep as experiencing less pain and having a less severe emotional reaction than vets (Thompson et al., 2014). While conclusions on the degree of pain experience by sheep cannot be drawn from the study, it does suggest that farmers are less likely to identify lameness, or associate that with compromised. Assessing the perception of welfare compromise along with an objective welfare assessment may help to indicate whether discrepancies in farmer sensitivity can lead to welfare compromise in sheep.

One study comparing attitudes to welfare and management issues identified an interesting relationship. Morgan-Davies and colleagues (2006) compared producer perceptions of welfare issues to welfare on farm. Those farmers that strongly associated ectoparasitic burden with poor welfare were more likely to experience ectoparasitic infestation every year. The study did not identify if producers were more concerned because it occurred more commonly, or were identifying cases more frequently because they perceived it to be of importance/concern. This does support the objective of the current project, insofar as the attitude of the farmer to welfare may likely reflect their practices.

It is well recognised that characteristics that determines a good stockperson include the welfare of their stock, that they possess good skills, attitude and aptitude, have a respect for their animals, a willingness to learn, and the ability to identify and prevent problems, especially chronic ones (Goddard, 2003). Job satisfaction and social recognition influence animal productivity and stockperson work efficiency as well (Boivin, 2003). In terms of understanding the impact of the farmer on mortality (and indeed other welfare concerns), it is important to appreciate (and research) the farmer's behavioural, normative and control beliefs that are associated with the key husbandry practices that are associated with mortality, such as provision of a suitable nutritional and health care, adequate supervision and identification of the problem and then prompt and effective intervention, etc. It is this knowledge that provides the basis for intervention strategies, such as cognitive-behavioural interventions, design to improve these welfare issues. Indeed, studies

of cognitive behavioural intervention by Hemsworth et al. (2002, 1994) and Coleman et al. (2000) demonstrate that this approach to training is practical and effective among a wide range of stockpeople working in a variety of situations.

Conclusions

The extensive management of sheep involves a significant risk of chronic welfare compromise throughout their lives, particularly for weaners and ewes. These chronic welfare issues also significantly impact the profitability of farms, yet trying to encourage behavioural change in farmers based on profitability alone will not lead to significant change. Understanding producer attitudes towards the welfare of sheep on farm, particularly chronic welfare compromise, will help elucidate farmer behaviour towards mortality and welfare issues. From here, this information will be able to be utilised to help modify attitudes with follow on impact to behaviour. Assessing attitudinal modification through the measurement of mortalities and other objective indicators of welfare and profitability changes will help evaluate the impact of any change.

REFERENCE LIST

ABARE, 2006. Farm surveys [WWW Document]. URL http://www.abareconomics.com/ame/mla/mla.asp

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50, 179–211. doi:10.1016/0749-5978(91)90020-T

Ajzen, I., Fishbein, M., 1980. Understanding attitudes and predicting social behaviour.

Albarracin, D., Johnson, B., Zanna, M., 2014. The handbook of attitudes, 2nd ed.

Animal Health Australia, 2014. Australian Animal Welfare Standards and Gudielines for Sheep.

AWSC, 2014. Sheep welfare research planning workshop.

Beausoleil, N.J., Stafford, K.J., Mellor, D.J., 2005. Sheep show more aversion to a dog than to a human in an arena test. Appl. Anim. Behav. Sci. 91, 219–232. doi:10.1016/j.applanim.2004.10.008

Boivin, X., 2003. The human-animal relationship, stockmanship and extensive sheep production. Improv. Sheep Welf. Extensively Manag. ….

Campbell, A., 2006. The effect of time of shearing on wool production and management of a spring-lambing merino flock.

Campbell, A., 2010. Weaner management, in: Cottle, D.J. (Ed.), International Sheep and Wool Handbook. Nottingham University Press, Nottingham, pp. 277–294.

Campbell, A.J.D., Broekhuizen, A., Curtis, K., Croker, K.P., Behrendt, R., Thompson, A.N., 2014. A survey of post-weaning mortality of sheep in Australia and its association with farm and management factors. Anim. Prod. Sci. 54, 783. doi:10.1071/AN13149

Campbell, A.J.D., Vizard, A.L., Larsen, J.W.A., 2009. Risk factors for post-weaning mortality of Merino sheep in south-eastern Australia . Aust. Vet. J. 2009, 305–312.

Campbell, I.P., Clarke, J.D., Love, K.J., 1986. Managing sheep reproduction, knowledge and practices of Victorian sheep producers (1974-1982).

Colditz, I., Ferguson, D., Collins, T., Matthews, L., Hemsworth, P., 2014. A Prototype Tool to Enable Farmers to Measure and Improve the Welfare Performance of the Farm Animal Enterprise: The Unified Field Index. Animals 4, 446–462. doi:10.3390/ani4030446

Colditz, I., Lloyd, J., Paull, D., 2009. Effect of the non-steroidal anti-inflammatory drug, carprofen, on weaned sheep following non-surgical mulesing by intradermal injection of cetrimide. Aust. Vet. ….

Coleman, G.., Hemsworth, P.., Hay, M., Cox, M., 2000. Modifying stockperson attitudes and behaviour towards pigs at a large commercial farm. Appl. Anim. Behav. Sci. 66, 11–20. doi:10.1016/S0168-1591(99)00073-8

Coleman, G.J., Rohlf, V., Toukhsati, S.R., Blache, D., 2014. Development of a public attitude monitoring scheme. Australian Pork Limited - final report.

Council of Europe, 1976. European Convention for the Protection of Farm Animals Kept for Farming Purposes.

Cronin, G.M., Barnett, J.L., Edge, M.K., Hemsworth, P.H., 2002. Identifying animal welfare issues for sheep in Australia. Wool Technol. sheep Breed. 50, 534–540.

Dwyer, C.M., 2008. The welfare of the neonatal lamb. Small Rumin. Res. 76, 31–41. doi:10.1016/j.smallrumres.2007.12.011

Dwyer, C.M., 2009. Welfare of sheep: Providing for welfare in an extensive environment. Small Rumin. Res. 86, 14–21. doi:10.1016/j.smallrumres.2009.09.010

Dwyer, C.M., Bornett, H.L.I., 2004. Chronic stress in sheep: assessment tools and their use in different management conditions. Anim. Welf. 13, 293–304.

Dwyer, C.M., Lawrence, A.B., 2008. Introduction to animal welfare and the sheep, in: Dwyer, C.M. (Ed.), The Welfare of Sheep. Springer, New York.

Eagly, A., Chaiken, S., 1993. The psychology of attitudes.

Edwards-Jones, G., 2006. Modelling farmer decision-making: concepts, progress and challenges. Anim. Sci. 82, 783–790.

FAWC, 2007. FAWC report on stockmanship and farm animal welfare [WWW Document]. Farm Anim. Welf. Counc.

Goddard, P., 2003. Improving sheep welfare on extensively managed flocks : economics , husbandry and welfare. Aberdeen.

Goddard, P., Waterhouse, T., Dwyer, C., Stott, A., 2006. The perception of the welfare of sheep in extensive systems. Small Rumin. Res. 62, 215–225. doi:10.1016/j.smallrumres.2005.08.016

Hargreaves, A.L., Hutson, G.D., 1990a. Changes in heart rate, plasma cortisol and haematocrit of sheep during a shearing procedure. Appl. Anim. Behav. Sci. 26, 91–101.

Hargreaves, A.L., Hutson, G.D., 1990b. An evaluation of the contribution of isolation, up-ending and wool removal to the stress response to shearing. Appl. Anim. Behav. Sci. 26, 103–113.

Hatcher, S., Eppleston, J., Graham, R.P., McDonald, J., Schlunke, S., Watt, B., Thornberry, K.J., 2008. Higher weaning weight improves postweaning growth and survival in young Merino sheep. Anim. Prod. Sci. 48, 966–973.

Hemsworth, P.H., Coleman, G.J., 2011. Human-Livestock Interactions, 2nd ed. CAB International, Oxon, UK.

Hemsworth, P.H., Coleman, G.J., Barnett, J.L., 1994. Improving the attitude and behaviour of stockpersons towards pigs and the consequences on the behaviour and reproductive performance of commercial pigs. Appl. Anim. Behav. Sci. 39, 349–362. doi:10.1016/0168-1591(94)90168-6

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. J. Anim. Sci. 80, 68–78.

Hemsworth, P.H., Coleman, G.J., Jongman, E.., Rice, M., 2010. Farmer and public attitudes to lamb finishing systems. DEPI Research Report.

Hemsworth, P.H., Coleman, G.J., Jongman, E.., Rice, M., n.d. Confinement of lambs - welfare implications. DEPI Research Report.

Holmes Sackett & Associates Pty. Ltd., 2005. Aginsights. Wagga Wagga.

Hötzel, M., Appleby, M., 2014. Improving Farm Animal Welfare: Is Evolution or Revolution Needed in Production Systems? Dilemmas Anim. ….

Hubbard, C., Scott, K., 2011. Do farmers and scientists differ in their understanding and assessment of farm animal welfare? Anim. Welf. 20, 79–87.

Hutchinson, K.J., 1965. BODYWEIGHT CRITERIA AND POST SHEARING DEATHS, CSIRO Publishing.

Hutson, G.D., Barnett, J.L., Cronin, G.M., Hemsworth, P.H., 2001. A review of welfare issues for sheep and beef cattle production in Australia. DEPI Research Report.

Jones, A., van Burgel, A.J., Behrendt, R., Curnow, M., Gordon, D.J., Oldham, C.M., Rose, I.J., Thompson, A.N., 2011. Evaluation of the impact of Lifetimewool on sheep producers. Anim. Prod. Sci. 51, 857. doi:10.1071/EA08303

Kelly, G.A., Kahn, L.P., Walkden-Brown, S.W., 2014. Risk factors for Merino ewe mortality on the Northern Tablelands of New South Wales, Australia. Aust. Vet. J. 92, 58–61.

Langlands, P., Donald, G.E., Paull, D.R., 1984. Effects of different stocking intensities in early life on teh productivity of Merino ewes grazed as adults at two stocking rates - 3. Survival of ewes and their lambs, and the implications for flock productivity. Aust. J. Exp. Agric. 24, 57–65.

Levot, G.W., Rothwell, J.T., Sales, N., Dawson, K.L., Lloyd, J.B., 2009. Effectiveness of a non-surgical alternative to the Mules operation in sheep. Aust. Vet. J. 87, 142–7. doi:10.1111/j.1751-0813.2009.00409.x

Martin, G., Blache, D., n.d. Review of animal welfare QA systems for livestock industries in the UK and Europe.

McGregor, B., 2007. Principal causes of reduced longevity and wastage in ewe flocks: a review. Dep. Prim. Ind. Attwood, Vic.

Mears, G.J., Brown, F.A., 1997. Cortisol and β-endorphin responses to physical and psychological stressors in lambs. Can. J. Anim. Sci. 77, 689–694.

Mellor, D.J., Stafford, K.J., 2004. Animal welfare implications of neonatal mortality and morbidity in farm animals. Vet. J. 168, 118–33. doi:10.1016/j.tvjl.2003.08.004

Morgan-Davies, C., Waterhouse, A., Milne, C.E., Stott, A.W., 2006. Farmers' opinions on welfare, health and production practices in extensive hill sheep flocks in Great Britain. Livest. Sci. 104, 268–277. doi:10.1016/j.livsci.2006.04.024

Phillips, C.J.C., Phillips, A.P., 2010. Attitudes of Australian sheep farmers to animal welfare. J. Int. Farm Manag. 5, 1–26.

Phythian, C., Phillips, K., Wright, N., Morgan, M., 2014. Sheep health, welfare and production planning 1. Recording and benchmarking performance indicators of flock health and production. In Pract. 36, 85–92. doi:10.1136/inp.g1197

Phythian, C.J., Michalopouluo, E., Jones, P.H., Winter, A.C., Clarkson, M.J., Stubbings, L.A., Grove-White, D., Cripps, P.J., Duncan, J.S., 2011. Validating indicators of sheep welfare through a consensus of expert opinion. Animal 5, 943–952.

Robertson, S.M., Wimalasuriya, R.K., 2004. Limitations to pasture and sheep enterprises and options for improvement in the Victorian Mallee. Aust. J. Exp. Agric. 44, 841. doi:10.1071/EA03030

Sackett, D., Holmes, P., Abbott, K., Jephcott, S., Barber, M., 2006. Assessing the economic cost of endemic disease on the profitability of Australian been cattle and sheep producers. Meat and Livestock Australia Limited, North Sydney.

Sanger, M.E., Doyle, R.E., Hinch, G.N., Lee, C., 2011. Sheep exhibit a positive judgement bias and stress-induced hyperthermia following shearing. Appl. Anim. Behav. Sci. 131, 94–103.

Sloane, B., Wentworth, S., 2010. A producer survey of sheep husbandry practices in Australia.

Stafford, K., 2014. Sheep veterinarians and the welfare of sheep: No simple matter. Small Rumin. Res. 118, 106–109. doi:10.1016/j.smallrumres.2013.12.008

Stott, A.W., Milne, C.E., Goddard, P.J., Waterhouse, A., 2005. Projected effect of alternative management strategies on profit and animal welfare in extensive sheep production systems in Great Britain. Livest. Prod. Sci. 97, 161–171. doi:10.1016/j.livprodsci.2005.04.002

Stott, A.W., Vosough Ahmadi, B., Dwyer, C.M., Kupiec, B., Morgan-Davies, C., Milne, C.E., Ringrose, S., Goddard, P., Phillips, K., Waterhouse, A., 2012. Interactions between profit and welfare on extensive sheep farms. Anim. Welf. 21, 57–64.

Thompson, C.S., Rutherford, K.M.D., Conington, J., Williams, J., Zanella, A.J., 2014. Farmers and veterinarians perceptions of lameness and pain in sheep.

Trompf, J.P., Gordon, D.J., Behrendt, R., Curnow, M., Kildey, L.C., Thompson, A.N., 2011. Participation in Lifetime Ewe Management results in changes in stocking rate, ewe management and reproductive performance on commercial farms. Anim. Prod. Sci. 51, 866. doi:10.1071/AN10164

Turner, S., Dwyer, C., 2007. Welfare assessment in extensive animal production systems: challenges and opportunities. Anim. WELFARE-POTTERS BAR ….

Walker, S.K., Kleemann, D.O., Bawden, C.S., 2002. Sheep reproduction in Australia: Current status and potential for improvement thruogh flock management and gene discovery.

Waterhouse, A., 1996. Animal welfare and sustainability of production under extensive conditions—A European perspective. Appl. Anim. Behav. Sci. 49, 29–40. doi:10.1016/0168-1591(95)00665-6

Weary, D.M., Jasper, J., Hötzel, M.J., 2008. Understanding weaning distress. Appl. Anim. Behav. Sci. 110, 24–41. doi:10.1016/j.applanim.2007.03.025

15.2 Stakeholder perceptions of welfare issues and indicators for extensively managed sheep

Doughty A. K., Coleman G. J., Hinch G. N. and Doyle R. E. 'The welfare of extensively managed sheep: a survey identifying issues and indicators'. International Society of Applied Ethology, Edinburgh, Scotland, July 2016

A survey was designed as a first step in developing a framework for the welfare assessment and monitoring of extensively managed sheep in Australia with the aim of identifying potential causes of welfare compromise, useful welfare indicators and current monitoring practices. The survey was developed and conducted online using Survey Monkey. It was distributed to contacts in industry, research institutions/universities, government agricultural organisations, the RSPCA and social media outlets. Participants were asked between 14 and 26 questions that varied from scaled (1-5) to open ended. A range of 20 welfare issues were provided for consideration including thermal comfort and painful procedures. A total of 952 people completed the survey in its entirety, representing four stakeholder groups: Public (53.6%), Producer (27.4%), Scientist (9.9%), and Service provider (9.1%). Descriptive statistics, principle components analysis, restricted maximum likelihood analysis and Pearson's correlations were conducted. Sheep welfare was considered to be important by all participating groups in this survey (average score of 3.78/4), and respondents felt the welfare of grazing sheep was generally adequate but improvement was desired (2.98/5). Flystrike (4.25/5), nutrition (4.07) and predation (3.95) were considered to pose the greatest risk to sheep welfare, whereas yarding (3.01) and the use of sheep dogs (2.87) were perceived to have the lowest risk. Stakeholder category significantly influenced respondents' perceptions of grazing sheep welfare ($p<0.001$) and their self-reported issues, with the public believing off-farm issues posed the most significant risk (n=189, 19.9%). Women were more concerned about welfare than men and consistently rated welfare issues to be of greater significance (all $p<0.05$). Key indicators recognised by all respondents were those associated with pain and fear (3.98/5), nutrition (4.23), food on offer (4.40), mortality/management (4.27) and number of illness/injures in a flock (4.33). Again, there were stakeholder and gender differences with women and the public rating most indicators of greater importance than other respondents (all $p<0.05$ and $p<0.01$, respectively). Within the Producer group the majority (>90%) indicated that they monitored sheep for all listed issues. Overall these results suggest that there is general agreement on the ranking of importance of key welfare issues and indicators of grazing sheep across a wide range of stakeholders. Therefore, broad agreement may be possible on factors suitable for inclusion in any welfare assessment scheme and monitoring framework developed in the future.

Doughty AK, Coleman GJ, Hinch GN and Doyle R. E. (2017). Stakeholder perceptions of welfare issues and indicators for extensively managed sheep. *Animals*. 7:28

Article

Stakeholder Perceptions of Welfare Issues and Indicators for Extensively Managed Sheep in Australia

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Simple Summary: This survey was designed as the first step in the development of a welfare assessment framework with the aim of identifying potential causes of welfare compromise and useful indicators for sheep in extensive Australian production systems. We asked the general public, sheep producers, service providers and sheep industry related scientists to provide their thoughts on the importance of a range of sheep welfare issues and possible key indicators. All respondents thought sheep welfare was adequate but that improvement was desired. Issues perceived to cause the most risk to sheep related to factors influenced by the environment (i.e., nutrition and food supply), heat stress and lameness while key indicators useful to assess welfare were nutrition and food availability, mortality/management issues, pain and fear related indicators, and numbers of illness/injuries. Women and the general public perceived all issues and indicators to be more important than other groups of respondents. These results highlight the need to consult a wide range of stakeholders in order to develop a broadly acceptable assessment system.

Abstract: An online survey was designed to form the basis of a framework for the welfare assessment of extensively managed sheep in Australia. The survey focused on welfare compromise and useful welfare indicators. A total of 952 people completed the survey in its entirety, representing four stakeholder groups: Public (53.6%), Producer (27.4%), Scientist (9.9%), and Service provider (9.1%). Animal welfare was considered to be important by all participating groups in this survey (average score of 3.78/4). Respondents felt the welfare of grazing sheep was generally adequate but improvement was desired (2.98/5), with female members of the public rating sheep welfare significantly worse than other respondents ($p < 0.05$). Environmental issues were considered to pose the greatest risk to welfare (3.87/5), followed by heat stress (3.79), lameness (3.57) and husbandry practices (3.37). Key indicators recognised by all respondents were those associated with pain and fear (3.98/5), nutrition (4.23), mortality/management (4.27), food on offer (4.41) and number of illness/injures in a flock (4.33). There were gender and stakeholder differences in the perceived importance of both welfare issues and indicators with women and the public consistently rating issues (all $p < 0.01$) and indicators (all $p < 0.05$) to be of greater significance than other respondents. These results highlight the importance of including all stakeholders and an even balance of genders when developing a welfare framework that can address both practical and societal concerns.

Keywords: animal welfare; attitudes; gender; general public; producers; survey; welfare indicators; welfare issues

1. Introduction

Extensive sheep production systems differ considerably from more intensive systems and sheep tend to be maintained on pasture outdoors year round and provided supplementary feed as required. The welfare of sheep in these systems is generally considered to be high (Turner and Dwyer 2007). This is largely due to sheep being perceived to be able to express natural behaviours in the farm setting. Three other drivers are also attributed to this perception: (1) the general public assumes that extensive conditions equal positive welfare; (2) issues faced in extensive production are perceived by producers as being 'natural' and therefore are either not easily addressed, and/or important to address; and (3) there is a belief that sheep have evolved in these extensive conditions, and so are well adapted to the environment in which we manage them (Turner and Dwyer 2007).

However, the extensive management that creates a positive perception of sheep welfare may also create welfare risks. Extensively managed sheep are at risk of climatic extremes, predation and variable nutrition. Their contact with humans can be limited, and so any contact that does occur is likely to be associated with fear and distress, and this also reduces the ability to identify and treat health problems (Fisher and Mellor 2002; Turner and Dwyer 2007). One comprehensive study that gauged the opinions of sheep experts (Phythian *et al.* 2011) identified welfare issues for sheep in extensive UK settings that incorporate all of the Five Freedoms: 14 issues were associated with hunger and thirst; 14 with discomfort; 11 with pain/injury/disease; 8 with ability to express normal behaviour; and 10 with fear and distress. This suggests that potential compromises to welfare do exist and are worth monitoring.

The scientific assessment of animal welfare provides objective evidence about what an animal is experiencing, has experienced or is likely to experience. While such assessment is complex, decisions about what are acceptable levels of animal welfare require ethical judgements that underlie determining what is the "right" or "wrong" way to treat an animal (Palmer and Sandøe 2011). A variety of factors influence a person's perceptions of an animal's welfare, much of which are driven by their attitudes and beliefs (Serpell 2004) and consequently perceptions about sheep welfare are likely to differ significantly based on who is asked. Expert opinion has been commonly used to identify welfare issues for the sheep industry (Cronin *et al.* 2002; Phythian *et al.* 2011), as well as providing information on key indicators (Phythian *et al.* 2012), and has given a meaningful focus for research and extension programs. Consulting more broadly also has its benefits. Producer perspectives of welfare are arguably the most important (Coleman *et al.* 2003; Vanhonacker *et al.* 2008; Kauppinen T *et al.* 2010) as they can identify a breadth of welfare issues seen on their farms, and have the day-to-day experience and control over the management of their animals. The perceptions that the general public have about welfare are also important as they consume the products and give the industry its "social licence" (Martin and Shepheard 2011), or public trust (Verbeke 2009). Public attitudes and values are also the drivers for animal welfare improvements, particularly the level of cognition and consciousness attributed to a species (Kirkwood and Hubrecht 2001), and while progress into understanding these differences has been made, there is still much more to be understood, including how citizens consider and assess animal welfare (Vanhonacker *et al.* 2010).

Surveys about extensively managed sheep have been conducted on individual stakeholders (Morgan-Davies *et al.* 2006; Phillips and Phillips 2010; Phythian *et al.* 2011), as have surveys about intensive sheep management across multiple stakeholder groups (Coleman *et al.* 2016). To our knowledge, the only survey investigating welfare issues across stakeholder groups for extensively managed sheep was conducted by Phillips et al. (2009). This survey assessed perceptions on welfare issues and compared welfare scenarios in sheep, goats and beef cattle, targeting specific stakeholder groups including animal rights advocates (Phillips *et al.* 2009), but did not survey the general public. There has also been little research on suitable indicators of sheep welfare in extensive systems. Work done by Phythian et al. (2011) on welfare indicators for sheep in a UK setting reported that there is a wide range of possible indicators that could be used in on-farm assessments and some of these have been utilised in a recently released welfare assessment protocol (AWIN 2015). Suitable indicators were identified through expert opinion groups; however it remains unclear how acceptable they are to both the producers, who will be utilising them, and the general public. While it is likely that the general public has little interest in developing a detailed knowledge of animal management and husbandry practices (Frewer *et al.* 2005; Coleman *et al.* 2016), areas of agreement between the various stakeholder

groups toward suitable key indicators should be considered along with reliability, validity and feasibility when developing a welfare assessment framework.

With this in mind, the current study was designed to form the basis of a comprehensive framework for the welfare assessment of extensively managed sheep in Australia, thus adding to the work outlined above. We did so by surveying interested stakeholders to identify what they considered to be the important risks to sheep welfare and key indicators of welfare state. Based on previously published evidence, it was hypothesised differences would exist between stakeholder groups (Phillips *et al.* 2009; Phillips and Phillips 2010; Coleman *et al.* 2016). Having a better understanding of perceptions of the welfare of extensively managed sheep can help to focus research needs and targeted engagement for stakeholder groups. This can also be useful information for future animal welfare standards and legislations.

2. Materials and Methods

This study received ethics approval from the University of Melbourne's School of Land and Environment Human Ethics Advisory Group on 14-11-2014 (Ethics ID: 1443082).

2.1. Survey Description

A large survey was conducted to obtain information about people's perceptions of extensively farmed sheep in Australia. The final format of the survey was determined through extensive consultation with an advisory group of 10 that comprised experienced animal welfare scientists (*n* = 3), industry advisors (2), sheep extension officers (2) and sheep producers (3). The survey was conducted online and was developed using the online survey platform Survey Monkey (Survey Monkey Inc. 2014). Once participants had read through the introduction, they selected which stakeholder category best described them: sheep farmer (producer), sheep industry service provider or advisor (service provider), sheep focused scientist/researcher (scientist), general public, or other. While all stakeholders answered a set of 11 common questions, some requiring multiple responses, participants also answered additional questions tailored specifically for that stakeholder group category. Questions covered perceived welfare issues, perceptions of welfare indicators and self-rated knowledge, along with basic demographic questions. The question formats varied with the question and involved: (1) respondents selecting a single choice from the range provided; (2) selecting the most appropriate response on a Likert scale; and (3) replying freely to an open-ended question (Table 1). Likert scales were 1–5 for all questions except for the question "What is your belief about animal welfare?", which had a scale of 1–4.

2.2. Survey Distribution

The survey was accessible from the 8 December 2014 to the 8 January 2015 inclusively. The link to the survey was distributed through a variety of sources, aimed at encouraging interested parties to participate. There was no reward/incentive for participating.

The survey was distributed throughout Australia in a variety of ways ranging from subscribers of the Cooperative Research Centre for Sheep Industry Innovation (Sheep CRC) news bulletin (which has 6000 subscribers, no prerequisites for joining, and is made up of producers, industry service providers and others with an interest in sheep production) to the Facebook pages of RSPCA Australia (both state and national) and to 15 research institutions/universities/state government agricultural organisations.

Table 1. Specific questions and response options for the topics "demographics", "knowledge and beliefs" and "risks to sheep welfare" and "key indicators" investigated in the survey.

Question Category	Stakeholder Group	Specific Question	Answer Options
Demographics	All	Gender	
		Highest level of education	No formal schooling; Primary school; High school; Technical or further educational institution (incl. TAFE); University or higher
		Year of birth	
		State of Australia	
		Current residential location	Urban; Suburban; Peri-urban; Regional city; Country town; Rural; Remote
Knowledge and beliefs	All	What is your belief about animal welfare?	An insignificant issue; Of minor importance; Of moderate importance; Of major importance
		I think the welfare of grazing sheep in Australia is…	Very poor; Poor with many areas for improvement; Generally adequate but some areas could be improved; Adequate; Excellent
		How would you rate your understanding of Australian sheep production systems?: • The sheep meat industry • The wool industry	Poor; Limited; Moderate; Knowledgeable; Very knowledgeable
	General public	How would you rate your understanding of the following sheep-related management practices in Australia?: • Parasite control • Lambing • Mulesing • Tail docking • Castration • Crutching/shearing • Nutritional requirements • General sheep husbandry	Poor; Limited; Moderate; Knowledgeable; Very knowledgeable

Factors affecting sheep welfare	All	Rate how important the following issues can be in compromising the welfare of grazing sheep in Australia: • Cold stress • Disease • Flystrike • Heat stress • Painful husbandry procedures (excluding mulesing) • Internal parasite burden • Lambing difficulties • Lameness • Mental state of the animal • Mulesing • Nutrition and food supply • Poisonous plants • Predation by dogs, pigs, foxes • Pregnant ewe body condition • Pregnant ewe health • Road transport • Shearing/crutching • Use of sheep dogs • Weekly monitoring • Yarding	Number from 1–5, with 1 = no compromise through to 5 = extreme compromise
		In your opinion, what are the three most important welfare issues in the Australian sheep industry? List in order of importance. You can use those from the question above or add your own.	Open-ended responses

Welfare indicators	All	What would you want to know if you were to assess the welfare of sheep?: • Changes in body condition score • Changes in liveweight • Environmental conditions • Ewe mortality across the whole flock • Fearfulness (distance of flight zone) • Feed on offer • Frequency of monitoring • Internal parasite burden • Lamb mortality across the whole flock • Level of pain mitigation used during husbandry procedures associated with pain • Mental state of the animal • Number of illness/injuries in a flock • Occurrences of husbandry procedures associated with pain • Occurrences of lameness • Severity of illness/injuries to individual animals • Stocking density under grazing conditions • Stockmanship skill level	Number from 1–5, with 1 = unimportant through to 5 = essential

2.3. Data Management and Statistical Analyses

All data were managed and analysed using the statistical program R (R Core Team, Vienna, Austria) (R Core Team 2016). Before analysis, responses were assessed for legitimacy. Four responses scored the maximum or minimum for all questions, and none of these gave comments/further information about their perceptions, so they were deemed uninformative and were removed from the dataset. Only the results from people who had completed the survey in its entirety were used for the analysis, and 88 respondents that identified themselves as 'other' were able to be reallocated to one of the four stakeholder groups for statistical analysis based on the written description they gave of their role in the sheep industry. Where details were insufficient the record was deleted.

Principal Components Analyses (PCA) with Oblimin rotations were used to summarise the 20 welfare issues and the 17 welfare indicators into meaningful components. PCA is widely used to assist in classifying terms that have been measured using Likert scales (Norman 2010). The criteria for classification of components were that the variable had to have a loading on the relevant component of at least 0.34 and must not load on more than one component (Tabachnick and Fidell 2007). This resulted in two components for the welfare issues and two issues remained independent of the components; for the welfare indicators, three components were generated and two indicators remained independent (Table 2). Composite scores for the components were then calculated by adding the Likert scores for each of the variables in the component and taking the average.

Table 2. Principal components analysis and variables for the survey questions.

Question	Component	Variables	Variance Accounted (%)	Eigenvalue (%)
Welfare issues	Environmental issues	Cold stress Disease Flystrike Internal parasite burden Lambing difficulties Nutrition and food supply Poisonous plants Predation by dogs, pigs, foxes Pregnant ewe body condition Pregnant ewe health	58.7	11.7
	Husbandry practices	Mental state of the animal Mulesing Painful husbandry procedures (excluding mulesing) Road transport Shearing/crutching Use of sheep dogs Weekly monitoring Yarding	9.2	1.8
	Independent	Lameness		
	Independent	Heat stress		
Welfare indicators	Pain and fear	Fearfulness (distance of flight zone) Frequency of monitoring Level of pain mitigation used during painful procedures Mental state of the animal Occurrences of procedures associated with pain Occurrence of lameness Severity of illness/injuries to individuals	50.8	8.6
	Nutrition	Changes in body condition score Changes in live weight Environmental conditions	9.8	1.7
	Mortality and management	Ewe mortality rate across flock Internal parasite burden Lamb mortality rate across flock Stocking density under grazing conditions Stockmanship skill level	4.8	0.8
	Independent	Feed on offer		
	Independent	Number of illness/injuries in the flock		

Parametric analyses were used for the Likert Scale data, which is a common way to manage survey data, particularly in the case of composite scores that arise from PCA (Norman 2010). Analyses of variance (ANOVA) were used to analyse differences between stakeholders and gender, with these factors (stakeholder and gender) and their interaction included as independent variables (Appleby 1999). An ANOVA was performed to investigate differences between the levels of self-rated knowledge the general public attributed to the different questions, and post-hoc comparisons were performed using least significant differences. Post-hoc comparisons were performed using Tukey's tests in the program Agricolae. Pearson's correlations were conducted to investigate relationships between demographics, welfare beliefs and self-rated industry knowledge, and Spearman's rank correlations were used to investigate the relationship between education (an ordinal variable) and beliefs about animal welfare and sheep welfare. Correlation values were classified as strong if coefficients were ≥ 0.5 and moderate if between 0.3 and 0.49 (Cohen 2013).

3. Results

3.1. Demographics

A total of 1535 people responded to the survey during the month it was open, and 956 of these completed the survey in its entirety. Of these, 15 were under 18 years of age. While the survey was voluntary, the ethics application only covered participants 18 years or over, and so these 15 were removed from the results. The breakdown of the 941 valid participants according to stakeholders was: General public = 499 (53.0%), Producer = 260 (27.6%), Scientist = 95 (10.1%), and Service provider = 87 (9.2%). The genders of the respondents were skewed towards women (61.2% overall), and a difference within each stakeholder category existed; the percentages of women represented in each group were: 27% for producers, 45% scientists, 25% service providers and 88% general public. The majority (70%) of survey respondents were tertiary educated, (a higher proportion than the 44% of Australians in the general population(Australian Bureau of Statistics 2016)) with others being trained at a technical institute (19.0%) or high school (11%). Participants age ranged from 18 years old to 82 years old, with both an average age and median age of 47 (1967) and the mode was 58 (1956).

All of Australia's states and territories were represented, with the largest portion coming from New South Wales (30.8%) and then Victoria (27.6%), South Australia (15.3%), Western Australia (10.8%), Queensland (9.9%), Tasmania (3.3%), the Australian Capital Territory (1.5%) and the Northern Territory (0.8%); with these proportions being roughly equitable with the overall distribution of the population. The general public, sheep industry service providers and sheep-specific scientists were asked to select their current residential location, with producers all being classified as rural and not included below. The majority of respondents were suburban (27.2%) and 14.2% were rural, followed by urban (11.4%), country town (9.5%), regional city (7.0%), peri-urban (3.5%) and remote (0.3%); which was again roughly equitable with the overall distribution of the population, except for rural respondents, which was higher and reflective of the agricultural focus of this survey.

3.2. Welfare Issues

The majority of respondents considered animal welfare to be of major importance and women scored significantly higher than men on this response ($F_1 = 21.66$, $p < 0.001$; Table 3). All of the 20 issues presented to respondents were identified as posing some degree of risk as all were above the midpoint of 2.5/5. Flystrike (4.25/5), nutrition (4.07) and predation (3.96) were perceived to be the greatest welfare issues; shearing (3.28), yarding (3.01) and the use of sheep dogs (2.87) were the least. While these three issues were considered to be of less risk, they were still above the scale midpoint.

Table 3. Gender-based differences in beliefs about animal welfare, specific welfare issues and indicators used to assess welfare. Means with standard deviations presented in parentheses.

Topic	Gender		Overall
	Female	Male	

Belief about animal welfare [1]		3.88 (±0.43)	3.61 (±0.69)	3.78 (±0.07)
Welfare issue [2]	Environmental	3.98 (±0.98)	3.69 (±0.78)	3.87 (±0.12)
	Husbandry practices	3.71 (±1.11)	2.85 (±0.89)	3.37 (±0.13)
	Heat stress	4.14 (±1.17)	3.23 (±1.08)	3.79 (±0.15)
	Lameness	3.81 (±1.15)	3.22 (±1.05)	3.57 (±0.15)
Welfare indicator [3]	Management issues	4.44 (±0.65)	4.01 (±0.70)	4.27 (±0.09)
	Food on offer	4.55 (±0.65)	4.19 (±0.70)	4.41 (±0.10)
	Number of illness/injuries in the flock	4.58 (±0.73)	3.93 (±0.96)	4.33 (±0.12)

[1] Responses could range from 1 = insignificant to 4 = major importance; [2] Responses could range from 1 = no compromise to welfare to 5 = significantly compromises welfare; [3] Responses could range from 1 = unimportant to know to 5 = essential to know.

The PCA identified four broad issues and, when analysing the composite scores derived from the PCA, environmental issues scored the highest and husbandry practices scored the lowest, and the scores were significantly different from each other ($F_3 = 37.52$, $p = 0.000$). Gender differences were noted for all welfare issues (all $p < 0.05$), with women consistently considering the risk of welfare compromise to be higher than men (Table 3). Stakeholder also significantly influenced the results, with the general public considering welfare to be more important than the other three groups ($F_3 = 13.20$, $p < 0.001$; Table 4). Respondents felt that the welfare of grazing sheep was generally adequate, but with improvement required, with a significant interaction between gender and stakeholder ($F_3 = 2.65$, $p = 0.048$; Figure 1).

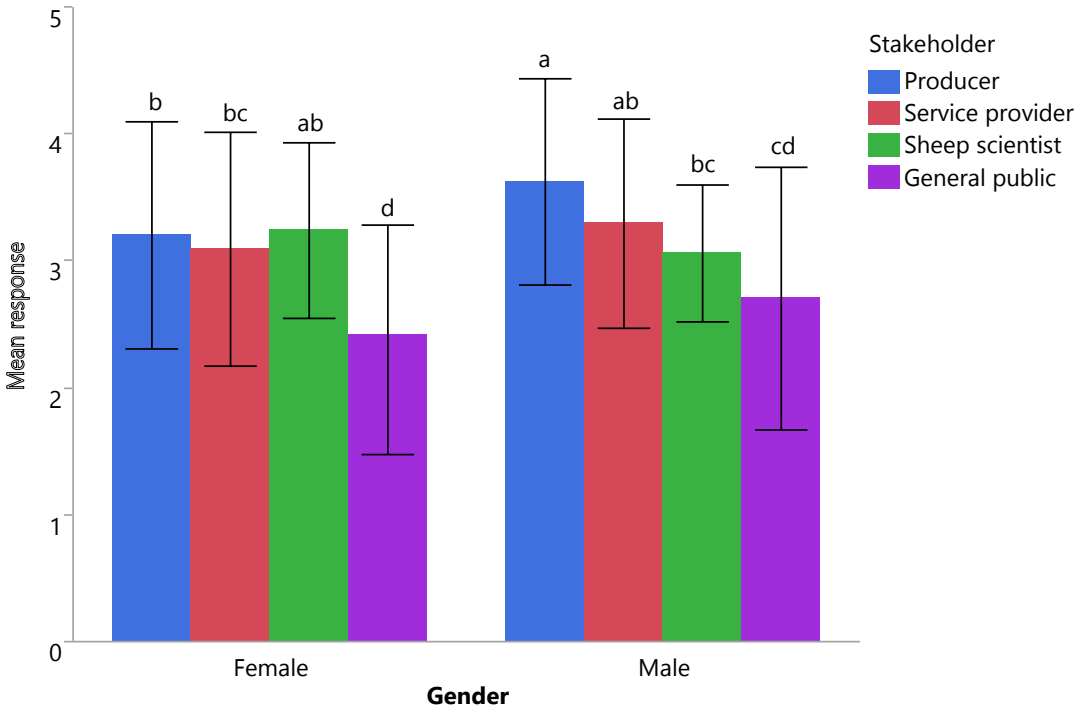

Figure 1. Belief about the welfare of grazing sheep in Australia according to different stakeholders and genders with a significant interaction present between gender and stakeholder ($p < 0.05$); survey responses could range from 1 = very poor to 5 = excellent; differences between letters ([a], [b], [c], [d]) indicate statistically different means at $p < 0.05$; bars represent standard deviations.

Table 4. Stakeholder-based differences in beliefs about animal welfare, specific welfare issues and indicators used to assess welfare. Means with standard deviations presented in parentheses.

Topic		Stakeholder Group				Overall
		Producers	Service Providers	Scientist	General Public	
Belief about animal welfare [1]		3.65 [b,*] (±0.70)	3.63 [b] (±0.53)	3.69 [b] (±0.49)	3.88 [a] (±0.46)	3.78 (±0.17)
Welfare issue [2]	Environmental	3.62 [b] (±0.77)	3.88 [ab] (±0.68)	3.91 [a] (±0.71)	3.98 [a] (±1.02)	3.87 (±0.27)
	Husbandry practices	2.73 [c] (±0.90)	2.316 [b] (±0.80)	3.09 [b] (±0.86)	3.83 [a] (±1.10)	3.37 (±0.30)
	Heat stress	3.14 [c] (±1.07)	3.38 [bc] (±1.01)	3.57 [b] (±1.05)	4.24 [a] (±0.78)	3.79 (±0.34)
	Lameness	3.05 [c] (±1.04)	3.46 [b] (±0.90)	3.49 [b] (±1.04)	3.90 [a] (±1.16)	3.57 (±0.33)
Welfare indicator [3]	Management issues	4.06 [b] (±0.72)	4.02 [b] (±0.65)	3.95 [b] (±0.69)	4.49 [a] (±0.63)	4.27 (±0.20)
	Food on offer	4.31 [b] (±0.77)	4.37 [ab] (±0.87)	4.12 [b] (±0.93)	4.52 [a] (±0.76)	4.41 (±0.24)
	Number of illness/injuries in the flock	3.97 [b] (±0.96)	3.99 [b] (±0.99)	4.10 [b] (±0.96)	4.65 [a] (±0.68)	4.33 (±0.25)

[1] Responses could range from 1 = insignificant to 4 = major importance; [2] Responses could range from 1 = no compromise to welfare to 5 = significantly compromises welfare; [3] Responses could range from 1 = unimportant to know to 5 = essential to know; * Values with different superscripts ([a], [b], [c]) indicate statistically significant differences within rows at $p < 0.05$.

A minor, negative correlation was present between the two welfare belief-related questions (r (928) = −0.29, $p < 0.001$), indicating that as belief about the importance of animal welfare increases, perception of the welfare of grazing sheep decreases. There were no statistically significant relationships between education and animal welfare beliefs (r (955) = −0.056, $p = 0.08$), or the perception of grazing sheep welfare (r (929) = 0.048, $p = 0.88$), nor were there for age and animal welfare beliefs (r (952) = 0.015, $p = 0.65$), or age and the perception of grazing sheep welfare (r (926) = 0.026, $p = 0.44$).

Following questions where respondents were asked to consider specific welfare issues, they were also asked to list the three welfare issues they perceived to be most important. This was an open-ended question provided to all participants and they could respond by either using issues from previous questions and/or include other issues they considered to be important. For position 1 (the most important welfare issue) the frequent responses were "Live export" (n = 189, 19.9%), followed by "Mulesing/wrinkle score of the sheep/alternatives to mulesing" (n = 124, 13.0%) and then "Flystrike" (n = 85, 8.9%). For position 2 (the second most important welfare issue) the frequent responses were "Mulesing/wrinkle score of the sheep/alternatives to mulesing" (n = 90, 9.5%), "Environmental comfort" (heat stress, inadequate shelter, cold stress, space; n = 72, 7.6%) and "Pain, painful/stressful husbandry practices, stress and pain management" (n = 68, 7.1%). In position 3 (the third most important welfare issue) the most frequent replies were "Nutrition" (adequate access to food, stocking rates, improving nutritional values of pasture, overstocking feed supply; n = 76, 8.0%), "Predation and predator attacks" (n = 67, 7.0%), "Pain, painful/stressful husbandry practices, stress and pain management" (n = 66, 6.9%) and "Environmental comfort" (heat stress, inadequate shelter, cold stress, space; n = 65, 6.8%). These open-ended responses were then summarised into 7 categories: disease and illness, environmental, injury and painful husbandry practices, management, nutrition, off-farm and other to enable visual comparisons (Table 5). Numerical differences of open-ended welfare issues were evident between stakeholders and genders. Male producers consistently identified disease/illness as the most important issue for sheep welfare and the general public consistently identified off-farm or injury/painful husbandry practices as the most important welfare issues. Variability existed within the other groups; scientists identified disease/illness as the most important issue, followed by injury/painful husbandry practices and there was a gender split between these two categories for the third most important issue. Industry service providers swapped between disease/illness and injury/painful husbandry practices with differences between the genders. Female producers had the greatest range of issues, with the most important issue being disease/illness, the second most important issue listed was off-farm and the third most was injury/painful husbandry practices.

3.3. Welfare Indicators

A total of 17 possible welfare indicators were presented to the participants and they were able to rank each indicator with a score ranging from 1, unimportant when assessing the welfare of a sheep, through to 5, essential when assessing welfare.

Three major components accounting for 15 variables and two independent indicators were identified following PCA. Of the composite scores derived from the PCA, feed on offer was found to have the highest mean score (4.40 ± 0.02) while the pain and fear related indicators had the lowest (3.98 ± 0.03) and the scores were significantly different (F_4 = 36.89, $p = 0.00$). There were significant gender differences between the perceived importance of management issues, food on offer and numbers of illness/injuries (all $p \leq 0.05$), with females consistently rating these welfare indicators as more important than males (Table 3). Respondents felt that indicators related to nutrition and levels of pain/fear were also important to know for the assessment of welfare, with significant interactions between gender and stakeholder for both indicators (F_3 = 3.76, $p = 0.011$ and F_3 = 2.78, $p = 0.040$, respectively; Figures 2 and 3). Stakeholder differences were noted for all welfare indicators (all $p < 0.05$) with the general public ranking indicators as being more important than other respondent groups (Table 4).

Table 5. The most important sheep welfare issue according to each stakeholder and gender; responses are provided as a % for each gender in each stakeholder group.

Issue	Stakeholder	Gender	Disease/Illness	Environmental	Injury/PHP	Management	Nutritional	Off Farm	Other
Issue 1	Producer	Female	26.4	6.9	25	13.9	4.2	9.7	8.3
		Male	34.7	9.5	24.2	7.9	8.9	4.2	7.4
	Service provider	Female	22.7	0	45.5	4.5	9.1	9.1	9.1
		Male	30.8	6.2	29.2	7.7	9.2	9.2	3.1
	Scientist	Female	48.8	7	16.3	2.3	4.7	18.6	2.3
		Male	34.6	1.9	28.8	9.6	13.5	3.8	5.8
	General public	Female	7.7	4.6	20.1	4.4	5.3	48.7	7.1
		Male	10	5	23.3	11.7	5	33.3	10
Issue 2	Producer	Female	18.1	8.3	22.2	13.9	4.2	20.8	9.7
		Male	28.4	5.3	24.7	8.9	7.4	12.6	7.4
	Service provider	Female	27.3	9.1	27.3	18.2	4.5	13.6	0
		Male	32.3	7.7	16.9	6.2	18.5	12.3	4.6
	Scientist	Female	16.3	7	46.5	14	4.7	2.3	4.7
		Male	28.8	7.7	28.8	9.6	5.8	9.6	5.8
	General public	Female	6.9	10.8	26.3	9.5	4	28.3	9.5
		Male	13.3	20	21.7	6.7	3.3	20	8.3
Issue 3	Producer	Female	6.9	9.7	26.4	20.8	2.8	11.1	12.5
		Male	24.7	7.4	18.9	16.3	4.7	5.3	12.1
	Service provider	Female	13.6	0	31.8	4.5	27.3	4.5	13.6
		Male	30.8	13.8	24.6	1.5	13.8	3.1	7.7
	Scientist	Female	25.6	4.7	23.3	9.3	14	9.3	9.3
		Male	21.2	7.7	32.7	7.7	15.4	7.7	5.8
	General public	Female	8	9.5	25.2	12.8	7.7	21	10.6
		Male	6.7	11.7	21.7	8.3	5	21.7	15

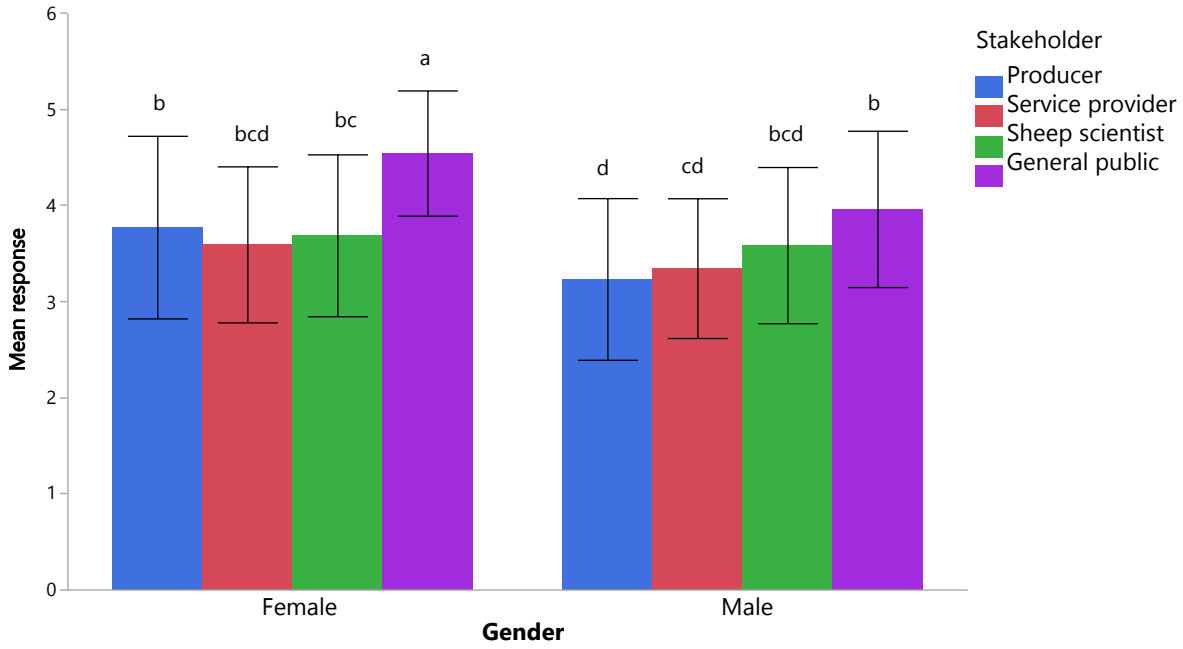

Figure 2. The importance of including welfare indicators relating to pain and fear in an on-farm assessment according to different stakeholders and genders with a significant interaction present between gender and stakeholder ($p < 0.05$); responses ranged from 1 = unimportant to know to 5 = essential to know; differences between letters ([a], [b], [c], [d]) indicate statistically different means at $p < 0.05$; bars represent standard deviations.

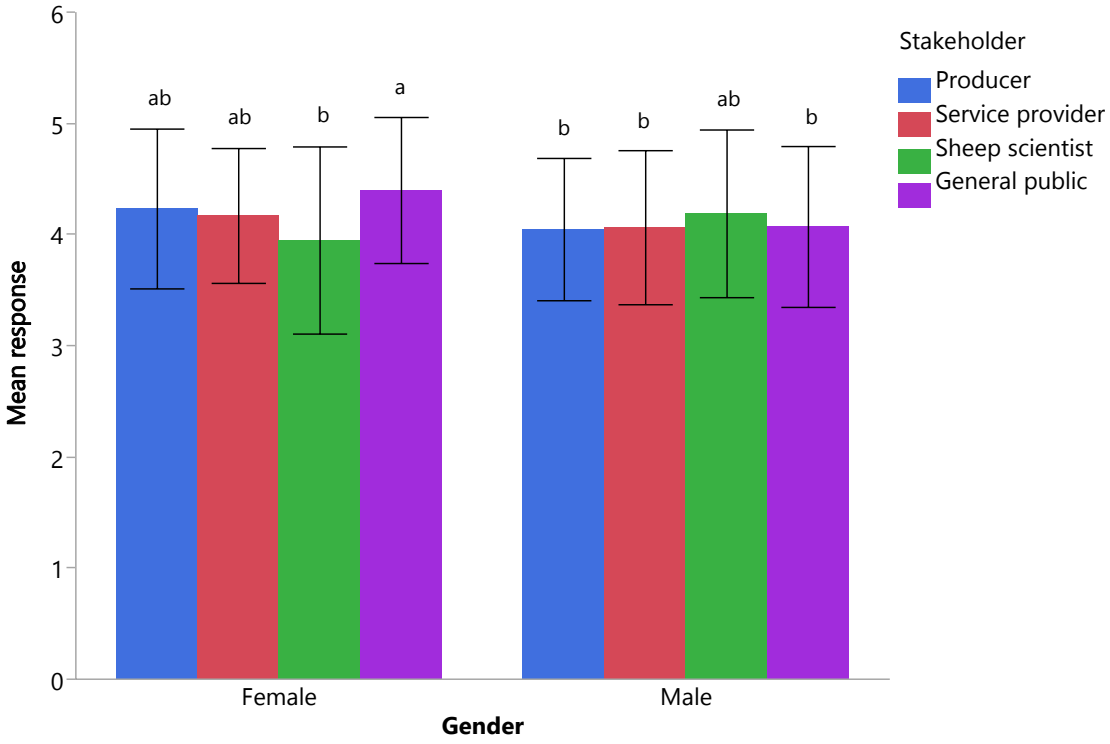

Figure 3. The importance of including welfare indicators relating to nutrition in an on-farm assessment according to different stakeholders and genders with a significant interaction present between gender and stakeholder ($p < 0.05$); responses ranged from 1 = unimportant to know to 5 = essential to know; differences between letters ([a], [b]) indicate statistically different means at $p < 0.05$; bars represent standard deviations.

Respondents were given the opportunity to list any other indicators they perceived as important to know when assessing sheep welfare and a total of 348 (36%) respondents provided additional indicators. As these were open-ended responses the terms used and level of detail differed, with some respondents providing more than one indicator. The following comments were commonly perceived as being important welfare indicators: the provision of water (10.9%), improved transport conditions (10.1%), the cessation of/or better control over live export (9.5%), and the provision of shelter and/or shade (9.2%).

3.4. Self-Rated Knowledge

Participants were asked to rate their knowledge of the sheep industry. Overall average score for the self-rated understanding of the sheep meat industry was 3.63/5 (1 = poor understanding, 5 = very knowledgeable) and the wool industry was 3.58, with a very strong and highly significant correlation between self-rated understanding of both production systems (r (929) = 0.82, $p < 0.001$). Weak negative correlations were seen between a person's belief about the importance of animal welfare and their understanding of the sheep meat industry (r (952) = −0.13, $p < 0.001$) and the wool industry (r (931) = −0.13, $p < 0.001$). Weak positive correlations were also seen between a person's belief about the welfare of grazing sheep and their understanding of the sheep meat industry (r (926) = 0.24, $p < 0.001$) and the wool industry (r (905) = 0.28, $p < 0.001$). Mean knowledge scores and associated correlations for each stakeholder category are presented separately in Table 6. Producer self-rated understanding of each industry was weakly correlated with their beliefs about sheep welfare. An increased understanding of the sheep production industry was associated with the view that the welfare of sheep in extensive systems was poorer, but otherwise no correlations between the perception of sheep welfare, and the importance of animal welfare, were seen.

Table 6. The mean scores and Pearson's correlations for the self-rated understanding on sheep production and beliefs and the welfare of grazing sheep; 1 = poor understanding, 5 = very knowledgeable.

Stakeholder	Self-Rated Knowledge	Mean Score	Pearson's Correlations *		
			Understanding of the Wool Industry	Belief about Animal Welfare	Belief about the Welfare of Grazing Sheep
Producer	Sheep meat industry	4.07	0.50 (<0.001)	−0.076 (0.22)	0.13 (0.034)
	Wool industry	3.98		−0.058 (0.363)	0.23 (<0.001)
Industry service provider	Sheep meat industry	4.46	0.54 (<0.001)	0.023 (0.83)	0.19 (0.08)
	Wool industry	4.44		0.153 (0.156)	0.035 (0.746)
Sheep specific scientist	Sheep meat industry	4.2	0.670 (<0.001)	0.075 (0.47)	0.026 (0.80)
	Wool industry	4.19		−0.11 (0.30)	0.10 (0.33)
General public	Sheep meat industry	3.15	0.89 (<0.001)	−0.046 (0.30)	0.009 (0.85)
	Wool industry	3.11		−0.06 (0.18)	0.068 (0.14)

***** r values are reported with p values presented in the parentheses.

Respondents from the general public were also asked to rate their level of understanding on some specific sheep management issues (Table 7). The general public rated their understanding of both meat and wool industries, tail docking and crutching/shearing highest and nutritional requirements, parasite control and lambing lowest ($F_{9, 5086} = 7.34$, $p < 0.001$).

Table 7. The mean scores of the General Public's self-rated understanding of sheep management; 1 = poor understanding, 5 = very knowledgeable.

Management Issue	Mean Score/5 *
The sheep meat industry	3.15 [a]
Tail docking	3.12 [a]
The wool industry	3.11 [a,b]
Crutching/shearing	3.11 [a]
Castration	3.07 [a,d]
Mulesing	2.97 [b,c,d,e]
General sheep husbandry	2.87 [c,e]
Lambing	2.86 [c]
Parasite control	2.84 [c]
Nutritional requirements	2.81 [c]
Pooled standard error of the mean	0.16

***** Values with different superscripts ([a], [b], [c], [d], [e]) indicate significant differences between rows at $p < 0.05$.

4. Discussion

The current study identified stakeholder perceptions of a variety of welfare issues facing extensively managed sheep. Stakeholder differences were present in three key responses: the perception of grazing sheep welfare, the importance of welfare issues (both specified and open-ended) and suitable key welfare indicators. The hypothesis was supported with the general public having a poorer perception of sheep welfare than producers, and the other two stakeholder groups having an intermediate perception. Additionally, there were gender differences throughout the results.

4.1. Stakeholder and Gender Influences

Across all groups, all welfare issues and indicators were considered to be important, with average scores across all categories being above the median. These results support the growing body of evidence that animal welfare is of broad societal concern (Appleby 1999); however we acknowledge that there was a significant degree of bias in the surveyed population and we have addressed this with our statistical approach. There was a much higher representation of women in the general public category, which in a voluntary survey suggests a greater level of interest and care about the topic. It has been well demonstrated that women do indeed have a greater concern for animals and their welfare (Herzog *et al.* 1991; Eldridge and Gluck 1996; Knight *et al.* 2004; Taylor and Signal 2005; Vanhonacker *et al.* 2007). This was reflected in our survey with women rating welfare issues as being able to cause more compromise and they also considered all welfare indicators to be of greater importance when compared to men. Gender is an important consideration when evaluating other survey results; for example another survey conducted on welfare issues in extensively managed sheep also reported stakeholder differences (Phillips *et al.* 2009), but gender was not further investigated as an underlying cause of stakeholder difference in that study.

A person's attitude and beliefs are dependent on a variety of demographic, experiential and knowledge factors (Serpell 2004; Hemsworth and Coleman 2011), and so it could be reasonably assumed that differences in knowledge of sheep may have driven the stakeholder differences. The general public had a low level of understanding about sheep production in the current study; a finding which is supported in the literature (Knight and Barnett 2008; Vanhonacker *et al.* 2010; Coleman *et al.* 2016). Although livestock welfare has been reported as an important issue for the general public in many different countries (Kjærnes and Lavik 2007), it has been proposed that consumers with less knowledge of and experience with farming have a higher concern for welfare (Frewer *et al.* 2005). Without a reasonable level of understanding within which to place welfare issues and indicators (Vanhonacker *et al.* 2012) and a high degree of anthropomorphism (Phillips *et al.* 2009), the general public may perceive all variables as being equally important. Given that knowledge is key in determining a person's attitudes and beliefs it seems reasonable to assume that background knowledge, or the lack of background knowledge, may have affected perceptions. However, no conclusive relationships were seen between self-rated knowledge about the sheep meat or wool industries and the perceptions of sheep welfare

and no relationships existed between perceived industry knowledge and the importance of animal welfare. The present evidence suggests that knowledge was not obviously associated with perception of sheep welfare. Essentially, people believe it to be important, regardless of how knowledgeable they are of the topic.

Other attitude modifiers consist of animal attributes, individual human attributes and cultural factors (Serpell 2004). In this study we did not focus on animal attributes, nor did we identify individual human attributes such as early childhood experiences with animals, current interactions with animals, religiosity and personality (Serpell 2004). The individual human attributes that were collected in this survey were gender, age, education, residence, knowledge, and of these factors, only gender was influential.

Understanding the role of our survey's voluntary respondents in shaping societal views around animal welfare is an important step when considering the validity of these results for a broadly accepted welfare framework. Work by Coleman and colleagues (Coleman *et al.* 2016) suggested that the most trusted sources of information about animal welfare, for the general public at least, included information received from friends and family, which suggests that the respondents to this survey may be an influential population. While our method for participant recruitment did not generate balanced demographics between stakeholder groups we believe that these results reflect those that are most interested in the topic, and so likely to be influencers around issues associated with sheep welfare and social licence. Future studies may use more targeted methods of recruitment to ensure an even distribution across genders. However, this may only be possible by setting quotas as voluntary surveys involving animal welfare issues tend to result in females being over-represented (Coleman *et al.* 2016).

4.2. Welfare Issues

In the current study the importance of sheep welfare was endorsed by all stakeholders with all believing it to be of importance, and that there was the capacity for it to be compromised. There was a stakeholder × gender interaction in regard to the respondents' perception of the welfare of grazing sheep with females from the general public stakeholder category believing welfare to be in more need of improvement than other groups. These findings are likely to be associated with the levels of understanding and knowledge of the general public, differences in perceptions between specific stakeholder groups such as the public and producers (Vanhonacker *et al.* 2008) as well as the higher levels of concern women have for the welfare of animals (Herzog *et al.* 1991), a more negative view of animal use (Knight *et al.* 2004), animal husbandry systems and painful animal husbandry practices (Eldridge and Gluck 1996; Kruse 1999).

When assessing risks to sheep welfare, some commonalities were evident with respondents' answers to the specified and open-ended questions. Of the specified issues, flystrike, nutrition and predation were considered most likely to compromise a sheep's welfare, and all of these contribute to the PCA component named "environmental issues". Participants also identified flystrike, other environmental factors, nutrition and predation to be major risks in the open-ended questions, although these may have been influenced by the specified issues posed in the earlier questions. The perceived significance of these environmental issues supports previous expert and producer studies which have also identified nutrition, predation and other environmental factors as issues that significantly influence the welfare of sheep. (Cronin *et al.* 2002; Goddard *et al.* 2006; Phillips and Phillips 2010; Phythian *et al.* 2011). Compared to international papers (Goddard *et al.* 2006; Phythian *et al.* 2011), flystrike featured more prominently in the current results. Flystrike is a common regional issue for Australian sheep producers, and so the focus it received in this study is understandable.

There was also one very prominent response to the open-ended question, with issues around live export being identified as the single most significant issue facing sheep welfare. Examples of welfare compromise in live-exported sheep have been prominent in the last few years in Australia and have received a significant amount of media coverage. This likely influenced the views of the general public, who offered all responses on live export. While this was not identified as a key issue by the other stakeholder groups in the current survey, the live export of sheep has been previously identified as a significant welfare issue facing the sheep industry in a variety of reviews (Ferguson *et al.* 2014), industry expert and producer studies (Cronin *et al.* 2002; Phillips and Phillips 2010). As this study was geared towards on-farm welfare, further consideration of this issue is not given here, but it highlights how issues within one area of the industry may affect broader perceptions, and thus may influence the social licence.

The results of the current survey show that the general public considered their understanding of both sheep meat and wool industries, tail docking and crutching/shearing highest, and nutritional requirements,

parasite control and lambing the lowest. A survey by Phillips et al. (2009) identified that stakeholders who were more removed from the production system ranked non-invasive issues, such as nutritional requirements and stockmanship, as lower welfare risks compared with more invasive practices like castration and tail docking. It is likely that these differences reflect the various perspectives and backgrounds of the stakeholder groups; animal health and productivity are likely to be of primary focus to a producer, while more injurious procedures are of immediate concern to the public as they are more visibly obvious. In this survey the self-rated knowledge of the public on general sheep husbandry did not influence what they considered to be the most important issues facing sheep (as determined by the open-ended welfare issues). An obvious limitation on further conclusions was that we assessed knowledge using a self-rated scale, which doesn't necessarily reflect actual knowledge. Further assessment of actual knowledge compared to perceived knowledge would be important for future work in this area, particularly as education is one way that attitudes can be modified (Hemsworth and Coleman 2011). The Welfare Quality® (WQ) framework consists of four principles of: good feeding, good housing, good health and appropriate behaviour (Blokhuis *et al.* 2010). These current results suggest that issues likely to compromise good feeding and housing (environmental issues and heat stress) were perceived to be more significant than those likely to compromise appropriate behaviour (husbandry practices).

4.3. Welfare Indicators

The ranking of welfare indicators showed that, in general, respondents found all listed indicators to be of some use when assessing the welfare of grazing sheep. All 17 of the indicators are found, in various forms, on the list of indicators suggested by a UK based expert group (Phythian *et al.* 2011), used in the AWIN welfare assessment protocol for sheep (AWIN 2015), and mentioned by Goddard (Goddard 2011) in his review of assessing sheep welfare. This highlights a general agreement across a broader range of stakeholders than previously reported in the literature. Additionally, there is substantial alignment between the indicators that respondents perceive as important and the WQ framework. For example, the nutrition related PCA component included indicators such as change in liveweight and body condition score which aligns well with the WQ principle of good feeding. This provides further indication that the perceived key welfare indicators in a grazing environment found in this study are acceptable when compared to more well-developed assessment and monitoring protocols. However, it should be noted that many of these indicators have not been scientifically validated, with only limited data on repeatability and reliability for specific indicators such as body condition score (Phythian *et al.* 2012).

The general public rated welfare indicators as more important than other stakeholders and an interaction was present between stakeholder and gender for the pain/fear and nutrition related composite scores. The pain/fear stakeholder × gender interaction showed that women from the general public believe this indicator to be more important when compared to other groups. As previously mentioned this corresponds with literature indicating that women place a greater significance on painful procedures in animals and rate occurrences of such procedures as being a significant compromise to welfare (Eldridge and Gluck 1996; Kruse 1999). The stakeholder × gender interaction for the nutrition related composite score was somewhat different in that it appears to be due to the scientist group of stakeholders with male scientists rating nutrition to be of higher importance than the other male stakeholders while female scientists rated these indicators as lessor importance, particularly when compared with the female members of the general public. It is difficult to draw conclusions on this data and it is possible this inconsistency is an artefact caused by a biased sample population of scientists.

Welfare indicators are generally identified through a process involving a literature review, discussion with an expert group (e.g., industry based stakeholders such as producers, veterinarians and industry service providers) and scientific testing (Phythian *et al.* 2011; AWIN 2015). This survey has taken a different approach and listed what appear to be the most valuable welfare indicators taken from a variety of sources (literature, industry consultants, and others involved in the sheep industry) and then attempted to confirm whether or not a broader group of stakeholders believe them to be of value. It is unlikely that consumers will be interested in the specific detail involved in a sheep production system (Frewer *et al.* 2005); however involving all stakeholders along the food supply chain and, if possible, gaining a consensus of useful measurement parameters may increase the acceptance of a food production system and trust between stakeholders.

5. Conclusions

Sheep welfare was an important consideration to all stakeholders in this survey, and all issues were perceived to cause some degree of welfare compromise. Welfare issues of key importance to the stakeholders were those relating to environmental issues, heat stress, lameness and husbandry practices. The welfare indicators perceived to be of key importance were those related to nutrition, pain and fear, mortality and management, feed on offer and the number of illness/injuries occurring within a flock. Both gender and stakeholder differences were clear, the most notable were women's greater concern for welfare and the general public's concern for off-farm issues. These results highlight the importance of including all stakeholders and an even balance of genders when developing a welfare framework that can address both practical and societal concerns.

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References

Appleby, MC (1999) Definition of welfare. *Applied Animal Behaviour Science* **65**, 159.

Australian Bureau of Statistics (2016) 'Themes: Education and Work.' Available at http://www.abs.gov.au/ausstats/abs@.nsf/0/556A439CD3D7E8A8CA257242007B3F32?Opendocument [Accessed 21 December 2016].

AWI (No Date) 'BESTWOOL/BESTLAMB VICTORIA.' Available at [Accessed 12 Oct].

AWIN (2015) 'AWIN welfare assessment protocol for sheep.' Available at http://www.animal-welfare-indicators.net/site/flash/pdf/AWINProtocolSheep.pdf. [Accessed 11 November 2015].

Blokhuis, HJ, Veissier, I, Miele, M, Jones, B (2010) The Welfare Quality® project and beyond: safeguarding farm animal well-being. *Acta Agriculturae Scandinavica, Section A — Animal Science* **60**, 129-140.

Calavas, D, Sulpice, P, Lepetitcolin, E, Bugnard, F (1998) Assessing the accuracy of a body condition scoring in ewes under field conditions. *Veterinary Research* **2**, 129-138.

Cohen, J (2013) 'Statistical power analysis for behavioural sciences.' (Routledge Academic: London, England)

Coleman, GJ, Jongman, EC, Greenfield, L, Hemsworth, PH (2016) Farmer and public attitudes to lamb finishing systems. *Journal of Applied Animal Welfare Science* **19**, 198-206.

Coleman, GJ, McGregor, M, Hemsworth, PH, 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**, 189-200.

Cronin, GM, Barnett, JL, Edge, ML, Hemsworth, PH (2002) Identifying animal welfare issues for sheep in Australia. *Wool Technology and Sheep Breeding* **50**, 534-540.

Curnow, M, Ferguson, M, Thompson, A (2011) Lifetime wool: ewe management handbook. *Agribusiness, Sheep updates* 14-24.

data, Mf (2017) 'Farm survey data for the beef, slaughter lambs and sheep industries.' Available at [Accessed 12 Oct].

Dwyer, C, Ruiz, R, Beltran de Heredia, I, Canali, E, Barbieri, S, Zanella, A (2015a) AWIN Welfare assessment protocol for sheep.

Dwyer, CM, Ruiz, R, Beltran de Heredia, I, Canali, E, Barbieri, S, Zanella, A (2015b) AWIN Welfare assessment protocol for sheep.

Eldridge, JJ, Gluck, JP (1996) Gender Differences in Attitudes Toward Animal Research. *Ethics & Behavior* **6**, 239-256.

Elliott, J (2012) The Roles of Attitudes, Social Influence and Human Behaviour in the Adoption of Strategies to Improve Lamb Survival by Sheep Producers. University of Western Australia.

Ferguson, DM, Schreurs, NM, Kenyon, PR, Jacob, RH (2014) Balancing consumer and societal requirements for sheep meat production: An Australasian perspective. *Meat Science* **98**, 477-483.
Fisher, MW, Mellor, DJ (2002) The welfare implicaitons of shepherding during lambing in extensive New Zealand farming systems. *Animal Welfare* **11**, 157.
Frewer, LJ, Kole, APW, van de Kroon, SMA, de Lauwere, C (2005) Consumer attitudes towards the development of animal-friendly husbandry systems. *Journal of Agricultural and Environmental Ethics* **18**, 345-367.
Glansville, E (2017) Does increasing ewe conception rates, and thus reproductive performance, pay? In 'Investment in Agriculture: Mackinnon Project Seminar. Werribee, Victoria'.
Goddard, PJ (2011) Welfare assessment in sheep. *Farm Animal Practice* **33**, 508-516.
Goddard, PJ, Waterhouse, T, Dwyer, CM, Stott, AW (2006) The perception of the welfare of sheep in extensive systems. *Small Ruminant Research* **62**, 215-225.
Hargreaves, A, Hutson, G (1990) An evaluation of the contribution of isolation, up-ending and wool removal to the stress response to shearing. *Applied Animal Behaviour Science* **26**, 103-113.
Hemsworth, PH, Coleman, GJ (2011) 'Human-Livestock interactions: The stockperson and the Productivity and Welfare of Intensively Farmed Animals.' (CAB International: Wallingford, UK)
Herzog, HA, Betchart, NS, Pittman, RB (1991) Gender, Sex Role Orientation, and Attitudes toward Animals. *Anthrozoos* **4**, 184-191.
Horton, B, Hogan, L (2010) FlyBoss: a web-based flystrike information and decision support system. *Animal Production Science* **50**, 1069-1076.
Kauppinen T, Vainio A, Valros, A, Rita H, Vesala K M (2010) Improving animal welfare: qualitative and quantitative methodology in the study of farmers' attitudes. *Animal Welfare* **19**, 523-536.
Kirkwood, JK, Hubrecht, R (2001) Animal Consciousness, Cognition and Welfare. *Animal Welfare* **10**, 5-17.
Kjærnes, U, Lavik, R (2007) Farm animal welfare and food consumption practice: results from surveys in seven countries. In 'Attitudes of Consumers, Retaliers and Producers to Farm Animal Welfare. Welfare Quality Reports No. 2.' (Eds U Kjærnes, M Miele, J Roex.) pp. 1-29. Retrieved 3 October 2015, from http://www.cardiff.ac.uk/cplan/sites/default/files/WQReport-2_0.pdf)
Knight, S, Barnett, L (2008) Justifying Attitudes toward Animal Use: A Qualitative Study of People's Views and Beliefs. *Anthrozoos* **21**, 31-42.
Knight, S, Vrij, A, Cherryman, J, Nunkoosing, K (2004) Attitudes towards animal use and belief in animal mind. *Anthrozoos* **17**, 43-62.
Kruse, CR (1999) Gender, views of nature and support for animal rights. *Society and Animals* **7**, 179-198.
Larsen, J, Anderson, N, Vizard, A, Anderson, G, Hoste, H (1994) Diarrhoea in Merino ewes during winter: association with trichostrongylid larvae. *Australian veterinary journal* **71**, 365-372.
Martin, P, Shepheard, M (2011) What is meant by social licence? In 'Defending the Social Licence of Farming. Issues, challenges and new directions for agriculture.' (Eds J Williams, P Martin.) (CSIRO Publishing: Collingwood, Australia)
Morgan-Davies, C, Waterhouse, A, Milne, CE, Stott, AW (2006) Farmers' opinions on welfare, health and production practices in extensive hill sheep flocks in Great Britain. *Livestock Science* **104**, 268-277.
Norman, G (2010) Likert scales, levels of measurement and the "laws" of statistics. *Adv Health Sci Educ Theory Pract* **15**, 625-32.
Palmer, C, Sandøe, P (2011) Animal Ethics. In 'Animal Welfare.' (Eds MC Appleby, JA Mench, IAS Olsson, BO Hughes.) pp. 1-12. (CAB International: Oxfordshire)
Phillips, CJC, Phillips, AP (2010) Attitudes of Australian sheep farmers to animal welfare. *Journal of International Farm Management* **5**, 1-26.
Phillips, CJC, Wojciechowska, J, Meng, J, Cross, N (2009) Perceptions of the importance of different welfare issues in livestock production. *Animal* **3**, 1152-1166.
Phythian, CJ (2011) Development of indicators for the on-farm assessment of sheep welfare. University of Liverpool.
Phythian, CJ, Hughes, D, Michalopoulou, E, Cripps, PJ, Duncan, JS (2012) Reliability of body condition scoring of sheep for cross-farm assessments. *Small Ruminant Research* **104**, 156-162.
Phythian, CJ, Michalopoulou, E, Jones, PH, Winter, AC, Clarkson, MJ, Stubbings, LA, Grove-White, D, Cripps, PJ, Duncan, JS (2011) Validating indicators of sheep welfare through a consensus of expert opinion. *Animal* **5**, 943-952.
Quinlivan, T (1968) Survey observations on ovine mastitis in New Zealand stud Romney flocks: 2. The bacteriology of ovine mastitis. *New Zealand veterinary journal* **16**, 153-160.
R Core Team, 2016. R: A language and environment for statistical computing R Foundation for Statistical Computing, Vienna, Austria.

Russel, A, Doney, J, Gunn, R (1969) Subjective assessment of body fat in live sheep. *The Journal of Agricultural Science* **72**, 451-454.
Serpell, JA (2004) Factors influencing human attitudes to animals and their welfare. *Animal Welfare* **13**, S145-151.
Stubsjøen, S, Hektoen, L, Valle, P, Janczak, A, Zanella, A (2011) Assessment of sheep welfare using on-farm registrations and performance data. *Animal Welfare* **20**, 239-251.
Survey Monkey Inc. (2014) 'Survey Monkey.' (Survey Monkey Inc. : http://www.surveymonkey.com/)
T Munro, IE (2009) Tail length in lambs - the long and short of it
Tabachnick, BG, Fidell, LS (2007) 'Using Multivariate Statistics.' (Pearson: Boston, MA, USA)
Taylor, N, Signal, TD (2005) Empathy and attitudes to animals. *Anthrozoos* **18**, 18-27.
Turner, SP, Dwyer, CM (2007) Welfare assessment in extensive animal production systems: challenges and opportunities. *Animal Welfare* **16**, 189-192.
Tyrell, L (2017) Does optimum stocking rate change with commodity price? In 'Investment in Agriculture: Mackinnon Project Seminar. Werribee, Victoria'.
Vanhonacker, F, Van Poucke, E, Tuyttens, F, Verbeke, W (2010) Citizens' views on farm animal welfare and related information provision: Exploratory insights from Flanders, Belgium. *Journal of Agricultural and Environmental Ethics* **23**, 551-569.
Vanhonacker, F, Verbeke, W, Van Poucke, E, Pieniak, Z, Nijs, G, Tuyttens, F (2012) The concept of farm animal welfare: Citizen perceptions and stakeholder opinion in Flanders, Belgium. *Journal of Agricultural and Environmental Ethics* **25**, 79-101.
Vanhonacker, F, Verbeke, W, Van Poucke, E, Tuyttens, F (2007) Segmentation based on consumers' perceived importance and attitude toward farm animal welfare. *International Journal of Sociology of Food and Agriculture* **15**, 84-100.
Vanhonacker, F, Verbeke, W, Van Poucke, E, Tuyttens, F (2008) Do citizens and farmers interpret the concept of farm animal welfare differently? *Livestock Science* **116**, 126-136.
Verbeke, W (2009) Stakeholder, citizen and consumer interests in farm animal welfare. *Animal Welfare* **18**, 325-333.

15.3 Farmers' opinions about sheep management and welfare

Munoz, C. A., Coleman, G. J., Campbell, A. J. D., Hemsworth, P. H., Doyle, R. E. 'Farmers' opinions about sheep management and welfare'. International Society of Applied Ethology, Edinburgh, Scotland, July 2016

Two focus groups were conducted to collect qualitative information on the opinions and concerns of extensive Merino sheep farmers. These discussions were conducted with the purpose of identifying the underlying beliefs that influence farmers' behaviour, and the consequences for the productivity and welfare of their sheep. Both discussions were approximately 60 min, followed semi-structured agenda and comprised of eight and seven farmers respectively (35 to 65 years). Farmers reported that monitoring of the flock was usually performed visually, without approaching the mob; all agreed that they visually assessed behaviour and body condition as indicators of individual sheep welfare, but did not assess either in close proximity. Understanding whether these distant observations are indicative of the welfare of sheep is important to determine. Farmers only visually assessed pasture quality and availability, and perceived barriers to more frequent/detailed management included time and la bour availabilities. There was strong acknowledgement that behaviour and attitudes towards moving sheep dictated a farmer's success, with direct quotes including 'if you say sheep are stupid and you are getting angry at them, it is probably because you are doing something wrong'. As farmer attitudes influence the human-animal relationship, farmer attitudes will likely affect sheep behaviour and fear. It was consistently acknowledged that the treatment of sheep by shearing and mulesing contractors was something farmers had little control over. Farmers also acknowledged that some husbandry procedures may be painful, and believed that the use of pain relief (Trisolfen) makes a 'huge difference' in how the sheep recover. Diseases like foot abscess and eye injury were identified as likely to cause pain, but veterinary intervention was rare and reserved only for particular diseases or to assess rams before mating. Understanding which sheep behaviours farmers use as indicators of pain may help to understand these opinions. Farmers participated in workshops and training courses, indicating a desire for further education. In summary, farmer attitudes to sheep were positive and welfare was expressed as an important consideration; however, the nature of extensive farming conditions prevent close, frequent interactions with sheep and a perceived lack of control in some aspects sheep management are likely barriers to welfare monitoring/improvement. This qualitative study informs a current longitudinal study measuring the welfare and behaviour of sheep in relation to farmer attitudes.

15.4 Animal-based measures to assess the welfare of extensively managed ewes

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Article

Animal-Based Measures to Assess the Welfare of Extensively Managed Ewes

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Simple Summary: The aim of this study was to assess the reliability and practicality of 10 animal-based welfare measures for extensively managed ewes, which were derived from the scientific literature, previous welfare protocols and through consultation with veterinarians and animal welfare scientists. Measures were examined on 100 Merino ewes, which were individually identified and repeatedly examined at mid-pregnancy, mid-lactation and weaning. Body condition score, fleece condition, skin lesions, tail length, dag score and lameness are proposed for on-farm use in welfare assessments of extensive sheep production systems. These six welfare measures, which address the main welfare concerns for extensively managed ewes, can be reliably and feasibly measured in the field.

Abstract: The reliability and feasibility of 10 animal-based measures of ewe welfare were examined for use in extensive sheep production systems. Measures were: Body condition score (BCS), rumen fill, fleece cleanliness, fleece condition, skin lesions, tail length, dag score, foot-wall integrity, hoof overgrowth and lameness, and all were examined on 100 Merino ewes (aged 2–4 years) during mid-pregnancy, mid-lactation and weaning by a pool of nine trained observers. The measures of BCS, fleece condition, skin lesions, tail length, dag score and lameness were deemed to be reliable and feasible. All had good observer agreement, as determined by the percentage of agreement, Kendall's coefficient of concordance (W) and Kappa (k) values. When combined, these nutritional and health measures provide a snapshot of the current welfare status of ewes, as well as evidencing previous or potential welfare issues.

Introduction

On-farm welfare assessments can be used for immediate or ongoing on-farm monitoring and benchmarking by farmers and veterinarians, and to demonstrate compliance with national and international legal welfare standards and farm assurance schemes [1,2]. For welfare assessments to be effective and acceptable to all key stakeholders (i.e., industry, animals, scientists, consumers and society), they must incorporate welfare measures that are meaningful with respect to animal welfare, provide repeatable outcomes when applied by different observers and practical under farm conditions; that is they must be valid, reliable and feasible [2,3]. Welfare measures can be classified into categories that assess housing and facilities (resource-based measures), farmer policies and management strategies (management-based measures), and

direct animal observations (animal-based measures) [4,5]. Animal-based measures often reflect the outcome of resource inputs and management practices, and therefore there is increasing interest to incorporate these measures in welfare assessments, as they provide an integrative and direct measurement of the welfare state of animals [6–8]. Some examples of animal-based measures include the assessment of the nutritional state (e.g., body condition score), environmental conditions (e.g., fleece cleanliness) and diseases (e.g., lameness). Welfare measures, however, cannot automatically be extrapolated from one species to another [3].

Welfare challenges differ depending of the species, production system, reproduction cycle and geographical location [9–11]. The unique characteristics and welfare challenges of extensive sheep systems highlights the importance of the development of reliable and feasible welfare measures that can be able to detect current welfare problems and risk of future welfare compromise. For instance, the nature of extensive systems, where sheep are managed in large flocks and outdoor all year, makes adequate monitoring, treatment and prevention of diseases more difficult to address. Extensively managed sheep are more exposed to predators and variation in climatic conditions. Variation in food quality and availability during the year leads to changes in body condition, which highlights the importance of measures that can be able to detect these differences. Body condition is widely accepted as a valid and important welfare measure that reflects the nutritional state of sheep [12,13], but discrepancies exist in the literature on the scoring scales and the precision needed (full-unit, half-unit or quarter-unit) to provide meaningful results on the nutritional status of sheep [13–15]. In Australia for example, flystrike (cutaneous myiasis) is a main welfare concern, and therefore, it is important to have sensible measures that can identify the risk of this disease. Larsen et al. [16] developed a detail 6-point scale to assess dags, lump matted faecal material hanging from the wool, and although this scoring system has been proved to be effective in assessing the risk of flystrike, it has not been tested for reliability and practicality to be included in welfare assessments. Previously, sheep have received considerably less attention in the development of welfare measures when compared with animals farmed intensively such as pigs, poultry and dairy cattle. Furthermore, most of the research has been conducted in European countries [10,13,15,17,18], where sheep are managed in small flocks and usually in more intensive, indoor-lambing systems [2]. The aim of the present study was to test the reliability and feasibility of some animal based measures for sheep welfare assessment. We hypothesized that some measures previously identified may not be reliable or feasible for sheep managed under extensive farming conditions.

2. Materials and Methods

2.1. Animals and Management

This study is part of a longitudinal on-farm study that was performed in Victoria, Australia between July and December, 2015 [19]. This study was approved by the University of Melbourne ethics committee (ethical review number 1513562.1). A total of 100 Merino ewes, aged 2–4 years, from a large flock of approximately 3000 breeding ewes were individually identified by a unique ear tag number and repeatedly examined at three-time points: Mid-pregnancy (MP; July), mid-lactation (ML; October) and weaning (WN; December). These periods were selected because they are known to be critical times affecting ewe welfare [15,18]. The ewes were managed under extensive conditions, in a year-round outdoor system, grazing annual/perennial pastures, and managed under commercial conditions. The ewe sample size was selected based on a power calculation assuming 50% prevalence of the trait under observation (the proportion requiring the greatest sample size when observing binomial traits), a 95% confidence interval and precision of ±10%. This number was supported by the AWIN sheep protocol which recommends a sample of 92 animals when the farm size is ≥ 2000 breeding ewes [10].

2.2. Animal-Based Welfare Measures

The animal-based measures examined in this study were selected after a review of the relevant literature and consultations with veterinarians and animal welfare scientists. The measures selected were: Body condition score (BCS) [14,20–22], rumen fill [23,24], fleece cleanliness [10], fleece condition [10], skin lesions [10], tail

length [25,26], dag score [16], foot-wall integrity [27–29], hoof overgrowth [27–29] and lameness [10]. They were considered valid on the basis that they have been shown to have validity in previous studies, further details are reported in Munoz et al. [19]. The measures selected address main welfare concerns for sheep, covering freedom from hunger, pain, injury or disease. The assessment criteria of the welfare measures are listed in Table 1.

Table 1. Animal-based welfare measures used to assess the welfare of extensively managed ewes.

Measure	Assessment Criterion
Body condition score	Scored on a 5 point scale from 1 (thin) to 5 (obese), using a quarter-unit precision [14,21]. Sheep were assessed by palpation of the backbone, muscle and short ribs [20,22].
Rumen fill	Scored on a 2 point scale: (0) If the animal's left-hand side is not sunken/or is convex between the hip bone and the ribs and (1) if the animals' left-hand side is deeply sunken between the hip bone and the ribs [23,24].
Fleece cleanliness	Scored on a 4 point scale: (0) Clean and dry (1) dry with slight mud/dirt (2) Wet with some areas contaminated by mud or dung (3) Filthy, very wet and coated in mud or dung [10].
Fleece condition	Scored on a 3 point scale: (0) Good fleece condition, when parted, the fleece has no scurf or lumpiness or signs of ectoparasites (1) some fleece loss, small shed or bald patches of no more than 10 cm diameter. When parted, the fleece may have some lumpiness or scurf, little evidence of ectoparasites, and (2) significant fleece loss with bald patches of greater than 10 cm in diameter, clear evidence of ectoparasites [10].
Skin lesions	Assessed by recording number, location and severity of the skin lesions. Lesions were classified as cuts, open wounds, old wounds or scars and abscesses [10].
Tail length	Scored on a 2 point scale: (0) The tip of the vulva is covered by the tail when held down (1) the tail is over-shortened or almost not present, or if the vulva and anus cannot be covered [25,26].
Dag score	Scored on a 6 point scale: (0) No evidence of fecal soiling, (1) very light soiling on the breech area, (2) moderate dag on the breech area extending ventrally, (3) severe dag predominantly on the breech area, extending ventrally and dorsally over the tail some soiling and dag around anus, (4) excessive dag on the breech area and on the hind legs (5) Very severe dag on the breech area and on the hind legs or below the level of the hocks [16].
Foot-wall integrity	Scored on a 4 point scale: (0) An undamaged wall, (1) 25% or less damaged wall (2) moderately damaged wall (from 25% to 75%), (3) severely damaged wall (>75%) [27–29].
Hoof overgrowth	Scored on a 3 point scale: (0) Appropriate length of the hoof and perfect shape of the wall area, (1) moderately misshapen/overgrowth, (2) a severely misshapen/overgrowth [27–29]
Lameness	Scored on a 4 point scale: (0) Not lame, (1) clear shortening of stride with obvious head nodding or flicking as the affected limb touches the floor, (2) clear shortening of stride with obvious head nodding and not weight-bearing on affected limb whilst moving, (3) reluctant to stand or move [10].

2.3. Welfare Assessment of the Ewes

The assessment of the ewes was always conducted between 900 h and 1600 h. To perform the assessment, and for practical reasons, the ewes were managed in four groups of 25 animals. The first nine measures, BCS, rumen fill, fleece cleanliness, fleece condition, skin lesions, tail length, dag score, foot-wall integrity and hoof overgrowth, were assessed in a single-file race within the farm's regularly-used sheep yards. The ewes were then released from the race (in small groups of 2 to 4 animals) and encouraged to walk to assess lameness. Feasibility of the assessment was measured by timing the assessment at each time-point, evaluating the resources required and the ability to collect these measurements across different farms. The advice of farm consultants, veterinarians and animal
welfare scientists was also considered.

2.4. Observers and 'Test Standard Observer'

A pool of nine observers from the University of Melbourne Veterinary and Agricultural Sciences Faculty (details provided in next paragraph) were recruited. Reliability was assessed by evaluating inter- and intra- observer agreement. Observer agreement was assessed in line with previous reliability studies [3,13,15,23]. Briefly, inter-

observer agreement and pair agreement was calculated by referencing the score given by each observer against a 'test standard observer' (TSO, CM). This approach is commonly used to assess if observers could be trained to apply a specific on-farm welfare assessment protocol and to identify any assessment bias [30,31]. To assess intra-observer reliability, the degree to which measurements taken by the same observer are consistent, all sheep were reassessed by the observers within a 15-day period in MP, and within a 24h period at both ML and WN. In an effort to maintain objectivity, observers did not have access to health or production records of the farm before performing the welfare assessment.

Observer 1 (CM), a veterinarian that developed the list of measures and provided training to all observers was nominated as the TSO. Observer 2 was a research assistant with 25 years of experience in working with sheep and classed as experienced assessor. Observers 4 and 7 were veterinarians classed as mid-experienced observers, and observers 3, 5, 6, 8 and 9 were graduate animal science students, classed as inexperienced observers. From the pool of nine observers, combinations of four observers performed the assessments on each observation period, and the TSO performed the assessment in all the observation periods. This approach was taken because it was difficult to have all the observers in all the farm visits.

Prior to individual assessments, observers were provided with an assessment protocol, containing details of the scoring scales and pictures. In addition, an on-farm training session was provided using 20 ewes at MP, and this training lasted for about 30 min, 25 ewes were used for training at ML, and this training lasted for about 1 h, and 30 ewes were used at WN and this training lasted for about 1 h 30 min. The animals used for training purposes were not included in the analyses. Thereafter, each observer independently evaluated the first nine measures on each sheep. Observers were placed in different locations of the race and were not allowed to exchange their observations. After the assessment in the race, ewes were encouraged to walk to detect lameness. For practical reasons, all the observers assisted with the identification of lame animals. One person was required to move the sheep along the race, another person was required to manipulate the gate at the end of the race and two persons were required to catch the lame sheep for individual identification. Therefore, only intra-assessment

agreement was assessed for lameness.

2.5. Statistical Analysis

Data analysis was performed using SAS statistical package (Statistical Analysis System, Release 9.4 2012; SAS Institute Inc., Cary, NC, USA). The welfare scoring scales consisted of categorical, ordinal (BCS, fleece cleanliness, fleece condition, skin lesions, dag score, foot-wall integrity, hoof overgrowth and lameness) and binary data (rumen fill and tail length). For ordinal scores, Kendall's coefficient of concordance (W) was used to assess overall observer agreement [32]. The scale used to assess agreement was as follows: a value of 0 indicates no agreement, from 0.10 to 0.40 poor agreement, 0.41 to 0.70 moderate, 0.71 to 0.90 substantial, 0.91 to 0.99 almost perfect and 1 perfect agreement. Pair-agreement, agreement between individual observers and the TSO, were assessed by the percentage of agreement; Kendall's W and the weighted kappa statistic (Kw). For binary scores, Fleiss's Kappa (k) [33] and Cohen's kappa (k) were used to assess overall observer agreement and pair-agreement respectively. All k results were interpreted according to Landis and Koch [34], therefore values ≤0.40 suggested 'poor' agreement, values from 0.41 to 0.60 suggested 'moderate' agreement, values ranging from 0.61 to 0.80 suggested 'substantial' agreement, and values ≥0.81 suggested 'almost perfect' agreement.

In addition, one-way ANOVA analysis was used to examine differences in the 'time spent assessing the ewes' between mid-pregnancy, mid-lactation and weaning. Multiple comparisons between means were performed using Fisher's Least Significant Difference (LSD) test.

3. Results

A total of five ewes were lost from the study period, with three ewes dying at lambing (reported dead by the farmer) and two presumed dead, which resulted in different numbers of ewes examined across the three-time points: Mid-pregnancy n = 100, mid-lactation n = 96 and weaning n = 95.

3.1. Inter- and Intra-Observer Agreement at Mid-Pregnancy

At mid-pregnancy, there was 'almost perfect' overall observer agreement for fleece cleanliness and fleece condition, 'moderate' agreement was found for BCS, skin lesions, foot-wall integrity and hoof overgrowth, and 'poor' agreement for rumen fill, and tail length (Table 2). In the same way, pair agreement was higher for fleece cleanliness and fleece condition, while BCS, rumen fill and tail length presented the lowest. Overall, the TSO and observer 2, the most experienced observer, had better percentage of pair-agreement for most of the measures compared to the results obtained by the TSO against observers 3 and 4, the less experienced observers. Results for intra-observer agreement are presented in Table 3. Overall, fleece cleanliness and fleece condition were the most repeatable measures. Dag score, foot wall-integrity and hoof overgrowth had moderate repeatability, while BCS and skin lesions had the lowest. Observer 1 and 2 showed the highest levels of repeatability for most of the measures compared to the other observers as determined by W and k values. Lameness was not assessed for intra-observer agreement because all the observers assisted with the identification of lame animals, but showed moderate intra-assessment agreement W = 0.53. According to the observers, rumen fill was the least feasible measures followed by foot-wall integrity and hoof overgrowth. Based on this, rumen fill was not included in the subsequent visits and therefore intra- observer agreement
was not assessed.

Table 2. Overall observer agreement (OA), percentage of agreement (%) and pair agreement at mid-pregnancy.

Measures	OA (W)	Pair Agreement				
		Observer Identity	%	Kendall's (W)	Weighted Kappa (95% CI)	Interpretation (W/Kw)
BCS	0.60	2	30	0.78	0.38 (0.28–0.54)	Substantial/poor
		3	24	0.74	0.30 (0.16–0.38)	Substantial/poor
		4	23	0.71	0.25 (0.09–0.33)	Substantial/poor
Rumen fill	0.14 *	2	73	n/a	0.12 ** (−0.11–0.32)	Poor
		3	70	n/a	0.13 ** (−0.08–0.34)	Poor
		4	75	n/a	0.31 ** (0.09–0.47)	Poor
Fleece cleanliness	1.00	2	100	1.00	1.00 (1.00–1.00)	Perfect agreement
		3	100	1.00	1.00 (1.00–1.00)	Perfect agreement
		4	100	1.00	1.00 (1.00–1.00)	Perfect agreement
Fleece condition	1.00	2	100	1.00	1.00 (1.00–1.00)	Perfect agreement
		3	100	1.00	1.00 (1.00–1.00)	Perfect agreement
		4	100	1.00	1.00 (1.00–1.00)	Perfect agreement
Skin lesions	0.41	2	98	0.50	0.66 (0.65–0.67)	Moderate
		3	99	0.83	0.66 (0.04–1.00)	Substantial/moderate
		4	99	0.69	0.39 (−0.17–0.93)	Moderate/poor
Tail length	0.35 *	2	86	n/a	0.38 ** (0.14–0.64)	Poor
		3	77	n/a	0.28 ** (0.10–0.45)	Poor
		4	71	n/a	0.28 ** (0.10–0.45)	Poor
Dag score	0.70	2	77	0.81	0.59 (0.43–0.72)	Substantial/moderate
		3	76	0.77	0.52 (0.37–0.66)	Substantial/moderate
		4	74	0.83	0.62 (0.48–0.76)	Substantial/moderate
Foot-wall integrity	0.44	2	90	0.68	0.47 (−0.15–1.00)	Moderate
		3	97	0.50	0.21 (−0.15–0.57)	Moderate/poor
		4	95	0.57	0.55 (0.20–0.90)	Moderate
Hoof overgrowth	0.65	2	91	0.84	0.66 (0.51–0.80)	Substantial/moderate
		3	79	0.75	0.50 (0.33–0.68)	Substantial/moderate
		4	66	0.63	0.43 (0.27–0.60)	Moderate

* Inter-observer agreement for nominal measures determined by Fleiss's Kappa (k); ** Pair-agreement with the test standard observer for nominal measures determined by Cohen's Kappa (k).

Table 3. Intra-observer agreement at mid-pregnancy.

Measures	Observer Identity	W	Kw	Interpretation (W/Kw)
BCS	1	0.68	0.22	Moderate/poor
	2	0.80	0.31	Substantial/poor
	3	0.61	0.10	Moderate/poor
	4	0.68	0.20	Moderate/poor
Fleece cleanliness	1	1.00	1.00	Perfect agreement
	2	1.00	1.00	Perfect agreement
	3	1.00	1.00	Perfect agreement
	4	1.00	1.00	Perfect agreement
Fleece Condition	1	1.00	1.00	Perfect agreement
	2	1.00	1.00	Perfect agreement
	3	1.00	1.00	Perfect agreement
	4	1.00	1.00	Perfect agreement
Skin lesions	1	0.49	0.48	Moderate
	2	1.00	1.00 **	Perfect agreement
	3	0.49	−0.01 **	Moderate/poor
	4	0.48	0.56 **	Moderate
Dag score	1	0.63	0.37	Moderate/poor
	2	0.64	0.39	Moderate/poor
	3	0.63	0.43	Moderate
	4	0.6	0.45	Moderate
Foot-wall Integrity	1	0.64	0.37	Moderate/poor
	2	0.58	0.39	Moderate/poor
	3	0.50	0.43	Moderate
	4	0.59	0.45	Moderate
Hoof overgrowth	1	0.79	0.57	Substantial/moderate
	2	0.78	0.50	Substantial/moderate
	3	0.83	0.59	Substantial/moderate
	4	0.72	0.44	Substantial/moderate

** Pair-agreement for nominal measures determined by Cohen's Kappa (k). Intra-observer agreement was done within a 15-day period.

3.2. Inter- and Intra-Observer Agreement at Mid-Lactation

At mid-lactation, 'substantial' to 'almost perfect' overall agreement was found for fleece cleanliness, fleece condition, BCS and skin lesions. 'Moderate' overall agreement was found for dag score, foot-wall integrity and hoof overgrowth, while tail length showed the lowest agreement
(Table 4). Similarly, pair agreement was higher for fleece cleanliness, fleece condition and skin lesions. 'Moderate' to 'substantial' pair agreement was obtained for BCS and dag score while tail length, foot-wall integrity and hoof overgrowth presented the lowest showing from 'poor' to 'substantial' pair agreement. The results of the intra- observer agreement are present in Table 5. Overall, fleece cleanliness, fleece condition, skin lesions and dag score were the most repeatable measures followed by BCS and tail length, while foot-wall integrity and hoof overgrowth presented the lowest levels of repeatability. The TSO showed the highest levels of repeatability for most the measures, and her repeatability increased at mid-lactation when compared to mid-pregnancy, particularly for the measures BCS and dag score that increased from 'moderate/poor' to 'substantial/moderate' agreement. The intra-assessment agreement of lameness increased to 'substantial' W = 0.79.

Table 4. Overall observer agreement (OA), percentage of agreement (%) and pair agreement at mid-lactation.

		Pair Agreement				
Measures	**OA (W)**	**Observer Identity**	**%**	**Kendal's (W)**	**Weighted Kappa (95% CI)**	**Interpretation (W/Kw)**
BCS	0.74	2	48	0.85	0.55 (0.53–0.76)	Substantial/moderate
		5	23	0.83	0.41 (0.29–0.50)	Substantial/moderate
		6	26	0.85	0.45 (0.36–0.55)	Substantial/moderate
Fleece cleanliness	1.00	2	100	1.00	1.00 (1.00–1.00)	Perfect agreement
		5	100	1.00	1.00 (1.00–1.00)	Perfect agreement
		6	100	1.00	1.00 (1.00–1.00)	Perfect agreement
Fleece condition	0.75	2	98	0.83	0.66 (0.04–1.00)	Substantial
		5	100	1.00	1.00 (1.00–1.00)	Perfect agreement
		6	100	1.00	1.00 (1.00–1.00)	Perfect agreement
Skin lesions	0.99	2	100	1.00	1.00 (1.00–1.00)	Perfect agreement
		5	100	1.00	1.00 (1.00–1.00)	Perfect agreement
		6	100	1.00	1.00 (1.00–1.00)	Perfect agreement
Tail length	0.18 *	2	97	n/a	−0.01 ** (−0.03–0.00)	Poor
		5	97	n/a	−0.01 ** (−0.03–0.01)	Poor
		6	97	n/a	−0.01 ** (−0.03–0.01)	Poor
Dag score	0.69	2	65	0.87	0.62 (0.49–0.76)	Substantial
		5	64	0.85	0.47 (0.34–0.61)	Substantial/moderate
		6	63	0.77	0.40 (0.24–0.55)	Substantial/poor
Foot-wall integrity	0.45	2	96	0.65	0.75 (0.44–1.00)	Moderate/substantial
		5	86	0.60	0.32 (−0.18–0.81)	Moderate/poor
		6	94	0.47	0.53 (−0.02–1.00)	Moderate
Hoof overgrowth	0.56	2	66	0.80	0.48 (0.31–0.64)	Substantial/moderate
		5	66	0.75	0.30 (0.22–0.48)	Substantial/poor
		6	40	0.79	0.27 (0.10–0.36)	Substantial/poor

* Inter-observer agreement for nominal measures determined by Fleiss's Kappa (k); ** Pair-agreement with the test standard observer for nominal measures determined by Cohen's Kappa (k).

Table 5. Intra-observer agreement at mid-lactation.

Measures	**Observer Identity**	**W**	**Kw**	**Interpretation (W/Kw)**
BCS	1	0.87	0.57 0.49	Substantial/moderate
	2	0.79	0.37	Substantial/moderate
	5	0.76		Substantial/poor
	6	0.62	0.22	Moderate/poor
Fleece cleanliness	1	1.00	1.00 1.00	Perfect agreement
	2	1.00	1.00	Perfect agreement
	5	1.00		Perfect agreement
	6	1.00	1.00	Perfect agreement
Fleece Condition	1	1.00	1.00 0.89	Perfect agreement
	2	0.83	1.00	Substantial
	5	1.00		Perfect agreement
	6	0.75	0.78	Substantial
Skin lesions	1	0.83	0.66 **	Substantial
	2	0.75	0.49 **	Substantial/moderate
	5	0.83	0.66 **	Substantial

	6	0.69	0.49 **	Moderate
Tail length	1	n/a n/a	0.58 **	Moderate
	2	n/a	1.00 **	Perfect agreement
	5		0.50 **	Moderate
	6	n/a	0.02 **	Poor

Table 5. *Cont.*

Measures	Observer Identity	W	Kw	Interpretation (W/Kw)
Dag score	1	0.87	0.60	Substantial/moderate
	2	0.85	0.61	Substantial
	5	0.90	0.67	Substantial
	6	0.70	0.32	Substantial/poor
Foot-wall Integrity	1	0.73	0.65	Substantial
	2	0.62	0.31	Moderate/poor
	5	0.54	0.21	Moderate/poor
	6	0.48	0.30	Moderate/poor
Hoof overgrowth	1	0.77	0.49	Substantial/moderate
	2	0.74	0.39	Substantial/poor
	5	0.79	0.55	Substantial/moderate
	6	0.60	0.13	Moderate/poor

** Pair-agreement for nominal measures determined by Cohen's Kappa (k). Intra-observer agreement was done within a 24 h period.

3.3. Inter- and Intra-Observer Agreement at Weaning

At weaning, most of the welfare measures presented from 'moderate' to 'almost perfect' overall agreement (Table 6). 'Almost perfect' pair agreement was obtained for fleece cleanliness, fleece condition and skin lesions. Body condition score, dag score and hoof overgrowth ranged from 'poor-moderate' to 'almost perfect' pair agreement. Foot-wall integrity and tail length had the lowest pair agreement, however k values for tail length ranged from 0.22 ('poor') to 1.00 ('almost perfect'). The intra-observer agreement results are presented in Table 7. The most repeatable measures at weaning were fleece cleanliness, fleece condition, skin lesion and BCS followed by dag score and tail length. The least repeatable measures were foot-wall integrity and hoof overgrowth. The intra-assessment agreement of lameness also increased significantly at weaning showing substantial levels of repeatability W = 0.86. The TSO showed the highest levels of repeatability, and her repeatability increased significantly, particularly for BCS, dag score and tail length which increased from 'substantial/moderate' at mid-lactation to 'substantial/almost perfect' at weaning.

Table 6. Overall observer agreement (OA), percentage of agreement (%) and pair agreement at weaning.

Measures	OA (W)	Pair Agreement				
		Observer Identity	%	Kendall's (W)	Weighted Kappa (95% CI)	Interpretation (W/Kw)
BCS	0.80	7	38	0.90	0.63 (0.54–0.72)	Almost perfect/substantial
		8	39	0.88	0.59 (0.48–0.70)	Substantial/moderate
		9	31	0.86	0.39 (0.27–0.50)	Substantial/poor
Fleece cleanliness	1.00	7	100	1.00	1.00 (1.00–1.00)	Perfect agreement
		8	100	1.00	1.00 (1.00–1.00)	Perfect agreement
		9	100	1.00	1.00 (1.00–1.00)	Perfect agreement
Fleece condition	0.93	7	90	0.88	0.60 (0.41–0.80)	Substantial/moderate
		8	99	0.96	0.88 (0.73–1.00)	Almost perfect
		9	99	0.92	0.88 (0.71–1.00)	Almost perfect
Skin lesions	0.96	7	99	0.96	0.92 (0.76–1.00)	Almost perfect
		8	100	1.00	1.00 (1.00–1.00)	Perfect agreement
		9	99	0.96	0.92 (0.76-1.00)	Almost perfect
Tail length	0.49 *	7	97	n/a	0.65 ** (0.29–1.00)	Substantial
		8	100	n/a	1.00 ** (1.00–1.00)	Perfect agreement
		9	94	n/a	0.22 ** (−0.19–0.62)	Poor

Table 6. *Cont.*

Measures	OA (W)	Pair Agreement				
		Observer Identity	%	Kendall's (W)	Weighted Kappa (95% CI)	Interpretation (W/Kw)
Dag score	0.68	7	79	0.75	0.35 (0.22–0.48)	Substantial/poor
		8	90	0.83	0.53 (0.40–0.65)	Substantial/moderate
		9	87	0.83	0.52 (0.39–0.64)	Substantial/moderate
Foot-wall integrity	0.52	7	92	0.63	0.43 (0.07–0.79)	Substantial/moderate
		8	92	0.83	0.64 (0.36–0.93)	Substantial
		9	93	0.68	0.37 (−0.03–0.76)	Substantial/poor
Hoof overgrowth	0.61	7	76	0.70	0.52 (0.37–0.67)	Substantial/moderate
		8	75	0.71	0.51 (0.36–0.65)	Substantial/moderate
		9	73	0.77	0.48 (0.32–0.64)	Substantial/moderate

* Inter-observer agreement for nominal measures determined by Fleiss's Kappa (k); ** Pair-agreement with the test standard observer for nominal measures determined by Cohen's Kappa (k).

Table 7. Intra-observer agreement at weaning.

Measures	Observer Identity	W	Kw	Interpretation (W/Kw)
BCS	1	0.90	0.64 0.56	Almost perfect/substantial
	7	0.87	0.58	Substantial/moderate
	8	0.87		Substantial/moderate
	9	0.85	0.59	Substantial/moderate
Fleece cleanliness	1	1.00	1.00 1.00	Perfect agreement
	7	1.00	1.00	Perfect agreement
	8	1.00		Perfect agreement
	9	1.00	1.00	Perfect agreement
Fleece Condition	1	0.92	0.88 0.65	Almost perfect
	7	0.91	0.74	Almost perfect/substantial
	8	0.86		Substantial
	9	0.77	0.69	Substantial
Skin lesions	1	0.86	0.82 0.90	Substantial/almost perfect
	7	0.95	0.71	Almost perfect Substantial
	8	0.86		
	9	0.90	0.65	Almost perfect/substantial
Tail length	1	n/a n/a	0.80 **	Substantial Moderate
	7	n/a	0.54 **	Substantial
	8		0.80 **	
	9	n/a	0.18 **	Poor
Dag score	1	0.79	0.61 0.37	Substantial
	7	0.70	0.41	Substantial/poor
	8	0.65		Substantial/moderate
	9	0.76	0.48	Substantial/moderate
Foot-wall Integrity	1	0.79	0.58 0.23	Substantial/moderate
	7	0.48	0.48	Moderate/poor Moderate
	8	0.66		
	9	0.70	0.34	Substantial/poor
Hoof overgrowth	1	0.77	0.54 0.49	Substantial/moderate
	7	0.75	0.32	Substantial/moderate
	8	0.62		Moderate/poor
	9	0.63	0.33	Moderate/poor

** Pair-agreement for nominal measures determined by Cohen's Kappa (k). Intra-observer agreement was done within a 24 h period.

The welfare assessment of the ewes using 10 animal-based measures took from 4 to 6 h. No differences in the time spent assessing the ewes were found between mid-pregnancy and mid-lactation, means were 3.4 min/ewe (SD ± 0.63) and 4.1 min/ewe (SD ± 1.03) respectively. However, the time spent performing the assessment significantly decreased (p = 0.001) at weaning to
2.5 min/ewe (SD ± 0.56), Figure 1.

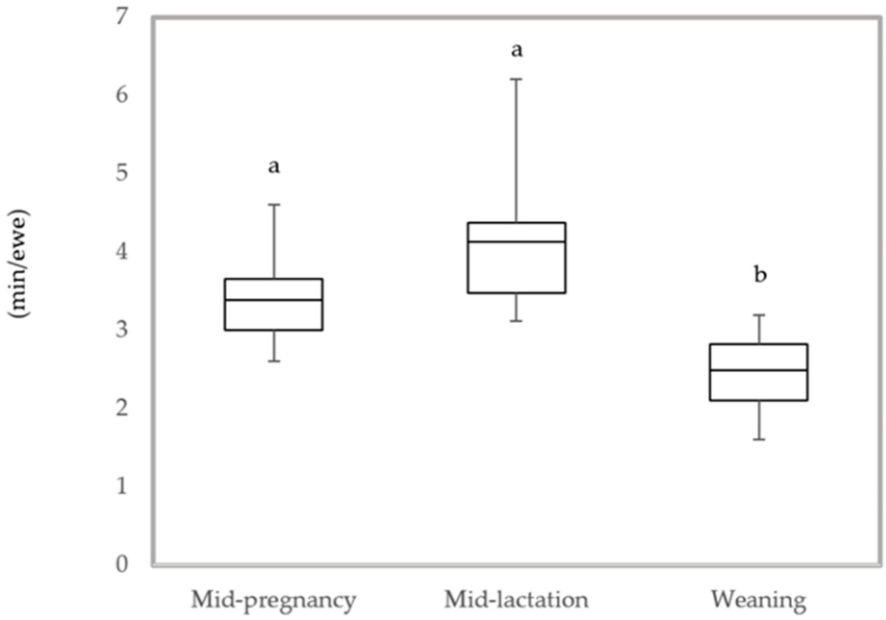

Figure 1. Time spent assessing the ewes (min/ewe) at mid-pregnancy, mid-lactation and weaning. Different letters indicate statistical difference ($p < 0.05$).

4. Discussion

This study assessed the reliability and feasibility of 10 animal-based welfare measures for extensively managed ewes. Body condition score, fleece condition, skin lesions, tail length, dag score and lameness are proposed for on-farm use in welfare assessments of extensive sheep production systems. These six valid measures address the main welfare concerns for ewes, and they are reliable and feasible. When combined, they provide an overview of the nutritional, health and welfare state of the ewes as well as evidencing previous or potential welfare concerns.

4.1. Reliability of the Animal-Based Welfare Measures

High inter- and intra- observer agreements, from 'substantial/moderate' to 'substantial/almost perfect' agreements, were found for BCS, fleece cleanliness, fleece condition, skin lesions, tail length, dag score and lameness. In the present study, BCS was the measure that increased the most, the inter-observer agreement and the intra-agreement of the TSO increased from 'moderate' at mid-pregnancy to 'almost perfect' at weaning. Body condition is widely accepted as a valid and important welfare measure that reflects the nutritional state of sheep [13,14]. Results in the present study suggests that a quarter-point scale is reliable, but that operators require sufficient training and experience to achieve high agreement in this measurement [27,35,36]. In this study, the experienced observers (TSO, observers 2 and 7) showed the highest agreement and repeatability for this measure. The increased training sessions and the clarification of the descriptive terms used may have help to achieved 'almost perfect' inter- and intra- observer agreement at the end of the study. Although individual differences, observer expertise and differences in intervals of reassessment (15-day period at MP vs. 24 h at ML and WN) may have influenced in the levels of agreement obtained, there is evidence that the level of observer agreement increases significantly when sufficient training is provided [13,18].

Rumen fill, foot-wall integrity and hoof overgrowth were the measures with lower agreement in this study. This is likely the result of difficulties associated with assessing these measures, e.g., presence of fleece and the fact that ewes often moved backwards and forwards along the race, which particularly affected how easily foot-wall integrity could be assessed. In addition, the scoring scales and the descriptive terms used for foot-wall integrity may have affected the levels of observer agreement. Simplifications of the scoring scales as well as clarification of the description terms may provide higher agreement and may be more useful for future on-farm assessments.

The performance of each welfare measure was evaluated in agreement with previous reliability studies [13,18,23,27]. Percentage of agreement was used as it provides an easy illustration of observer agreement. However, as this method does not estimate the amount of agreement that could occur by chance, Kendall's coefficient of concordance (W) and Kappa (k) were selected to statistically assess the inter and intra-observer agreement of ordinal and binominal measures. Care is needed however when interpreting k values, because they are affected by the prevalence of the condition under consideration. Populations with few animals presenting the condition of interest will provide very low values of k that may not necessarily reflect low levels of observer agreement [37]. In the present study, the length of the tail was a simple binominal scale and presented high percentage of agreement across the three-time points examined (MP: 71–86%; ML: 85–97%; WN: 96–100%). However, k values were consistently low; from 0.28 to 0.39 at MP, from −0.01 to 0.56 at ML and from 0.37 to 1.00 at WN. Discrepancies between the percentage of agreement and k values may be a consequence of the low number of animals that had adequate tail length in this study (n = 8, as determined by the TSO, while 92% n = 87 had short-docked tails at weaning), and may not necessarily mean low inter- observer agreement. It is possible that higher k values would have been achieved if more animals in this study had adequate tail length. Similar difficulties in the interpretation of k values have been reported in previous studies [23,37,38]. Other factors that need to be considered when evaluating reliability is intervals of reassessments. In the present study, low intra observer reliability at mid-pregnancy cannot be completely attributed to lack of consistency of the observers, as the length of the reassessment at this stage (15-day period) may have affected the levels of intra- observer agreement of dag score, skin lesions, foot-wall integrity and hoof overgrowth.

Overall, there is wide variation in the scientific literature on how reliability of welfare measures is assessed. Currently, there is no agreement on the number of animals, number of observers or the methodology that should be used. For instance, a reliability study in lambs used four observers to assess 966 lambs [23], a study of welfare assessment for adult sheep used two observers and 360 ewes [15], and studies assessing reliability on locomotion scoring in various species have used five observers and 83 cows [39], three observers and 30 video clips of sheep [40], and three observers and 80 photographs and videos of foot-rot lesions in sheep [27]. The sample size selected in the present study was based on a power calculation and recommendations by the AWIN sheep protocol [10], and the fact that the performance of the measures was tested on-farm during different stages of production of sheep further supports their reliability and applicability under farm conditions.

4.2. Feasibility of the Animal-Based Welfare Measures

Welfare measures need to be practical if they are to be valuable. Sheep farms in Australia can commonly have 12,000 animals, and they are usually managed by a single person [9,41]. This, highlights the need for feasible measures that can be taken in short periods of time with low need of resources and personnel as time and labor force are limited in extensive sheep systems. When assessing the feasibility of the measures of this study a variety of factors were considered such as time spent in the assessment, resources required and the ability to collect these measurements across different farms. Feasibility was assessed for a third party to perform the assessment, not a farmer. Generally, the measures tested proved to be feasible, requiring on average 2.5 min to assess an individual ewe at weaning. The significant decrease in the time spent in the assessment at weaning might have been influenced by individual differences of the observers, and familiarization with the scoring scales and assessment protocol. Although no differences were found in the time spent assessing the ewes between mid-pregnancy and mid-lactation. Lactation was considered the least practical period due to the presence of lambs, which made sheep handling difficult during the assessment. This needs to be considered when deciding for key times to perform on-farm welfare assessments.

The most feasible measures were found to be BCS, fleece cleanliness, fleece condition, skin lesions, tail length, dag score and lameness. Clear advantages of these measures in terms of practicality are that no measures required specialized equipment; the only infrastructure required is a raceway, which is a common facility on sheep farms, and other than the labor required to bring the sheep into the yards, they do not interrupt farm management practices. It should also be considered that most farmers visually monitor their sheep in the paddock, rather than gathering them into the yards. In this context, it has been shown that some of these

measures, e.g., thin body condition, lameness and dags can be examined from the distance during key stages of the production cycle [2,42] with minimal interference with farm work. Thus, the measures selected may be considered more acceptable by producers. Foot-wall integrity and hoof overgrowth on the other hand, were found less practical as they were time-consuming and they were not easy to assess as ewes often moved backwards and forwards. Additionally, their implementation across farms is limited as they should be assessed in races with no covered walls alongside.

4.3. Recommended Measures for On-Farm Welfare Assessment of Extensively Managed Ewes

This research is important because it identified measurements the are suitable for use under commercial conditions [43]. The validity of these measures reported in Munoz et al. [19], plus their reliability and feasibility examined in this study indicate that these six animal-based measures; BCS, fleece condition, skin lesions, tail length, dag score and lameness are appropriate/recommended to include in welfare protocols for ewes managed extensively, particularly in Australia. When these measures are combined, they provide a snapshot of the current welfare status of ewes, as well as providing evidence of past or potential welfare risks. For example, combining a decline in BCS, poor fleece condition and high dag score helps to identify that the welfare of that animal is compromised,while also facilitating the identification of the problem and the appropriate treatment. These measures address important welfare issues identified by producers, industry, specialist and general public [10,38,44].

Fleece cleanliness, although repeatable and feasible, might not be meaningful for extensive systems. Fleece cleanliness has previously been proposed as an important welfare measure for sheep, as it can provide information about the quality of the environment [10,15,18,23,45]. However, this measure is more valuable for intensive indoor lambing systems where is important to assess the cleanliness of the floor/bedding and how the animal is coping with this environment. Rumen fill, foot-wall integrity and hoof overgrowth were discarded based on poor reliability and feasibility. Rumen fill has been identified as a relevant animal-based measure for sheep and lambs as provides short-term information of food access [38]. In the present study, rumen fill was difficult to assess and this was reflected in the poor levels of agreement achieved. The presence of the fleece was the main factor affecting the levels of inter-observer agreement. Similar results have been obtained in a previous study on lambs where only 'moderate' inter-observer agreement was obtained [2]. In view of the difficulties of assessing rumen fill in ewes that are not in short wool and its limitations in assessing sheep welfare, the measure was excluded. Foot-wall integrity and hoof overgrowth showed poor repeatability and feasibility to be implemented across different farms. It should also be considered that broader measures, such as lameness, may be more relevant to assess ewe welfare than foot-wall integrity and hoof overgrowth.
Besides the importance of discriminating which welfare measures would be more suitable for extensive conditions, it is also important to identify alternatives that could be used to measure on-farm welfare in sheep. For instance, limited research has been done to develop practical assessments of fear of humans in sheep, and studies on this topic vary in methodology and performance [46]. The majority of this research has been focused on intensively managed sheep [15,47–49], and usually under experimental conditions [41,47,50]. Further work is needed to validate a practical on-farm assessment of fear of humans that could be applied to extensive systems. Recent studies by Hazard et al. [51,52] have investigated several behavioral traits in sheep that could be used to validate the assessment of fear of human in extensive farming conditions. Additionally, limited work has been done to develop practical on-farm assessments for clinical and sub-clinical mastitis [10]. Udder examination and collection of milk samples to perform an on-farm test (e.g., California mastitis test) is time-consuming and labor intensive, which make these assessments less appealing for on-farm use. Further studies in the development of practical welfare assessments should consider the incorporation of new technologies for practical assessment of mastitis and to track grazing behavior and sheep movement to detect sick/lame animals. Finally, it should be considered that extensive systems are characterized by seasonal variation in both, climate and food availability, which results in seasonal variation in the welfare status of sheep [18]. Welfare measures therefore must be able to detect variation in the welfare status of ewes over main risk periods of the production cycle [18], as well as be sensible to identify differences between farms. Further research into the development

of welfare assessment for extensive systems should assess both seasonal variation of the measures selected and their ability to detect differences between farms as only one property was examined in the present study.

5. Conclusions

The results obtained in the present study suggest that BCS, fleece condition, skin lesions, tail length, dag score and lameness are reliable and feasible measures that can be included in welfare protocols for extensive sheep production systems. The high levels of inter- and intra- agreement found for these measures also suggests that the scoring scales and the descriptive terms used are reliable. When these measures are used in combination with resource-based and management-based measures they can be used to address welfare compromise. Lactation was considered the least practical period due to the presence of lambs, which needs to be considered when deciding for key times to perform on-farm welfare assessments. Further research examining the ability of these measures to detect seasonal variation and between-farm differences will provide further evidence of their effectiveness in assessing the welfare condition of ewes managed extensively.

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References

1. Veissier, I.; Butterworth, A.; Bock, B.; Roe, E. European approaches to ensure good animal welfare. *Appl. Anim. Behav. Sci.* **2008**, *113*, 279–297. [CrossRef]
2. Phythian, C.J.; Toft, N.; Cripps, P.J.; Michalopoulou, E.; Winter, A.C.; Jones, P.H.; Grove-White, D.; Duncan, J.S. Inter-observer agreement, diagnostic sensitivity and specificity of animal-based indicators of young lamb welfare. *Animal* **2013**, *7*, 1182–1190. [CrossRef] [PubMed]
3. Knierim, U.; Winckler, C. On-farm welfare assessment in cattle: Validity, reliability and feasibility issues and future perspectives with special regard to the Welfare Quality approach. *Anim. Welf.* **2009**, *18*, 451–458. [CrossRef]
4. Capdeville, J.; Veissier, I. A Method of Assessing Welfare in Loose Housed Dairy Cows at Farm Level,

Focusing on Animal Observations. *Acta Agric. Scand. Sect. A* **2001**, *51*, 62–68. [CrossRef]

5. Smulders, D.; Verbeke, G.; Mormède, P.; Geers, R. Validation of a behavioral observation tool to assess pig welfare. *Physiol. Behav.* **2006**, *89*, 438–447. [CrossRef] [PubMed]
6. Broom, D.M. Animal Welfare Defined in Terms of Attempts to Cope with the Environment. *Acta Agric. Scand.*

Sect. A **1996**, *27*, 22–28.

7. Alban, L.; Ersbøll, A.K.; Bennedsgaard, T.W.; Johnsen, P.F. Validation of Welfare Assessment Methods at Herd Level: An Example. *Acta Agric. Scand. Sect. A* **2001**, *51*, 99–102. [CrossRef]
8. Main, D.C.J.; Whay, H.R.; Leeb, C.; Webster, A.J.F. Formal animal-based welfare assessment in UK certification schemes. *Anim. Welf.* **2007**, *16*, 233–236.
9. Goddard, P.; Waterhouse, T.; Dwyer, C.; Stott, A. The perception of the welfare of sheep in extensive systems. *Small Rumin. Res.* **2006**, *62*, 215–225. [CrossRef]
10. AWIN Welfare Assessment Protocol for Sheep. Available online: http://www.animal-welfare-indicators.net/site/flash/pdf/AWINProtocolSheep.pdf (accessed on 24 October 2017).
11. European Food Safety Authority (EFSA). Scientific Opinion on the welfare risks related to the farming of sheep for wool, meat and milk production. *EFSA J.* **2014**, *12*. [CrossRef]
12. Caldeira, R.M.; Belo, A.T.; Santos, C.C.; Vazques, M.I.; Portugal, A.V. The effect of body condition score on blood metabolites and hormonal profiles in ewes. *Small Rumin. Res.* **2007**, *68*, 233–241. [CrossRef]

13. Phythian, C.J.; Cripps, P.J.; Michalopoulou, E.; Jones, P.H.; Grove-White, D.; Clarkson, M.J.; Winter, A.C.; Stubbings, L.A.; Duncan, J.S. Reliability of indicators of sheep welfare assessed by a group observation method. *Vet. J.* **2012**, *193*, 257–263. [CrossRef] [PubMed]
14. Calavas, D.; Sulpice, P.; Lepetitcolin, E.; Bugnard, F. Assessing the accuracy of BCS in ewes under field conditions. *Vet. Res.* **1998**, *29*, 129–138. [PubMed]
15. Stubsjøen, S.M.; Hektoen, L.; Valle, P.S.; Janczak, A.M.; Zanella, A.J. Assessment of sheep welfare using on-farm registrations and performance data. *Anim. Welf.* **2011**, *20*, 239–251.
16. Larsen, J.; Anderson, N.; Vizard, A.; Anderson, G.; Hoste, H. Diarrhoea in Merino ewes during winter: Association with trichostrongylid larvae. *Aust. Vet. J.* **1995**, *72*, 75–76. [CrossRef]
17. Napolitano, F.; De Rosa, G.; Ferrante, V.; Grasso, F.; Braghieri, A. Monitoring the welfare of sheep in organic and conventional farms using an ANI 35 L derived method. *Small Rumin. Res.* **2009**, *83*, 49–57. [CrossRef]
18. Phythian, C.J. *Development of Indicators for the On-Farm Assessment of Sheep Welfare*; University of Liverpool: Liverpool, UK, 2011.
19. Munoz, C.; Campbell, A.; Hemsworth, P.; Doyle, R. Using longitudinal assessment on extensively managed ewes to quantify welfare compromise and risks. **2017**, under review.
20. Russel, A. Body condition scoring of sheep. *Practice* **1984**, *6*, 91–93. [CrossRef] [PubMed]
21. Ferguson, M.; Thompson, A.; Gordon, D. *Lifetime Wool: Ewe Management Handbook*, 2nd ed.; Behrendt, R., Whale, J., Curnow, M., Eds.; Lifetimewool: Victoria, Australia, 2011; ISBN 9780980344851.
22. Russel, A.J.F.; Doney, J.M.; Gunn, R.G. Subjective assessment of body fat in live sheep. *J. Agric. Sci.* **1969**, *72*, 451–454. [CrossRef]
23. Phythian, C.; Michalopoulou, E.; Duncan, J.; Wemelsfelder, F. Inter-observer reliability of Qualitative Behavioural Assessments of sheep. *Appl. Anim. Behav. Sci.* **2013**, *144*, 73–79. [CrossRef]
24. Izumi, K.; Nagata, S.; Nakamura, J.; Okamoto, M. A study of rumen fill on eating behaviour and voluntary intake in sheep using rumen digesta exchange method. *J. Anim. Feed Sci.* **2004**, *13*, 103–106. [CrossRef]
25. Munro, T. Tail Length in Lambs—The Long and Short of It. Available online: http://www.flyboss.com.au/files/pages/management/tail-length/Kondinin_Tail_Length_article_130410.pdf (accessed on 1 August 2017).
26. Sutherland, M.A.; Tucker, C.B. The long and short of it: A review of tail docking in farm animals. *Appl. Anim. Behav. Sci.* **2011**, *135*, 179–191. [CrossRef]
27. Foddai, A.; Green, L.E.; Mason, S.A.; Kaler, J. Evaluating observer agreement of scoring systems for foot integrity and footrot lesions in sheep. *BMC Vet. Res.* **2012**, *8*, 65. [CrossRef] [PubMed]
28. Kaler, J.; Green, L.E. Naming and recognition of six foot lesions of sheep using written and pictorial information: A study of 809 English sheep farmers. *Prev. Vet. Med.* **2008**, *83*, 52–64. [CrossRef] [PubMed]
29. Kaler, J.; Medley, G.F.; Grogono-Thomas, R.; Wellington, E.M.H.; Calvo-Bado, L.A.; Wassink, G.J.; King, E.M.; Moore, L.J.; Russell, C.; Green, L.E. Factors associated with changes of state of foot conformation and lameness in a flock of sheep. *Prev. Vet. Med.* **2010**, *97*, 237–244. [CrossRef] [PubMed]
30. Martin Bland, J.; Altman, D. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* **1986**, *327*, 307–310. [CrossRef]
31. Mullan, S.; Edwards, S.A.; Butterworth, A.; Whay, H.R.; Main, D.C.J. Inter-observer reliability testing of pig welfare outcome measures proposed for inclusion within farm assurance schemes. *Vet. J.* **2011**, *190*, e100–e109. [CrossRef] [PubMed]
32. Kendall, M.G.; Smith, B.B. The Problem of m Rankings. *Ann. Math. Stat.* **1939**, *10*, 275–287. [CrossRef]
33. Fleiss, J.L.; Levin, B.; Paik, M.C. Statistical Methods for Rates and Proportions. *Technometrics* **2004**, *46*, 263–264. [CrossRef]
34. Landis, J.R.; Koch, G.G. The Measurement of Observer Agreement for Categorical Data. *Biometrics* **1977**, *33*, 159–174. [CrossRef] [PubMed]
35. Gibbons, J.; Vasseur, E.; Rushen, J. A training programme to ensure high repeatability of injury scoring of dairy cows. *Anim. Welf.* **2012**, *21*, 379–388. [CrossRef]
36. Grandin, T. On-farm conditions that compromise animal welfare that can be monitored at the slaughter plant. *Meat Sci.* **2017**, *132*, 52–58. [CrossRef] [PubMed]
37. Viera, A.J.; Garrett, J.M. Understanding interobserver agreement: The kappa statistic. *Fam. Med.* **2005**, *37*, 360–363. [PubMed]

38. Phythian, C.J.; Michalopoulou, E.; Jones, P.H.; Winter, A.C.; Clarkson, M.J.; Stubbings, L.A.; Grove-White, D.; Cripps, P.J.; Duncan, J.S. Validating indicators of sheep welfare through a consensus of expert opinion. *Animal* **2011**, *5*, 943–952. [CrossRef] [PubMed]
39. Channon, A.J.; Walker, A.M.; Pfau, T.; Sheldon, I.M.; Wilson, A.M. Variability of Manson and Leaver locomotion scores assigned to dairy cows by different observers. *Vet. Rec.* **2009**, *164*, 388–392. [CrossRef] [PubMed]
40. Kaler, J.; Green, L.E. Farmers' practices and factors associated with the prevalence of all lameness and lameness attributed to interdigital dermatitis and footrot in sheep flocks in England in 2004. *Prev. Vet. Med.* **2009**, *92*, 52–59. [CrossRef] [PubMed]
41. Hargreaves, A.L.; Hutson, G.D. The stress response in sheep during routine handling procedures. *Appl. Anim. Behav. Sci.* **1990**, *26*, 83–90. [CrossRef]
42. Phythian, C.; Cripps, P.; Grove-White, D.; Jones, P.; Michalopoulou, E.; Duncan, J. Observing lame sheep: Evaluating test agreement between group-level and individual animal methods of assessment. *Anim. Welf.* **2013**, *22*, 417–422. [CrossRef]
43. Grandin, T. *Improving Animal Welfare: A Practical Approach*; Grandin, T., Ed.; CABI: Cambridge, UK, 2010; ISBN 1845935411.
44. Doughty, A.K.; Coleman, G.J.; Hinch, G.N.; Doyle, R.E. Stakeholder perceptions of welfare issues and indicators for extensively managed sheep in Australia. *Animals* **2017**, *7*. [CrossRef] [PubMed]
45. Llonch, P.; King, E.M.; Clarke, K.A.; Downes, J.M.; Green, L.E. A systematic review of animal based indicators of sheep welfare on farm, at market and during transport, and qualitative appraisal of their validity and feasibility for use in UK abattoirs. *Vet. J.* **2015**, *206*, 289–297. [CrossRef] [PubMed]
46. Forkman, B.; Boissy, A.; Meunier-Salaün, M.C.; Canali, E.; Jones, R.B. A critical review of fear tests used on cattle, pigs, sheep, poultry and horses. *Physiol. Behav.* **2007**, *92*, 340–374. [CrossRef] [PubMed]
47. Le Neindre, P.; Poindron, P.; Trillat, G.; Orgeur, P. Influence of breed on reactivity of sheep to humans. *Genet. Sel. Evol.* **1993**, *25*, 447–458. [CrossRef]
48. Coulon, M.; Hild, S.; Schroeer, A.; Janczak, A.M.; Zanella, A.J. Physiology & Behavior Gentle vs. aversive handling of pregnant ewes: II. Physiology and behavior of the lambs. *Physiol. Behav.* **2011**, *103*, 575–584. [CrossRef] [PubMed]
49. Napolitano, F.; De Rosa, G.; Girolami, A.; Scavone, M.; Braghieri, A. Avoidance distance in sheep: Test-retest reliability and relationship with stockmen attitude. *Small Rumin. Res.* **2011**, *99*, 81–86. [CrossRef]
50. Hutson, G.D. "Flight distance" in Merino sheep. *Anim. Prod.* **1982**, *35*, 231–235. [CrossRef]
51. Hazard, D.; Moreno, C.; Foulquié, D.; Delval, E.; François, D.; Bouix, J.; Sallé, G.; Boissy, A. Identification of QTLs for behavioral reactivity to social separation and humans in sheep using the OvineSNP50 BeadChip. *BMC Genom.* **2014**, *15*, 778. [CrossRef] [PubMed]
52. Hazard, D.; Bouix, J.; Chassier, M.; Delval, E.; Foulquié, D.; Fassier, T.; Bourdillon, Y.; François, D.; Boissy, A. Genotype by environment interactions for behavioral reactivity in sheep. *J. Anim. Sci.* **2016**, *94*, 1459–1471. [CrossRef] [PubMed]

15.5 Using Longitudinal Assessment on Extensively Managed Ewes to Quantify Welfare Compromise and Risks

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Article

Using Longitudinal Assessment on Extensively Managed Ewes to Quantify Welfare Compromise and Risks

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Simple Summary: Sheep managed extensively can be exposed to several welfare challenges during the year, and the risk of some diseases can increase in warmer and wetter seasons. In this study, the welfare of Merino ewes was examined over a calendar year. The welfare of these animals, kept on a single farm with consistent management, varied substantially. Overall, the largest number of ewes experienced compromise and risk to welfare at weaning, indicating that this was the most vulnerable time. The main welfare issues identified were under and over feeding, ewe mortality, lameness, ecto-parasites (flystrike) and mastitis, all of which could be improved by modifying management practices, such as improved nutritional management and monitoring and better tail docking procedures. Future research must consider that significant variation in the on-farm welfare of ewes occurs during a calendar year, which needs to be accounted for when conducting on-farm assessments.

Abstract: This study examined variation in the welfare of extensively managed ewes and potential welfare risks. A total of 100 Merino ewes (aged 2–4 years) were individually identified and examined at three key stages: pregnancy, lactation and weaning. Eight animal-based welfare measures were used to assess welfare: flight distance, body condition score (BCS), fleece condition, skin lesions, tail length, dag score, lameness and mastitis. Data were analysed by ANOVA and McNemar's statistics. Overall, the average BCS of the group was in agreement with industry recommendations. However, a number of animals were classified with inadequate condition (either too thin or too fat) across the three observation periods. The presence of heavy dags was greatest at mid-lactation (87%, $P < 0.0001$), lameness was greatest at weaning (14%, $P = 0.01$), clinical mastitis was 1% annually, and five ewes were lost from the study. Ewes had better health at mid-pregnancy compared to mid-lactation and weaning. The main welfare issues identified were under and over feeding, ewe mortality, lameness, ecto-parasites (flystrike) and mastitis, all of which have the potential to be reduced with improved management practices. Future welfare assessment programs must consider that significant variation in on-farm welfare will occur in extensively managed systems and this needs to be accounted for when evaluating farms.

Keywords: animal-based indicators; animal welfare; on-farm welfare assessment; sheep

1. Introduction

The sheep industry is facing increasing financial and social pressures for assurances of good animal welfare and to maintain its 'social license' to operate [1]. In order to do this, further investigation of the current on-farm welfare status of sheep and potential welfare risks are needed [1,2]. Sheep that are farmed extensively in large flocks, in a year-round outdoor system and with low labour input, have the opportunity to live under more natural conditions and express natural behaviours [2]. This behavioural freedom creates opportunities for a better quality of life and a perception of positive welfare. Other aspects of extensive systems, however, do not necessarily guarantee good welfare, as extensively managed sheep can be at risk of several welfare challenges from a fluctuating environment and intermittent, unpredictable human interactions [3,4]. For example, fluctuation in environmental and climatic conditions produce important differences in food quality and availability. This, combined with changes in the sheep reproductive cycle, leads to variation in body condition over the course of the year [5,6]. Different seasons also increase the risk of some diseases in warmer and wetter periods, such as cutaneous myiasis [7] and foot rot [8]. In addition, the extensive nature of the industry makes feeding, predation control and prevention and treatment of diseases more difficult to monitor and promptly address, as there is limited individual care and supervision of animals [9]. Recent studies have suggested that the main on-farm welfare problems include poor nutrition (under and over-feeding), ecto- and endoparasites, reproductive health (e.g., mastitis, vulval cancer), lameness (and associated foot diseases) and mortality [2,4,10,11]. While the issues have been clearly identified, the extent of the issues are unknown as many sheep producers cannot accurately estimate the mortality rates in their farms [2].

Ewes' health and welfare relates closely to both lamb and weaner survival, with healthy ewes in a good welfare state producing strong offspring at lower risk of chronic welfare compromise throughout their lives [12–14]. Ewes are vital to farm productivity, and maintaining ewes in good welfare has a significant impact on farm health and profitability. To date, most of the studies investigating sheep welfare have been conducted on lambs at transport [15,16], abattoirs [17,18], or in more intensive sheep farming conditions [1,6,19,20] and less attention has been given to the on-farm welfare of extensively managed ewes. This could be attributed to the general perception of positive welfare under extensive conditions but also to the complexity of assessing welfare in extensive systems, where time and labour limitations make it difficult to observe ewes in an undisturbed state, particularly in larger flocks and/or paddocks [7]. The present longitudinal study was designed to address this knowledge gap by examining variation in the on-farm welfare of one flock of extensively managed ewes and potential

welfare risks over the course of three key stages; pregnancy, lactation and weaning.

2. Materials and Methods

2.1. Animals and Husbandry

This study is part of a longitudinal on-farm study that was performed in Victoria, Australia between July and December, 2015 [21]. The study was approved by the University of Melbourne ethics committee (ethical approval number 1513562.1). A total of 100 adult Merino ewes (aged 2–4 years), randomly selected from a larger flock of approximately 3000 breeding ewes, were individually identified by a unique ear tag number and examined at three-time points: mid-pregnancy (June), mid-lactation (October) and weaning (December). These reproductive periods were selected because they are known to be critical times for sheep welfare [1,7]. The ewes were managed under extensive commercial conditions, in a year-round outdoor system, and grazing a mix of annual and perennial pastures. The ewe sample size was selected based on a power calculation assuming 50% prevalence of the trait under observation (the proportion requiring the greatest sample size when observing binomial traits), a 95% confidence interval and precision of ±10%. This number was supported by the AWIN sheep protocol which recommends a sample of 92 animals when the farm size is ≥2000 breeding ewes [22]. Animals were not scanned for pregnancy before the study. However, farm records over the past three years were: 120% pregnancy rate, 100% lamb marking rate and 98% weaning rate. Upon physical examination of the

udder at mid-lactation, it was found that 26% of the ewes (*n* = 25) failed to lamb or rear a lamb. This information was considered and the factor 'reproductively active' and 'non-reproductively active' was included in the analyses of the data.

2.2. Identification of Welfare Measures

The measures used to examine on-farm ewe welfare were derived from a review of the relevant scientific literature (including research papers, conference proceedings, theses and literature reviews published from 1994 to 2016). A total of 73 papers were identified, and those that included suitable animal-based measures for Australian extensive sheep farming conditions were evaluated for validity, reliability and practicality [23]. Valid welfare measures are those that provide meaningful information with respect to animal welfare, reliable measures provide repeatable outcomes when applied by different observers and practical measures are able to be collected in a large number of animals (≥100), in a short period of time, with minimum labour input.

The welfare measures identified in the literature were compared to welfare measures identified in a large on-line survey of producers, industry experts and the general public [4], the AWIN sheep protocol [22], the Welfare Quality Assurance program [24], consultations with veterinarians and animal welfare scientists, and were then matched with the five domains of welfare compromise [25]. Table 1 shows the main animal-based welfare measures identified in the literature. The measures used in the present study were flight distance (FD), body condition score (BCS), fleece condition, skin lesions, tail length, dag score, lameness and mastitis. They were selected based on their reported validity (Table 1), and their reliability and feasibility reported in Munoz et al. [21].

2.3. Assessment of Seasonal Variation in the Welfare of Ewes

In order to perform the assessment, the ewes were managed in four groups of 25 animals. The assessment consisted of a group flight distance test (FD), and individual examination of BCS, fleece condition, skin lesions, tail length, dag score, lameness and mastitis. The assessment was performed using a holding pen (9 m × 8 m) and a single-file race within the farm's regularly-used sheep yards, and was always conducted between 900 h and 1600 h.

The first step of the assessment was to measure flight distance (FD). The ewe's response to an unfamiliar human was assessed with the assumption that the behavioral response of sheep to an individual will reflect the way in which they would respond to the farmer and/or external contractors and veterinarians, reflecting the process of stimulus generalization [26,27]. To test FD, a single human stimulus, always the same person (CM), quietly entered the pen holding a group of 25 ewes, walked around the perimeter and stood again at the entry point. From here, the observer waited for an ewe to be orientated towards her before approaching the animal. The ewe was approached by the observer in a standardised way (e.g., taking one step per second, maintaining the right arm in an angle of 45° in front of the body and the palm pointing towards the floor) [20,22]. The test ended when the ewe withdrew, defined as stepping away from the observer. Flight distance was estimated by counting the steps between the observer's hand and the ewe's head at the moment of withdrawal, and the behaviour of the ewe when approached by the observer was scored by using a 4-point score system as follows: a score of (0) if behaved calmly when approached; a score of (1) if there is some avoidance; a score of (2) if there is marked avoidance and struggling to escape; and a score of (3) if the ewe attempt to escape by jumping out of the pen [1]. Flight distance was measured in 5 ewes randomly selected from each of the four groups of 25 ewes, and was repeated at each stage. The ewes were not individually identified during the test, but the ewes tested were randomly selected from different locations within the group. The probability of not testing the same animal was 65%.

The group of ewes was then moved to the single file race for individual examination of BCS, fleece condition, skin lesions, tail length, dag score, lameness and mastitis. The assessment criteria of the welfare measures are listed in Table 2. Mastitis was assessed by physical inspection of the udder and milk collection at mid-lactation and weaning. Ewes were restrained during this procedure in a purpose-built crate that allowed the ewe to remain in a standing position. At mid-lactation and weaning, all lactating ewes had approximately 35 mL of milk collected via hand milking. Prior to milk collection, teats were cleaned using an 80% ethanol solution. Milk was

collected for both California Milk Test and somatic cell counts, with the person collecting the milk wearing gloves to eliminate any transfer of bacteria between human and sheep and vice versa.

Table 1. Animal-based welfare measures identified for extensively managed ewes.

Five Domains Principles	Category	Indicator	Animals	Validity	Reference
Nutrition	Nutrition Feed and water	Body condition score Rumen fill	Lambs/ewes Lambs/ewes	H L/M	[1,7,28–30] [31,32]
Environmental challenge	Shade and shelter	Panting Fleece cleanliness	Ewes Ewes	H H	[19,33,34] [1,7,19,20]
Disease, injury, functional impairment	Gastrointestinal health	Faecal soiling	Ewes	H	[6,7,35]
	Integument alterations	Fleece condition Skin lesions	Ewes Ewes	H H	[1,6,7] [1,7,20]
	Foot condition and lameness	Foot-wall integrity Hoof overgrowth Gait score	Ewes Ewes Ewes	L/M M M/H	[7,36–39] [7,20,37,40] [6,7,19,20,41,42]
	Reproductive health	Mastitis Tail length	Ewes Lambs/ewes	M/H H	[7,43] [7,44]
	Systemic disease	Social withdrawal	Ewes	M	[6]
Behavioural restriction	Agonistic behaviour Abnormal behaviour	Aggression Stereotypies	Ewes Ewes	M H	[5,45,46] [46,47]
Mental state	Behaviour HAR #	QBA * Flight distance	Wethers/ewes Lambs/ewes	M/H L/M	[6,31,48–51] [1,20,52,53]

* QBA refers to Qualitative Behaviour Assessment; # HAR refers to human-animal relationships. Validity scale was as follows: H = high, M = moderate and L = low. High validity was given to animal-based measures validated in previous research, medium validity was given to measures without a reliable method of assessment and low validity was given to measures that have been suggested in scientific literature but without evidence that they assess welfare.

Table 2. Animal-based welfare measures used to assess the welfare of extensively managed ewes.

Welfare Measure	Assessment Criteria
Flight distance	Flight distance was estimated by counting the steps between the observers' hand and the ewes' head at the moment of withdrawal [20,22]. The behaviour of the ewe when approached by the observer was scored by using a 4-point score system as follow: (0) behaved calmly when approached; (1) some avoidance; (2) marked avoidance and struggling to escape; and (3) attempts to escape by jumping out of the pen [1].
Body condition score	Scored on a 5 point scale from 1 (thin) to 5 (obese), using a quarter-unit precision. Sheep were assessed by palpation of the backbone, muscle and short ribs [28,30]
Fleece condition	Scored on a 3 point scale: (0) good fleece condition, when parted, the fleece has no lumpiness or signs of ectoparasites; (1) some fleece loss, small shed or bald patches of no more than 10 cm diameter. When parted, the fleece may have some lumpiness or scurf, little evidence of ectoparasites; and (2) significant fleece loss with bald patches of greater than 10 cm in diameter, clear evidence of ectoparasites [22].
Skin lesions	Assessed by recording number, location, type and size of the skin lesions. Lesions were classified as cuts, open wounds, old wounds or scars and abscesses.
Tail length	Scored on a 2 point scale: (0) the tip of the vulva is covered by the tail when held down; (1) the tail is over-shortened or almost not present, or if the vulva and anus cannot be covered [22,54]

Table 2. *Cont.*

Welfare Measure	Assessment Criteria
Dag score	Scored on a 6 point scale: (0) no evidence of faecal soiling; (1) very light soiling on the breech area; (2) Moderate dag on the breech area extending ventrally; (3) Severe dag predominantly on the breech area, extending ventrally and dorsally over the tail some soiling and dag around anus; (4) excessive dag on the breech area and on the hind legs; (5) Very severe dag on the breech area and on the hind legs or below the level of the hocks [35]
Lameness	Scored on a 4 point scale: (0) not lame; (1) clear shortening of stride with obvious head nodding or flicking as the affected limb touches the floor; (2) clear shortening of stride with obvious head nodding and not weight-bearing on affected limb whilst moving; (3) reluctant to stand or move [22].
Mastitis	Scored on a 5 point scale: (0) normal udder; (1) a small fibrotic lesion within the mammary tissue, normal secretion; (2) A more extensive fibrosis of the udder. Milk ranged from normal to purulent; (3) Extensive swelling of the udder, that could be abscessed or ruptured; (4) Peracure mastitis. Complete udder involvement with severe inflammation. Secretion from serum-like to purulent. Mammary lymph nodes enlarged. Body temperature elevated [55].

2.4. Statistical Analysis

The welfare measures scoring scales consisted of numerical and categorical, ordinal data. Descriptive analysis of the data was performed in Excel® before data were transferred to SAS statistical package (Statistical Analysis System, Release 9.4 2012; SAS Institute Inc., Cary, NC, USA). A two-way ANOVA (group composition × stage of reproduction) was used to examine differences in flight distance between the three reproductive stages examined. Multiple comparisons between means were performed using Fisher's Least Significant Difference (LSD) test. Group composition refers to the four groups of 25 animals assessed each time. As the test depends on how the ewes behave towards the experimenter, ewes were not individually identified during the test. However, we identified the composition of each of the four groups at each stage, and this showed that different groups of sheep were formed at each time. In addition, a one-way ANOVA analysis was used to examine differences in BCS between 'reproductively active' and 'non-reproductively active' ewes.

A within animal comparison, to test differences in ewe welfare at the three stages, was performed by McNemar's statistics (test for dependent dichotomous variables). McNemar's statistic is used to examine the change in a binary repeated measurement, and can be used to test change in agreement over time [56]. To conduct this test, the seven animal-based welfare measures used for individual examination were transformed to binominal data. Body condition score was classified as adequate or inadequate according to industry recommended values [57], and 'reproductively active' and 'non-reproductively active' ewes were assessed independently. Fleece condition was transformed to adequate/inadequate (adequate fleece corresponding to ewes with a score of 0, see in Table 1). Skin lesions, dag score, lameness and mastitis were reclassified as present/absent.

3. Results

Assessment of Seasonal Variation in the Welfare of Ewes

The results of the individual welfare assessment are presented in Table 3. Five ewes were lost from the study period, with three ewes dying at lambing (reported dead by the farmer) and two presumed dead. Thus, different numbers of ewes were examined at mid-pregnancy (n = 100), mid-lactation (n = 96) and weaning (n = 95), and equals to a 5% mortality rate for ewes between mid-pregnancy and weaning. At mid-pregnancy, the mean BCS was 2.8 for 'reproductively active' ewes and 2.9 for 'non-reproductively active' ewes, and no statistical differences were found (F = 0.47, P = 0.49). At mid lactation, the mean BCS of the 'reproductively active' ewes was 3.1, while the mean BCS of the 'non-reproductively active' ewes was 3.3. The ANOVA analysis showed that the BCS between these groups were significantly different (F = 3.81, P = 0.05). At weaning, the mean BCS of the

'reproductively active' ewes was 2.9, whereas the mean BCS of the 'non-reproductively active' ewes was 3.1, and the ANOVA analysis showed that they were significantly different (F = 4.84, P = 0.03). In general, the number of animals classed with adequate/inadequate body condition varied over the course of the study. At mid-pregnancy, 29% of the ewes were below and 11% were above the recommended values. At mid-lactation, 10% of the ewes were below and 48% were above recommended values, and at weaning 12% of the ewes were below and 34% were above recommended values. A within animal comparison showed that the BCS of the 'reproductively active' ewes significantly decreased from mid-lactation to weaning (P = 0.03). The BCS of the 'non-reproductively active' ewes on the other hand, did not change over time (P = 0.73). Most of the 'non-reproductively active' ewes had a BCS of

3.5 ≥ (above recommended values) at mid-lactation and stayed in this category at weaning.

Table 3. Mean, minimum and maximum scores, recommended values (RV), percentage of ewes identified within recommended values (% within RV) and above recommended values (% above RV) at mid-pregnancy, mid-lactation and weaning; standard deviation in parentheses.

Measures	Mean Score	Min	Max	RV	% within RV	% above RV
			Mid-pregnancy			
BCS	2.83 (0.45) *	2	3.75	2.7–3.3 #	60%	11%
Fleece condition	0.02 (0.14)	0	1	0 a	98%	2%
Skin lesions	0.00 (0.14)	0	1	0 a	99%	1%
Dag score	0.54 (0.76)	0	3	0–1 a	99%	1%
Lameness	0.06 (0.27)	0	2	0 a	95%	5%
			Mid-lactation			
BCS	3.11 (0.42) *	2.5	4	2.7–3 #	42%	48%
Fleece condition	0.03 (0.17)	0	1	0 a	97%	3%
Skin lesions	0.01 (0.08)	0	1	0 a	92%	8%
Dag score	3.94 (0.89)	1	5	0–1 a	13%	87%
Lameness	0.06 (0.28)	0	2	0 a	95%	5%
Clinical mastitis	0.00 (0.00)	0	0	0 a	100%	0%
			Weaning			
BCS	2.88 (0.52) *	1.5	3.75	2.5–3 #	54%	34%
Fleece condition	0.09 (0.39)	0	2	0 a	95%	5%
Skin lesions	0.07 (0.27)	0	1	0 a	93%	7%
Dag score	0.94 (0.25)	0	3	0–1 a	98%	2%
Lameness	0.13 (0.35)	0	1	0 a	86%	14%
Clinical mastitis	0.06 (0.49)	0	4	0 a	99%	1%

* Mean BCS of 'reproductively active' ewes; # Industry recommendations of BCS [57]; a Score recommended by [22].

Fleece condition was overall adequate during the three periods examined. The percentage of ewes scored with adequate fleece condition ranged from 99% at mid-pregnancy to 95% at weaning. Skin lesions followed the same trend, with lesions mostly observed at weaning and related to cutaneous myiasis (flystrike; 86% of affected ewes, n = 6) and dermatophilosis (lumpy wool; 14% of affected ewes, n = 1). Dag scores were within the recommended values (scores 0–1) at mid-pregnancy and weaning, but significantly increased at mid-lactation (P < 0.0001) where 87% of the ewes had dag scores between 4 and 5. It was identified that 84 ewes that presented low dag score at mid-pregnancy (score 0–1) later presented high dag score at mid-lactation (score 4–5), and four ewes remained with a dag score of 3 at weaning, and their BCS ranged from 2.5 to 2.25. A total of 92% of the ewes at weaning (n = 87) had short-docked tails. Lameness increased significantly over time, from 5% (n = 5) at mid-pregnancy to 14% (n = 13) at weaning (P = 0.01). One ewe was lame at all three data collection times, and her lameness score increased from a score of 1 (clear shortening of stride) at mid-pregnancy to a score of 2 (not weight-bearing on affected limb) at weaning, and her BCS decreased from 2.75 at mid-pregnancy to 1.5 at weaning. At mid-lactation, no signs of clinical mastitis were observed, but the California Mastitis Test

and somatic cell counts showed that 10% of the lactating ewes presented weak or distinct positive results to subclinical mastitis and somatic cell counts ranged from 29,000 to 4,022,000 cells/mL of milk. At weaning, the California Mastitis Test and somatic cell counts showed that 8% of the ewes presented weak or distinct positive results to subclinical mastitis, and somatic cell counts ranged from 38,000 to 17,177,000 cells/mL of milk. At this stage, 1% clinical mastitis was found and the affected ewe presented gangrenous mastitis, which corresponded to a score of 4. Ewes flight distance (FD) differed between each reproductive stage ($P < 0.0001$). The mean FD at mid-pregnancy was 5.15 m (SE ± 0.2), this significantly increased to 6.17 m (SE ± 0.3) at mid-lactation and decreased to 4.00 m (SE ± 0.2) at weaning (Figure 1). The behaviour score of the ewes when approached by the experimenter ranged
from a score of 1 to a score of 2 during the study, and did not differ between reproductive stages.

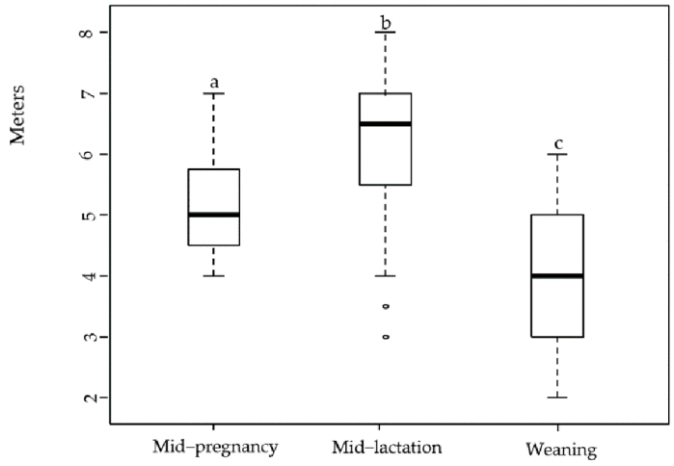

Figure 1. Median, minimum and maximum flight distance (FD) observed at mid-pregnancy, mid-lactation and weaning. Different letters indicate statistical difference ($P < 0.05$).

4. Discussion

The welfare of extensively farmed ewes on a single farm with consistent management varied substantially. This variation was seen both between individuals and within individuals during the study period. The animal welfare measures included in this study show both welfare compromise (evident at weaning) and welfare risk (high dag scores at mid-lactation). When assessing the biological functioning of the ewes, the largest number of ewes experienced compromise and risk to welfare at weaning. At this stage, 12% of the ewes were classed with a BCS below 2.5, 6% of the ewes presented skin lesions related to flystrike, there was 1% clinical mastitis and 14% lameness, indicating that this was the most vulnerable time. Results show that some welfare measures such as BCS, dag score and lameness can detect differences at key time points and predict the likelihood of individual ewes experiencing future welfare compromise. While identified welfare issues may be exacerbated by the season, there is potential for improvement with changed management practices at each stage of the reproductive cycle. As a result, we discuss the results of the welfare assessment in conjunction with management activities that could reduce these issues.

In this study, the average BCS of ewes studied was in agreement with industry recommendations. However, a number of animals were classified with inadequate condition, either too thin or too fat, across the three observation periods. Body condition scoring of sheep has been validated [7,21,28,58] and is widely accepted as an animal-based measure that can be used to monitor past nutritional management and potential welfare risks of sheep [7,59]. It is possible that some of the pregnant ewes classed with low body condition at mid-pregnancy, particularly the ones classed with a BCS < 2.5, may have experienced reduced placental development and foetal growth [60,61], and were more susceptible to metabolic diseases, such as pregnancy toxemia [59]. The ewes scored fat at mid-pregnancy, besides being at more risk of metabolic diseases, may also be more likely to experience difficulties at lambing [62]. Results from udder inspection at mid-lactation detected that 26% of the flock failed to lamb or rear lambs, suggesting that either a significant number of ewes were not pregnant, had lost pregnancies or lost lambs at or soon after birth. Based on the farm history on reproductive rates and results

for BCS in the study, it is likely that a large number of ewes had lost lambs soon after birth [63]. By tracking the same ewes over the study, a 5% mortality rate between mid-pregnancy and weaning was identified. Generalizing this figure across the whole flock, it would translate to 150 ewe deaths in the 6 months of the study, which has welfare and economic consequences. Previous studies suggests that lack of information on farm mortality could produce a disconnection between perceived and actual ewe mortality, and this underestimates welfare issues on the farm and may lead to a lack of interest by producers to address particular welfare concerns [10]. To comprehensively assess ewe welfare, measures such as BCS cannot be taken in isolation, and they need to be integrated with further details of farm records, management and resources. The fact that a consistent number of animals had inadequate body condition during the study, making them susceptible to several diseases, highlights the importance of appropriate nutritional management to reduce individual welfare compromise. Overall, the main welfare risks identified in this study may have arisen because of both under and over feeding. Condition scoring at key times and pregnancy scanning of ewes to identify ewes that are not pregnant, or carrying single or multiple lambs allows farmers to use a targeted feeding approach to ensure that ewes carrying multiple lambs receive adequate levels of nutrition [63].

The presence of heavy dags is an important indicator of potential welfare risk of flystrike. A ewe with a dag score of 4 is seven times more susceptible to flystrike than a ewe with a dag score of 1 [64]. In addition, the presence of heavy dags could also indicate current welfare compromise as scouring and dags could be related to worm burdens or larval challenge in ewes with depressed immunity, but it could also be reflection of rapid changes in the diet, which causes nutritional scours. In the present study, a large percentage of ewes (87%) were classed with high dag scores (scores 4 to 5) at mid-lactation. A possible cause for this increase may be related to a rapid change to a high-quality pasture with high water content of spring grass, as the number of ewes presenting high dag scores significantly decreased by weaning (late spring). This decrease in scouring and dags may be indicating an adaptation to the spring grass, however, four ewes remained with a dag score of 3 until weaning, and they had a BCS of ≤ 2.5 which may be an indication of worm burdens or larval challenge or other gastrointestinal condition [7,35,64]. Parasitised sheep usually present poor body condition, low growth rates, reduced wool and milk production, and are more susceptible to other diseases such as flystrike [59,65]. In addition, the fact that 6% of the group presented skin lesions related to flystrike highlights the importance of early treatment in extensive systems. Effective management of dags and scouring is essential. Dags can be managed by 'crutching' (wool from around the tail and between the rear is shorn), but it is important to perform worm egg counts to monitor worm burdens and improve worm management and drench programs to understand the cause and appropriate treatment for any scouring [7,64,66].

Lameness is a worldwide problem in sheep, and it is an important health and welfare concern due to the pain, discomfort and debilitation that it causes [36]. In this study, the percentage of lame ewes increased significantly from 5% at mid-pregnancy to 14% at weaning, similar to a previous study investigating seasonal variation in lameness in extensive systems in the UK [8]. An increase in lameness at weaning may be associated with footrot lesions [41], hoof overgrowth, and foot abscess due to environmental conditions such as warmer and wetter conditions [67,68]. In some areas of South Eastern Australia, footrot is considered an endemic disease, with more than 20% of the farms affected [69]. In this study, it was not possible to identify the cause of lameness on the farm since the ewes were not individually restrained for further inspection. Although this assessment cannot give details of what is causing lameness, a high lameness percentage can alert farmers to a musculoskeletal problem affecting animal welfare that warrants more investigation. Previous studies have shown that lame sheep may experience pain and discomfort which reduces mobility, feed intake and weight gain, decreasing body condition and wool production [37,70]. The fact that a number of ewes were lame at weaning (14%) emphasize the importance of early intervention and frequent monitoring to reduce individual animal welfare compromise [37].

Overall, 92% of the ewes assessed had short-docked tails (less than three palpable joints) when compared with recommended guidelines [54]. Since the vast majority of the ewes had short docked tails in this study, relationships between tail length and welfare issues were not examined. However, previous studies have demonstrated that sheep with short-docked tails may experience more pain and poor healing after tail docking and may be more susceptible to bacterial arthritis [71], rectal prolapse, dags, flystrike [72] and vulva cancer [54].

By using tail length as an indicator of past welfare compromise and future welfare risks, it is possible that a number of the ewes in the flock experienced or would be at risk of one or more of these welfare compromises. Mastitis is increasingly recognised as an important health and production concern in extensively-managed sheep flocks. Mastitis can be categorised as clinical or sub-clinical and the majority of the cases occur in the month post lambing or before weaning, and/or following adverse weather conditions [43]. In the present study, no signs of clinical mastitis were observed at mid-lactation, but 10% of lactating ewes had subclinical mastitis. At weaning, 8% of the ewes presented subclinical mastitis and 1% clinical mastitis (gangrenous mastitis). These results are in agreement with previous studies that have reported 7% subclinical mastitis and 1–2% clinical mastitis in Merino ewes [73]. However, since little is known about the prevalence and incidence of mastitis in Merino flocks, it is possible that figures may be higher than currently identified. It has been shown that ewes affected may experience pain and discomfort, which can result in body condition loss, lameness and mismothering of lambs [55]. While it represents compromised welfare and productivity of ewes and their lambs, assessing mastitis on-farm in sheep that are not managed as milking flocks, is time-consuming, labour-intensive and frequently impractical. Since this study was conducted in one flock, further research is needed to describe mastitis prevalence in extensively-managed wool and meat flocks, and its impact on ewe and lamb welfare.

Flight distance (FD) was used to examine the quality of the human-animal relationships (HAR) of extensively managed ewes [20,74]. There is currently limited information on these relationships in animals farmed extensively, where human-animal interactions are infrequent and often stressful for both animals and farm staff e.g., at castration, tail docking and shearing [5,74]. The ewes examined in the present study had a mean FD of 5.15 m at mid-pregnancy, 6.17 m at mid-lactation and 4 m at weaning. In addition, ewes usually presented marked avoidance to the experimenter, indicating fear towards humans, particularly at mid-lactation. The FDs and the behaviour scores recorded in this study were higher than what has been observed in intensively managed ewes [1,20] but in agreement with results obtained by Hutson [75] who examined FD in sheep farmed extensively. It is possible that results observed in the present study do not necessarily indicate a negative HAR, as the likelihood of having a short FD, in systems where animals do not frequently receive human contact, would be low, suggesting that the current interpretation of this measure is unrealistic for extensive systems. While only one flock at one farm was assessed, the variation observed in FD suggests that this measure may be influenced by the time-point of the assessment, and/or ewes' familiarity with the test/experimenter. Previous studies have shown that FD varies significantly between pregnant and non-pregnant ewes [76,77]. Ewes with lambs at foot tend to be more reactive to external stimulus to protect their off spring [78], which could explain the significant increase in FD at mid-lactation. Following the removal of lambs, FD reduced significantly at weaning to a level lower than mid-pregnancy. This may be related to habituation to the testing situation as well as the experimenter of this study, as it has been shown that repetitive exposure or habituation to certain procedures changes the animal's response/perception of that stimulus [79]. The test performed in this study is consistent with other human-approach tests for livestock; however, results in this study indicate that the short FD suggested for intensively managed sheep cannot be extrapolated to sheep managed extensively and that the time-point of the assessment may affect FD. A limitation of this group test is that ewes were not individually identified during the test, and therefore, some ewes may have been assessed repeatedly during the study. Further work is needed to validate a reliable and practical on-farm assessment of fear of humans that could be applied to extensive systems.

5. Conclusions

When assessing the biological functioning of the ewes, the largest number of ewes experienced compromise and risk to welfare at weaning than at mid-pregnancy and mid-lactation which needs to be considered when deciding key times to conduct on-farm welfare assessments. The main welfare issues identified were poor nutrition (under and over feeding), ewe and potentially lamb mortality, lameness, flystrike and mastitis. The main welfare risks identified were the possibilities of metabolic diseases and dystocia due to inadequate BCS, flystrike from heavy dags, and reproductive problems due to short tail length. The majority of the welfare issues and potential welfare risks identified in this study could be improved by modifying management practices, such as improved nutritional management and monitoring and better tail docking procedures. Further information on disease records, early detection and intervention of sick animals and mortality records need to be

incorporated in the assessment to examine prospective welfare issues. Further research must consider that significant variation occurs at key periods of the sheep production cycle which needs to be accounted for when conducting on-farm
welfare assessments.

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References

1. Stubsjøen, S.M.; Hektoen, L.; Valle, P.S.; Janczak, A.M.; Zanella, A.J. Assessment of sheep welfare using on-farm registrations and performance data. *Anim. Welf.* **2011**, *20*, 239–251.
2. Turner, S.P.; Dwyer, C.M. Welfare assessment in extensive animal production systems: Challenges and opportunities. *Anim. Welf.* **2007**, *16*, 189–192. [CrossRef]
3. Goddard, P. Welfare assessment in sheep. *Practice* **2011**, *33*, 508–516. [CrossRef]
4. Doughty, A.K.; Coleman, G.J.; Hinch, G.N.; Doyle, R.E. Stakeholder perceptions of welfare issues and indicators for extensively managed sheep in Australia. *Animals* **2017**, *7*, 28. [CrossRef] [PubMed]
5. Dwyer, C.; Bornett, H. Chronic stress in sheep: Assessment tools and their use in different management conditions. *Anim. Welf.* **2004**, *13*, 293–304.
6. Phythian, C.J.; Michalopoulou, E.; Cripps, P.J.; Duncan, J.S.; Wemelsfelder, F. On-farm qualitative behaviour assessment in sheep: Repeated measurements across time, and association with physical indicators of flock health and welfare. *Appl. Anim. Behav. Sci.* **2016**, *175*, 23–31. [CrossRef]
7. Phythian, C.J. Development of Indicators for the On-Farm Assessment of Sheep Welfare. Ph.D. Thesis, University of Liverpool, Liverpool, UK, 2011.
8. Dwyer, C.; Wemelsfelder, F.; Beltran, I.; Ruiz, R.; Richmond, S. Assessing Seasonal Variation in Welfare

Indicators in Extensively Managed Sheep. In Proceedings of the 6th International Conference on the Assessment of Animal Welfare at Farm and Group Level, Clermont-Ferrand, France, 3–5 September 2014.

9. Dwyer, C.M. Welfare of sheep: Providing for welfare in an extensive environment. *Small Rumin. Res.* **2009**, *86*, 14–21. [CrossRef]
10. Phillips, C.J.C.; Phillips, A.P. Attitudes of Australian sheep farmers to animal welfare. *J. Int. Farm Manag.* **2010**, *5*, 1–26.
11. Phythian, C.J.; Michalopoulou, E.; Jones, P.H.; Winter, A.C.; Clarkson, M.J.; Stubbings, L.A.; Grove-White, D.;

Cripps, P.J.; Duncan, J.S. Validating indicators of sheep welfare through a consensus of expert opinion. *Animal* **2011**, *5*, 943–952. [CrossRef] [PubMed]

12. Corner-Thomas, R.A.; Hickson, R.E.; Morris, S.T.; Back, P.J.; Ridler, A.L.; Stafford, K.J.; Kenyon, P.R. Effects of body condition score and nutrition in lactation on twin-bearing ewe and lamb performance to weaning.

N. Z. J. Agric. Res. **2015**, *58*, 156–169. [CrossRef]

13. Griffiths, K.J.; Ridler, A.L.; Heuer, C.; Corner-Thomas, R.A.; Kenyon, P.R. The effect of liveweight and body condition score on the ability of ewe lambs to successfully rear their offspring. *Small Rumin. Res.* **2016**, *145*, 130–135. [CrossRef]
14. Hickson, R.E.; Kenyon, P.R.; Blair, H.T.; Harding, J.E.; Oliver, M.H.; Jaquiery, A.L.; Nicoll, G.B.; Burt, K.G. The effect of liveweight and liveweight gain of ewes immediately post-weaning on the liveweight and survival of subsequent lambs. *Anim. Prod. Sci.* **2011**. [CrossRef]
15. Phillips, C. The welfare risks and impacts of heat stress on sheep shipped from Australia to the Middle East. *Vet. J.* **2016**, *218*, 78–85. [CrossRef] [PubMed]
16. Rodriguez, A.I.; Cezar, A.; Calvo, L.; Vergara, H. Effect of bedding materials during transport on welfare indicators and microbiological quality in lambs. *Anim. Prod. Sci.* **2017**, *57*, 1924. [CrossRef]

17. Llonch, P.; King, E.M.; Clarke, K.A.; Downes, J.M.; Green, L.E. A systematic review of animal based indicators of sheep welfare on farm, at market and during transport, and qualitative appraisal of their validity and feasibility for use in UK abattoirs. *Vet. J.* **2015**, *206*, 289–297. [CrossRef] [PubMed]
18. King, E.; Green, L. Identification of indicators of cattle and sheep welfare in abattoirs. *Vet. Rec.* **2014**, *174*, 125. [CrossRef] [PubMed]
19. Phythian, C.J.; Cripps, P.J.; Michalopoulou, E.; Jones, P.H.; Grove-White, D.; Clarkson, M.J.; Winter, A.C.; Stubbings, L.A.; Duncan, J.S. Reliability of indicators of sheep welfare assessed by a group observation method. *Vet. J.* **2012**, *193*, 257–263. [CrossRef] [PubMed]
20. Napolitano, F.; De Rosa, G.; Ferrante, V.; Grasso, F.; Braghieri, A. Monitoring the welfare of sheep in organic and conventional farms using an ANI 35 L derived method. *Small Rumin. Res.* **2009**, *83*, 49–57. [CrossRef]
21. Munoz, C.; Campbell, A.; Hemsworth, P.; Doyle, R. Animal-Based Measures to Assess the Welfare of Extensively Managed Ewes. *Animals* **2017**, *8*, 2. [CrossRef] [PubMed]
22. AWIN Welfare Assessment Protocol for Sheep. Available online: http://www.animal-welfare-indicators.net/site/flash/pdf/AWINProtocolSheep.pdf (accessed on 24 March 2017).
23. Knierim, U.; Winckler, C. On-farm welfare assessment in cattle: Validity, reliability and feasibility issues and future perspectives with special regard to the Welfare Quality approach. *Anim. Welf.* **2009**, *18*, 451–458. [CrossRef]
24. Blokhuis, H.J.; Veissier, I.; Miele, M.; Jones, B. The Welfare Quality® project and beyond: Safeguarding farm animal well-being. *Acta Agric. Scand. Sect. A Anim. Sci.* **2010**, *60*, 129–140. [CrossRef]
25. Mellor, D.; Beausoleil, N. Extending the "Five Domains" model for animal welfare assessment to incorporate positive welfare states. *Anim. Welf.* **2015**, *24*, 241–253. [CrossRef]
26. Hemsworth, P.H.; Brand, A.; Willems, P. The behavioural response of sows to the presence of human beings and its relation to productivity. *Livest. Prod. Sci.* **1981**, *8*, 67–74. [CrossRef]
27. Barnett, J.L.; Hemsworth, P.H.; Jones, R.B. Behavioural responses of commercially farmed laying hens to humans: Evidence of stimulus generalization. *Appl. Anim. Behav. Sci.* **1993**, *37*, 139–146. [CrossRef]
28. Russel, A. Body condition scoring of sheep. *Practice* **1984**, *6*, 91–93. [CrossRef]
29. Morgan-Davies, C.; Waterhouse, A.; Pollock, M.L.; Milner, J.M. Body condition score as an indicator of ewe survival under extensive conditions. *Anim. Welf.* **2008**, *17*, 71–77.
30. Calavas, D.; Sulpice, P.; Lepetitcolin, E.; Bugnard, F. Assessing the accuracy of BCS in ewes under field conditions. *Vet. Res.* **1998**, *29*, 129–138. [PubMed]
31. Phythian, C.; Michalopoulou, E.; Duncan, J.; Wemelsfelder, F. Inter-observer reliability of Qualitative Behavioural Assessments of sheep. *Appl. Anim. Behav. Sci.* **2013**, *144*, 73–79. [CrossRef]
32. Izumi, K.; Nagata, S.; Nakamura, J.; Okamoto, M. A study of rumen fill on eating behaviour and voluntary intake in sheep using rumen digesta exchange method. *J. Anim. Feed Sci.* **2004**, *13*, 103–106. [CrossRef]
33. Silanikove, N. Effects of heat stress on the welfare of extensively managed domestic ruminants.

Livest. Prod. Sci. **2000**, *67*, 1–18. [CrossRef]
34. Cockram, M.S. A review of behavioural and physiological responses of sheep to stressors to identify potential behavioural signs of distress. *Anim. Welf.* **2004**, *13*, 283–291.
35. Larsen, J.; Anderson, N.; Vizard, A.; Anderson, G.; Hoste, H. Diarrhoea in Merino ewes during winter: Association with trichostrongylid larvae. *Aust. Vet. J.* **1995**, *72*, 75. [CrossRef]
36. Fitzpatrick, J.; Scott, M.; Nolan, A. Fitzpatrick—Assessment of pain and welfare in sheep. *Small Rumin. Res.* **2006**, *62*, 55–61. [CrossRef]
37. Kaler, J.; Green, L.E. Recognition of lameness and decisions to catch for inspection among sheep farmers and specialists in GB. *BMC Vet. Res.* **2008**, *4*, 41. [CrossRef] [PubMed]
38. Foddai, A.; Green, L.E.; Mason, S.A.; Kaler, J. Evaluating observer agreement of scoring systems for foot integrity and footrot lesions in sheep. *BMC Vet. Res.* **2012**, *8*, 65. [CrossRef] [PubMed]
39. Kaler, J.; Green, L.E. Naming and recognition of six foot lesions of sheep using written and pictorial information: A study of 809 English sheep farmers. *Prev. Vet. Med.* **2008**, *83*, 52–64. [CrossRef] [PubMed]
40. Kaler, J.; Medley, G.F.; Grogono-Thomas, R.; Wellington, E.M.H.; Calvo-Bado, L.A.; Wassink, G.J.; King, E.M.; Moore, L.J.; Russell, C.; Green, L.E. Factors associated with changes of state of foot conformation and lameness in a flock of sheep. *Prev. Vet. Med.* **2010**, *97*, 237–244. [CrossRef] [PubMed]

41. Kaler, J.; Green, L.E. Farmers' practices and factors associated with the prevalence of all lameness and lameness attributed to interdigital dermatitis and footrot in sheep flocks in England in 2004. *Prev. Vet. Med.* **2009**, *92*, 52–59. [CrossRef] [PubMed]
42. King, E.M.; Green, L.E. Assessment of farmer recognition and reporting of lameness in adults in 35 lowland sheep flocks in England. *Anim. Welf.* **2011**, *20*, 321–328.
43. González-Rodríguez, M.C.; Cármenes, P. Evaluation of the California mastitis test as a discriminant method to detect subclinical mastitis in ewes. *Small Rumin. Res.* **1996**, *21*, 245–250. [CrossRef]
44. Sutherland, M.A.; Tucker, C.B. The long and short of it: A review of tail docking in farm animals. *Appl. Anim. Behav. Sci.* **2011**, *135*, 179–191. [CrossRef]
45. Wemelsfelder, F.; Farish, M. Qualitative categories for the interpretation of sheep welfare: A review. *Anim. Welf.* **2004**, *13*, 261–268.
46. Aguayo-Ulloa, L.A.; Miranda-de la Lama, G.C.; Pascual-Alonso, M.; Fuchs, K.; Olleta, J.L.; Campo, M.M.; Alierta, S.; Villarroel, M.; María, G.A. Effect of feeding regime during finishing on lamb welfare, production performance and meat quality. *Small Rumin. Res.* **2013**, *111*, 147–156. [CrossRef]
47. Nowak, R.; Porter, R.H.; Blache, D. Behaviour and the welfare of the sheep. In *The Welfare of Sheep*; Dwyer, C.M., Ed.; Springer Science + Business Media BV: Dordrecht, the Netherlands, 2008; pp. 81–134, ISBN 978-1-4020-8553-6.
48. Wickham, S.L.; Collins, T.; Barnes, A.L.; Miller, D.W.; Beatty, D.T.; Stockman, C.; Blache, D.; Wemelsfelder, F.; Fleming, P.A. Qualitative behavioral assessment of transport-naive and transport-habituated sheep. *J. Anim. Sci.* **2012**, *90*, 4523–4535. [CrossRef] [PubMed]
49. Wickham, S.L.; Collins, T.; Barnes, A.L.; Miller, D.W.; Beatty, D.T.; Stockman, C.A.; Blache, D.; Wemelsfelder, F.; Fleming, P.A. Validating the Use of Qualitative Behavioral Assessment as a Measure of the Welfare of Sheep During Transport. *J. Appl. Anim. Welf. Sci.* **2015**, *18*, 269–286. [CrossRef] [PubMed]
50. Fleming, P.A.; Wickham, S.L.; Stockman, C.A.; Verbeek, E.; Matthews, L.; Wemelsfelder, F. The sensitivity of QBA assessments of sheep behavioural expression to variations in visual or verbal information provided to observers. *Animal* **2015**, *9*, 878–887. [CrossRef] [PubMed]
51. Stockman, C.A.; Collins, T.; Barnes, A.L.; Miller, D.; Wickham, S.L.; Verbeek, E.; Matthews, L.; Ferguson, D.; Wemelsfelder, F.; Fleming, P.A. Qualitative behavioural assessment of the motivation for feed in sheep in response to altered body condition score. *Anim. Prod. Sci.* **2013**, *54*, 922–929. [CrossRef]
52. Hargreaves, A.L.; Hutson, G.D. The stress response in sheep during routine handling procedures. *Appl. Anim. Behav. Sci.* **1990**, *26*, 83–90. [CrossRef]
53. Vandenheede, M.; Bouissou, M.F.; Picard, M. Interpretation of behavioural reactions of sheep towards fear-eliciting situations. *Appl. Anim. Behav. Sci.* **1998**, *58*, 293–310. [CrossRef]
54. Munro, T. Tail Length in Lambs—The Long and Short of It. Available online: http://www.flyboss.com.au/files/pages/management/tail-length/Kondinin_Tail_Length_article_130410.pdf (accessed on 1 August 2017).
55. Quinlivan, T.D. Survey observations on ovine mastitis in new zealand stud romney flocks: 1. The Incidence of Ovine Mastitis. *N. Z. Vet. J.* **1968**, *16*, 149–153. [CrossRef] [PubMed]
56. McNemar, Q. Note on the sampling error of the difference between correlated proportions or percentages. *Psychometrika* **1947**, *12*, 153–157. [CrossRef] [PubMed]
57. Ferguson, M.; Thompson, A.; Gordon, D. *Lifetime Wool: Ewe Management Handbook*, 2nd ed.; Behrendt, R., Whale, J., Curnow, M., Eds.; Lifetimewool: Struan, Australia, 2011; ISBN 9780980344851.
58. Russel, A.J.F.; Doney, J.M.; Gunn, R.G. Subjective assessment of body fat in live sheep. *J. Agric. Sci.* **1969**, *72*, 451–454. [CrossRef]
59. Caldeira, R.M.; Belo, A.T.; Santos, C.C.; Vazques, M.I.; Portugal, A.V. The effect of body condition score on blood metabolites and hormonal profiles in ewes hormonal profiles in ewes. *Small Rumin. Res.* **2007**, *68*, 233–241. [CrossRef]
60. Muñoz, C.; Carson, A.F.; McCoy, M.A.; Dawson, L.E.R.; O'Connell, N.E.; Gordon, A.W. Effect of plane of nutrition of 1- and 2-year-old ewes in early and mid-pregnancy on ewe reproduction and offspring performance up to weaning. *Animal* **2009**, *3*, 657–669. [CrossRef] [PubMed]
61. Addah, W.; Karikari, P.K.; Baah, J. Under nutrition in the ewe: Foeto-placental adaptation, and modulation of lamb birth weight: A review. *Livest. Res. Rural Dev.* **2012**, *24*, 10.
62. Thomas, J.O. Survey of the causes of dystocia in sheep. *Vet. Rec.* **1990**, *127*, 574–575. [CrossRef] [PubMed]

63. Kenyon, P.; Cranston, L. Nutrition management. In *Advances in Sheep Welfare*; Ferguson, D., Lee, C., Fisher, A., Eds.; Elsevier Science & Technology: Amsterdam, the Netherlands, 2017; Volume 1, pp. 153–170.
64. Sheep CRC Ltd. Worm and Dag Management. Available online: http://www.flyboss.com.au/management/ worm-and-dag-management.php (accessed on 29 September 2017).
65. Festa-Bianchet, M. Nursing behaviour of bighorn sheep: Correlates of ewe age, parasitism, lamb age, birthdate and sex. *Anim. Behav.* **1988**, *36*, 1445–1454. [CrossRef]
66. Horton, B.; Hogan, L. FlyBoss: A web-based flystrike information and decision support system. *Anim. Prod. Sci.* **2010**, *50*, 1069–1076. [CrossRef]
67. Whittington, R. Observations on the indirect transmission of virulent ovine footrot in sheep yards and its spread in sheep on unimproved pasture. *Aust. Vet. J.* **1995**, *72*, 132–134. [CrossRef] [PubMed]
68. Winter, A. Lameness in sheep 2. Treatment and control. *Practice* **2004**, *26*, 130–139. [CrossRef]
69. The Mackinnon Project. *Footrot Control & Eradication*, 2nd ed.; Webb, J., Ed.; The Mackinnon Project: Melbourne, Australia, 2015.
70. Marshall, D.J.; Walker, R.I.; Cullis, B.R.; Luff, M.F. The effect of footrot on body weight and wool growth of sheep. *Aust. Vet. J.* **1991**, *68*, 45–49. [CrossRef] [PubMed]
71. Lloyd, J.; Kessell, A.; Barchia, I.; Schröder, J.; Rutley, D. Docked tail length is a risk factor for bacterial arthritis in lambs. *Small Rumin. Res.* **2016**, *144*, 17–22. [CrossRef]
72. Fisher, M.W.; Gregory, N.G.; Kent, J.E.; Scobie, D.R.; Mellor, D.J.; Pollard, J.C. Justifying the appropriate length for docking lambs' tails—A review of the literature. In *Proceedings—New Zealand Society of Animal Production*; New Zealand Society of Animal Production: Rotorua, New Zealand, 2004; Volume 64, pp. 293–296.
73. Omaleki, L.; Barber, S.R.; Allen, J.L.; Browning, G.F. Mannheimia species associated with ovine mastitis. *J. Clin. Microbiol.* **2010**, *48*, 3419–3422. [CrossRef] [PubMed]
74. Forkman, B.; Boissy, A.; Meunier-Salaün, M.C.; Canali, E.; Jones, R.B. A critical review of fear tests used on cattle, pigs, sheep, poultry and horses. *Physiol. Behav.* **2007**, *92*, 340–374. [CrossRef] [PubMed]
75. Hutson, G.D. "Flight distance" in Merino sheep. *Anim. Prod.* **1982**, *35*, 231–235. [CrossRef]
76. Viérin, M.; Bouissou, M.F. Influence of maternal experience on fear reactions in ewes. *Appl. Anim. Behav. Sci.* **2002**, *75*, 307–315. [CrossRef]
77. Viérin, M.; Bouissou, M.F. Pregnancy is associated with low fear reactions in ewes. *Physiol. Behav.* **2001**, *72*, 579–587. [CrossRef]
78. Morgan, P.D.; Arnold, G.W. Behavioural relationships between Merino ewes and lambs during the four weeks after birth. *Anim. Prod.* **1974**, *19*, 169–176. [CrossRef]
79. Petherick, J.C.; Doogan, V.J.; Holroyd, R.G.; Olsson, P.; Venus, B.K. Quality of handling and holding yard environment, and beef cattle temperament: 1. Relationships with flight speed and fear of humans. *Appl. Anim.*

Behav. Sci. **2009**, *120*, 18–27. [CrossRef]

15.6 Reliability and feasibility of animal-based indicators to assess the welfare of extensively managed ewes

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Reliability and feasibility of animal-based indicators to assess the welfare of extensively managed ewes.

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Summary

The reliability and feasibility of 10 animal-based indicators of ewes welfare (body condition score (BCS), rumen fill, fleece cleanliness, fleece condition, skin lesions, tail length, dag score, foot-wall integrity, hoof overgrowth and lameness) were examined for on-farm use in extensive sheep production systems. The indicators were independently examined on 100 Merino ewes (from 2 to 4 years old) during late-pregnancy (LP), mid-lactation (ML) and weaning (WN) by a pool of nine trained observers. Levels of observer agreement were determined by Kendall's coefficient (W) and Kappa statistics. Overall, good agreement (from 'moderate' to 'almost perfect' agreement) were found for the indicators BCS, fleece condition, skin lesions, dag score and lameness, and the inter- and intra- observer agreement of these indicators increased from LP through to WN. This study presents five valid, reputable and feasible indicators for on-farm assessments of extensively managed ewes.

Introduction

Welfare assessments can be a useful way to demonstrate compliance with national and international legal welfare standards and for on-farm monitoring and benchmarking by farmers and veterinarians (Phythian et al., 2013). Thus, studies have recently started to examine indicators that could be used in welfare protocols for sheep (Stubsjøen et al., 2011; Phythian et al., 2013). Animal-based indicators are seen as the outcome of resource inputs and management practices, and therefore there is increasing interest in the incorporation of these indicators in welfare assessments, as they provide an integrative and direct measurement of the welfare state of animals.

Welfare problems that affect sheep are mainly influenced by the farming system, production cycle and geographical location (Phythian, 2011). Thus, not all animal-based indicators identified for sheep can be broadly applied. Indicators need to be examined in terms of their validity (meaningful with respect to animal welfare), reliability (repeatable outcomes when applied by different observers), and feasibility (practical under farm conditions). The aim of the present study was to identify if 10 animal-based indicators were both reliable and feasible, and therefore appropriate for inclusion in welfare protocols for extensively managed ewes.

Materials and methods

Animals and management

A longitudinal on-farm study was performed in Victoria, Australia from July to December 2015. The reliability and feasibility of 10 welfare indicators extensively used in research, (BCS, rumen fill, fleece cleanliness, fleece condition, skin lesions, tail length, dag score, foot-wall integrity, hoof overgrowth and lameness), were examined on 100 Merino ewes (2-4 years old) by a pool of nine trained observers. Ewes were marked within a large flock of approximately 3000 sheep and examined during late-pregnancy (LP) (July), mid-lactation (ML) (November) and weaning (WN) (December). These periods were selected because they are critical times in the concerns for ewe welfare (Stubsjøen al., 2011). The ewes were managed under extensive conditions, in a year-round outdoor system, grazing annual pastures, and managed under commercial conditions. The indicators were assessed in all animals individually, and the assessment was performed in a raceway.

The validity of these indicators was established by a literature review of indicators commonly used in research, by consultations with an expert group and from European-based protocols for sheep, so they were assumed to be valid.

Animal based-Indicators and reliability assessment

Nine observers, all with animal science backgrounds, with different levels of expertise of working with sheep, were recruited. Prior to individual assessments, observers were provided with an assessment protocol, and an on-farm training session using on average 25 ewes. Thereafter, each observer independently evaluated the 10 indicators on each sheep. The protocols were taken from Phythian (2011) and AWIN (2015). Reliability was assessed by evaluating test agreement between different observers, in

line with previous studies of welfare indicators for sheep (Phythian et al., 2013). This is done by comparing the score given by each observer against a reference or 'test standard observer' (TSO). In the present study, observer 1 (CM), a veterinarian who developed the list of the indicators and provided training to the other observers was nominated as the TSO. From the pool of nine observers, combinations of four observers performed the assessments on each observation period, but the TSO performed the assessment in all the observation periods. To assess intra-reliability (the degree to which measurements taken by the same observer are consistent), all sheep were reassessed by the observers within a 15-day period in late-pregnancy, and within 24 hours at both mid-lactation and weaning. The observers subjectively evaluated the feasibility of assessing these indicators after the farm visits.

Statistical analysis

Reliability data were analysed using SAS statistical package (Statistical Analysis System, Release 9.4, 2012). The overall level of inter-observer reliability for multiple observer assessments was determined by Kendall's coefficient of concordance (W) for ordinal data (BCS, fleece cleanliness, fleece condition, skin lesions, dag score, wall integrity, wall overgrowth and lameness) and Fleiss's Kappa for binary data (rumen fill and tail length). The level of pair agreement (agreement between the TSO and observers 2 to 9) and intra-observer agreement was analysed by Kendall's (W) and Weighted Cohen's *k* for ordinal data and Simple Cohen's *K* for binary data. All W and *k* results were interpreted according to Landis and Koch (1977), therefore values ≥ 0.81 suggested 'almost perfect' agreement, values from 0.61 to 0.80 indicated 'substantial' agreement, values from 0.41 to 0.60 suggested 'moderate' agreement, values from 0.21 to 0.40 suggested 'fair' agreement and values ≤ 0.20 indicated 'slight' to 'poor' agreement.

Results and Discussion

Overall, good observer agreements were found for the majority of the indicators, and the inter- and intra-observer agreement increased from LP through to WN. The indicators fleece cleanliness, fleece condition and dag score obtained 'moderate' to 'almost perfect' agreement during the three observation periods. Similarly, the indicators BCS and skin lesions increased from 'moderate' agreement at late-pregnancy to 'substantial-almost perfect' agreement at weaning (BCS W=0.60 (LP) 0.74 (ML) 0.80 (WN) skin lesions W= 0.41 (LP) 0.75 (ML) 0.93 (WN). Lameness was not assessed for inter-observer reliability because all the observers assisted with the identification of lame animals, but showed good intra-observer agreement (W= 0.53 (LP) 0.79 (ML) 0.86 (WN)). On the other hand, rumen fill, tail length, foot-wall integrity and hoof overgrowth were the indicators with only 'poor' to 'moderate' agreement. The difficulties of assessing these indicators (as numerous ewes where gathered in a race), along with the number of scoring categories and the descriptive terms used, may have adversely affected the levels of observer agreement in this study.

Rumen fill, fleece cleanliness, foot-wall integrity and hoof overgrowth were considered not very relevant for assessing welfare under extensive management conditions, even though some of these measures were repeatable and reliable. For example, fleece cleanliness had good reliability and feasibility. However, this indicator may be more valuable for indoor conditions to assess the cleanliness of the pens, but might provide less information on the condition of paddocks, and associated sheep welfare, in extensive settings. On the other hand, the indicator rumen fill showed low reliability and feasibility. This indicator is heavily influenced by how long sheep have been yarded, and although it could provide short-term information of food access, its inclusion in assessment protocols may be more valuable and feasible in lambs rather than ewes (Pythian et al., 2013). In the same way, the assessment of foot-wall integrity may be less relevant and feasible than the assessment of other indicators that are broader and thus provide an integrative assessment such as lameness (Kaler et al., 2011). In general, the indicators tested proved to be feasible, requiring 2 to 4 min to assess an individual ewe.

Conclusion

The outcomes of this study indicate that BCS, fleece condition, skin lesions, dag score and lameness are valid, reliable and feasible indicators for on-farm use in welfare protocols for extensively managed ewes. When combined, these indicators provide a snapshot of the current welfare status of ewes, as well as evidence of previous or potential welfare issues. Further research examining the effectiveness of these indicators in assessing seasonal variation and between-farm differences will provide additional evidence of their usefulness for incorporation into on-farm welfare assessments for extensively managed ewes.

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References

AWIN. (2015). AWIN welfare assessment protocol for sheep. Animal Welfare Indicators.

Kaler, J., George, T., & Green, L. E. (2011). Why are sheep lame? temporal associations between severity of foot lesions and severity of lameness in 60 sheep. Animal Welfare, 20(3), 433-438.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. Biometrics, 159-174.

Phythian, C. (2011). Development of indicators for the on-farm assessment of sheep welfare. (Doctoral thesis). The University of Liverpool, England.

Phythian, C., Toft, N., Cripps, P., Michalopoulou, E., Winter, A., Jones, P., Grove-White, D. & Duncan, J. 2013, "Inter-observer agreement, diagnostic sensitivity and specificity of animal-based indicators of young lamb welfare", animal, vol. 7, no. 07, pp. 1182-1190.

Stubsjøen, S., Hektoen, L., Valle, P., Janczak, A., & Zanella, A. (2011). Assessment of sheep welfare using on-farm registrations and performance data. Animal Welfare, 20(2), 239

15.7 Assessment of human-animal relationship in extensively managed ewes

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The quality of the human-animal relationship is a key factor affecting the welfare of farm animals, however methods for its practical assessment in sheep are lacking. The current exploratory study investigated some measures to assess the human-animal relationship in extensively managed ewes. 100 Merino ewes (2-4 years old) were marked within a large flock of approximately 3000 sheep and their responsiveness to the presence of a human was tested at three time points: mid-pregnancy (MP), mid-lactation (ML) and weaning (W). Ewes were managed under extensive conditions, in a year-round outdoor system, and they were tested in the yard using a group pen and a race. To measure flight distance (FD), a single observer, always the same person, quietly entered the pen (n=25 group size in the pen, dimentions: 9m x 8m), walked around the perimeter and stood opposite the entry point. From here, the observer waited for a ewe to be orientated towards her before approaching the animal in a standardised way (i.e. at one step per second). The test ended whenever the ewe withdrew, defined as stepping away from the observer, and the FD was estimated. FD was measured in 20 ewes (randomly selected from the 100 ewes) per reproduction stage. At the end of this test, a count of the number of vigilant sheep in the group (defined as head above shoulder height and orientated towards the observer) was recorded. Ewes were then moved to a single file race and vigilance was again recorded (observer was at 2 m distance away from the race and was stationary). The mean FD were 5.2 m (MP), 6.2 m (ML) and 4 m (W) and were significantly different from each other (P<0.001) as showed by the two-way analysis of variance and LSD test. Analysis of vigilance also showed significant difference. At all-time points and in both tests, the majority of the ewes were vigilant; however, the n° of vigilant animals decreased significantly over time (100, 82 and 61 ewes in the four groups at each point respectively (McNemar's test, MP vs. ML (P<0.001), MP vs. W (P<0.001) and ML vs. W (P<0.001) and 84, 77 and 61 ewes in the race at each point respectively (LP vs. ML (P<0.001), MP vs. W (P<0.001) and ML vs. W (P<0.001)). While only one flock at one farm was assessed, the variation observed in FD and vigilance suggests that these measures may be influenced by the reproduction stage of the ewes, the presence of lambs at foot, and/or their familiarity with the test/experimenter. The test performed in this study is consistent with other human-approach tests for livestock; however, our results indicate that the repeatability of the measures need to be assessed comprehensively and caution may be required when interpreting results at different reproductive stages.

15.8 Indicators to examine sheep welfare

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This study investigated whether nine animal-based measures of ewe welfare (body condition score (BCS), fleece cleanliness, fleece condition, skin lesions, tail length, dag score, foot-wall integrity, hoof overgrowth, and lameness) were reliable, feasible and able to detect seasonal variation in the welfare of sheep, and therefore appropriate for on-farm use in welfare assessments of extensive sheep production systems. The measures were examined on 100 Merino ewes (aged 2-4) during mid-pregnancy (MP), mid-lactation (ML) and weaning (WN) by a pool of nine trained observers. The ewes were marked within a flock of 3000 sheep, and they were managed under commercial conditions, in a year-round outdoor system. Good inter-observer agreement existed for the measures BCS, fleece condition, skin lesions, tail length, faecal soiling and lameness, determined by percentage of agreement, Kendall's coefficient (W) and Kappa (k) values, with inter- and intra- observer agreement increasing from MP ('moderate') through to WN ('almost perfect'). This study presents six valid measures that proved to be reputable and feasible measures for on-farm use, and they can also detect variation in the welfare of sheep in key periods of the production cycle, whereas three of the measures -fleece cleanliness, foot-wall integrity and hoof overgrowth- are more suited to more intensive sheep production systems. More measures such as practical on-farm assessment of fear of humans and the incorporation of different technologies such infrared thermography for practical assessment of mastitis and lameness, and global positioning system (GPS) to track grazing behaviour and sheep movement to detect sick/lame animals may need to be developed if the welfare of extensively managed ewes is going to be assessed effectively.

15.9 Farmer attitude and practices questionnaire

Questionnaire

Thank you for agreeing to participate in this research project. This study is funded by Meat and Livestock Australia and is being conducted by Carolina Munoz (PhD student), Dr Rebecca Doyle (University of Melbourne), Dr Angus Campbell (University of Melbourne), Professor Paul Hemsworth (University of Melbourne) and Professor Grahame Coleman (University of Melbourne).

This questionnaire complements the on-farm assessment performed in your farm, therefore your participation is very important and appreciated. The questionnaire is completely anonymous, and has been approved by the Human Research Ethics Committee of the University of Melbourne.

SECTION A. Sheep management and husbandry. There are no right or wrong answers. All we want is your honest answer. Please read each question and then indicate using the following scale: 'not at all important', 'slightly important', 'moderately important', 'important' and' very important'.

	Not at all important	**Slightly important**	**Moderately Important**	**Important**	**Very important**
	1	**2**	**3**	**4**	**5**
A.1 How important is to daily check:					
Dry ewes					
Pregnant ewes					
Ewes with lambs at foot					
A.2 How important is monthly checking of body condition for:					
Dry ewes					
Pregnant ewes					
Ewes with lambs at foot					
A.3 How important is it to measure pasture availability?					
A.4 How important is it to measure pasture quality?					
A.5 How important is it to allocate pregnant ewes in different groups according to their nutritional needs?					

	Not at all important	Slightly important	Moderately Important	Important	Very important
	1	2	3	4	5
A.6 How important is it to perform pregnancy scans annually?					
A.7 How important is it to assist ewes with dystocia?					
A.8 How important is it to provide ewes with shelter during winter?					
A.9 How important is it to provide ewes with shelter during summer?					
A.10 How important is it to have the ewes annually checked by a veterinarian?					
A.11 How important is it to have a written health plan in the farm?					
A.12 How important is it to treat ewes for parasites?					
A.13 How important is it to test ewes for parasites before drenching sheep?					
A.14 How important do you think mulesing is to prevent fly strike?					
A.15 How important is it to provide local anaesthesia or pain relief at mulesing?					
A.16 How important is it to calculate annual disease rates in your farm?					
A.17 How important is it to calculate annual mortality rate in your farm?					
A.18 How important is it to calculate annual culling rate in your farm?					

There are no right or wrong answers. All we want is your honest answer. Please read each question and then indicate using the following scale: 'Strongly disagree', 'Disagree' 'Neither agree nor disagree', 'Agree', 'Strongly agree'.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
	1	2	3	4	5
A.19 I'm responsible for the welfare of my animals					
A.20 Farm animals have feelings like people have feelings					
A.21 Farm animals experience physical pain as humans do					
A.22 Farm animals generally aren't affected by the way they are treated					
A.23 Ewes are intelligent					
A.24 The way how people handle ewes will impact ewes' fearfulness					
A.25 Ewes are stubborn animals					
A.26 Ewes have a gentle nature					
A.27 Ewes are frustrating to work with					
A.28 Ewes are easy to train to a routine					
A.29 Moving sheep is an easy task					
A.30 The best way to move sheep is by not rushing them					
A.31 Using sheepdogs is the best way to move the ewes					
A.32 Using trained sheepdogs is not stressful for ewes					
A.33 Ewes are easy to handle					
A.34 Ewes do not require a great deal of care					
A.35 Mulesing is not painful for sheep					
A.36 I think ewes can be annoying					
A.37 Shearing is not stressful for ewes					

There are no right or wrong answers. All we want is your honest answer. Please read each question and then indicate using the following scale: 'Strongly disagree', 'Disagree' 'Neither agree nor disagree', 'Agree', 'Strongly agree'.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

	1	2	3	4	5
A.38 I really like being a sheep farmer					
A.39 I look forward to the days I have to work sheep in the yards**.**					
A.40 I am good at handling sheep					
A.41 If someone is roughly handling my sheep, I would intervene					
A.42 It is really important for me to try hard at work.					
A.43 I am the type of person who gets over-involved with my job.					
A.44 It is important to me that I do a good job.					
A.45 I get bored easily in my job.					
A.46 I do not like having a lot of responsibility at work.					
A.47 I feel respected for the work I do.					
A.48 I'm able to do things that don't go against my morals					
A.49 I do not have the chance to do something that makes use of my abilities					
A.50 I feel rewarded from this job					
A.51 No matter how hard I try, a constant number of ewes will always die					
A.52 Weather will influence lamb survival more than any management decisions I make					

SECTION B: There are no right or wrong answers. All we want is your honest answer.

When faced with a difficult situation on your farm, who would you seek advice/guidance from? Please indicate using the following scale: I **never, rarely, occasionally, frequently** or **always** seek advice/guidance from him/her.

	Never	Rarely	Occasionally	Frequently	Always
	1	2	3	4	5
Veterinarians					
More experienced farmers					
Closest family members (e.g. spouse, parents, siblings, etc.)					
Friends					
Other (please specify)					

Please answer the following questions thinking of the person you always or frequently seek advice/guidance from. How do you think your trusted advisor would rate these issues? Read each question and then indicate using the following scale: 'not at all important', 'slightly important', 'moderately important', 'important' and' very important'.

	Not at all important	Slightly important	Moderately important	Important	Very important
	1	2	3	4	5
B.1 How important does your trusted advisor believe it is to check daily:					
Dry ewes					
Pregnant ewes					
Ewes with lambs at foot					
B.2 How important does your trusted advisor believe it is to check monthly the body condition of:					
Dry ewes					
Pregnant ewes					
Ewes with lambs at foot					
B.3 How important does your trusted advisor believe it is to measure pasture availability?					
B.4 How important does your trusted advisor believe it is to measure pasture quality?					

	Not at all important	Slightly important	Moderately Important	Important	Very important
	1	2	3	4	5

B.5 How important does your trusted advisor believe it is to allocate pregnant ewes in different groups according to their nutritional needs?					
B.6 How important does your trusted advisor believe it is to pregnancy scan annually?					
B.7 How important does your trusted advisor believe it is to assist ewes with dystocia?					
B.8 How important does your trusted advisor believe it is to provide ewes with shelter during winter?					
B.9 How important does your trusted advisor believe it is to provide ewes with during summer?					
B.10 How important does your trusted advisor believe it is to have the ewes annually checked by a veterinarian?					
B.11 How important does your trusted advisor believe it is to have a written health plan of the farm?					
B.12 How important does your trusted advisor believe it is to treat ewes for parasites annually?					
B.13 How important does your trusted advisor believe it is to test ewes for parasites before drenching?					
B.14 How important does your trusted advisor believe it is mulesing to prevent fly strike?					
B.15 How important does your trusted advisor believe it is to provide local anaesthesia or pain relief at mulesing?					
B.16 How important does your trusted advisor believe it is to calculate annual disease rates?					
B.17 How important does your trusted advisor believe it is to calculate annual mortality rate?					
B.18 How important does your trusted advisor believe it is to calculate annual culling rate?					

SECTION C: There are no right or wrong answers. All we want is your honest answer. Please read each question and then indicate using the following scale: 'not at all difficult', 'slightly difficult', 'moderately difficult', 'difficult' and' very difficult'.

	Not at all difficult	Slightly difficult	Moderately Difficult	Difficult	Very difficult
	1	2	3	4	5
C.1 How difficult is it for you to perform daily checking of:					
Dry-ewes					
Pregnant ewes					
Ewes with lambs at foot					
C.2 How difficult is it for you to monthly check body condition of:					
Dry-ewes					
Pregnant ewes					
Ewes with lambs at foot					
C.3 How difficult is it for you to measure pasture availability?					
C.4 How difficult is it for you to measure pasture quality?					
C.5 How difficult is it for you to allocate pregnant ewes in different groups according to their nutritional needs?					
C.6 How difficult is it for you to perform pregnancy scan annually?					
C.7 How difficult is it for you to assist ewes in case of dystocia?					
C.8 How difficult is it for you to provide ewes with a form of shelter during winter?					
C.9 How difficult is it for you to provide ewes with a form of shelter during summer?					
C.10 How difficult is it for you to have the ewes annually checked by a veterinarian?					
C.11 How difficult is it for you to have a written health plan in the farm?					

	Not at all difficult	Slightly difficult	Moderately Difficult	Difficult	Very difficult
	1	2	3	4	5
C12. How difficult is it for you to test ewes for parasites before drenching?					

C13. How difficult is it for you to annually treat ewes for parasites?					
C.14 How difficult is it for you to provide any form of local anaesthesia or pain relief at mulesing?					
C.15 How difficult is it for you to calculate annual disease rates					
C.16 How difficult is it for you to calculate annual mortality rate.					
C.17 How difficult is it for you to calculate annual culling rate?					
C.18 How difficult is it for you to be prepared for a bad season?					

SECTION D: CHARACTERISTICS OF THE PROPERTY.

This section contains general questions about your farm. If you don't know the answer to any question, please give your best estimate.

D.1 How long have you farmed sheep? _____Years

D.2 What is the approximate size of the property? _____Hectares

D.3 What is your main farming enterprise? (Please tick a box)

Activity	**Percentage of land used**
Sheep (wool)	
Sheep (prime lamb)	
Cattle	
Pigs	
Poultry	
Crop	
Other	

D.4 Rainfall for the area? Average annual rainfall _____ mm

D.6 What is the number of full-time labour units (workers) on the farm? (Including yourself, family members and employees) _____

SECTION E: EWE MANAGEMENT

This section contains general questions about your ewes. If you don't know the answer to any question, please give your best estimate.

E.1 How often are the ewes checked throughout the year (not including during lambing)?

- ☐ Daily
- ☐ Every 2nd day
- ☐ Weekly
- ☐ Fortnightly
- ☐ Monthly
- ☐ Never

E.2 How are the ewes checked? _____

E.3 How often are ewes checked during lambing?

- ☐ Daily
- ☐ Every 2nd day
- ☐ Weekly
- ☐ Fortnightly

☐ Monthly
☐ Never

E.4 How are the ewes checked during this time?_____

E.5 what do you think is the main reason why people do not perform regular surveillance? (Please tick ONE box)

☐ Size of the farm
☐ Labour
☐ Cost
☐ Lack of time
☐ Other _____

E.6 Do you body condition score your ewes?

1 ☐ Yes 2 ☐ Sometimes 3 ☐ No

How? _____

When?_____

E.7 What do you think is the main reason why people do not body condition score their ewes? (Please tick ONE box)

☐ Size of the farm
☐ Labour
☐ Cost
☐ Lack of time
☐ Other _____

E.8 Do you measure pasture availability?

1 ☐ Yes 2 ☐ No

E.9 How?_____

E.10 Do you measure pasture quality?

1 ☐ Yes 2 ☐ No

E.11 How? _____

E.12 What do you think is the main reason why people do not measure pasture availability/quality? (Please tick ONE box)

☐ Size of the farm
☐ Labour
☐ Cost

☐ Lack of time
☐ Other _____

E. 13a What was the average amount of supplement feed provided to your ewe flock over last 12 months (kg/head/week)? _____

E. 13b How long have you supplement? _____

E.14a Do you pregnancy scan annually?

1☐ Yes 2☐ Sometimes 3☐ No

E.14b What percentage of your ewes do you pregnancy scan annually? _____%

E14.c Do you keep 'singles' and 'twins' separate?

1☐ Yes 2☐ Sometimes 3☐ No

E.15 When do you pregnancy scan? _____

E.16 What has been the average conception rate in the last three years? _____

E.17 Do you keep records of conception rate?

1☐ Yes 2☐ Sometimes 3☐ No

E.18 What has been the marking percentage in the last three years? _____%

E.19 Do you keep records of marking percentage?

1☐ Yes 2☐ Sometimes 3☐ No

E.20 What has been the weaning percentage in the last three years? _____%

E.21 Do you keep records of weaning percentage?

1☐ Yes 2☐ Sometimes 3☐ No

E.22 What do you think is the main reason why people do not maintain records? (Please tick ONE box)
☐ Size of the farm
☐ Labour
☐ Cost
☐ Lack of time

☐ Other _____

E.23 What do you think is the main reason why people do not scan for pregnancy?

☐ Size of the farm
☐ Labour
☐ Cost
☐ Lack of time
☐ Other _____

E.24 Are ewes assisted during lambing in case of dystocia?

1 ☐ Yes 2 ☐ Sometimes 3 ☐ No

E.25 Do the ewes have access to shade/shelter during adverse weather conditions?

1 ☐ Yes 2 ☐ Sometimes 3 ☐ No

If yes, please specify _____

E.26 Before drenching sheep, are ewes tested for parasites?

1 ☐ Yes 2 ☐ Sometimes 3 ☐ No

E.27 How are the ewes tested? _____

E.28 How often are the ewes treated for parasites?

☐ Never
☐ Once a year
☐ Twice a year
☐ Three times a year
☐ More than 3 times per year

E.29 When are ewes treated for parasites? _____

E.30 What is the average greasy wool production per head? _____

E.31 What was the average carcase price that you received (for/if animals sold ≤ 1 year old) the last 12 months ($/kg CWT)? _____

E.32 Does the farm have a written health plan?

1 ☐ Yes 2 ☐ No

E.33 Are annual disease rates recorded and calculated on the farm?

1 ☐ Yes 2 ☐ Sometimes 3 ☐ No

E.34 What is the average mortality rate per year of adult ewes on the farm? _____

E.35 Is annual ewe mortality rate recorded and calculated on the farm?

1 ☐ Yes 2 ☐ Sometimes 3 ☐ No

E.36 What do you think is the main reason why people do not record mortality rates? (Please tick ONE box)

☐ Size of the farm
☐ Labour
☐ Cost
☐ Lack of time
☐ Other _____

E.37 Which do you think is the most significant cause of mortality in your farm? (Please tick ONE box)

☐ Disease (if yes, please specify: _____)
☐ Fly strike
☐ Predation
☐ Nutritional (e.g. under nutrition, deficiencies, etc.)
☐ Other _____

E.38 What is your culling rate of ewes? _____

E.39 What is your main reason for culling? (Please tick ONE box)

☐ Age
☐ Reproductive failure
☐ Fly strike
☐ Other _____

Do you cull 1-2 years ewes? _____Why?_____

E.40 Are male lambs on the farm usually castrated?

1 ☐ Yes 2 ☐ No

E.41 If yes, what method is used to castrate lambs:

☐ Rubber rings (elastration)
☐ Burdizzo or other form of clamp
☐ Knife/surgical castration
☐ Banding
☐ Other (specify)

E.42 Is any form of local anaesthesia or pain relief given at castration?

1 ☐ Yes 2 ☐ Sometimes 3 ☐ No

E.43 Do you perform mulesing to prevent flystrike?

1 ☐ Yes 2 ☐ Sometimes 3 ☐ No

E.44 If yes, who performs this procedure on the farm?

_____

E.45 Is any form of local anaesthesia or pain relief given at mulesing?

1 ☐ Yes 2 ☐ Sometimes 3 ☐ No

E.46 Have you or any of your staff members attended an animal handling course?

1 ☐ Yes 2 ☐ No

E.47 Have you or any of your staff members attended any workshop or training sessions on how to improve productivity/welfare in the last 12 months?

1 ☐ Yes 2 ☐ No

If yes, please specify_____

E.48 Are you a member of any industry-based organisations?

1 ☐ Yes 2 ☐ No

If yes, please list _____

SECTION F: Demographic characteristics.

This section contains general questions about you. Please note that your individual responses will remain **strictly confidential.** Only average results for the entire sample will be used and reported.

F.1 Are you? (Please tick box)

1 ☐ Male 2 ☐ Female

F.2 What year were you born? _____

F.3 What is your highest level of education? (Please tick one box)

☐ No formal schooling
☐ Primary school
☐ Secondary school
☐ Technical or further education institution (including TAFE College)
☐ University or post-graduate degree
☐ Other educational institution (please specify) _____

15.10 On-farm ewe welfare and its relationship with farmer management styles

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This study investigated the relationship between on-farm ewe welfare and farmer management styles in 25 sheep flocks in Victoria, Australia. One hundred ewes (aged 2-5) were assessed at each farm. Animals were managed extensively in a year-round outdoor system and farm visits were conducted after weaning (spring/summer 2016). The ewes were assessed by six valid animal-based measures: body condition score (BCS), fleece condition, skin lesions, tail length, dag score and lameness. Management-based measurements were collected through an interview with the farmers or farm managers. All measurements were collected by a single observer. To examine the relationship between ewe welfare and management, farmers were classified as having a 'passive' or 'proactive' management style. Farmers who do not measure the body condition of their ewes, do not maintain mortality records and do not scan for pregnancy, or scan but do not manage single and multiple ewes differently were classified as passive. Flock sizes ranged from 430 to 9400 (2714 ± 2147). Overall, 56% (n=14) of the farmers were classified as passive and 44% (n=11) as proactive. No differences were found in the average BCS of passive (2.9 ± 0.25) and proactive flocks (2.8 ± 0.19). However, a binomial generalized linear model showed that passive farmers had more ewes in inadequate BCS (too thin or too fat according to industry recommendations) (P=0.004), and more ewes needed further care in passive flocks (due to flystrike, severe lameness, etc.) compared to proactive flocks (P=0.017), indicating that farmers with passive management style have more ewes at risk of welfare compromise. This study constitutes the first investigation of sheep welfare and its relationship with management styles in Australia. These data will be further investigated to develop an intervention strategy to improve sheep welfare and productivity, with the ultimate goal of ensuring sustainability for the sheep industry.

15.11 Investigating the effect of pen size and pen shape on group flight distance of extensively managed ewes

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A stockperson's attitudes and behaviours has a direct impact on animal fear, stress, welfare and productivity. Extensive environments that sheep are kept in result in infrequent handling, and can be coupled with aversive interactions and social isolation, all of which can lead to significant fear responses in sheep. Flight distance tests is a valid indicator of this relationship, but a test of this nature for use on farm has not been validated for use in extensively managed sheep. One key limitation to being able to develop this is between-farm differences in pens, making direct comparisons difficult. This study aimed to assess the effect of different pens on the flight distance of ewes, and to trial a method to adjust for this.

A flock of 200 single-bearing Merino ewes (2-4 years) in early pregnancy was randomly selected. From this group, eight groups of 25 animals were created and six animals were selected to be focal animals (total=48). Ewe flight distances were tested in four pens: rectangle (4.8m x 5.8m), small rectangle (3.3m x 7.2m), large rectangle (11m x 19.6m) and curved pen (31.5m perimeter). Once a group of 25 were in the pen, the observer entered and approached each focal ewe in a standardised way to measure flight distance. For four days, this was repeated for each ewe until each group had been tested in each pen.

Group flight distance ranged from 1.1 m to 14.8 m (mean 4.7 m) and there was a significant Day x Pen interaction ($F = 2.58$, $P = 0.008$). Post-hoc tests revealed a clear difference across pens, but no clear relationship across days. Flight distances were then divided by the largest dimension of each pen. This modification resulted in flight distance proportions ranging from 0.15 m to 0.66 m (mean 0.36 m). There was still a statistically significant interaction of Day x Pen ($F = 3.01$, $P = 0.002$), but no clear pattern across pens or days was evident.

Pen size and shape clearly affects flight distance of ewes, but by adjusting for pen dimension flight distances can be made comparable. This is the first step in developing a flight distance test that allows for comparisons across farms. There was no evidence of habituation on the ewes, as indicated by a change in distance over days, suggesting that this test could be repeatable.