Final Report

PART A

Project code: W.LIV.3032

Prepared by: Dr Sarah Wickham, Dr Trish Fleming, and Dr Teresa Collins
Murdoch University

Date published: 01 February 2017

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Development and assessment of livestock welfare indicators

Survey

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Table of Contents

1 Abstract

1.1 Survey results

There is significant public interest in the Australian live export industry, and a need to develop a program that can measure and monitor animal welfare throughout the supply chain. An assessment of stakeholder opinions of the livestock export industry (LEI) and relevant animal welfare measures was performed via an online survey completed by 921 participants (74% public; 26% LEI workers). Overall, the surveyed public had greater concern for the welfare of animals throughout the LEI supply chain, with the least concern shown for animals at Australian feedlots, and rated factors that could influence animal welfare more importantly than surveyed LEI workers. The majority of the surveyed public believe that data collected on animal welfare should be made public, collected by independent welfare officers, and used by government to regulate the industry and impose penalties for poor welfare. Surveyed LEI workers believe that the data should be confidential to the industry, collected by LEI workers, and used by the industry to self-regulate. Overall, the surveyed public rated the importance and practicality of a number of potential welfare indicators more highly than surveyed LEI workers, although both stakeholder groups had analogous views in the order of importance and practicality of those indicators.

1.2 Welfare indicators

According to the Australian Standards for the Export of Livestock (ASEL), there are a number of animal welfare related factors that should be measured and recorded for livestock along the Livestock Export Industry (LEI) supply chain. However, currently, the Australian LEI, stakeholders, and the Australian Government primarily use on-board mortality and non-compliance with the Exporter Supply Chain Assurance System (ESCAS) as the key indicators of welfare. The issue with on-board mortality and non-compliance is that they only indicate problems retrospectively (after any events) and do not identify areas where conditions could be modified or welfare improved prospectively. Rather than only being alerted once there is a problem, identifying issues earlier may potentially avoid negative incidents and provide solutions through pre-emptive modifications and adaptive management. This report recommends a number of animal welfare indicators that could be benchmarked by industry to allow a comparative analysis and the sharing of ideas, which may initiate change within the existing system. Such a program will likely encourage continual review and drive improvement in welfare outcomes for stock which in turn will meet the wider stakeholder concerns and contribute to a more sustainable industry.

2 Milestone description

This milestone report includes:

- Survey (complete). Results from a stakeholder survey conducted between March and June 2015 to determine stakeholder preference for a number of welfare indicators. We request permission to submit this manuscript for publication (*Animal Production Science*).
- Benchmarking system (draft). A list of recommendations of welfare indicators suitable for the livestock export industry as a benchmarking program.

3 Project objectives

Objectives of the project follow the Terms of Reference. These are to:

1. Identify internationally accepted indicators of animal welfare for sheep, cattle and goats.
2. Identify existing measures and indicators of animal welfare for sheep, cattle and goats throughout the Australian livestock export chain.
3. Develop key animal welfare indicators that:
    a. Are important to stakeholders
    b. Are practical for assessing livestock (sheep, cattle and goats) throughout the live export chain
    c. Are economical
    d. Are measurable and quantifiable
    e. Demonstrate industry's commitment to animal welfare.
4. Determine a method to benchmark industry's current welfare performance

4 Success in achieving milestone

As part of this milestone requirement we have achieved the following:

Literature review of welfare measures

> A review of literature for animal welfare measures and their relevance to the live export industry has been submitted. This is currently under review for re-submission in Milestone 5.

Analysis of stakeholder survey

> The stakeholder survey was developed and distributed to stakeholders both within and external to the livestock export industry. The survey was open from March until June 2015. There was a good response rate and the results have been analysed and written up in publication format (attached as Appendix 1). A copy of the survey is attached as Appendix 2.

Recommended welfare indicators

> Based on information gathered in a literature review, the results from the stakeholder survey, a review of the current standards and regulations in the livestock export industry (LEI), and a meeting of project researchers, a number of welfare indicators have been recommended for use in the LEI. A description of these indicators, with suggestions on how and where along the supply chain they should be used has been written up in publication format (attached as Appendix 3; details of key measures in Appendix 4).

5 Conclusions/recommendations

Analysis of the survey and development of welfare indicators has progressed well. Results indicate that there is a good level of agreement between livestock export workers and the surveyed public in their opinions on animal welfare indicators.

6 Appendix 1 - What do stakeholders think about animal welfare in the Australian live export industry? A survey

Sarah L. Wickham[1], Teresa Collins[1], Anne L. Barnes[1], David W. Miller[1], Nigel Perkins[2], Patricia A. Fleming[1]

[1] Veterinary and Life Sciences, Murdoch University, WA 6150, Australia; [2] AusVet Animal Health Services, 109 Herries Street, Toowoomba, QLD 4350, Australia.

6.1 Abstract

There is significant public interest in the Australian live export industry, and a need to develop a program that can measure and monitor animal welfare throughout the supply chain. An online survey of stakeholder opinions of the LEI and animal welfare measures was carried out with responses by 921 participants (74% public; 26% LEI workers). Overall, the surveyed public had greater concern for the welfare of animals throughout the LEI supply chain, with the least concern shown for animals at Australian feedlots. Factors that could influence animal welfare were rated more important by the surveyed public than the surveyed LEI workers. The majority of surveyed public believe data collected on animal welfare should be made public, collected by independent welfare officers, and used by the government to regulate the industry and impose penalties for poor welfare. By contrast, surveyed LEI workers think that these data should be confidential to the industry, collected by LEI workers, and used by the industry to self-regulate. Overall, the surveyed public rated the importance and practicality of a number of welfare indicators greater than surveyed LEI workers, in general, both stakeholder groups shared an analogous view of the importance and practicality of those indicators. These findings can be utilised to build a program of welfare assessment that ensures better understanding between citizens and industry members, leads to welfare improvements and promotes a greater transparency for the LEI.

6.2 Introduction

The Australian live export industry (LEI) is a major contributor to the Australian economy. In the 2014-15 financial year, Australia exported 1.38 million cattle, 2.18 million sheep and 91,950 goats to 32 countries as part of the livestock export trade, via sea and air; these animals were valued at $1.6 billion (MLA, 2015). However the value of the LEI goes beyond the price of the sales alone, with 13,000 people employed in the industry across Australia, including livestock producers, transporters, and exporters. Many of these jobs are located in rural and regional areas throughout Australia, and therefore many communities directly and indirectly benefit from this trade.

The general public currently seek greater assurance about the treatment and welfare outcomes of exported animals. Livestock welfare provokes wide social discussion, particularly when the media deal with incidents of current disadvantage or harm to production animals (Kauppinen et al., 2010). The rise of animal advocacy groups and the broad recognition of animals as sentient beings have led to the need for a better understanding of the various perceptions of animal welfare that exist among stakeholders. Public concerns cannot be ignored, as they can influence animal welfare law and regulation

(Degeling and Johnson, 2015), as demonstrated by legal regulations that have been enacted in the European Union for intensive production systems (Izmirli and Phillips, 2012).

Of real significance to the LEI is the call for the cessation of the live sheep from Australia to the Middle East by some societal groups (Ferguson et al., 2014). Societal perceptions are influenced by multiple factors, including personal convictions, values, norms, knowledge and interests (Te Velde et al., 2002), and thus identifying issues of high and low potential conflict with regard the LEI is an important first step to building public confidence in the industry and/or modifying livestock production practices that cause high concern. A Eurobarometer study (covering 31 European countries) indicated that 82.3% of Europeans rated farm animal welfare within the range of moderate to very bad. Also, 89.3% indicted they did not receive enough information concerning welfare conditions of animals farmed in the EU, which illustrates the need for more and clearer information (European Commission, 2005). Producers, on the contrary, have shown a more positive perception of farm animal welfare, and studies have explained that the opposite perceptions between citizens and farmers can be explained by a different interpretation of welfare components (Te Velde et al., 2002; Vanhonacker et al., 2008). Thus, surveying perceptions of animal welfare from participants within the Australian live export trade in terms of their underlying values and preferences for welfare indicators would be informative.

In Australia, animal welfare is important for the live export industry, in terms of both economic returns and community attitudes. Meeting the demands of industry, consumers, and the broader public is an on-going challenge for livestock industries. Societal demands for sustainable and ethical animal production systems and practices will continue, and therefore industry must remain proactive in their effort to ensure the welfare of the animals (Ferguson et al., 2014). Additionally, understanding the values and beliefs of industry, consumers and the broader public is critical in addressing challenges and implementing innovations (Kauppinen et al., 2010). We support the concept of a welfare assessment program based on a broad set of indicators that can operate as an industry-driven management system, to be benchmarked within the LEI, that promotes continuous improvement over and above legislative requirements.

A number of surveys and reviews have examined public perception in terms of belief in whether the live export trade should persist or not (e.g. Bennett et al., 2002; Phillips, 2005). However, the attitudes and perceptions towards assessment of animal welfare as part of this trade are not well understood. Additionally, public perception is likely to be strongly influenced through media and public interest in the welfare of the animals rather than knowledge of current practice *per se*, and therefore a comparison between the general public and workers within the live export industry can prove useful in terms of identifying where similarities and differences in opinion lie. Understanding the perceptions of people from different countries or cultures will facilitate the development of welfare standards (Izmirli and Phillips, 2012; Degeling and Johnson, 2015), especially for an industry whose stakeholders span multiple cultures and belief systems. We therefore surveyed stakeholders from multiple points of the export chain to determine their perceptions of animal welfare in order to contribute towards identifying specific animal welfare measures that are perceived as both important and practical. Such measures could be collated into an industry-driven benchmarking program to provide a framework for continual welfare improvements.

6.3 Methods

A survey instrument (Appendix 2) was distributed to key stakeholder representatives (from members of the community, animal welfare groups and industry). The survey was constructed using SurveyGizmo (www.surveygizmo.com) using a combination of multiple choice and visual analogue scale questions, with options to add comment where appropriate.

The survey was advertised on social media, local and rural newspaper media releases, industry newsletters, and via personal contact. All voluntary participants that completed the survey between March and June 2015 were accepted. Participants were asked whether they worked in the LEI or not, and used their responses to allocate stakeholders to 'public' and 'LEI worker' categories.

The survey collected information on participant demographics (age, gender, location) and experience with the LEI. Public participants were asked to select from options to indicate reasons for their interest in the LEI (where they could select more than one option).

All participants were asked where they sourced their information on the LEI (where they could select more than one option) and participants were asked a number of questions regarding their opinion of animal welfare within the industry.

Participants were asked to rate the importance of time spent during land, sea and air transport, and at feedlots in Australia and overseas using a visual analogue scale (not important to important).

Each participant was asked to rate a series of potential animal welfare measures in terms of whether or not they thought that they were important and practical. We also asked participants to indicate who they believed should be assessing animal welfare as part of the LEI, and how they want to see that information used.

Descriptive statistics were calculated for demographic answers, and comparisons between stakeholder groups (public and LEI workers) for their answers to opinions on the LEI and welfare indicators were evaluated using χ^2 analyses with expected values calculated assuming that there were no differences between the stakeholder groups (LEI or general public). Responses on visual analogue scales were converted to numerical data where minimum = 0 and maximum = 100; these data were compared using correlation analyses, or Mann-Whitney U test (*Z*) to compare between stakeholder groups.

6.4 Results

Demographics

921 participants completed the survey (74% public, 26% work in LEI). The majority of participants were both born (Figure 1a) and worked (Figure 1b) in Australia, with approximately 23% of participants born outside of Australia. More LEI participants lived in a rural area compared to the surveyed public (public 33%, LEI 65%; χ^2_1= 30.17; p<0.001).

Of the total, 68% of participants were female and 32% were male. There was significantly more female participants in the surveyed public compared to surveyed LEI workers (χ^2_1= 86.60; p<0.001). Participants ranged from 18–71+ years of age (Figure 2a).

Significantly more of the public participants had a postgraduate degree (e.g. Masters, PhD) (25%) compared to LEI participants (18%) (χ^2_1= 4.14; p=0.042); however there were no differences between the two stakeholder groups in the proportion of participants that did not complete high school (5% of all participants), had graduated high school or equivalent (19%), held a post-secondary school qualification (e.g. diploma) (24%), or an undergraduate degree (30%).

Connection with the LEI

The majority of public participants indicated that they were interested in the LEI due to their concern for animals (82%), with 41% indicating they were animal welfare advocates. Other options selected were that they had a friend/relative working in the LEI (11%), were connected with the industry through research (7%) or journalism (3%). LEI participants included exporters, inspectors, researchers, producers, transporters and abattoir workers (Figure 2b).

There were significant differences in responses by public and LEI participants in terms of where they sourced their information on the LEI; the surveyed public selected journalism media (e.g. print, television and the internet) (public 83%, LEI 54%; χ^2_1= 9.26; p=0.002) and social media (public 61%, LEI 27%; χ^2_1= 28.23; p<0.001) significantly more than LEI participants as a source of knowledge, while LEI participants indicated they drew on personal experience (public 55%, LEI 91%; χ^2_1= 101.06; p<0.001). There were no differences for communication with friends (public 48%, LEI 39%; χ^2_1= 0.32; p=0.569) and use of scientific journals (public 37%, LEI 31%; χ^2_1= 0.07; p=0.784) between stakeholder groups.

Experience

Survey participants working within the LEI spent 63% of their time working with cattle, 32% working with sheep, and 5% of their time working with goats.

Not surprisingly, more surveyed LEI workers had visited or seen sections of the LEI than the surveyed public: visited or seen a feedlot (public 51%, LEI 84%; χ^2_1= 51.46; p<0.001), an abattoir (public 53%, LEI 82%; χ^2_1= 39.36; p<0.001), a live export ship (public 51%, LEI 63%; χ^2_1= 6.94; p=0.008), or an aircraft carrying livestock (public 6%, LEI 24%; χ^2_1= 119.15; p<0.001). Only 4 % of surveyed public and 8% of surveyed LEI workers had never seen or visited any aspect of the industry (LEI participants were employed in administration and management).

Opinions

The surveyed public rated companion animals as more important compared to the ratings given by surveyed LEI workers (public 86%, LEI 76%; Z= 4.90; p<0.001). LEI participants rated the importance of animals as food (public 53%, LEI 92%; Z= 10.23; p<0.001), working (public 53%, LEI 78%; Z= 7.28; p<0.001), clothing (public 47%, LEI 72%; Z= 4.90; p<0.001), entertainment (public 25%, LEI 37%; Z= 5.85; p<0.001), performance (public 17%, LEI 24%; Z= 4.90; p<0.001), and as religious symbols (public 15%, LEI 17%; Z= 2.60; p=0.006) greater than the public participants.

The surveyed public rated how much time an animal spends in all parts of the LEI supply chain as significantly more important than surveyed LEI workers (*Z*; $p<0.001$ for each; Figure 3). Both groups rated time during transport (truck, ship and plane) as more important than the time at feedlots (both in Australia and overseas) (Figure 3).

The surveyed public consistently rated 26 factors that could influence animal welfare as more important (on a visual analogue scale) than surveyed LEI workers (*Z*; effective slaughter procedures $p=0.001$, $p<0.001$ for remainder) (Figure 4). Both stakeholder groups rated effective slaughter procedures and the competency and attitude of stockpersons as the most important of these 26 factors, and the use of an electric prod and the use of a working dog as least important (Figure 4). However, responses for use of an electric prod and working dog were not a reliable indication of the welfare opinion of participants because many participants commented that they believed neither an electric prod nor a working dog should be used, but then rated the importance of these tools as 'not important'. Therefore, those who rated them as 'not important' and those who rated them as 'important' may arguably be conveying the same opinion regarding the welfare implications of their use.

Significantly more public participants stated that they always have concerns about livestock within the LEI (public 57%, LEI 7%; $p<0.001$ for all χ^2 tests for each species/scenario) while the majority of LEI participants stated that they never or only sometimes have concerns for the welfare of the animals (public 20%, LEI 62%; $p<0.001$ for all χ^2 tests) (Figure 5).

Nearly all public participants (92%) believe that data collected on animal welfare in the LEI should be made publically available, while the majority of LEI participants think that information should be confidential to the industry and government only (data confidential: public 8%, LEI 41%; $\chi^2_1= 336.66$; $p<0.001$).

Survey participants were asked how they would like to see data collected on animal welfare used in the industry. LEI participants would prefer to see animal data being used to self regulate (public 29%, LEI 73%; $\chi^2_1= 151.84$; $p<0.001$) and highlight areas for research (public 50%, LEI 61%; $\chi^2_1= 5.15$; $p=0.023$), whereas public participants would rather see the government using the data to regulate the industry (public 63%, LEI 35%; $\chi^2_1= 30.37$; $p<0.001$), impose penalties and restrictions for poor welfare (public 82%, LEI 62%; $\chi^2_1= 12.10$; $p<0.001$), and provide measures of performance to back to the public (public 67%, LEI 52%; $\chi^2_1= 8.06$; $p=0.005$). There was no difference between stakeholder groups in whether they thought data collected on animal welfare should be used to award incentives for good welfare (public 58%, LEI 65%; $\chi^2_1= 2.14$; $p=0.144$) or highlight areas for investment in welfare improvement (public 70%, LEI 73%; $\chi^2_1= 0.33$; $p=0.564$) (Figure 6a).

Participants were asked who they would like to see collecting data on animal welfare in the industry. LEI participants would prefer to see those working within the industry responsible for monitoring animal welfare, such as stockpersons (public 10%, LEI 16%; $\chi^2_1= 44.00$; $p<0.001$), veterinarians who work for the industry (public 10%, LEI 16%; $\chi^2_1= 51.09$; $p<0.001$), and exporters (public 8%, LEI 13%; $\chi^2_1= 50.36$; $p<0.001$). Public participants would prefer to see animal welfare monitored by people who are independent from the industry, such as independent welfare inspectors (public 20%, LEI 11%; $\chi^2_1= 43.83$; $p<0.001$), animal welfare inspectors (public 18%, LEI 10%; $\chi^2_1= 41.99$; $p<0.001$), and veterinarians that work for the Australian government (public 16%, LEI 12%; $\chi^2_1= 11.27$;

p<0.001. There was no difference between stakeholders groups in whether they want to see veterinarians that work for an overseas government (public 7%, LEI 9%; χ^2_1= 1.64; p=0.200), or abattoir animal welfare officers (public 12%, LEI 13%; χ^2_1= 1.51; p=0.219) monitoring animal welfare (Figure 6b).

The surveyed public expressed their opinion (via comments) that inspectors need to be impartial from the industry and government, and not penalised for reporting negative welfare, while those working within the industry do not want animal rights/activist groups monitoring welfare. More than 17% of all survey participants think that it is everyone's responsibility to monitor and measure animal welfare in the LEI.

Welfare measures

The majority of surveyed public and LEI workers generally agreed on whether a number of physiological, health and environmental-based welfare indicators were important and practical (yes or no) as welfare measures (Figure 7), although more of the general public thought that the measures described were important and practical compared with LEI workers (χ^2_1 tests; p<0.05 for each), and more LEI workers rated meat quality as important (p>0.05).

For both groups, the greatest number of respondents considered injury/wounds and ventilation as important, while fewest considered sneezing and smell as important. Similarly, for practicality, more participants rated injury/wounds, inability to stand, ventilation and amount of shade/shelter as practical to measure, and fewest identified pain and smell as practical to measure. While the majority of surveyed public and LEI workers agreed that disease and death were important and practical physiological welfare indicators, they differed in their opinions for other physiological indicators: fewer surveyed LEI workers identified invasive measure (e.g. heart rate and stress hormones) as important and practical than the surveyed public.

6.5 Discussion

We had a good response rate to our voluntary survey and thus, the opinions of the participants should be representative of the general public and LEI workers. This study reveals that there are similarities in perception and expectations of community and industry stakeholders in terms of animal welfare assessment. Importantly, how participants ranked the practicality and importance of different welfare measures reveals potential future direction for the LEI industry that can address community concerns and improve welfare.

We have identified some differences between the surveyed public and LEI workers in their opinion on welfare indicators. Overall, there was agreement between both groups in how health and environmental welfare indicators ranked in terms on their perceived importance and practicality (Table 1). Differences in the order of ranking for physiological measures could be due to differences in experience within the industry and with experience of collecting those measures themselves. For example, invasive procedures are involved to measure heart rate, stress hormones, and body temperature, and LEI workers may not see the value in collecting them if they are labour intensive and have a negative welfare impact to the animal during collection (i.e. handling, isolation). The surveyed public, on the other hand, may not be aware of the limitations in measuring some of these indicators, and on further conversation with some participants, they thought that technology could be used to

remotely measure body temperature and heart rate, and did not see any limitations in the practicality of measuring them.

We identified differences in how the surveyed public would like to see welfare data collected and used compared to surveyed LEI workers, with the surveyed public requiring more access to data, seeking independent welfare assessors, and wanting to see data used as a means to impose penalties for poor welfare. Of interest, 62% of the surveyed LEI workers also supported the idea that the data should be used to impose penalties. This illustrates the desire from within the industry to have improved welfare outcomes. Thus, industry should be encouraged to use data in new ways, to allow feedback back to operators, and to increase public transparency.

In 2004, the Livestock Export Program identified seven key indicators of welfare on-board ship based on opinions from nine stakeholder groups: mortality, clinical disease, respiration rate, wet bulb temperature, space allowance, change in body weight, and ammonia levels (Pines et al., 2004). We identified differences in public and LEI worker perceptions with the 2004 review (Table 1). Our data showed that the surveyed public and LEI generally agreed about both the practicality and importance of animal welfare assessment measures; injury/wounds, ability to stand, disease and ventilation were identified as important by the highest number of respondents for both stakeholder groups. While mortality was the prime indicator identified by Pines et al. (2004), for our survey, 'death' was ranked 5–7 in number of respondents indicating its importance. Pines et al. (2004) identified respiration rate and air temperature as key welfare indicators, but these were ranked amongst the bottom half of the measures in our survey.

Of the top seven indicators from Pines et al. 2004, three were resource-based measures compared to our study, where only one resource-based measure (ventilation) was listed in the top-seven ranked important measures. This may demonstrate a convergence of views between stakeholder groups over time about the relative importance of animal-based measures. Another farm animal welfare survey by Te Velde et al. (2002) indicated farmers and citizens showed similar values with regard to measures of physical health (adequate food and water, heating) but differed in how much they valued behaviour; e.g. citizens included additional values of *freedom to move* and *freedom to fulfil natural desires* to which the farmers showed indifference. In our study, 'behaviour' was ranked 12 and 14 in terms of the number of public and LEI workers who identified the measure as 'important', respectively, suggesting both stakeholder groups believe measuring behaviour to be important. Caution is needed in drawing conclusions across studies as various stakeholder groups may or may not have similar motives, despite common interests, e.g. farmers and LEI workers may be more economically driven, and consumers may be more interested in the supply of healthy cheap food, and citizens may be more interested in ethical production systems (Vanhonacker et al., 2008).

A number of additional measures can be considered for further investigation in the future. We did not specifically ask participants about the importance of space allowance or ammonium levels, although we asked about a range of similar physical conditions (amount of shade, shelter from weather, amount of light, or air quality and humidity). Providing basic information to the public on space allowance and other physical provisions such as air temperature could be considered.

A LEI framework of continued improvement and increased transparency is important to unite, not divide, the various stakeholders involved. Phillips (2005) surveyed views of farmers and other industry personnel, overseas consumers, the Australian public, and veterinarians. He concluded that the debate as to whether Australia should continue with the trade will be best served by consideration of the interests of all parties in the trade, including those of the consumers and animals, which are among the most affected by the trade. Different people will place different weighting on the rights and interests of these groups, but extreme positions are often adopted because people fail to understand or have sufficient concern for the position of all stakeholders in the trade.

A sustained interest in concern from the general community for animal welfare in livestock production is anticipated (Rousing et al., 2001; Colditz et al., 2014; Ferguson et al., 2014). This growing concern can have an impact on the LEI's social licence to operate, which currently allows the industry approval. The lack of standardisation of welfare certification schemes involved in international trade worldwide adds to the complexity of providing assurance to the community (Main et al., 2014). The live export industry has demonstrated rapid responses to welfare challenges in the past (e.g. Stinson, 2007), and looks to public perception of the trade to guide future management options, as evidenced by financial support of studies such as the present one. Further surveys may be useful to determine a communication strategy, including what specific information the public would like to see from the industry, and how best to educate the public on LEI practices.

6.6 Conclusion

This study captures the views and opinions of the surveyed general public and LEI workers in regard to an extensive number of animal welfare indicators. Although the interpretation of a complex and multi-dimensional concept such is animal welfare is challenging, the survey showed little discordance between industry and public perceptions in terms of the types of measures to collect for welfare assessment and benchmarking. However we also show that there is some variance in the views on how such data is used, and hence there is scope for industry to bring about changes that will build community trust. Consistently meeting the needs of consumers and the broader public, while maintaining a sustainable industry, will be an ongoing challenge. Hence there is urgent need for transparent and open management that provides good animal welfare outcomes and demonstrates aligned values around the care of animals.

Acknowledgements

This study was supported by a grant from Meat and Livestock Australia, and LiveCorp. We thank the survey participants for their participation in this study.

6.7 References

Bennett, R. M., J. Anderson, and R. J. P. Blaney. 2002. Moral intensity and willingness to pay concerning farm animal welfare issues and the implications for agricultural policy. Journal of Agricultural and Environmental Ethics 15: 187-202.

Colditz, I. G., D. M. Ferguson, T. Collins, L. Matthews, and P. H. Hemsworth. 2014. A prototype tool to enable farmers ro measure and improve the welfare performance of the farm animal enterprise: The unified field index. Animals 4: 446-462.

Degeling, C., and J. Johnson. 2015. Citizens, consumers and animals: what role do experts assign to public values in establishing animal welfare standards? Journal of Agricultural and Environmental Ethics 28: 961-976.

European Commission. 2005. Attitudes of consumers towards the welfare of farmed animals Special Eurobarometer 229/Wave 63.2-tns Opinion & Social.

Ferguson, D. M., N. M. Schreurs, P. R. Kenyon, and R. H. Jacob. 2014. Balancing consumer and societal requirements for sheep meat production: An Australasian perspective. Meat Science 98: 477-483.

Izmirli, S., and C. J. C. Phillips. 2012. Attitudes to animal welfare and rights throughout the world in the modern era: a review. Eurasian Journal of Veterinary Sciences 28: 65-68.

Kauppinen, T., A. Vainio, A. Valros, H. Rita, and K. M. Vesala. 2010. Improving animal welfare: qualitative and quantitative methodology in the study of farmers' attitudes. Animal Welfare 19: 523.

Main, D. et al. 2014. Best practice framework for animal welfare certification schemes. Trends in Food Scince and Technology 37: 127-136.

MLA. 2015. Australian livestock export industry statistical review FY 2014-15, Meat & Livestock Australia Limited, Sydney, Australia.

Phillips, C. J. C. 2005. Ethical perspectives of the Australian live export trade. Australian Veterinary Journal 83: 558-562.

Pines, M., C. Petherick, J. B. Gaughan, and C. Phillips. 2004. Developing alternative methods of measuring animal welfare on ships. Stage One: Survey of Industry Opinion, Meat & Livestock Australia.

Rousing, T., M. Bonde, and J. T. Sorensen. 2001. Aggregating welfare indicators into an operational welfare assessment system: A bottom-up approach. Acta Agriculturae Scandinavica, Section A, Animal Science 30(S): 53-57.

Stinson, P. R. 2007. Two incidents that changed quality management in the Australian livestock export industry. Veterinaria Italiana 44: 177-186.

Te Velde, H., N. Aarts, and C. Van Woerkum. 2002. Dealing with ambivalence: farmers' and consumers' perceptions of animal welfare in livestock breeding. Journal of Agricultural and Environmental Ethics 15: 203-219.

Vanhonacker, F., W. Verbeke, E. Van Poucke, and F. A. M. Tuyttens. 2008. Do citizens and farmers interpret the concept of farm animal welfare differently? Livestock Science 116: 126-136.

Figures

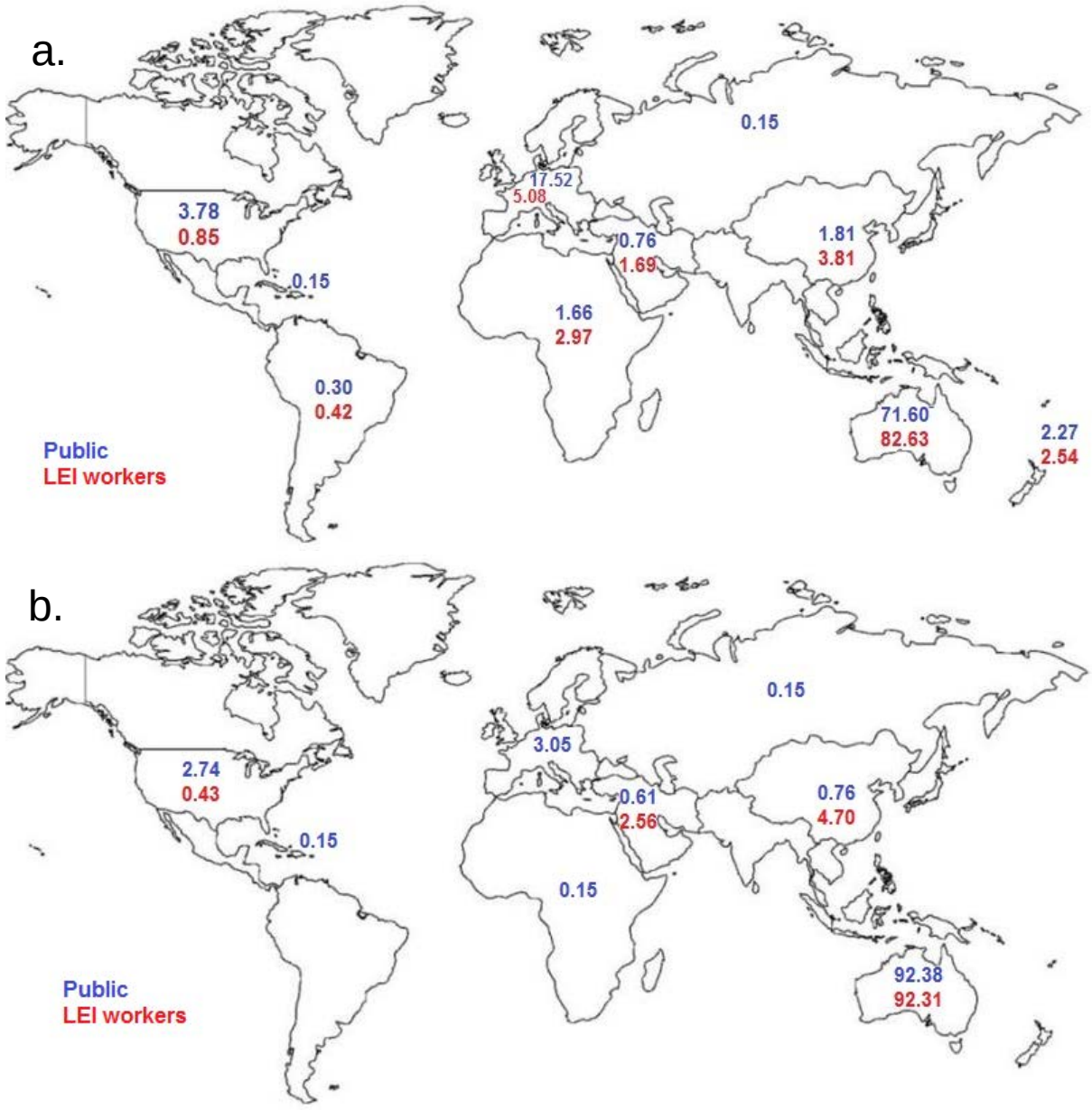


Figure 1. Percentage of survey participants by a) country of birth and b) place of work for general public (n=682 participants) or Live Export Industry (LEI) workers (n=239 participants).

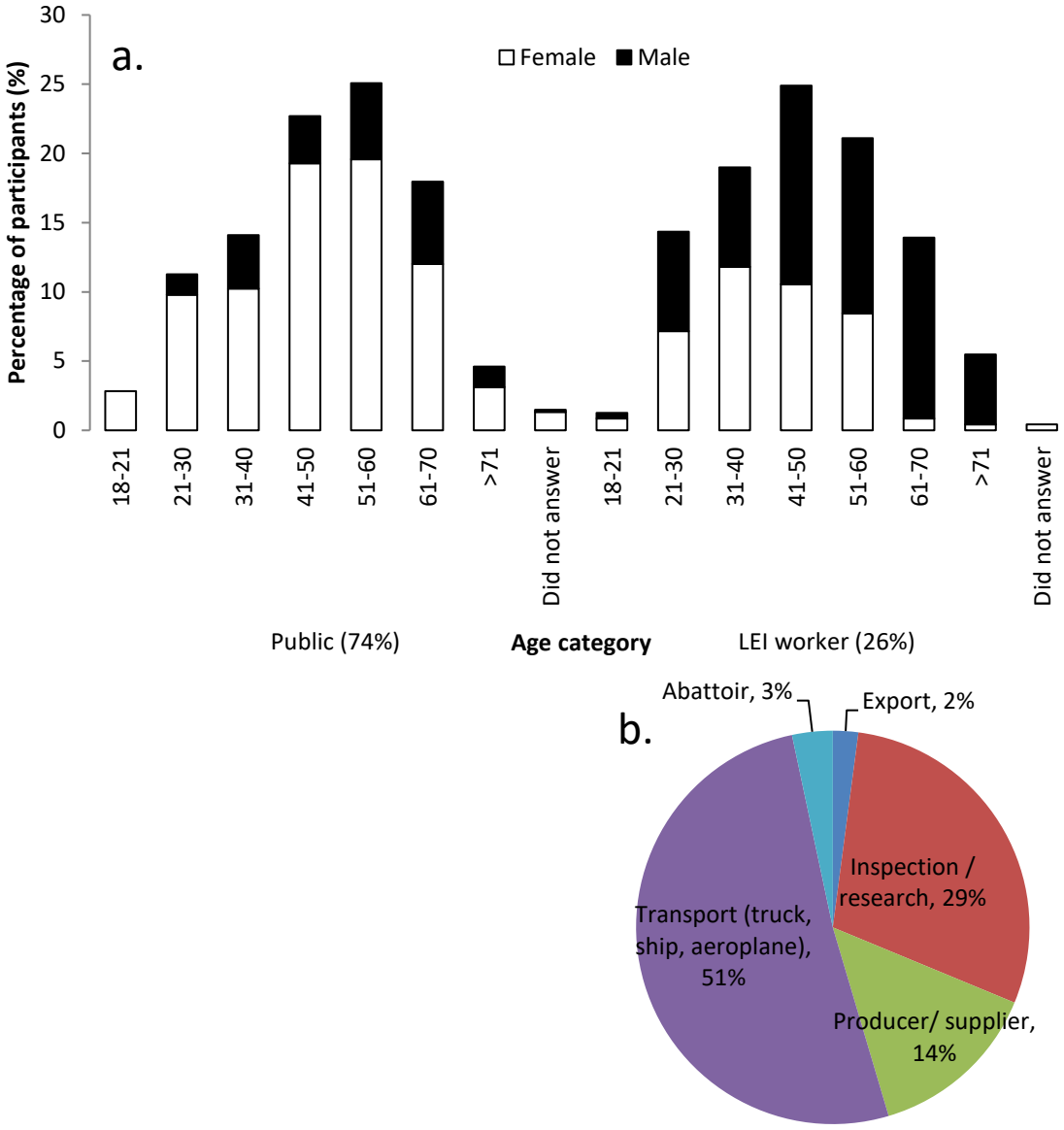


Figure 2. a) Age and gender of participants classified as public or LEI workers, and b) distribution of surveyed LEI workers across the industry.

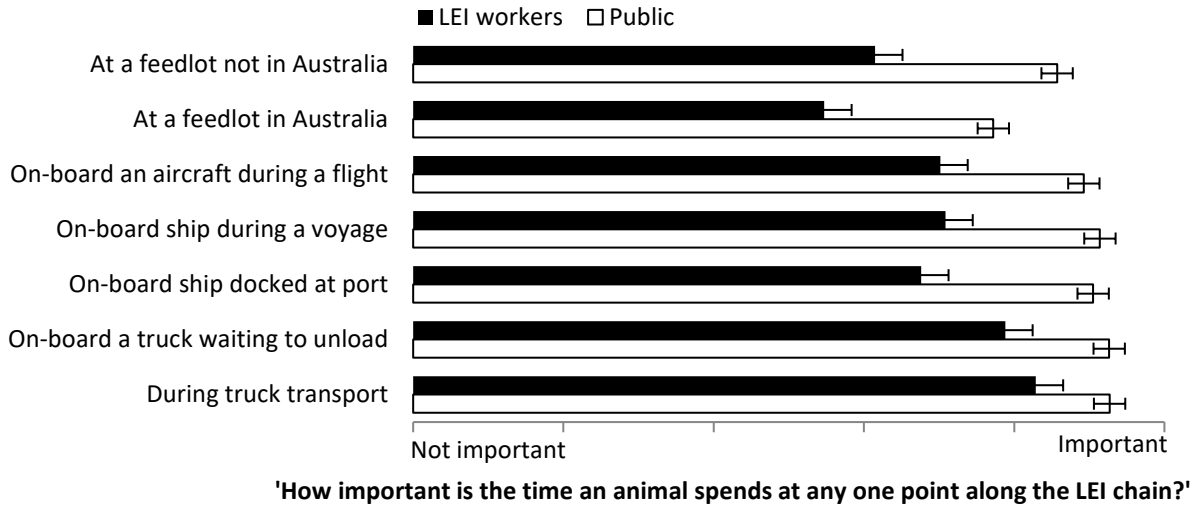


Figure 3. Rating of the importance of how much time an animal spends at each location. Data were collected using a visual analogue scale. Values are means ± 1SE. All differences were significant at $p<0.001$.

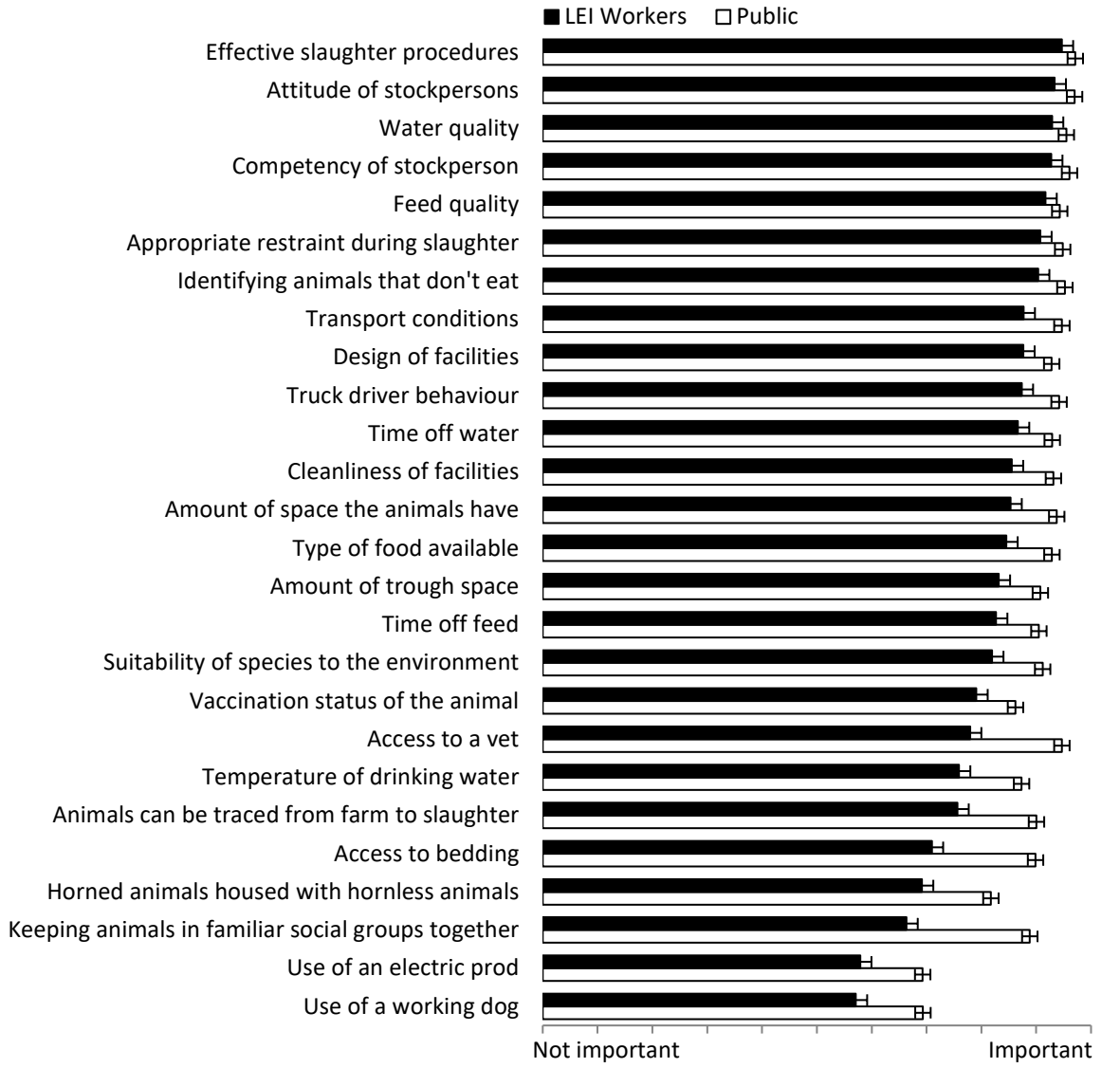
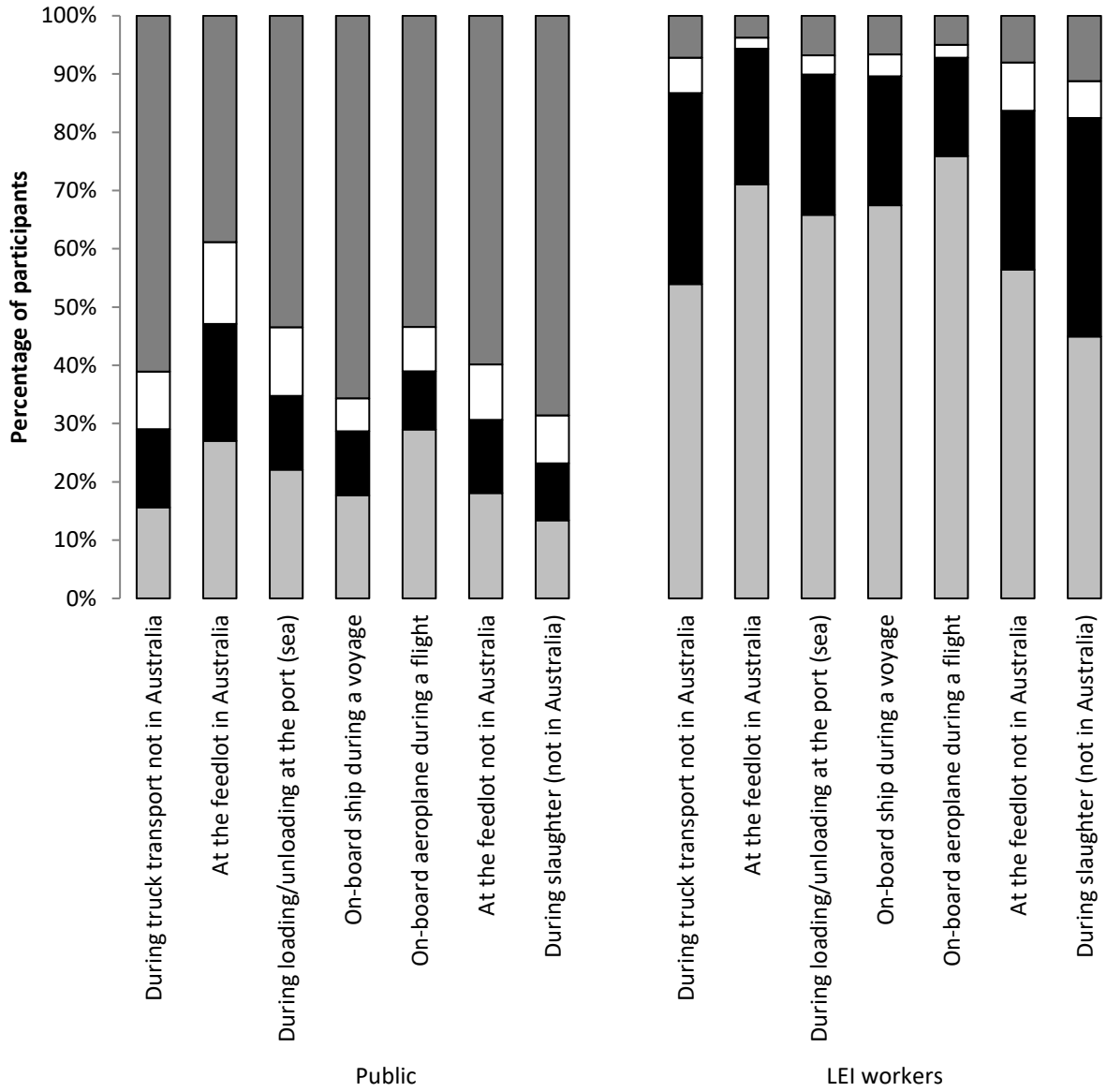


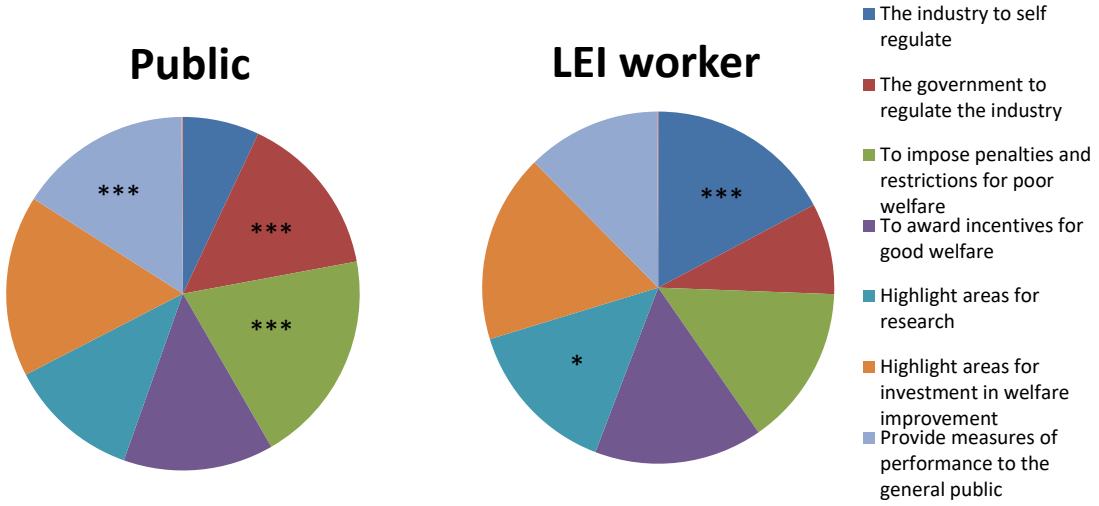
Figure 4. Ratings on how important different welfare factors are in the LEI. Data were collected using a visual analogue scale. Values are means ± 1SE. All differences were significant at $p<0.001$, except for effective slaughter procedures ($p<0.01$).



	Never	Sometimes	Frequently	Always
Public	20%	13%	10%	57%
LEI workers	62%	26%	5%	7%

Figure 5. Percentage of participants that expressed concerns for livestock along different points of the LEI.

a. 'What do you think measuring animal welfare should be used for?'



b. 'Who do you think should be monitoring and measuring animal welfare?'

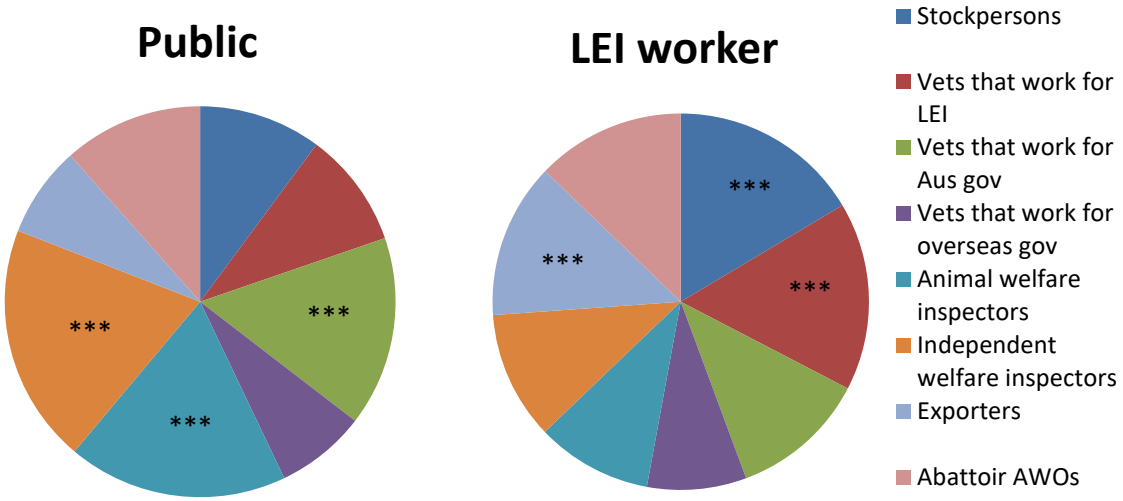
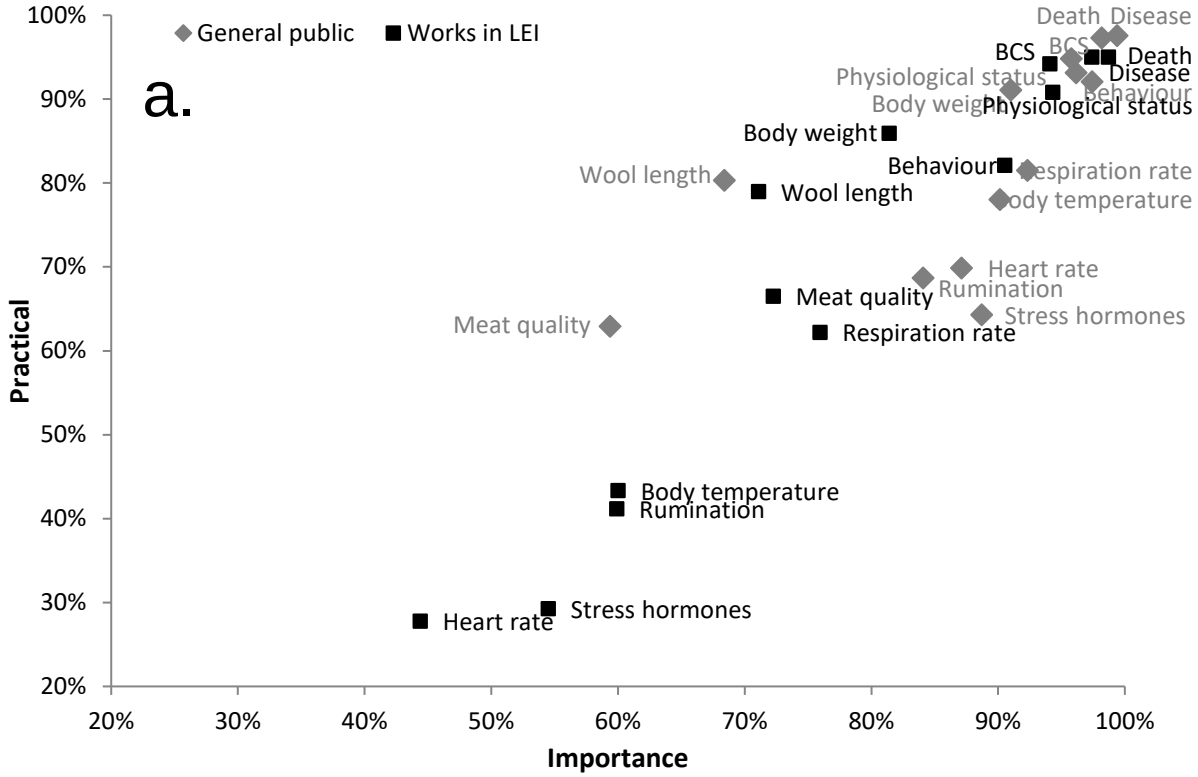
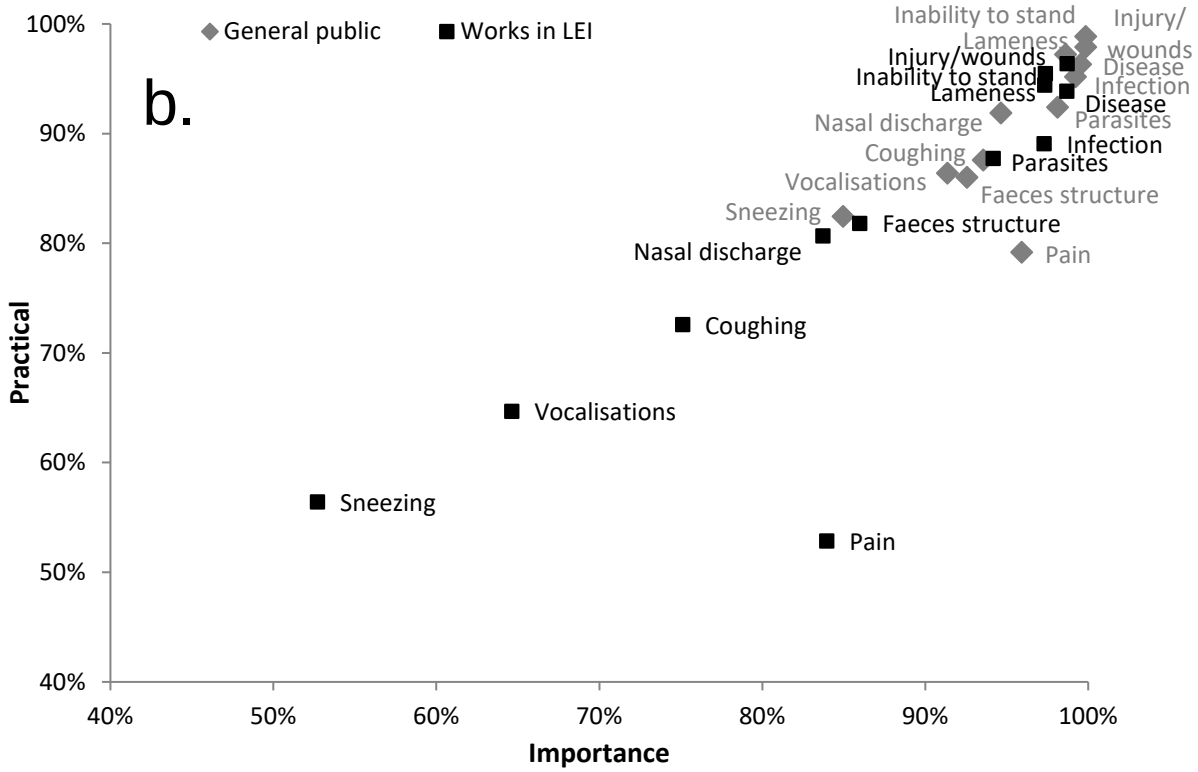


Figure 6. Stakeholder opinions on the purpose of animal welfare assessments and who they believe should be responsible for these assessments. AWO: animal welfare officer. Significant differences indicated by *** $p<0.001$, * $p<0.05$.


a.
General public
Works in LEI
Practical
Importance
100%
90%
80%
70%
60%
50%
40%
30%
20%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Death
Disease
BCS
Physiological status
Behaviour
Body weight
Wool length
Heart rate
Rumination
Meat quality
Stress hormones
Respiration rate
Body temperature


b.
General public
Works in LEI
Practical
Importance
100%
90%
80%
70%
60%
50%
40%
40%
50%
60%
70%
80%
90%
100%
Inability to stand
Lameness
Injury/wounds
Disease
Infection
Nasal discharge
Parasites
Coughing
Vocalisations
Faeces structure
Sneezing
Pain

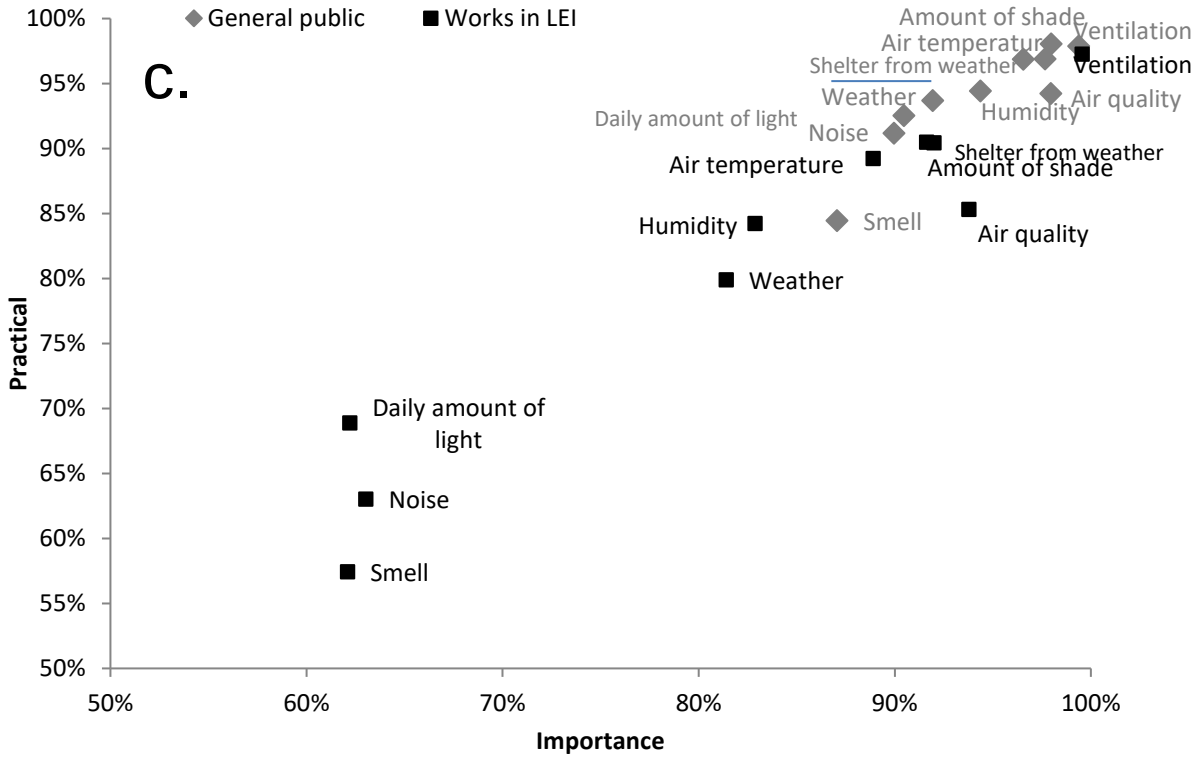


Figure 7. Proportion of the surveyed public (grey symbols) and LEI workers (black symbols) who rated each (a) physiological, (b) health, and (c) environmental indicator as important (x-axis) and practical (y-axis).

Table 1. Ranking of 34 animal welfare indicators in terms of their importance and practicality by surveyed public and LEI workers, and the top 5 indicators from Pines et al. (2004).

	Importance		Practicality		'key indicators'
	Public	LEI workers	Public	LEI workers	(Pines et al., 2004)
1	Injury/wounds	Ventilation	Inability to stand	Ventilation	Death
2	Inability to stand	Disease	Amount of shade	Injury/wounds	Disease
3	Disease	Injury/wounds	Injury/wounds	Inability to stand	Respiration rate
4	Ventilation	Inability to stand	Ventilation	Death	Air temperature
5	Infection	Death	Disease	Disease	Space allowance
6	Lameness	Lameness	Death	Lameness	Body weight
7	Death	Infection	Lameness	BCS	Ammonia levels
8	Parasites	Physiological status	Shelter from weather	Physiological status	
9	Amount of shade	Parasites	Air temperature	Shelter from weather	
10	Air quality	BCS	Infection	Amount of shade	
11	Shelter from weather	Air quality	BCS	Air temperature	
12	Behaviour	Amount of shade	Humidity	Infection	
13	Air temperature	Shelter from weather	Air quality	Parasites	
14	Physiological status	Behaviour	Weather	Body weight	
15	Pain	Air temperature	Physiological status	Air quality	
16	BCS	Faeces structure	Daily amount of light	Humidity	
17	Nasal discharge	Pain	Parasites	Behaviour	
18	Humidity	Nasal discharge	Behaviour	Faeces structure	
19	Coughing	Humidity	Nasal discharge	Nasal discharge	
20	Faeces structure	Weather	Noise	Weather	
21	Respiration rate	Body weight	Body weight	Wool length	
22	Weather	Respiration rate	Coughing	Coughing	
23	Vocalisations	Coughing	Vocalisations	Daily amount of light	
24	Body weight	Meat quality	Faeces structure	Meat quality	
25	Daily amount of light	Wool length	Smell	Vocalisations	
26	Body temperature	Vocalisations	Sneezing	Noise	
27	Noise	Noise	Respiration rate	Respiration rate	
28	Stress hormone	Daily amount of light	Wool length	Smell	
29	Heart rate	Smell	Pain	Sneezing	
30	Smell	Body temperature	Body temperature	Pain	
31	Sneezing	Rumination	Heart rate	Body temperature	
32	Rumination	Stress hormones	Rumination	Rumination	
33	Wool length	Sneezing	Stress hormones	Stress hormones	
34	Meat quality	Heart rate	Meat quality	Heart rate	

7 Appendix 2 - Survey tool

Please see attached PDF document

8 Appendix 3 – Welfare indicators for the Australian Live Export Industry

Sarah L. Wickham[1], Teresa Collins[1], Anne L. Barnes[1], David W. Miller[1], Nigel Perkins[2], Patricia A. Fleming[1]

[1] Veterinary and Life Sciences, Murdoch University, WA 6150, Australia; [2] AusVet Animal Health Services, 109 Herries Street, Toowoomba, QLD 4350, Australia.

8.1 Abstract

According to the Australian Standards for the Export of Livestock (ASEL), there are a number of animal welfare related factors that should be measured and recorded for livestock along the Livestock Export Industry (LEI) supply chain. However, currently, the Australian LEI, stakeholders, and the Australian Government primarily use on-board mortality and non-compliance with the Exporter Supply Chain Assurance System (ESCAS) as the key indicators of welfare. The issue with on-board mortality and non-compliance is that they only indicate problems retrospectively (after any events) and do not identify areas where conditions could be modified or welfare improved prospectively. Rather than only being alerted once there is a problem, identifying issues earlier may potentially avoid negative incidents and provide solutions through pre-emptive modifications and adaptive management. This report recommends a number of animal welfare indicators that could be benchmarked by industry to allow a comparative analysis and the sharing of ideas, which may initiate change within the existing system. Such a program will likely encourage continual review and drive improvement in welfare outcomes for stock which in turn will meet the wider stakeholder concerns and contribute to a more sustainable industry.

8.2 Introduction

Animal welfare is an important issue for the live export industry, in terms of both economic returns and community attitudes. Meeting the requirements and demands of industry, consumers and the broader public is an on-going challenge for livestock industries. Societal demands for sustainable and ethical animal production systems and practices will continue, and therefore industry must remain proactive in their effort to ensure the welfare of the animals (Ferguson et al., 2014).

According to the Australian Standards for the Export of Livestock (ASEL), there are a number of animal welfare-related factors that must be measured and recorded for livestock along the LEI supply chain. However, currently, the Australian LEI, Australian Government, and stakeholders only use non-compliance with the Exporter Supply Chain Assurance System (ESCAS) (Table 1; many measures are not appropriate to all levels of the LEI) and on-board mortality as indicators of welfare. Heightened public awareness around the LEI means that avoiding high mortality situations is a priority.

The issue with on-board mortality and non-compliance is that they only indicate problems retrospectively. While mortality intuitively can indicate poor welfare conditions, optimising welfare requires that we can identify potential issues well before death occurs; identifying issues earlier may potentially avoid negative incidents and provide solutions through pre-emptive modifications and adaptive management. Additionally, disease outbreaks can

significantly influence mortality figures and their stochastic nature means that mortality figures are sometimes not reflective of general welfare conditions. Furthermore, a single incidence of high mortality contributes towards negative community attitudes to live export, while the continued efforts made by the industry towards managing animal welfare along the whole supply chain go unrecognised. Thus, routine animal monitoring and welfare assessments should also be in place to encourage an ethos of continual improvement among those that are responsible for day to day care of the animals, rather than simply being compliance-based. In addition, identifying specific areas of increased production resulting from improved management or welfare outcomes would further encourage uptake of best practice along the supply chain.

In 2004, the Livestock Export Program identified seven key indicators of welfare on-board ship: mortality, clinical disease, respiration rate, wet bulb temperature, space allowance, change in body weight, and ammonia levels (Pines et al., 2004). Although many of these are already collected in reports on the LEI carried out by the government, these measures are not reviewed in a method that can assist in the management of animals, nor improve their welfare. Many of the measures are not sufficiently dynamic to enable progressively higher standards (Main et al., 2014). Additionally, some of these indicators have little potential for broad application or practicality of use. Furthermore, for many measures, the baseline information (that would allow deviance from optimum and/or critical levels to be detected) has not been established. Application of welfare measures across the whole supply chain (including on trucks, in feedlots, and in abattoirs both in Australia and at the export destination) requires indicators that can be applied more broadly. Furthermore, behavioural indicators were not identified as part of the 2004 Livestock Export Program project (Pines et al., 2004), although an understanding and application of behavioural measurements to assess welfare have markedly advanced over the intervening decade (e.g. Fleming et al., 2016).

Continuous improvement can be achieved where the industry promotes welfare interest within an existing management system, responds to public concerns, and encourages some form of external involvement or review. Developing a program that allows stakeholders such as transporters, feedlotters and exporters to collect and benchmark their data and seek internal feedback is a key first step towards improved practice, that will likely bring support for a continued social licence for the industry (Main et al., 2014). For example, developing key indicators within an information management system that manages animal welfare and other performance criteria has brought benefits to industry such as the poultry meat supply chain (Manning et al., 2008).

In this project, we identified potential animal welfare measures through a literature review and a survey of public and LEI workers. We then compared these measures with current practice within the LEI (including consideration of current standards and regulations). We suggest developing a QA dashboard, a database interface where industry can collect, register and analyse key measures in order to benchmark a variety of welfare outputs.

8.3 Methods

Summary of literature review (Wickham et al., 2016a)

An animal's welfare is based on its response to its environment, as well as resources available and management practices. Animal-based measures (an animal's response, such as behaviour or physiology) can directly indicate welfare, whereas resource-based measures (physical environment and resources available to the animal, such as space and housing) and management-based measures (management practices of the farm, such as use of anaesthetics and analgesics) are indicators of a welfare risk.

Animal-based measures are a direct measure of how the animals experience their environment, and this can dynamically alter as their environment changes. By contrast, most resource and management-based measures do not need direct contact with the animals, but tend to capture static data. Resource and management-based measures have tended to be relied upon for ease of data collection, and where these are known to correlate with animal welfare, they can be good reflection of a current situation. For example, an increase in wet bulb temperature is known to correlate with an increase in body temperature and increased panting score (Gaughan et al., 2008). The increasing emphasis on animal-based measures globally, however, recognises that resource- and management-based measures are not sufficient on their own.

This review describes many welfare measures that have been identified through research across a wide range of situations. It is clear from this work, that no one particular measure can reliably indicate an animal's welfare, and different measures have greater relevance for specific situations. We therefore conclude that a multifactorial approach to animal welfare assessment is necessary to obtain a comprehensive and accurate view of an animal's welfare (Webster, 2005).

Finally, when deciding on appropriate welfare indicators, consideration of legislative requirements is also important, in addition to whether the indicators are acceptable to stakeholders (including the public), economical and practical for the industry. This aspect of welfare assessment is particularly relevant to the LEI.

In our selection of welfare indicators relevant to the LEI, we have therefore identified:

- New animal-based measures, which support current practice which is largely focussed on resource- and management-based measures
- A wide range of measures that have broad applicability across different stages in the export chain
- Measures that have been identified through survey of the general public and LEI workers as important and practical to carry out.

Summary of stakeholder survey results (Wickham et al., 2016b)

In August 2015, the authors surveyed 921 participants (74% public; 26% LEI workers) who were asked to score 34 potential measures of animal welfare in terms of their practicality and perceived importance as part of the LEI. The surveyed public considered factors that could influence animal welfare more important than surveyed LEI workers. Overall, the surveyed public had greater concern for the welfare of animals throughout the LEI supply chain (least

concern shown for animals at Australian feedlots). The majority of surveyed public believe data collected on animal welfare should be made public, collected by independent welfare officers, and used by the government to regulate the industry and impose penalties for poor welfare, while surveyed LEI workers think that is should be confidential to the industry, collected by LEI workers, and used by the industry to self-regulate.

There was consensus between the surveyed public and LEI participants in regard to ranking welfare measures as important and practical to measure. The top seven welfare indicators, ranked in terms of their perceived importance, were injury/wounds, inability to stand, disease, ventilation, infection, lameness and death. With the exception of infection, both the surveyed public and LEI participants also rated these indicators as the most practical. Both stakeholder groups rated the amount of shade (public) and body condition score (LEI participants) as more practical to measure than infection.

In our selection of welfare indicators relevant to the LEI, we have therefore identified:

- Measures that are perceived as important to the general public and LEI workers, as well as those that are practical to undertake.

8.4 Results - Proposed welfare indicators

We considered a total of 56 potential measures of animal welfare for relevance to the LEI (Table 2); further details of these categories are given in Appendix 4. Of these, 26 are animal-based categories, 14 are environment-based, and 16 are management-based measures. These indicators are relevant to a range of different points along the supply chain; we have indicated where our experience suggests each measure may be relevant ('X' in Table 2).

We propose daily (Table 3), as well as once-off, transient and cumulative data collection (Table 4), dependent on the measures in question. These example scoring sheets demonstrate how assessments can be carried out using simple scoring sheets where the measures and scoring methods are kept as brief and relevant as possible.

We propose that data collection is cumulated for particular consignments – groups of animals handled/treated in the same way at each stage (i.e. on farm collection, road transport, lairage, on ship or in the air). Alternatively, assessments could be carried out for each stage in the export chain. For daily recording (Table 3), we propose that there are sentinel groups that are monitored regularly over time to ensure that it is possible to capture potential changes in welfare over time. An alternative plan would be to carry out sampling of random groups, although we note that interpreting the outcomes of these measures will require greater statistical interpretation to ensure that multiple factors (e.g. animal age, breed, sex, wool length) are accounted for. For sites where there are fewer groups, an overview assessment for each group can be carried out.

Scoring sheets can easily be built into apps appropriate for smart phones or tablets, facilitating the direct assimilation of these data in real time. This circumvents potential issues around difficulty of internet access and avoids delays in data entry. Immediate interpretation of trends in the data can be facilitated in this way. It would also be possible,

once thresholds have become established, that the computer system could flag outlying values or trends of concerns for further investigation. Data analysis would be submitted to further analysis by industry experts to produce industry-wide statistics of welfare performance and for external review for the purpose of feedback.

Training of welfare assessors will be required to ensure that each person is carrying out their data recording in a similar manner. Where this is not possible (especially where the animals move across countries and therefore are transient at each point in the export chain), it is possible to train assessors using footage of animals that they all watch in common during initial training sessions. Following animals through the export chain can also allow direct comparison of assessor's scores for validation purposes.

The measures we propose could be incorporated into an online 'QA dashboard' interface that serves to collate data on a daily/monthly basis (depending on the welfare measure). This QA dashboard we propose will build upon current practice, engaging with data that is already collected such as assessments at feedlots or the shipping Daily Voyage Reports. For the indicators we identified for the LEI, data from assessments should be sent to a central database, either at sourcing, before and after transport, or daily, depending on the frequency of evaluation for the indicators being assessed. When collated and analysed, this data can provide valuable feedback for relevant sections of the industry. Direct, real-time feedback will facilitate immediate action where this is relevant. In addition to direct access to existing data, overarching feedback could be derived from review by a panel of experts, thus meeting the general public's request for independent review of the LEI. The industry can use this information to formulate management strategies to deal with any upcoming welfare issues, or to change management of future animals.

For the list of recommended indicators, an industry average is calculated each time data is submitted for a particular point in the chain. The exporter/manager can then directly compare their individual measures across time (Figure 1), or against the industry average data (Figure 2). Suppliers could use this information to improve the preparedness of livestock for export, or alter the facilities or management type where appropriate. Exporters could use this information to provide feedback to suppliers on where the inherent risks lie with respect to specific consignments of stock, and what factors (ship structure, stockperson management, or animal) affect the overall welfare outcome of the stock.

8.5 Discussion

We have outlined a considerable number of indicators that could be combined into an assessment program that meet the following criteria:

a) they are practical to collect without excessive cost or imposition upon livestock; and
b) they are meaningful, measureable, quantifiable and demonstrate industry's commitment and performance on animal welfare.

This benchmarking program will be industry-supported and -owned. Hence the commendation for transparency and change is fully driven by and for the LEI. Having a central data repository would allow future assessment of the industry and provide baseline data against which to map improvements.

The essence of the benchmarking system is to measure current performance against an industry average, provide feedback to industry (possibly from review by a panel of experts), and identify areas for improvement. Benchmarking can be defined as a process of identifying, sharing and using knowledge and best practices (Maire, 2002). Benchmarking is an on-going practice aimed at continuous improvement that should align with current regulations and management systems, as well as addressing community concerns. It is important to ensure that any requirement for data collection remains attractive to the user, thus access to information that will help the user identify and implement improvement is essential (Manning et al., 2008). A benchmarking program can be built on over time, and may include various portals that 1) collate data for industry stakeholders to review 2) allow review by experts to provide feedback to the industry to promote improvement 3) allow public access to limited data 4) align to compliance or regulations.

A prime example of an industry benchmarking report is an extensive Canadian benchmarking study of long haul cattle transport (González et al., 2012). Analysis of 6,152 journeys involving 16 companies required information collected on cattle, loading, unloading, drivers, driving conditions, and equipment use, and identified industry norms and extremes. This study provided baseline information that was subsequently used to determine the impact of specific practices on cattle welfare and to identify areas where further research was needed. The information allowed the industry the ability to assess the impact of potential changes to recommendations or regulations (González et al., 2012).

We suggest a tiered approach to a QA dashboard (Figure 3), where data can be discussed and compared internally by other users, and then subsequently analysed vertically by reviewers/assessors either internal or external to the industry for the provision of feedback. We propose a QA dashboard where three tiers of communication would occur:

- Firstly, all data obtained from monitoring stock and management records would feed into the main QA dashboard, where aggregate measures for each species or class of animal, and thresholds can be established. These data could be shared horizontally between transporters feedlotters and exporters to allow benchmarking of sector functioning for specific stages of the supply chain. An industry self-audit can also be carried out, to evaluate a whole of chain analysis, and allow comparisons between supply chains with different destinations.
- A second tier of communication would encourage internal or external review, at regular intervals (e.g. semi-annual) by a nominated panel of experts, with provision of science-based information and resources to share. The purpose of this review is to promote the culture of continual improvement by allowing the identification of problem areas and highlighting of areas of best practice. Any initiation of change, either technological, practical, or cultural, can be reviewed and assessed. Feedback from benchmarking should allow industries to feel greater ownership of the methodology for monitoring welfare performance over and above the existing system where welfare standards are imposed on them.
- The final tier of communication, that can occur at a subsequent stage (e.g. not less than 12 months after data collection), can allow the transfer of information packages to the public. This can include summaries of specific data collected, either at specific points or whole of supply chain, together with educational information about the monitoring program and information about standards.

A time frame for implementation of the QA Dashboard

The overall aim is to promote a culture of continuous improvement, via regular internal monitoring of agreed animal welfare measures. In addition, there is the opportunity to provide information about the monitoring program and subsets of data back to the community by way of public reports to address concerns, promote confidence and transparency of the industry. At a later stage, the data could be linked to show adherence to regulations. Therefore, feedback from QA Dashboard should create incentive for continuous improvement and industry ownership of methods of monitoring.

It is proposed that for many of these indicators recording and collection of data start with 3–6 months (Table 2). This can then enable stakeholders to use this data to assist in determining thresholds for certain welfare indicators, which may take 6–24 months. For welfare indicators that are measured by compliance, it is proposed that assessment of these commence with 3–6 months, once appropriate assessment documents have been generated. There may be some indicators that require further validation in the field.

It is not recommended that penalties be imposed for breaching thresholds or non-compliance in the first 12–24 months after the introduction of a welfare indicator. It is important that these indicators signal achievement of satisfactory to good standards of care, at the various points in the supply chain, and not seen as the tipping point to signal the requirement of remedial intervention. Benchmarking seeks to demonstrate areas of best practice, not to highlight any system failures.

A public reporting program

A public reporting program of welfare indicators could be established by setting up public access via a portal to the QA dashboard. This directly addresses one of our survey findings, as the surveyed Australian public request greater transparency and access to data (Wickham et al., 2016b). Initially, the public could be presented with the overarching principles of welfare and a snapshot of the various stages of animal management within the LEI, including listing recent improvements. The public could then have access to the industry average for a set of indicators and data as to how that changes over time (note that data for individual stakeholders would be kept confidential at all times). The public might only have access to certain measures that are significant and important to the public. This information will balance the rather skewed information that the public receive currently, as only the negative stories of mishap or misfortune are presented by the media. Access to such data will make the industry more transparent and demonstrate the industry's increased commitment to animal welfare and to the shared values about animal care. Public access to data can be determined by the industry and changed over time. The industry could also release action plans taken in response to analysis by the expert panel.

Compliance

Current assessment procedures for the LEI are largely based on standards that are often interpreted as all or nothing thresholds that only need to be exceeded and not continually improved upon. Continual improvement can be engaged through a benchmarking program, where outcomes of a management system can be compared within the industry. Records kept for self-audit and internal review will also contribute to external auditing. Following initial review and comparison to benchmarks, priority areas and targets can be identified and

agreed upon, setting achievable targets and actions. In this way, stockmen should be able to generate their own understanding of good practice. For example, allowing farmers to identify their own benchmarking targets was considered a key step for the successful implementation of health plans on sheep farms (Phythian et al., 2014), and thus encouraging stock managers to set their own welfare goals within the LEI is recommended.

Many welfare indicators are already required by ASEL to be measured/recorded (Table 1). Additionally, there are welfare indicators used in ESCAS that could be applied to the LEI supply chain from sourcing to discharge at the final port (Table 2). However, the problem lies in that there may not be any collation of this data, or analysis, to provide feedback to sections of the LEI that could result in changes to improve animal welfare.

There are two ways that these indicators can be measured; either as compliance with standards, or as consequences of non-compliance. Reporting of compliance with the welfare indicators could be done in a similar manor to the ESCAS Animal Welfare Audit. Yes/No boxes and numbers/percentage of animals (Table 4) can indicate compliance with the standards and space allowed for comments.

8.6 Conclusion

Industry should be encouraged to collect and use data in new ways, to increase data analysis and feedback to operators, and to increase public transparency. The LEI has endorsed an industry reform strategy that, in summary, includes development of welfare indicators to increase transparency, benchmark performance and support improved engagement with stakeholders.

Currently only two indicators of welfare are used by industry or stakeholders – on-board mortality and non-compliance with ESCAS. These are too broad in nature, do not demonstrate enough of a 'commitment to the welfare of the animals involved' and are taken too late in the supply chain process to enable change or improvement for a current shipment of stock. Furthermore, the public are seeking more information about the supply chain and voyage conditions as they demonstrate a heightened concern for all animals in the primary production system, and in particular those in the LEI. The industry can address these concerns by providing more transparency and increased monitoring of welfare, as demand for ethical productions systems will increase.

Our recommendation is to value-add to current practice carried out during transport and in lairage by establishing a benchmarking program (a QA Dashboard). We recognise that there are practical limitations on our ability to impose measures upon land (truck), sea and air transport, and have therefore attempted to identify the benefits of different measures relevant to each of these transport environments. We have also emphasised the importance of including measures that have broad applicability for stakeholders, including the general public and LEI staff. This breadth of welfare assessment approaches ensures that we increase our chances of recording the most relevant and valuable measures for each step of the livestock export chain. The benchmarking program allows for a flexible system that can develop with time and experience. It will bring engagement with the public and other stakeholders, allow the industry to show its commitment to welfare improvements, and contribute to an ongoing social licence for a sustainable industry.

8.7 References

Ferguson, D. M., N. M. Schreurs, P. R. Kenyon, and R. H. Jacob. 2014. Balancing consumer and societal requirements for sheep meat production: An Australasian perspective. Meat Science 98: 477-483.

Fleming, P. A. et al. 2016. The contribution of Qualitative Behavioural Assessment to livestock welfare assessment. An. Prod. Sci. In Press, Accepted Oct 2015.

Gaughan, J. B., T. L. Mader, S. Holt, and A. Lisle. 2008. A new heat load index for feedlot cattle. Faculty Papers and Publications in Animal Science Paper 613.

González, L. A., K. S. Schwartzkopf-Genswein, M. Bryan, R. Silasi, and F. Brown. 2012. Benchmarking study of industry practices during commercial long haul transport of cattle in Alberta, Canada. J. An. Sci. 90: 3606-3617.

Jubb, T., and N. Perkins. 2015. The Veterinary Handbook for the Livestock Export Industry, Australian Livestock Export Corporation Limited.

Main, D. et al. 2014. Best practice framework for animal welfare certification schemes. Trends in Food Scince and Technology 37: 127-136.

Maire, J.-L. 2002. A model of characterization of the performance for a process of benchmarking. Benchmarking: An International Journal 9: 506-520.

Manning, L., R. Baines, and S. Chadd. 2008. Benchmarking the poultry meat supply chain. Benchmarking: An International Journal 15: 148-165.

MLA. 2001. Investigation of the Ventilation Efficacy on Livestock Vessels, Meat and Livestock Australia Limited, Sydney, Australia.

MLA. 2006. Recognising excessive heat load in feedlot cattle: tips and tools, Meat and Livestock Australia Limited, Sydney, Australia.

Phythian, C., E. Michalopoulou, J. Duncan, and F. Wemelsfelder. 2013. Inter-observer reliability of Qualitative Behavioural Assessments of sheep. Applied Animal Behaviour Science 144 73-79.

Phythian, C., K. Phillips, N. Wright, and M. Morgan. 2014. Sheep health, welfare and production planning 1. Recording and benchmarking performance indicators of flock health and production. In Practice 36: 85-92.

Pines, M., C. Petherick, J. B. Gaughan, and C. Phillips. 2004. Developing alternative methods of measuring animal welfare on ships. Stage One: Survey of Industry Opinion, Meat & Livestock Australia.

Webster, J. 2005. Animal welfare: Limping toward Eden 2005. Blackwell Publishing, Oxford, UK.

Wickham, S. L. et al. 2016a. A literature review of livestock welfare indicators relevant for the Australian live export industry. In preparation.

Wickham, S. L. et al. 2016b. What do stakeholders think about animal welfare in the Australian live export industry? A survey. In preparation.

Tables and figures

Table 1. A summary of animal welfare related factors used in ESCAS animal welfare audits that are not found in ASEL.

	Land transport/discharge	Feedlot / holding	Lairage	Slaughter (Stun)	Slaughter (no stun)
Slips	X	X	X	X	X
Falls	X	X	X	X	X
Vocalisations	X	X	X	X	X
Baulking	X	X	X	X	X
Excessive noise (shouting & banging)	X	X	X	X	X
Undue pressure on animals with nowhere to go	X	X	X	X	X
Isolation	X	X	X	X	X
Restraint method				X	X
Stunning				X	X
Slaughter procedure				X	X

Table 2. A summary of animal welfare related factors that should be measured/recorded (X) from farm to delivery at an overseas port in the LEI supply chain according to ASEL.

		Relevant situation ('consignment event')					Importance, practicality†			Time to implement (months)		
		On-farm sourcing	Land transport	Feedlot	On ship	Air transport	Gen. Pub.	LEI	Scoring ¥	3-6	6-12	12-24
	Animal-based measures											
1.	Animal type and number	X							O			
2.	Vaccination status	X							O			
3.	Horn status/length	X							O			
4.	Wool length (sheep)	X					33,28	25,21	O			
5.	Conditioned to handling *(goats)*	*X*							O			
6.	Animal health status	X	X	X	X	X						
7.	Body Condition Score (visual)	X		X	X		16,11	10,7	D			
8.	Live weight	X				X	24,21	21,14				
9.	Disease			X	X		3,5	2,5	C	+		
10.	Parasites			X	X		8,17	9,13	C			
11.	Infection			X	X		5,10	7,12	C			
12.	Rejection criteria									+		
13.	Injury/wounds	X	X	X	X	X	1,3	3,2	D	+		
14.	Lameness	X	X	X	X	X	6,7	6,6	D	+		
15.	Inability to stand	X	X	X	X	X	2,1	4,3	D	+		
16.	Pregnancy status & weaning	X				X			O	+		
17.	Fitness to travel		X		X	X			T	+		
18.	Mortality (number of deaths)		X	X	X	X	7,6	5,4	D	+		
19.	Faeces structure			X	X		20,24	16,18	D			
20.	Animal behaviour		X	X	X	X	12,18	14,17	D			
21.	Respiration (Panting Score)			X	X	X	21,27	22,27	D	✱	✱	
22.	Coughing			X	X		19,22	23,22	D			
23.	Sneezing			X	X		31,26	33,29	D			
24.	Nasal discharge			X	X		17,19	18,19	D			
25.	Vocalisation						23,23	26,25				
26.	Slipping/falling when moved	X	X	X	X	X	-	-	T	✱	✱	
	Environment-based measures											
27.	Design & maintenance of facilities		X	X	X	X			O			
28.	Ventilation				X	X	4,4	1,1	O	✱		
29.	Air quality				X	X	10,13	11,15	D	✱		
30.	Shade			X	X		9,2	12,10	O	+	+	
31.	Shelter from weather			X	X		11,8	13,9	O	+	+	
32.	Air temperature				X	X	13,9	15,11	D	✱		
33.	Humidity				X	X	18,12	19,16	D	✱		
34.	Daily amount of light			X	X		25,16	28,23	O			
35.	Noise			X	X	X	27,20	27,26	D			
36.	Bedding (access and freshness)				X				D			
37.	Feed & water supply (type, amount)		X	X	X				D			
38.	Feed consumption				X				C	+		
39.	Weather				X		22,14	20,20	D			
40.	Management in keeping with weather	X	X	X	X				D	+		
	Management-based measures											
41.	Vendor declaration	X							O	+		
42.	Individual animal identification	X		X		X			O			♯
43.	Agricultural chemical use	X							O			
44.	Veterinary medicine use	X			X	X			C	+		
45.	Journey travel plan and log		X		X	X			O	+		
46.	Feed and water withdrawal		X			X			T	+		
47.	Minimum time at feedlot			X					O	+		
48.	Loading plan, stocking density		X	X	X	X			O	+		
49.	Electric prod use		X						T			

		Relevant situation ('consignment event')					Importance, practicality†			Time to implement (months)		
		On-farm sourcing	Land transport	Feedlot	On ship	Air transport	Gen. Pub.	LEI	Scoring ¥	3-6	6-12	12-24
50.	Use of a dog		X						T			
51.	Compliance with external regulations			X	X	X			C	+		
52.	Biosecurity		X	X	X	X			C	+		
53.	Personnel (including a vet) available			X	X				O			
54.	Inspection & reporting procedures				X	X			O	+		
55.	Risk/emergency management plans				X	X			O			
56.	Veterinary equipment available				X				O			

† Ranking by the surveyed general public and LEI workers in terms of importance, practicality. Factors that were surveyed but are not included here due to low ranking in terms of importance or practicality are physiological status, pain, body temperature, stress hormones, heart rate, rumination, meat quality and smell (environmental). Blank: surveys did not include this question.

¥ Scoring can be carried out on a group-based (pen ID for tracking) system using a brief scoring sheet that can be set up on a smart phone or tablet app and accumulated data fed directly into a database: O once for the group, T in transit (i.e. during loading/unloading), D daily (Table 3), or C cumulative over the whole consignment event.

✳ Monitoring and recording can commence immediately in order to collect data to help determine thresholds and management strategies, which can be implemented in 6-12 or 12-24 months.

+ A version of this measure is already being carried out under current practice; monitoring and recording can commence immediately (3-6 months), or within 6-12 months if infrastructure is required.

♯ Individual identification only currently required for cattle. Identification for sheep and goats should be required to trace animals from farm to slaughter to gain a better understanding of an individual's welfare journey.

Table 3 Example Daily Scoring assessment sheet

PEN ID | Date/time: | Assessor:

Species: *Circle one* Sheep Cattle Goat Breed:

Location: *Circle most appropriate* On-farm In transit Feedlot On ship Air transport

Details: *e.g. deck (truck/ship), pen*

Mortality *Number of animals dead* | Comments:

Environmental measures

Wet bulb temperature:	Bedding temperature:
CO2 concentration:	NH3 concentration:

Noise: Quiet Medium Noisy

Air quality: Poor OK Good

Amount of shelter available (shade / protection from wind / access to bedding) — None of the pen 0% | Whole pen 100%

Amount of feed and water accessible — None of the pen 0% | Whole pen 100%

Health

Indicate on the scale (X) the percentage of animals exhibit the following signs:

	none of them 0%	all of them 100%
Coughing		
Sneezing		
Nasal discharge		
Unable to stand		
Isolated and depressed		
Bright, alert and responsive		
Eating		
Drinking		
Ruminating		
Resting		
Wounds/lesions		
Lame		
Gut empty		
Vocalising		

Panting score: *Circle most appropriate* 0 1 2 3 4

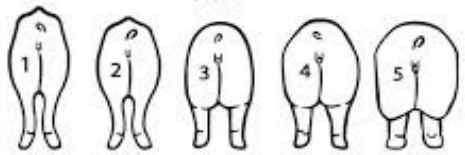
Comments:

	0	1	2	3	4
Breathing	*Not visible*	*Visible flank movements*	*Visible, elevated*		
Mouth:	*Closed*	*Closed*	*Closed*	*Open sometimes*	*Open continuously, tongue out*
Drooling:			*Some*	*Heavy*	
Head/neck:				*Neck extended*	*Head dropped*

Faecal structure: *Circle most appropriate* 1 2 3

1 *normal* — 3 *loose and watery*

Body condition score 1 — 5



Indicate average (A), minimum(M) and maximum(X) on the scale

Behaviour – *indicate on the line how the animals appear to you:*

Agitated	Calm
Inactive	Active
Lethargic	Responsive
Alert	Relaxed

Table 4 Example scoring assessment sheet for once-off group data that will contribute towards cumulative data collection for the consignment

PEN ID	Date/time:			Assessor:	
Species: *Circle one*	Sheep	Cattle	Goat	Breed:	
Location: *Circle most appropriate*	On-farm	In transit	Feedlot	On ship	Air transport
Details:	*e.g. deck (truck/ship), pen*		Number in group:		
Details of animals	Vaccination status			Conditioned to handling	
	Horn status/length			Pregnancy status & weaning	
	Wool length (sheep)				
Consignment source	Was a Vendor Declaration lodged?	☑	Loading/unloading	How long were feed and water withdrawn for this group?	
	Was on farm chemical use declared?	☑		Was an electric prod used for loading?	Y/N
	Were individual animals identified (i.e. NSID tags)?	☑		Was a dog used for loading?	Y/N
Design & maintenance of facilities	Old OK Good			Fitness to travel – how many animals were removed	
Is there appropriate	Ventilation	Y/N		Number of animals slipping/falling when moving animals	
	Shade	Y/N		Total number of animals observed	
	Shelter from weather	Y/N	For this consignment, has there been any evidence of	Disease *details*	Y/N
	Daily amount of light (average hours)				
Journey	Was a Journey Travel Plan lodged?	☑			
	Was a Loading Plan lodged?	☑			
	What was the maximum time at feedlot?			Parasites *details*	Y/N
	Was stocking density considered appropriate?	Y/N			
	Were Inspection & reporting procedures approved?	Y/N		Infection *details*	Y/N
	Were Risk/emergency management plans lodged?	Y/N			
	Was appropriate personnel (including a vet) available?	Y/N		Was veterinary treatment required? *details*	Y/N
	Was veterinary equipment available?	Y/N			

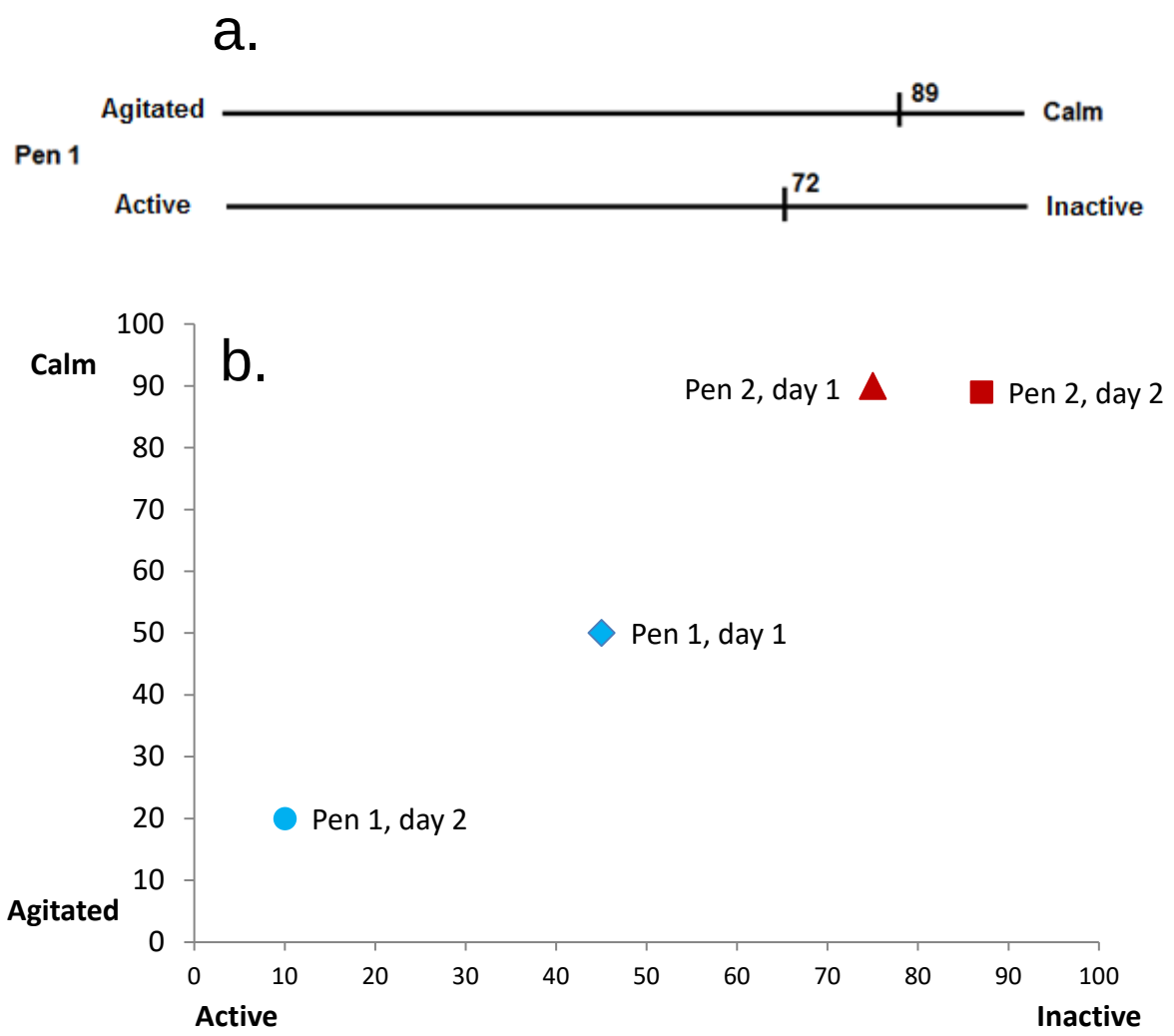


Figure 1. (a) Numerical values assigned to scores for two pens on the visual analogue scale and (b) how these assessments might appear comparing different pens on-board ship, or at a feedlot over two consecutive days. Animals in pen 1 have become more agitated and active over time, whilst animals in pen 2 have become more relaxed (with similar levels of calmness) over time.

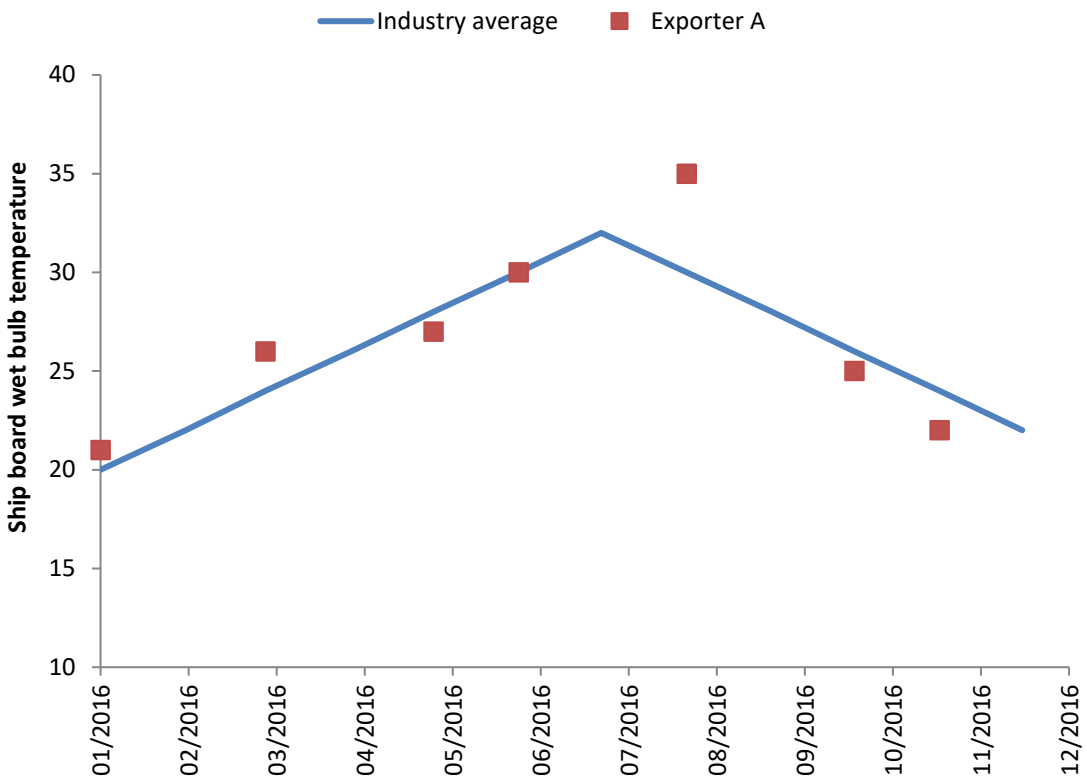


Figure 2. Example of individual stakeholder compared to industry average of maximum wet bulb temperature on-board ship.

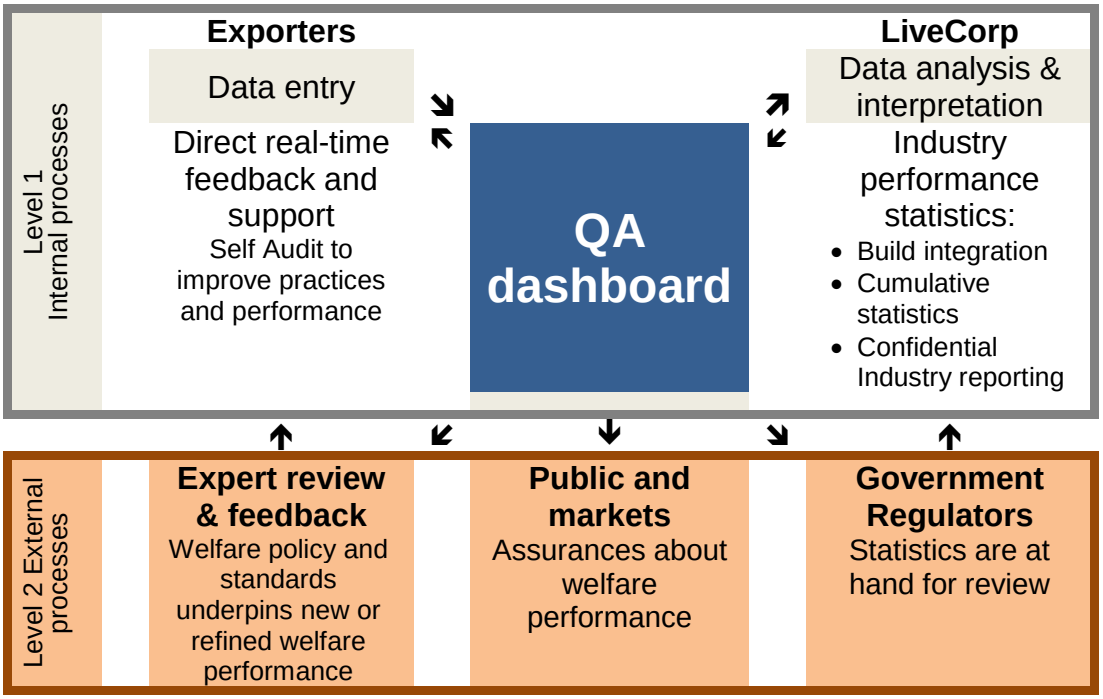


Figure 3. Overview of the QA dashboard, showing tiers of communication between internal and external stakeholders.

9 Appendix 4 - Detailed description of background relevant to each benchmarking welfare measure

9.1 Animal based measures

Mortality

Mortality is currently reported to the Department of Agriculture, Forestry and Fisheries (DAFF) on-board ship daily, and at the end of the voyage for both sea and air. Thresholds for mortality are stated in ASEL (sheep and goats 2%; cattle on voyages less than 10 days 0.5%; cattle on voyages more than 10 days 1%). After each voyage, mortality rate is calculated by DAFF, and if thresholds are exceeded, an investigation into the cause occurs. This results in a retrospective analysis of causes. ASEL also defines thresholds for investigation by a veterinarian of mortality at registered premises (sheep and goats 0.25%; cattle 0.1%, on any given day), and these standards require that daily monitoring must occur. However, these records are kept by the registered premises and are not regularly monitored by regulators.

Measuring mortality has no impact on the animals, and can be performed during routine monitoring and has little economic impact. Mortality should be assessed at all points along the LEI supply chain (i.e. truck, feedlots, on-board ship/plane), and reported to DAFF, as well as the person in charge of the animals at their location (i.e. manager, head stockperson, veterinarian). Mortality should be reported daily for animals housed at pre-embarkation and destination feedlots and on-board ship, and at the end of truck and plane transport. This data can then be analysed daily and feedback given to the industry, who can then use this information to formulate management strategies to immediately deal with any upcoming welfare issues, or to change management of future animals.

Health and morbidity

Livestock are currently assessed for health issues from sourcing to slaughter. Health status is an important measure in the LEI, and rejection criteria are based on the health status of the animal and whether the animals comply with the relevant import permit. Additionally, health status is important for the welfare of the animal during the live export process. ASEL states that animals should be monitored daily (at feedlots), day and night (on-board ship) and before and after transport (land, sea and air), and that any animal identified as being sick or injured should be given immediate attention and treatment. However, whilst ASEL lists signs of diseases to be monitored, such as lameness or nasal discharge, there are no defined criteria on how to measure these signs, nor are there defined thresholds across the LEI supply chain. Further work is required to address the lack of criteria and thresholds.

Seven broad syndromes have been identified as important and relevant to the LEI; respiratory disease, gastrointestinal problems, trauma/accident/injury, musculoskeletal/neuromuscular problems, external parasites, scabby mouth, and pink eye. The least invasive and initial indicators of these syndromes are visual evaluation of clinical signs. Further diagnostic work may be required in developing a management plan.

1. Respiratory disease. Indicators of respiratory disease include coughing, sneezing, nasal discharge, body posture (head position, hunched, down/ability to stand),

mobility/gait, and behaviour (e.g. isolated and depressed, or bright, alert, and responsive).

2. Gastrointestinal system. Indicators of gut problems include faecal structure, measures of feed and water intake, rumination, gut fill, body posture, mobility/gait, and behaviour.

3. Trauma/accident/injury. Indicators of trauma/accident/injury include lameness, wounds, lesions, discharge, foreign body, abnormal horn growth, body posture, mobility/gait, and behaviour.

4. Musculoskeletal/neuromuscular problems. Indicators of musculoskeletal/neuromuscular issues are abnormal body swellings, lameness, body posture, mobility/gait, abnormal position of body parts (e.g. head tilt), abnormal behaviour (e.g. aggressive/violent).

5. Scabby mouth. Early indicators of scabby mouth include reddening of the skin around the muzzle, followed by the development of blisters which develop into pustules.

6. Pink eye. Early indicators of pink eye include tearing, redness and squinting, followed by marked tearing, closed eye, cloudy cornea, and sometimes a central ulcer.

It is proposed that current monitoring regimes as per ASEL continue; however, monitoring of scabby mouth and pink eye should only be done at pre-embarkation feedlots, due to increased animal welfare risks if the ship is denied docking at the export country. Observing animals for these syndromes can be done from outside of a pen, or by walking through pen, with little impact on the welfare of the animals, and can be performed during routine inspection.

Determining thresholds and management strategies for health issues is complicated, and may take longer to establish (12-24 months). We propose that a risk assessment of these syndromes be undertaken to determine appropriate management strategies. For example, a broken leg has high welfare risk for an individual animal but a low transmission risk for other animals; by contrast, pneumonia may initially have a low welfare risk but is highly transmissible. Further work is required, in consultation with stakeholders, to determine appropriate thresholds for health and morbidity, and management strategies to deal with any issues.

Behaviour

While behaviour is not officially recorded for animals during the LEI, it is the basis of many observations made my stockpersons and veterinarians. The benefits of behavioural assessment is that is it quick, cheap (limited resources needed), non-invasive to the animal (low welfare risk to the animal), immediate and can be performed by any person on individual animals or groups of animals. Advantages of using animal-based measure, such as behaviour, as opposed to resource-based measures is that they reflect how the animal is coping, and they do not rely heavily on farmer involvement nor impinge on farm management practices.

A set of animal-based indicators assessed by observation including demeanour, response to stimulation, standing ability, posture and eye condition has been used to detect welfare conditions, such as lameness and thin body condition in young lambs (Phythian et al., 2013; Fleming et al., 2016). It is proposed that the assessor (stockperson, vet, or other) at any livestock collection point can be given terms that are used to describe the behaviour the animals (standing ability, posture, active) and the animals' demeanour (*calm*, *agitated*). It is recommended that stakeholders determine which terms to use in each section of the LEI. The assessor observes the animal(s) for 30 seconds to 2 minutes and scores the animal, or group of animals, on a visual analogue scale (Figure 1a; Table 3). These scores are then graphed to provide a visual representation of the demeanour of those animals (Figure 1b). This assessment can be done at any point along the LEI supply chain, providing the assessor is able to observe the animals.

Behavioural assessment is a comparison tool, and a single measure does not provide a welfare measure for the animal, or group of animals. The scale used to measure the behavioural expression is arbitrary, and therefore any value obtained on any single measure does not determine the actual behavioural expression of the animal/s, but rather how they compared to a previous time point, or to another animal/group of animals. Therefore, no thresholds for this measure can be developed. However, movement of animals from a positive to a negative demeanour should be investigated to determine a cause. Management strategies should then be implemented to try to reverse the negative change in behavioural expression.

It is proposed that behaviour is assessed daily, and on a pen basis at pre-embarkation and destination feedlots and on-board ship. It is difficult to practically assess behaviour during truck and plane transport; however, assessments could be made before and after transport. Assessments are be made from outside the pen, with minimal disturbance to the animals, as is currently carried out under the Gunson Inspection Method (Jubb and Perkins, 2015).

Feed consumption

Average feed consumption per head is currently calculated and submitted to DAFF in daily (on long haul) and end of voyage reports on-board ship. However, this data is not used to supply information back to the ship to identify potential problems, trends in feeding behaviour, or to supply information for research. Adequate feed and water avoids hunger and thirst, and is essential for animals to maintain or gain condition. Additionally, illness, injury or poor mental demeanour can result in changes to feed intake. A reduction in feed intake is often the first sign of a problem in ruminants.

Indicators of appetite depression may include whether animals are seen to be eating from the feed troughs, active rumination, the amount of residual feed after a certain period of time, gut fill (whether the gut looks full or empty), and a visual body condition score (BCS). It is proposed that these indicators of appetite depression be assessed daily at pre-embarkation and destination feedlots and on-board ship if automatic feeders are used, or before feed is given if animals are fed by hand. Feed intake, gut fill, rumination and BCS will vary between animals and therefore thresholds would be difficult to determine. It is proposed that changes in these measures across time points would be more effective for monitoring than establishing thresholds, and the changes used to identify potential issues.

Respiratory character/panting score

Respiration rate is a good indicator of heat stress in ruminants as it reflects an animal's response to the climate (Gaughan et al., 2008). Respiratory character is currently assessed on-board ship at a pen and deck level, as 'normal', 'panting', or 'gasping' and is usually the first visible response during hot conditions, and can be assessed without interfering with the animal and impacting on its welfare. Respiratory character can be assessed by any personnel that are familiar with observing animals. Meat and Livestock Australia has published a comprehensive guide to measure panting score and has defined thresholds for domestic feedlot cattle (MLA, 2006). We recommend development of a similar scoring system for sheep and goats, and establishment of thresholds and management strategies for all species.

Panting score can be assessed at multiple points to indicate animal response over time. We propose that respiratory character/panting score be assessed at feedlots (pre-embarkation and destination) and on-board ship early in the morning (when animals should be coolest) and late afternoon (when animals are hottest). Some training will be required to use the established scoring system. It is necessary not to disturb the animals in assessing panting score. Respiratory character is very difficult to assess during truck and air transport, but could be evaluated before and after transport to inform management decisions.

9.2 Environmental measures

Ventilation and air quality

Ventilation and air quality are important for sea and air transport, as their failure can result in mortalities. Both the surveyed public and LEI workers rated ventilation as one of the most important welfare indicators. Under ASEL, ventilation should be recorded on-board ship and during air transport.

To ensure adequate ventilation, it is important that the ship/plane is able to remove excess heat, water vapour, microorganisms, dust, gases, provide a uniform distribution of air, and provide the correct air speed for stock. Ventilation is normally measured by the volumetric airflow being introduced to the area. This airflow should be monitored by the mechanical ventilation on-vessels, but can also be measured using hand held devices.

In addition to the airflow, there are a number of other factors that can be monitored to determine whether the ventilation system is exchanging the air as per the Australian Maritime Safety Authority (AMSA) MO43 regulations (Australian Maritime Safety Authority, 2006). These are wet bulb temperature, CO_2 and NH_3 concentrations, and ship structure (design of ship for air flow) and bedding temperatures (MLA, 2001). Oxygen levels are also useful in determining adequate ventilation. All of these can be measured using hand held devices.

Measuring environmental indicators has little welfare cost to the animals, and once equipment is purchased, has little economic impact. It is proposed that ventilation be monitored twice daily on-board ship, and continuously on-board aircraft via remote sensing systems. On-board ship, airflow, wet bulb temperature, O_2, CO_2 and NH_3 concentrations, and ship structure and bedding temperatures could be measured at animal head height on each deck, at the bow, stern and amidships.

Thresholds for airflow are stated in AMSA MO43, and there is a heat stress threshold for wet bulb temperature. However, there are no thresholds set for O_2, CO_2 and NH_3 concentrations, and ship structure and bedding temperatures. As a guide, SafeWork Australia has defined safe thresholds for human exposure to airborne contaminants (Safe Work Australia, 2011). It is proposed that thresholds and management strategies for O_2, CO_2 and NH_3 concentrations, and ship structure and bedding temperatures be developed for on-board ship and plane.

Temperature and humidity

Temperature and humidity during sea and air transport form part of the ventilation measures as wet bulb temperature. Currently, exporters are required to complete a Heat Stress Risk Assessment (HSRA), before transporting animals by sea, to assess the risk of mortality due to heat stress, and allow them to formulate a management plan, reviewed by MLA, 2008.

In feedlots, wet bulb globe temperature (which incorporates dry bulb temperature, relative humidity, wind speed and visible and infrared radiation) should be used along with Bureau of Meteorology (BOM) predication data (including sheep weather alerts, and cattle heat forecasts) to pre-empt any extremely hot or cold days, allow the feedlot time to prepare and implement measures to either help cool the animals or shelter them from critically cold weather.

Wet blub globe temperature should be recorded twice daily, around sunrise and during the hottest part of the day. These data could be used to identify, predict and mitigate periods of high risk, or to further develop strategies (e.g. increasing amount of shade available) to combat high heat loads to improve the welfare of animals.

Shade and shelter

Shade and shelter are important for the welfare of animals, especially during times of extreme heat and cold. Both of these indicators were highly important for the surveyed public and LEI workers. All of the animal cruelty legislation in Australia states that animals should be provided with adequate or reasonably necessary shelter.

Shelter can be provided by trees, scrub, walls, or solid panels fixed to fences, and should still be well ventilated. However, there are no guidelines as to how much shade and shelter should be provided on any given day. It is proposed that a reasonable expectation is that at least 50% of the animals can access shade and shelter at any given time, and that on extremely hot and cold days, enough shade and shelter should be provided for all animals.

The wet bulb globe temperature and BOM predicative data could be used to determine when additional shade and shelter should be provided. For example, if the wet bulb globe temperature reaches 30 or above, shade should be provided for all animals housed outdoors. If weather alerts are issued, shelter should be provided for all animals, or if practical, the animals should be relocated to sheds.

Additionally, once thresholds have been established, panting score and mortality could indicate the need for increased shade and shelter.

The reporting of the provision of shade and shelter would be done by compliance.

Welfare Indicators

Hello and welcome

Page description:

Unique ID **Action: Hidden Value**
Value: [survey("counter"), startat="WI01"],

ID 270

Hello,
I am an independent researcher at Murdoch University in Perth, Western Australia, and I am undertaking a research project, funded by Meat and Livestock Australia, to develop key animal welfare measures for the livestock export industry, that:

- are informative about an animals' welfare
- are important to stakeholders (you)
- are practical for assessing livestock (sheep, cattle and goats) throughout the live export supply chain
- are economical, and
- are measurable and quantifiable

We want to know what you think about animal welfare in the live export industry, and what you want.
You have been sent this survey because you either work within the live export industry, or you have an interest in the industry, in particular animal welfare within the industry.

This survey will take approximately 30 minutes to complete.
You can save your progress and continue at a later stage by clicking 'save and continue' at the top of the screen at any point. Please remember to come back and complete the survey because your participation is important to us.

If you are uncomfortable completing the survey online, we can arrange for you to complete the survey by telephone.

We appreciate your time to complete this survey, and ask that you complete the whole survey as accurately and honestly as possible.
Information collected from this survey will be analysed and used to recommend welfare measures to Meat and Livestock Australia and the livestock export industry.
Your privacy is very important to us. Your participation in this study and any information will be treated in a confidential manner.

This study has been approved by the Murdoch University Human Research Ethics Committee (Approval 2015/013). If you have any reservation or complaint about the ethical conduct of this research, and wish to talk with an independent person, you may contact Murdoch University's Research Ethics Office (Tel. 08 9360 6677 (for overseas studies, +61 8 9360 6677) or e-mail ethics@murdoch.edu.au). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

If you have any questions at any time during the completion of this survey, or would like to receive a copy of the results once the study is complete (estimated completion time January 2016) please send me an email at AWResearch@murdoch.edu.au
Results will also be available on our facebook page https://www.facebook.com/animalwelfareresearch at the completion of the study.

There are comment boxes throughout the survey, if you wish to leave comments as you go.

Thank you

ID 756

1. **CONSENT**

1. I agree voluntarily to take part in this study.
2. I have read the Information Sheet provided and been given a full explanation of the purpose of this study, the procedures involved and of what is expected of me.
3. I understand that I will be asked to complete a survey
4. The researcher has answered all my questions and has explained possible problems that may arise as a result of my participation in this study.
5. I understand I am free to withdraw from the study at any time without needing to give any reason.
6. I understand I will not be identified in any publication arising out of this study.
7. I understand that my name and identity will be not be collected.
8. I understand that all information provided by me is treated as confidential and will not be released by the researcher to a third party unless required to do so by law.

Do you consent to participate in this survey? *

- Yes, I consent to participate in this survey

Demographics

Page description:

ID 271

The questions in this section all relate to your background.
All information collected is kept confidential and will not be released to any third party.

ID 3

2. What is your gender?

- Male
- Female

ID 4

3. What age category are you?

- 18-21
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- >71

ID 390

4. Where were you born?

- Australia
- New Zealand / South Pacific
- Middle East
- Europe
- Asia
- Africa
- North America
- South America
- Other

*

LOGIC Show/hide trigger exists.

ID 391

5. Where are you currently based for work?
If you are not currently working, please select the location of your last employment.

- Australia
- New Zealand / South Pacific
- Middle East
- Europe
- Asia
- Africa
- North America
- South America
- Other

*

LOGIC Hidden unless: Question "Where are you currently based for work?
If you are not currently working, please select the location of your last employment." #5 is one of the following answers ("Australia")

ID 392

6. In which State or Territory are you based for work?

- WA
- SA
- NSW
- QLD
- NT
- TAS
- ACT
- VIC

ID 96

7. Where have you lived most of your life?

- Rural / countryside only
- City/town only
- Mainly rural / countryside, some city/town
- Mainly city/town, some rural / countryside

ID 21

8. What is your highest level of education?

- Did not complete high school
- Graduated high school or equivalent
- Post-secondary school qualification (e.g. diploma)
- Undergraduate degree
- Post-graduate degree (e.g. Masters, PhD)

VALIDATION Min = 0 Max = 100

ID 496

9. Rate how important animals are to you in the following roles

	Not important	Important
As food		
As clothing		
As a companion		
For working		
For entertainment (i.e. racing)		
For performance (i.e. circus)		
As a religious symbol		

Comments

Stakeholder group

Page description:

ID 272

This section is to determine your connection with the livestock export industry

LOGIC Show/hide trigger exists.

ID 66

10. Do you work with the live export industry (i.e. employed, supply, inspect, research)? *

- Yes
- No

LOGIC Show/hide trigger exists. Hidden unless: Question "Do you work with the live export industry (i.e. employed, supply, inspect, research)?" #10 is one of the following answers ("Yes")

ID 519

11. In which area of the livestock export industry to you work most?

- Producer / supplier
- Transport (truck, ship, aeroplane)
- Export
- Abattoir
- Inspection / research

LOGIC Hidden unless: Question "In which area of the livestock export industry to you work most?" #11 is one of the following answers ("Transport (truck, ship, aeroplane)")

ID 521

12. In which transport areas do you work?

- [ ] Truck company owner / driver
- [ ] Ship owner / Captain
- [ ] Aeroplane owner / pilot
- [ ] Stockperson (ship)
- [ ] Airport freight
- [ ] At the sea port
- [ ] Administration

LOGIC Hidden unless: Question "In which area of the livestock export industry to you work most?" #11 is one of the following answers ("Export")

ID 525

13. In which export areas do you work?

- [ ] Stockperson at a feedlot
- [ ] Pre-export assembly depot manager
- [ ] Exporter
- [ ] Administration / management

LOGIC Hidden unless: Question "In which area of the livestock export industry to you work most?" #11 is one of the following answers ("Inspection / research")

ID 524

14. In which areas do you inspect / research?

- [ ] Truck transport
- [ ] Feedlot (in Australia)
- [ ] Sea or air port (In Australia)
- [ ] On-board ship
- [ ] On-board aeroplane
- [ ] Feedlot (not in Australia)
- [ ] Abattoir (not in Australia)

(untitled)

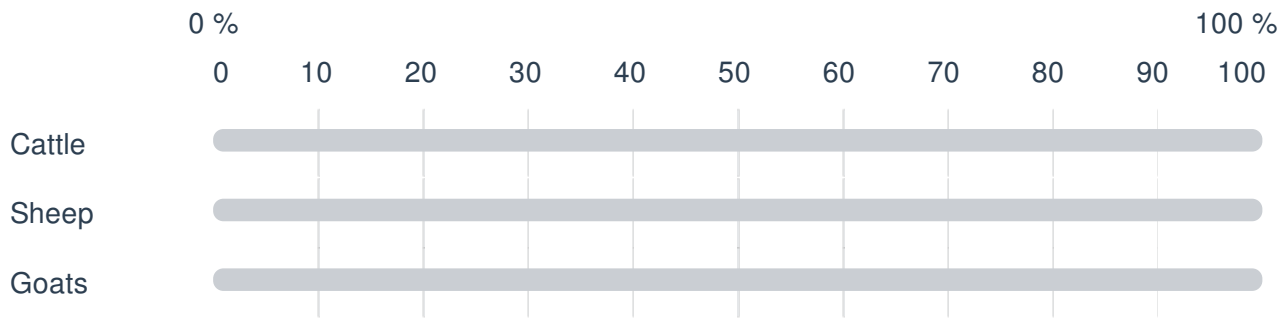
Page entry logic:
This page will show when: Question "Do you work with the live export industry (i.e. employed, supply, inspect, research)?" #10 is one of the following answers ("Yes")

Page description:

VALIDATION Min = 0 Max = 100

ID 17

15. What percentage of your work is associated with each of the following species? e.g. cattle: 50%, sheep: 40%, goats: 10%.



Comments

LOGIC Show/hide trigger exists.

ID 601

16. Have you ever visited the following? Tick all that apply.

- [ ] Feedlot
- [ ] A live export ship or the port
- [ ] An aircraft carrying livestock
- [ ] Abattoir
- [ ] None of the above

ID 602

17. How many times have you visited each of the following locations?

	Cattle	Sheep	Goats

Comments

ID 685

17. On average, how often do you see livestock being transported by truck?

Cattle	Daily Once a week Once a fortnight Once a month Once every 6 months
Sheep	Daily Once a week Once a fortnight Once a month Once every 6 months
Goats	Daily Once a week Once a fortnight Once a month Once every 6 months

Comments

Experience

Page entry logic:
This page will show when: Question "Do you work with the live export industry (i.e. employed, supply, inspect, research)?" #10 is one of the following answers ("No")

Page description:

ID 72

19. What is your interest in the live export industry?
Please select all that apply

- [ ] Relative/friend works in the live export industry
- [ ] Concern for animals
- [ ] Animal welfare advocate
- [ ] Researcher/scientist
- [ ] Journalist/writer/media
- [ ] Don't care about it
- [ ] Other

LOGIC Show/hide trigger exists.

ID 615

20. Have you ever visited or seen the following? Tick all that apply.

- [ ] Livestock being transported by truck
- [ ] Feedlot
- [ ] A live export ship or the port
- [ ] An aircraft carrying livestock
- [ ] Abattoir
- [ ] None of the above

ID 616

21. How many times have you visited each of the following locations?

	Cattle	Sheep	Goats

Comments

ID 699

21. On average, how often do you see livestock being transported by truck?

Cattle	Daily Once a week Once a fortnight Once a month Once every 6 months
Sheep	Daily Once a week Once a fortnight Once a month Once every 6 months
Goats	Daily Once a week Once a fortnight Once a month Once every 6 months

Comments

Opinions

Page description:

ID 299

This section addresses what you think about animal welfare in the livestock export industry.

ID 117

23. What is your source of knowledge of the livestock export industry?

- [ ] Journalism media (print, television, internet)
- [ ] Social media (Facebook, Twitter etc...)
- [ ] Personal experience
- [ ] Chatting to friends
- [ ] Scientific journals
- [ ] Other

ID 765

24. What is your opinion of the livestock export industry as it is today?
Please indicate for each species

	Continue as is	Continue with improvements	Should stop	Undecided
Cattle	○	○	○	○
Sheep	○	○	○	○
Goats	○	○	○	○

Comments

ID 503

25. Do you have concerns about the welfare of animals during the livestock export process?

	Cattle	Sheep	Goats
During truck transport not in Australia	Sometimes Frequently Always	Sometimes Frequently Always	Sometimes Frequently Always
At the feedlot in Australia	Sometimes Frequently Always	Sometimes Frequently Always	Sometimes Frequently Always
During loading/unloading at the port (sea)	Sometimes Frequently Always	Sometimes Frequently Always	Sometimes Frequently Always
On-board ship during a voyage	Sometimes Frequently Always	Sometimes Frequently Always	Sometimes Frequently Always
On-board aeroplane during a flight	Sometimes Frequently Always	Sometimes Frequently Always	Sometimes Frequently Always
At the feedlot not in Australia	Sometimes Frequently Always	Sometimes Frequently Always	Sometimes Frequently Always
During slaughter (not in Australia)	Sometimes Frequently Always	Sometimes Frequently Always	Sometimes Frequently Always

Comments

(untitled)

ID 481

Now we are going to give you some examples of animal welfare measures and ask your opinions on them.

ID 705

26. Which of the following indicators do you think are important when assessing animal welfare?

Description of welfare indictors
*Behaviour means how an animal is expressing itself, or refers to what an animal is doing
**Body condition score refers to how much fat is on an animal, whereas body weight encompasses the whole animal
***Respiration rate and character refers to how quickly and how easily an animal is breathing
****Rumination rate refers to how quickly food moves through the digestive system

	Do you think it is important to measure?			Do you think it is practical to measure?		
	Yes	No	Don't know	Yes	No	Don't know
Behaviour	○	○	○	○	○	○
Body condition score	○	○	○	○	○	○
Body temperature	○	○	○	○	○	○
Body weight	○	○	○	○	○	○
Death	○	○	○	○	○	○
Disease / health	○	○	○	○	○	○
Heart rate	○	○	○	○	○	○
Physiological status (i.e. pregnant / lactating)	○	○	○	○	○	○
Rumination rate	○	○	○	○	○	○
Respiration rate and character	○	○	○	○	○	○
Stress hormones	○	○	○	○	○	○
Wool length	○	○	○	○	○	○
Meat quality	○	○	○	○	○	○

Comments

(untitled)

ID 742

27. Which of the following **health** measures do you think are important when assessing animal welfare?

	Do you think it is important to measure?			Do you think it is practical to measure?		
	Yes	No	Don't know	Yes	No	Don't know
Presence of disease	○	○	○	○	○	○
Parasites	○	○	○	○	○	○
Infection	○	○	○	○	○	○
Injury/wounds	○	○	○	○	○	○
Lameness	○	○	○	○	○	○
Pain	○	○	○	○	○	○
Sneezing	○	○	○	○	○	○
Coughing	○	○	○	○	○	○
Nasal discharge	○	○	○	○	○	○
Faeces structure	○	○	○	○	○	○
Inability to stand	○	○	○	○	○	○
Vocalisations	○	○	○	○	○	○

Comments

(untitled)

ID 748

28. Which of the following **environmental** measures do you think are important when assessing animal welfare?

	Do you think it is important to measure?			Do you think it is practical to measure?		
	Yes	No	Don't know	Yes	No	Don't know
Smell	○	○	○	○	○	○
Amount of ventilation	○	○	○	○	○	○
Air quality	○	○	○	○	○	○
Amount of shade	○	○	○	○	○	○
Amount of shelter from weather	○	○	○	○	○	○
Humidity	○	○	○	○	○	○
Air temperature	○	○	○	○	○	○
Daily amount of light	○	○	○	○	○	○
Noise	○	○	○	○	○	○
Weather	○	○	○	○	○	○

Comments

(untitled)

VALIDATION Min = 0 Max = 100

ID 733

29. How important is the time an animal spends at any one point along the live export chain?

	Not important	Important
During truck transport		
On-board a truck waiting to unload		
On-board ship docked at port		
On-board ship during a voyage		
On-board an aircraft during a flight		
At a feedlot in Australia		
At a feedlot not in Australia		

Comments

(untitled)

VALIDATION Min = 0 Max = 100

ID 666

30. How important do you think the following factors are for the welfare of livestock in the live export industry?

	Not important	Important
Vaccination status of the animal		
Access to a vet		
Design of facilities		
Cleanliness of facilities		
Competency of		

stockperson

Attitude of stockpersons

Animals can be traced from farm to slaughter

Suitability of species to the environment

Keeping animals in familiar social groups together

Animals with horns housed with animals without horns

Amount of space the animals have

Access to bedding

Use of an electric prod

Use of a working dog

Type of food available

Feed quality

Water quality

Temperature of drinking water

Amount of trough space

Identifying animals that don't eat

Time off feed

Time off water

Transport conditions

Truck driver

behaviour

Appropriate restraint during slaughter

Effective slaughter procedures

Comments

(untitled)

ID 752

31. What do you think measuring animal welfare should be used for?
Tick all that apply.

- [ ] The industry to self regulate
- [ ] The government to regulate the industry
- [ ] To impose penalties and restrictions for poor welfare
- [ ] To award incentives for good welfare
- [ ] Highlight areas for research
- [ ] Highlight areas for investment in welfare improvement
- [ ] Provide measures of performance to the general public
- [ ] Not used for any reason
- [ ] Other

*

ID 753

32. Who do you think should be monitoring and measuring animal welfare?
Tick all that apply.

- [ ] Stockpersons
- [ ] Veterinarians that work for the live export industry
- [ ] Veterinarians that work for the Australian government
- [ ] Veterinarians that work for an overseas government
- [ ] Animal welfare inspectors
- [ ] Independent welfare inspectors
- [ ] Exporters
- [ ] Abattoir animal welfare officers
- [ ] Other

*

ID 754

33. Do you think that data collected on animal welfare should:

- ○ be confidential to the industry and government only
- ○ be available to the public

(untitled)

Page description:

LOGIC Show/hide trigger exists.
ID 680

34. Are there any other animal welfare measures that we have not mentioned that you think are important?

- ○ Yes
- ○ No

LOGIC Hidden unless: Question "Are there any other animal welfare measures that we have not mentioned that you think are important?" #34 is one of the following answers ("Yes")
ID 435

35. List any animal welfare indicators that we have not mentioned that you think are important? Please list them in order of importance, with the indicator you think is most important as #1.

	Animal welfare indicator	Do you think it is practical to measure?	
		Yes	No
1		○	○
2		○	○
3		○	○
4		○	○
5		○	○
6		○	○
7		○	○
8		○	○
9		○	○
10		○	○

ID 769

Please press the submit button at the bottom of this page

Thank You!

ID 1

Thank you for taking our survey. Your response is very important to us.

Results of this survey will be used to recommend appropriate animal welfare measures to the livestock export industry.

If you have any questions or comments, you can email me at AWResearch@murdoch.edu.au

If you would like to recieve a copy of the results once the study is complete (estimated completion time January 2016) please send me an email at AWResearch@murdoch.edu.au
Results will also be available on our facebook page https://www.facebook.com/animalwelfareresearch at the completion of the study.

Final Report

PART B

Project code: W.LIV.3032

Prepared by: Dr Sarah Wickham, Dr Trish Fleming, Dr Teresa Collins, Dr Anne Barnes, Dr David Miller
Murdoch University

Date published: 30 March 2017

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Development and assessment of livestock welfare indicators

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Table of Contents

1 Abstract

1.1 Outcomes of the literature review

We reviewed a total of 54 potential animal welfare measures that address 12 welfare criteria and 4 welfare principles. We identified those measures that would be appropriate for use as part of the live export chain, and categorised these as animal-, environment- and resource-based. We identified 20 specific measures already carried out under current practice that can be expanded upon to form a QA dashboard: a LEI-specific online interface for collecting QA data that will contribute towards benchmarking the industry. We identified another 26 that are relevant to the LEI and that could be developed into a benchmarking system. We identified and dismissed measures that were not appropriate as measures for the LEI due to impracticality.

Some areas where more research is required are noted; for example the development of measures suitable to determine whether animals in the LEI have a positive emotional state. Despite this, we suggest the next step for industry is to pilot the use of the QA dashboard, using the 46 potential measures identified at several points along the supply chain, for both sheep and cattle.

2 Report description

This milestone report includes:

- Literature review (complete). Final review of 54 animal welfare measures relevant to the live export industry. We request permission to submit this manuscript for publication (*Animal Production Science*).

3 Project objectives

Objectives of the project follow the Terms of Reference. These are to:

1. *Identify internationally accepted indicators of animal welfare for sheep, cattle and goats.*
2. *Identify existing measures and indicators of animal welfare for sheep, cattle and goats throughout the Australian livestock export chain.*
3. *Develop key animal welfare indicators that:*
    a. *Are important to stakeholders*
    b. *Are practical for assessing livestock (sheep, cattle and goats) throughout the live export chain*
    c. *Are economical*
    d. *Are measurable and quantifiable*
    e. *Demonstrate industry's commitment to animal welfare.*
4. *Determine a method to benchmark industry's current welfare performance*

4 Success in achieving milestone

As part of this milestone requirement we have achieved the following:

Literature review of welfare measures

> Completed (Attached) – we request permission to submit this manuscript for publication.

Analysis of stakeholder survey

> Under review with LiveCorp – we request permission to submit this manuscript for publication.

Recommended welfare indicators

> Under review with LiveCorp.

5 Conclusions/recommendations

We suggest the next step for industry is to pilot the use of a QA dashboard: a LEI-specific online interface for collecting QA data that will contribute towards benchmarking the industry. This literature review and the survey of stakeholders (general public and LEI workers; Milestone 4) together indicate animal welfare measures that are relevant and practical for the LEI, and are broadly accepted as relevant to the industry. Additionally, we also suggest some areas where more research is yet required; for example the development of measures suitable to determine whether animals in the LEI have a positive emotional state.

6 Review of livestock welfare indicators relevant for the Australian live export industry

Sarah L. Wickham[1], Anne L. Barnes[1], David W. Miller[1], Teresa Collins[1], Nigel Perkins[2], Patricia A. Fleming[1]*

[1] School of Veterinary and Life Sciences, Murdoch University, WA 6150, Australia

[2] AusVet Animal Health Services

*Correspondence: t.fleming@murdoch.edu.au Tel: 08 93606577

Contents

Abstract

Animal welfare is an important issue for the live export industry (LEI), in terms of economic returns, community attitudes and international socio-political relations. Mortality is the main welfare measure currently recorded within the livestock export industry; however mortality is usually acted upon after adverse events and generally does not allow proactive welfare enhancement. We reviewed a total of 54 potential animal welfare measures, identifying those measures that would be appropriate for use as part of the live export chain, and categorised these as animal-, environment- and resource-based. Current LEI welfare assessments are largely focussed around resources provided for animals, and this is likely to remain the basis for licence and accreditation as well as auditing and compliance. However aspirational objectives are more likely to be met through animal- and management-based measures addressing 'good feeding' and 'good housing', while animal-based measurements are required for 'good health' and 'appropriate behaviour'. We identified 20 specific measures already carried out under current practice that can be expanded upon to form a quality assurance (QA) dashboard: a LEI-specific online interface for collecting QA data that will contribute towards benchmarking the industry. We identified another 26 that are relevant to the LEI and that could be developed and integrated into a benchmarking system for the future.

Keywords: physiology, behaviour, quality assurance, welfare indicators, benchmarking.

Introduction

Within the livestock production sector, there is recognition that perceptions of the general community are increasingly determining the social licence to operate, which allows the industry to have ongoing approval and broad acceptance within the local community and other stakeholders. In particular, there has been an increase in concern from the general community for animal welfare in livestock production (Rousing *et al.* 2001; Colditz *et al.* 2014b). These concerns have particularly impacted upon the live export industry (LEI), where there is a divide between community expectation and LEI performance that needs to be addressed. Quantifying and monitoring animal welfare across the entire live export chain is an important step towards quality assurance (QA) as part of the industry, as well as offering greater opportunity for reassurance of the general community.

Currently, the Australian LEI and stakeholders use on-board mortality and non-compliance with the Exporter Supply Chain Assurance System (ESCAS) as indicators of welfare. The heightened public awareness around the industry means that avoiding high mortality situations is a priority. However, a single incidence of high mortality substantially contributes towards negative community attitudes to live export, while the continued efforts made by the industry towards managing animal welfare along the supply chain go unrecognised.

The issue with on-board mortality and non-compliance is that they only indicate problems retrospectively and do not identify areas where conditions could be modified or welfare improved prospectively. Being able to act proactively may potentially avoid negative incidents and provide solutions through pre-emptive modifications and adaptive management. Under current animal welfare reporting, the main welfare issues identified for the LEI are morbidity and mortality (**Fig. 1**), as well as the environmental conditions for the animals (**Fig. 2**), and improvements in these areas are not identified nor addressed under the current welfare assessment actions.

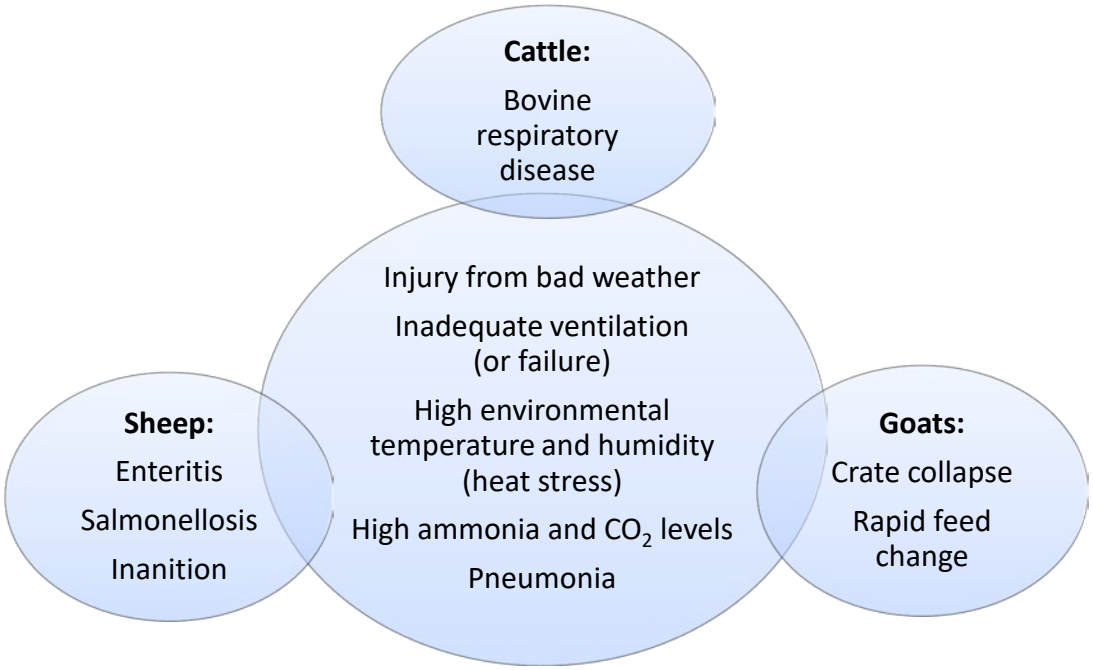


Figure 1. Main causes of mortality for livestock during sea and air transport (DAFF 2014b).

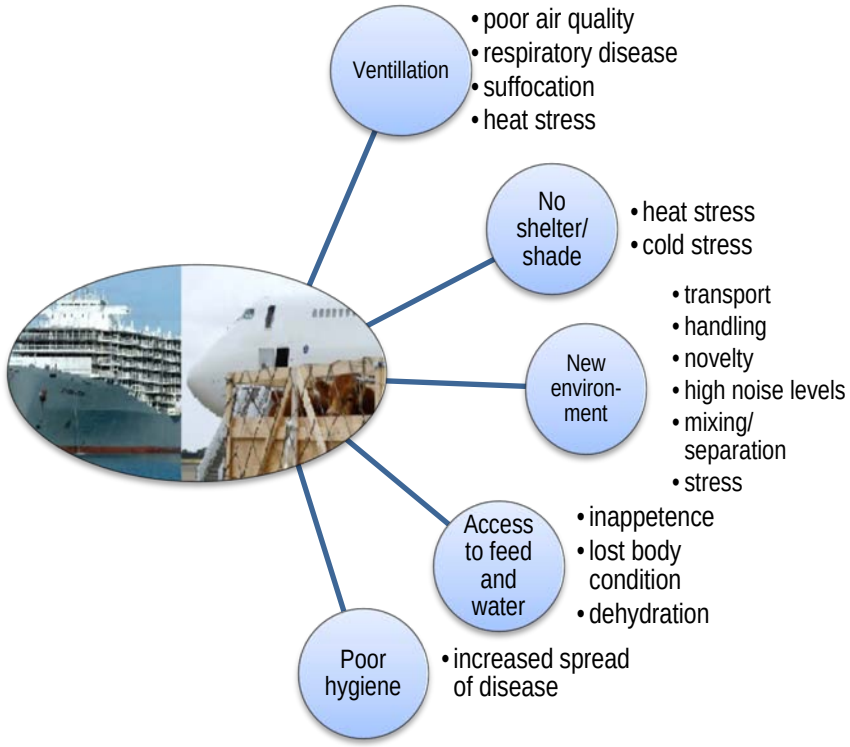


Figure 2. Environmental conditions and their consequences encountered by animals during live export.

What is animal welfare?

In order to begin to measure welfare, we need to first understand what welfare is. There is a growing body of literature that examines the definition of what good animal welfare means (Botreau *et al.* 2007a; Botreau *et al.* 2007b; Colditz *et al.* 2014a; Mellor and Webster 2014; Mellor and Beausoleil 2015). It is important to remember that animal welfare is about both positive and negative mental states (Sandøe and Simonsen 1992; Keeling 2009), and that welfare is a multidimensional concept that embraces the physical and mental aspect of the animal, such as health and emotion, as well as the animal's physiology and functioning, and its interaction with its environment.

Many measures of welfare are needed, because stressors can act on one or several parameters at different times and to differing degree (Sevi 2009). For example, an animal seeking shade on a hot day will *feel* uncomfortable, shows *physiological* signs of hyperthermia, alters its behaviour in seeking out shade and may have a lowered reproductive *function*. Mellor and colleagues (Green and Mellor 2011; Mellor and Webster 2014) have proposed five domains of animal welfare: four physical/functional domains which all impact on the fifth domain, that of mental state. The European Union Welfare Quality® program similarly recognises four key welfare principles and 12 welfare criteria for animal welfare assessment (Blokhuis 2008). We have used these Domains and Principles (**Fig. 3**) as a framework for understanding animal welfare for the current review.

Five Domains	Welfare principles	Welfare criteria	
1. Nutrition	Good feeding	1	Absence of prolonged hunger
		2	Absence of prolonged thirst
2. Environment	Good housing	3	Comfort around resting
		4	Thermal comfort
		5	Ease of movement
3. Health	Good health	6	Absence of injuries
		7	Absence of disease
		8	Absence of pain induced by management procedures
4. Behaviour	Appropriate behaviour	9	Expression of social behaviours
		10	Expression of other behaviours
		11	Good human-animal relationship
5. Mental state		12	Positive emotional state

Figure 3. The Five Domains of animal welfare (Mellor and Beausoleil 2015) and their association with the Principles and Criteria forming the basis of the Welfare Quality® assessment protocols.

Why do we need to measure animal welfare in the LEI?

Australia is a major exporter of livestock, and the industry employs 11,000 people across Australia (Department of Agriculture 2015) and is worth $2.98 billion to the Australian economy (MLA 2014). In the 2014-15 financial year, Australia exported 3.6 million cattle, sheep and goats to 32 countries as part of the livestock export trade, via sea and air (**Fig. 4**). The sheer numbers of animals that are processed through the LEI warrants specific focus and the development of animal welfare assessment tools that are tailored to the conditions experienced within the chain.

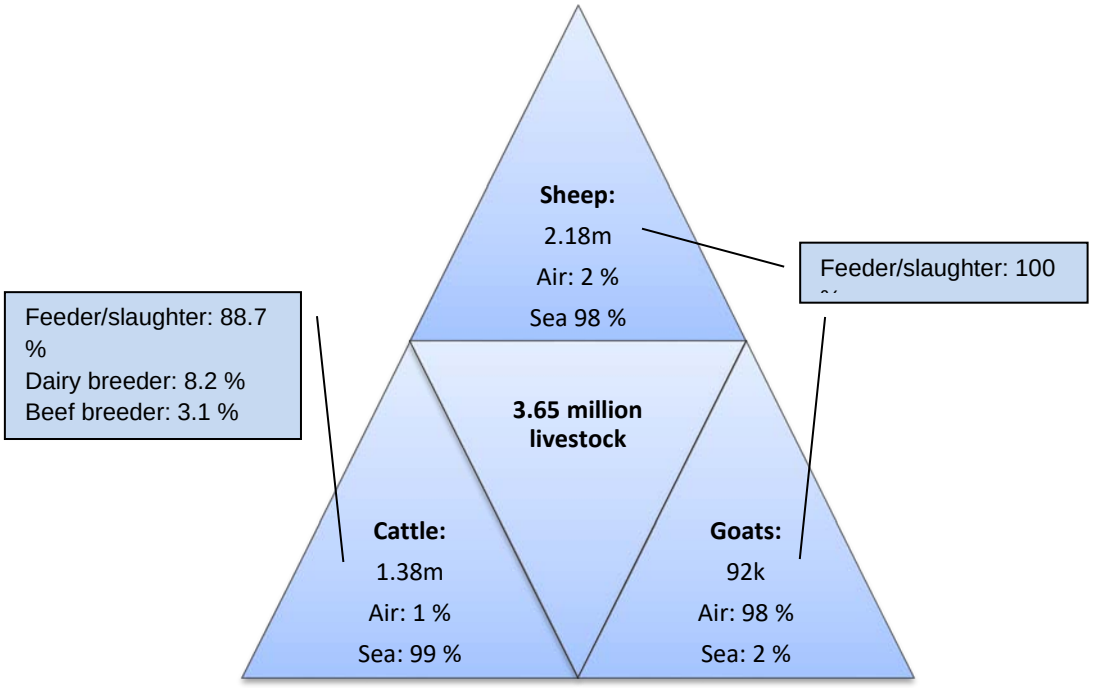


Figure 4. Livestock export numbers from Australia for the 2014/2015 financial year (MLA 2014, 2015a).

The need to monitor animal welfare usually arises to address compliance with law and legislation, policy and regulatory standards, market assurance, welfare management and risks, and in response to public attitude and concerns (Main *et al.* 2003; Colditz *et al.* 2014b). The welfare status of animals also influences the quality of the product, either directly or indirectly via consumer perceptions (Jago *et al.* 2000). Proactive animal welfare monitoring and engagement with all stakeholders is needed to ensure continued social licence to trade.

The Farmer Review recommended that LEI develop and implement a through-chain QA system to complement government regulatory compliance programs (Farmer 2011). Most importantly, quantifying animal welfare as part of the LEI will enable benchmarking – establishing criteria that can become aspirational and shifting the industry towards continuous improvement. This approach is supported by stakeholders, and the industry's desire to avoid adverse publicity and to be seen to be doing things well, but it will require careful and incremental implementation. Care is needed for compliance/assurance approaches based on environment- or resource-based measures and tick-the-box assessment (i.e. using threshold values), since these are not necessarily associated with good welfare outcomes (Main *et al.* 2001). Mortality reporting is an example where there are already fixed thresholds that trigger a formal mortality investigation.

The need for effective feedback and continuous improvement requires established and detailed protocols for consistency over time and between practices. Monitoring can be useful for exporters to measure the performance of a facility or supply chain or management team, such as by differentiating between average and high performers, or detecting declines in performance

before actual non-compliance occurs (Department of Agriculture 2015). However we should keep in mind the different objectives of assurance systems compared with benchmarking. While assurance systems work towards compliance, they do not naturally engender self-driven improvements. In the case of the LEI, benchmarking is likely to increase ownership/investment in the system, with the LEI participants determining how they best modify their own systems to improve welfare outcomes.

Who should carry out welfare assessments?

As part of developing animal welfare assessment methods for the LEI, the individuals who will be undertaking the assessments should be considered first and foremost. Although welfare assessment is something that proficient stockmen do as a matter of course when working with their livestock (Fleming *et al.* 2016), more formal evaluations that are documented and have a particular purpose are likely to involve external agencies to develop a level of impartial review. The stockman can have a role in such an evaluation but, generally we will assume that trained and independent assessors are likely to be involved. The frequency and duration of the assessment visits can influence the credibility of the procedure, so careful consideration of the review period and the selection of assessors with suitable auditing and inspection skills are required (Main *et al.* 2001).

Industry and legislative context

Animal welfare in live export is a complex regulatory issue within Australia. Exports are within the domain of the Commonwealth, but animal welfare and disease control are regulated at State/Territory levels (**Table 1**). In some States, there is further delegation of responsibility to other bodies (RSPCA inspectors, etc.). This leads to conflicts and lack of clarity over roles and responsibilities and relevant legislative instruments (Farmer 2011).

In Australia, there is a broad trend in regulatory reform to reduce prescriptive regulation and to move to a more shared-responsibility model with non-government stakeholders (industry, community) playing more direct roles. This is described in general government information related to good regulatory practice and in current Commonwealth and state regulatory reforms, as illustrated through new Biosecurity Bills/Acts at Commonwealth and State levels.

In the live export supply chain, the development of the Livestock Global Assurance Program (LGAP) is an important component of this general trend (MLA 2015b). LGAP will follow a number of international standards (OIE, ESCAS and WTO and 17 other international programs, standards or practices). The program owner for LGAP will be an internationally-appointed independent organisation. Under current auditing (ESCAS), exporters are responsible for appointing auditors who report to government via the exporters. Under LGAP, facilities and operators will perform internal audit to be prepared for external auditing, and LGAP will appoint auditors who will review all levels of the chain directly back to LGAP. New LEI welfare indicators are likely to be implemented through LGAP.

Table 1. Jurisdiction: (I) International, (C) Commonwealth, and (S) State/territory laws or regulations that are relevant to the live export industry. Included are examples of industry-led management guidelines.

Jurisdiction		Purpose
I	International Air Transport Association (IATA) Live Animal Regulations (LAR)[1]	Global standards and guide to transporting animals by air in a safe, humane and in a cost-effective manner
	World Organisation for Animal Health (OIE) standards[2]	International trade standards for the transport and slaughter of animals produced for consumption
	Improved Animal Welfare Programme (OIE 2015)	Training and capacity building programme to assist countries in implementing improved welfare standards
C	Navigation Act 2012	Regulate international shipping
	Australian Maritime Safety Authority Marine Order 43 (AMSA MO43)	Cargo and cargo handling – livestock
	Australian Meat and Livestock industry Act 1997	Regulate industries
	Australian Meat and Livestock industry (Export Licensing) Regulations 1998	Regulate industries
	The Australian Standards for the Export of Livestock (ASEL)	Standardise export procedures
	Exporter Supply Chain Assurance Scheme (ESCAS)	Regulate supply chain - requires evidence that animals will be handled and processed in accordance with the internationally-accepted OIE animal welfare guidelines
	Export Control Act 1982 and Export Control (Animals) Order 2004	Regulate animal export industries
C/S	National Land Transport Standards[3]	Guidelines for land transport of livestock
S	Animal Welfare Acts	Overarching animal welfare legislation
	Codes of Practice[4]	State-level codes
Industry-led examples	Livestock Global Assurance Program (LGAP)	Overarching review and regulation of the LEI
	Livestock Production Assurance program[5]	
	Grazing Best Management Practices (Grazing BMP)[6]	Identifying best management practices
	National Dairy Industry Animal Welfare Strategy[7]	Leadership to improve animal welfare
	National Feedlot Accreditation Scheme[8]	Quality System for beef feedlots
Other	Approved Supply Chain Improvements Program[9]	Subsidisation of industry investment in importing countries and training on OIE welfare standards delivered through the OIE Improved Animal Welfare Programme
	Australian Animal Welfare Strategy (AAWS)	Information and development of future directions for improvements in animal welfare – no longer funded
	Animal Health Australia (AHA) Standards and Guidelines	Coordinating the development of national livestock welfare standards and guidelines

[1] http://www.iata.org/publications/pages/live-animals.aspx
[2] http://www.oie.int/animal-welfare/oie-standards-and-international-trade/
[3] http://www.animalwelfarestandards.net.au/land-transport/
[4] http://www.agriculture.gov.au/animal/welfare/standards-guidelines
[5] http://www.mla.com.au/Meat-safety-and-traceability/Livestock-Production-Assurance
[6] https://www.bmpgrazing.com.au/#&panel1-2
[7] http://www.dairyaustralia.com.au/~/media/Documents/Animal%20management/Animal%20welfare/Welfare%20overview/DA_ADIC-welfarestrategy.pdf
[8] https://www.ausmeat.com.au/audits-accreditation/nfas-feedlot-assurance.aspx

Constraints to the measurement of welfare indicators

Comparison of welfare across different stages of the export chain may be limited due to vast differences in the environments animals are exposed to and the constraints to animal welfare measurement. There are major constraints to potential animal welfare assessment approaches for various parts of the live export chain, and welfare assessment tools therefore need to be developed that are specific to the environmental conditions.

On ship

- **Individual vs. group assessments** – the animals can be densely packed and human presence moving through the group causes disturbance that can confound the measurements being recorded. It is difficult to conduct a physical examination on any individual animal (e.g. temperature, auscultation, palpation, inspection of mucous membranes, collection of samples) because restraint of individual animals agitates all animals in the pen possibly causing injury and trauma. Sick animals will be moved to the hospital pen where they can be restrained for individual animal examination and treatment, but these are individual exceptions. Most observations are made at the group (pen) level.
- **Visibility** – low light conditions may mean that a single vantage point has restricted visibility of some parts of the pen. Pen design organically follows the structure of the ship decks, and therefore there can be some parts of the pens that are obstructed from view. Stocking density will preclude visibility of all parts of each animal and bedding is likely to reduce visibility of the animals' feet.
- **Restricted movement** – limited movement by the animals due to stocking density will mean that behavioural differences (e.g. differences in gait) will not be obvious. Closer inspection by human presence can disturb animals and some animals will react to the presence of an observer by moving away and showing alert type behaviour.

Loading and unloading

- **Restricted timeframes** – loading and unloading are carried out over short timeframes to reduce ship docking times. Any animal welfare assessment therefore needs to be carried out as part of the loading/unloading procedures. Gait is obvious at this time. All animals are likely to show alert behaviour and there would be limited capacity for other behavioural assessments.

Holding and lairage

- **Livestock handling** – stockmanship experience and skills are likely to vary greatly between destination countries and there are also different attitudes towards livestock handling across the globe.
- **Use of yards** – the use of yards, races and crushes to move and restrain animals to allow handling, examination and treatment can vary between destinations and between livestock species. Cattle in Asian countries tend to be handled individually with varying or little use of yards etc. Sheep in Middle East countries may be managed in yards/feedlots that are similar to those in Australia. In some cases it may be appropriate to argue for a change in the way animals are handled to facilitate measurement of welfare indicators.
- **Condition of facilities** – where handling facilities are used for holding and lairage, the age, condition and hygiene of these facilities can vary markedly.

[9] http://www.agriculture.gov.au/animal/welfare/export-trade/approved-supply-chain-improvements-program

Review of potential animal welfare measures and their applicability to the LEI

In 2004, the Livestock Export Program identified seven key indicators of welfare on-board ship: mortality, clinical disease, respiration rate, wet bulb temperature, space allowance, change in body weight, and ammonia levels (Pines *et al.* 2004). Some of these indicators have little potential for broad application or practicality of use. Furthermore, for many measures, the baseline information that would allow deviance from optimum and/or critical levels to be detected has not been established. Application of welfare measures across the whole supply chain (including on trucks, in feedlots, and in abattoirs both in Australia and at the export destination) would require other indicators that can be applied more broadly. Behavioural indicators were not identified as part of the 2004 Livestock Export Program, although understanding and application of behavioural measurements to assess welfare have markedly advanced over the intervening decade. A recent review described 19 animal-based indicators considered valid for assessing sheep welfare and of these nine were considered feasible for use in UK abattoirs (Llonch *et al.* 2015). These indicators were: body cleanliness, carcass bruising, diarrhoea, skin lesions, skin irritation, castration, ear notching, tail docking, and 'obviously sick' animals. Therefore, further work is required to develop a system that can be tailored to the logistics and requirements of the Australian livestock industries to include current measures as well as further identify non-invasive, cost effective, and implementable indicators that incorporate animal based factors, such as behaviour and physiology and environmental-based factors relevant to sheep, cattle and goats (independently).

This review aims to identify internationally-accepted and currently-used indicators of animal welfare, identify relevant indicators for each point in the supply chain, and contribute to developing a benchmarking method for animal welfare along the supply chain using a QA dashboard. We propose that appropriate welfare measures would become part of the LGAP QA system to document performance and identify non-compliance early enough to allow preventive or rapid remedial action.

We reviewed 55 potential indicators of animal welfare. We describe these in terms of animal-, environment-, resource-, and management-based measures (**Table 2; Appendices and references therein**). Some of these measures are carried out at individual animal level (e.g. body temperature), and therefore a subsample of sentinel animals can be monitored as part of the LEI process. Other measures can be carried out at a group level (e.g. lameness score or respiratory panting score in a pen of animals) (Goddard 2011; Phythian *et al.* 2012; Widowski *et al.* 2012; Phythian *et al.* 2013).

Measures that are already undertaken by the LEI. Many measures are currently undertaken within the LEI as part of day-to-day action, e.g. as part of Daily Voyage Report and End of Voyage Report requirements[10] authorised under 4A.15 of the Export Control (Animal) Orders 2004. These existing compliance requirements could be used as the starting basis for development of welfare indicators, and some/many of these measures could be extended forward in the supply chain to cover the post-discharge phase of live export. Some of these data could be directly transferred (with varying degree of modification) to form the basis of industry-reported welfare indicators. Development of appropriate forms for handheld devices that would feed into a web-based database (as part of a QA dashboard) would facilitate the collection of this information and make reporting requirements more efficient and effective. Collating and recording these data over a period of time would value add to current practice, providing the baseline data against which industry improvements can be measured. In reviewing the literature (**Appendices and references therein**), we have considered measures that are currently undertaken at different levels of the LEI, and identified how these could be brought together as part of a QA dashboard.

[10] http://www.agriculture.gov.au/export/live-animals/livestock/information-exporters-industry/forms

Measures relevant for specific situations (e.g. research, sentinel animals). We also recognise that there are numerous animal welfare measures that have relevance for specific contexts that are unlikely to be feasible under normal LEI practice due to impracticality of measurement (e.g. heart rate, hormones), or where the measure recorded would be irrelevant to the short time frame within the LEI (e.g. reproductive rate).

Measures that are unlikely to be relevant to the LEI. Our comprehensive literature review also considered measures that we believe would have limited capacity for further development for the LEI.

Table 2. Mapping of all possible animal welfare measures or indicators onto the European Union's Welfare Quality® framework. Some measures have direct relevance to the welfare Principles or Criteria, while others do not; e.g. *'absence of pain induced by management procedures' does not have measures that are directly relevant. There are also animal- and environment-based indicators specific to the LEI that are not captured under the four Welfare Principles (herein identified as 'other'). Measures are identified as (C) currently used as part of the LEI in some form, (R) Relevant to the LEI, (I) largely irrelevant to the LEI due to impracticality or lack of opportunity.

			Possible animal welfare measures or indicators					
Welfare principles	Welfare criteria			Animal-based		Environment-based		Resource-based
Good feeding	1	Absence of prolonged hunger	R R	Digestion Weight and body condition score (BCS)			C C C R R	Feed access Feed consumption Feed hygiene Time off feed Time to resume feeding and drinking
	2	Absence of prolonged thirst	I I	Acid-base disturbances Hormones			C C C R R	Water access Water consumption Water hygiene Time off Water Time to resume drinking
Good housing	3	Comfort around resting	R R	Ethograms QBA			R	Cleanliness, dry lying area at all times¥
	4	Thermal comfort	R I	Respiration rate (RR) and panting Body temperature	C	Shade and shelter (type, construction,material)	R	Enough shade/shelter for all animals to access
	5	Ease of movement	C R	Ethograms QBA	C	Space allowance	C	Adequate space (housed sheep), rough terrain
		Other				Ship/plane: R Ventilation R Ammonia R Temperature & humidity R Noise R Smell R Lighting Land transport: R Driving conditions, balance, slipping/falling C Journey Plan R Driving conditions R Carrier design R Facilities (ramp/ race, holding yard and pen) condition, design R Hygiene of facilities		
Good health	6	Absence of injuries	C C	Mortality Morbidity and health				
	7	Absence of disease						
	8	Absence of pain induced by management procedures*						
		Other	I I I C I	Hormones Haematology Reproductive efficacy Pregnancy status Meat quality and yield†				
Appropriate behaviour	9	Expression of social behaviour	C I R	Ethograms Stereotypy Emotional state				
	10	Expression of other behaviour	I I	Heart rate (HR) Heart rate variability (HRV)				
	11	Good human-animal		?				

		relationship					
	12	Positive emotional state	R	QBA			
Other				Management-based		Industry-management		Management-based
			C	Appropriate sourcing (incl. breed, genotype, size, age)	C	License and Accreditation	C	Stocking rate
			C	Mixing	C	Assurance schemes	R	Slaughter method
			C	Isolation/ separation	C	Auditing and compliance	R	Time at feedlot
			C	Hospital pen	C	Documentation and Reporting		
			R	Previous experience				
			R	Traceability	R	Stockmanship		
			C	Rejections	C	Standard operating procedures		
			R	Use of electric prods/dogs				

¥ some consideration of this measure is required, because under hot conditions, having a cool wet place may be beneficial, while on ship, a deep-packed manure layer will contribute to comfort around lying.

† Becoming increasingly important and a driver for change in some destination markets.

Here we summarise these findings and relevance for the LEI. Supporting information for each measure is detailed in the Appendices and references therein.

Measures that are already undertaken by the LEI. A number of measures are currently recorded as part of animal welfare assessment at some stage of the LEI chain, and could be included in a QA dashboard:

- Mortality is already recorded as part of current ASEL reporting requirements (Daily Voyage Report, End of Voyage Report, reporting from the assembly depot). Mortality is recorded under the Daily Voyage Report ("1. Daily and cumulative mortality for each class of livestock and deck, and 2. Comment on cause of mortality"). Mortality is also recorded under the End of Voyage Report ("the total and percentage mortality for each species and class of livestock and the total and percentage mortality for each deck of the vessel"). This information and additional requirements are submitted by the AAV or exporter directly to the Commonwealth (Department of Agriculture) and is not accessible or used for any other purpose. Daily mortality records could be included under the proposed QA dashboard, and breaking down these data in terms of location of events (e.g. decks) or class of animals could inform and help manage future potential risks. Tracking animals (e.g. ASEL tags) with respect to morbidity (and mortality) is recommended as a first step towards developing this understanding of potential underlying causative factors.
- Morbidity and records of animal treatment are important for the LEI as a method of monitoring health status and screening for potential disease outbreak. Because acute outbreaks of disease may be unavoidable, evidence of active management responses towards disease or injury may be more relevant for a QA dashboard than simply the incidence of disease. Health issues ("hospital pen report including medication and treatments") are reported under the Daily Voyage Report and Health and as part of the End of Voyage Report ("any treatments given to the livestock during the voyage"). Current stockmanship practice includes scans of groups of animals for individuals that show clinical signs of disease, or are lying down or unresponsive to human presence. These could be expanded upon to include other measures of poor demeanour or abnormal behaviour, and classed as 'obviously sick' thus relevant to health status. Clinical signs that indicate poor welfare may include lameness, dyspnoea, coughing, nasal discharge, diarrhoea, ocular health or scratching or rubbing. These can all be assessed at the pen level without touching the animal.
- Environmental factors influence the welfare of animals during live export, and can be measured and controlled. Many of these indicators are already measured during export

by sea and air, and it may be relatively simple to move the recording systems into a welfare QA system. e.g. Daily records of 1. average dry bulb and wet bulb temperature for each deck, 2. humidity for each deck, and 3. bridge temperature (ambient) are reported under the Daily Voyage Report and a summary of environmental conditions ("comment on weather, temperature, humidity, ventilation and decks/bedding") as part of the End of Voyage Report. Collating this information as part of a QA dashboard would provide a robust method of monitoring and determining long-term trends.

- Collating land transport journey details along with any issues for specific groups of sheep could provide long term monitoring and identify trends to indicate areas for improvement.
- Appropriate design and construction of facilities can increase productivity and reduce welfare risks. The ESCAS welfare audit contains measures of facilities, such as avoidance of protrusions or gaps where animals may be injured or trapped, adequate fencing to provide restraint, width of races, non-slip flooring, rate of animal slips and falls, and number of times animal flow stops. The use of the ESCAS welfare audit may be a starting point for welfare assessment earlier in the chain. Hygiene indicators need to be developed, so that a hygiene assessment regime for transport vehicles and feedlots can be utilised.
- More research is required to identify the effects of feed and water withdrawal and novel welfare indicators are needed to assess short term hunger and thirst (Llonch *et al.* 2015). Feed and water consumption are part of the Daily Voyage Report ("average per head"). Feed and water access are part of the End of Voyage Report (ASEL), although there is no guideline for the collection of this information: "Feed and water – comment on stock access and if there were any issues with maintenance", leaving reporting of this information to individual discretion. These measures have the potential to be expanded upon as part of the QA dashboard, and developing guidelines for their recording would improve standardisation and repeatability of monitoring.
- Animal management substantially influences the welfare of the animals under consideration. A number of measures are monitored by ASEL standards. For example, ESCAS has collated information on pre-slaughter stunning (Department of Agriculture 2015) which promises to make substantial differences to public perception. Being able to capitalise on improvements in this area requires traceability of livestock though the LEI chain, which could be facilitated through better tracking of RFID tags and central collation of these data.
- Industry management measures include a number of measures that are currently undertaken, which could be supported by inclusion of recording levels of stockmanship competence across the LEI chain. Recording certification of stockperson training in low stress handling, and experience etc. for crew, for each shipment, has the potential to be expanded upon as part of the QA dashboard.

Other relevant measures not currently recorded hold promise for welfare assessment under revised practice:

- Rumination or gut fill are relatively easy to observe and can provide an indication of recent feed consumed and the behavioural state of the animals. Rumination is best observed in undisturbed animals at rest, and as a group measure. Gut fill could be subjectively assessed using a series of image charts (similar to those used for body condition scoring). Relevance to the LEI is good due to the importance of inappetence and its potential for salmonellosis.

- Body weight and body condition scoring (BCS) allows a subjective assessment of an animal's nutritional history and potential energy reserves. ASEL state the minimum and maximum weight and BCS for animals entering the LEI. It is important for the welfare of the animals to follow these standards and monitor weight and BCS. Monitoring BCS through the live export chain may reveal where issues with inappetence lie. Carcass classification is an alternative to BCS with the possibility of video image analysis technologies being tested (Rius-Vilarrasa *et al.* 2009).
- Pregnant animals should not be sourced as feeder/slaughter animals in the LEI and pregnancy status is therefore already monitored as a measure of compliance. These figures are reported under the Daily Voyage Report ("Births and abortions including estimated stage of pregnancy") and health and welfare of the livestock ("the number of livestock born, the number of abortions and estimated stage of pregnancy") as part of the End of Voyage Report. Collating this information as part of a QA dashboard would be advised.
- Meat quality measures are usually obtained post-mortem so provide only retrospective information for the animals tested. However, meat quality can be directly associated with feeding status and stress of the animals, and therefore combined with environmental and management data, collated information can indicate best practice management that results in optimum welfare for healthy animals and premium product. Additionally, abattoir surveillance for disease and carcase condemnation provides data about the health of the animals.
- Both heat stress and respiratory disease are problems for the LEI. Respiratory rate (RR) or a panting score are currently assessed daily on a group basis during voyages by sea. RR is a quick, non-invasive indicator of welfare that can be used in all areas of the LEI, which, in combination with panting scores, may reveal respiratory problems and heat stress. RR and character (1 = normal, 2 = panting, 3 = gasping) and "Whether and to what extent the livestock show heat stress" are recorded under the Daily Voyage Report. Environmental conditions ("comment on weather, temperature, humidity, ventilation and decks/bedding") are included as part of the End of Voyage Report. These data can be collated and compared with weather conditions and animal handling procedures to reveal potential part of the LEI chain of concern.
- Assessing the behaviour of an animal is done through visual observation and is non-invasive and non-intrusive, and usually does not require specific equipment or training. For example, shivering should be recorded as an indicator of possible thermal discomfort. Developing quick assessment methods to detect the 'obviously sick' animals, to assess the animal's overall current mental state (e.g. fear and distress) and to assess body cleanliness and/or evidence of ectoparasite infestation can be built-in to the QA dashboard.
- Ethograms are an easy measure that be performed by stockmen, targeting welfare-relevant behaviour (e.g. eating, resting, agonistic bouts). Specific abnormal behaviour can be targeted, identifying animals to be removed from a pen for treatment. Although ethograms can be time consuming with thousands of animals, developing monitoring protocols for sentinel groups is achievable. These measures have the potential to be expanded upon as part of the QA dashboard.
- Qualitative Behavioural Assessment (QBA) can indicate 'how' the animal is behaving rather than what it is doing, and does this by looking at how the animal interacts with its environment. QBA should be applicable for all species and in all areas of the LEI supply chain. Some degree of training is needed to analyse and interpret results. Developing

quick protocols can provide immediate feedback to the assessors, but the data can also contribute to long-term analyses. For example, current practice around sorting animals at loading and scanning pens as part of daily monitoring involves stockmen observing animals and using their judgement to identify animals that behave differently; this is an informal QBA approach. A more formal approach could be developed using appropriate scoring sheets developed for particular stages of the LEI chain, and results from this could feedback to training packages for stockmen for their more informal approach. These measures have the potential to be expanded upon as part of the QA dashboard which would then start to build up long-term datasets.

Measures that are unlikely to be relevant to the LEI. A number of reviewed measures were impractical or had little or no relevance for animal welfare monitoring as part of the LEI:

- Body temperature is not a practical animal-based measure for the LEI; use is limited to necropsy, sick animals, those that are individually examined, and those used in research.
- Heart rate and heart rate variability are too variable and can be affected by the act of measuring them. Remote methods for monitoring may have relevance for controlled situations. Relevance in the LEI is therefore limited.
- 'Stress hormones' such as cortisol as well as haematology and blood biochemistry (including acid-base disturbance) measures require blood sampling for assessment. Animals need to be restrained to collect a sample, which is then sent away for testing. This can be costly and does not provide immediate results. Additionally, other measures need to be used in conjunction to provide enough information for correct interpretation. Relevance in the LEI is therefore limited.
- Reproductive efficiency is only relevant for breeding animals, and data is only available some time after the animals have arrived at their export destination.
- Measuring the emotional state in animals needs carefully designed methodology, and may not be practical in the LEI. However, consideration could be given to behavioural methods that capture the valence of behavioural expression.
- Stereotypical behaviour is common in confined animals, and can be used to indicate boredom in feedlots and during sea transport. Enrichment to the environment can improve animal welfare. Recording the expression of stereotypies *per se* is not likely to be directly relevant to the LEI because stereotypy generally indicates long-term challenges for animals, i.e. over months or longer (Mason and Rushen 2008).

Conclusions

Currently the LEI welfare assessments are largely focussed around mortality and resources provided for animals, and this is likely to remain the basis for licence and accreditation as well as auditing and compliance. However aspirational objectives are more likely to be met through animal- and management-based measures addressing 'good feeding' (the absence of prolonged hunger or thirst) and 'good housing' (comfort around resting, thermal comfort, and ease of movement), while animal-based measurements are required for 'good health' (absence of injuries, disease, and pain induced by management procedures), and 'appropriate behaviour' (expression of social behaviour, other behaviour, good human-animal relationship, and a positive emotional state).

We reviewed a total of 54 potential animal welfare measures that address 12 welfare criteria and 4 welfare principles (Fig. 5). We identified those measures that would be appropriate for use as part of the live export chain, and categorised these as animal-, environment- and resource-based. We identified 20 specific measures already carried out under current practice that can be expanded upon to form a QA dashboard: a LEI-specific online interface for collecting of QA data that will contribute towards benchmarking the industry. We identified another 26 that are relevant to the LEI and that could be developed into a benchmarking system. We identified and dismissed measures that were not appropriate for the LEI due to impracticality.

Some areas where more research is required are noted; for example the development of measures suitable to determine whether animals in the LEI have a positive emotional state. Despite this, we suggest the next step for industry is to pilot the use of the QA dashboard, using the 46 potential measures identified at several points along the supply chain, for both sheep and cattle.

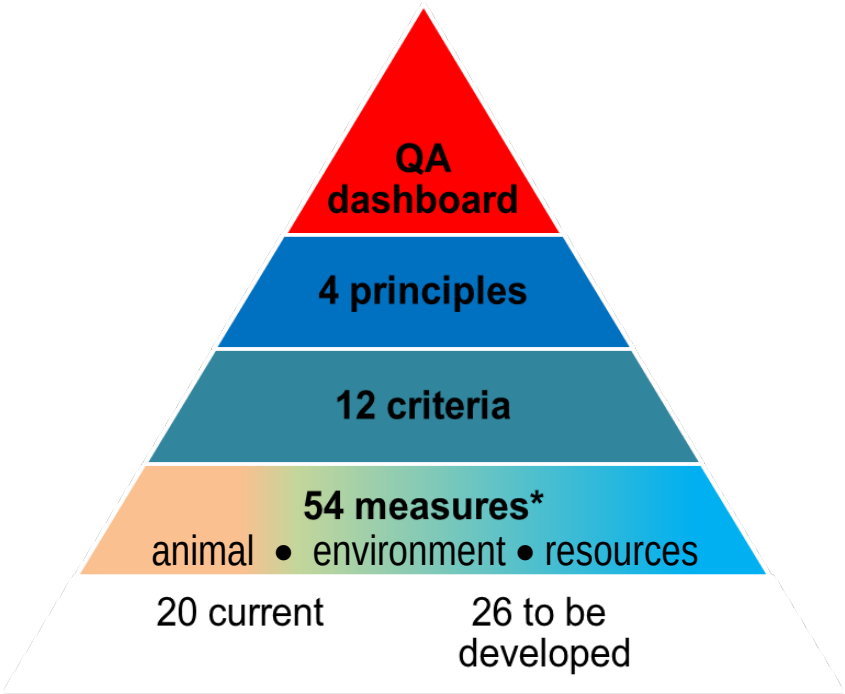


Fig. 5. Inclusion of animal-, environment-, and resource-based measures towards development of a live export QA dashboard: a LEI-specific online interface for collecting of QA data that will contribute towards benchmarking the industry. *we reviewed 54 measures and identify 46 that are relevant to the live export industry; not all measures are appropriate for all stages of the live export chain.

References

Blokhuis, HJ (2008) International cooperation in animal welfare: the Welfare Quality® project. *Acta veterinaria scandinavica* **50**, 1.

Botreau, R, Bonde, M, Butterworth, A, Perny, P, Bracke, M, Capdeville, J, Veissier, I (2007a) Aggregation of measures to produce an overall assessment of animal welfare. Part 1: a review of existing methods. *Animal* **1**, 1179-1187.

Botreau, R, Bracke, M, Perny, P, Butterworth, A, Capdeville, J, Van Reenen, C, Veissier, I (2007b) Aggregation of measures to produce an overall assessment of animal welfare. Part 2: analysis of constraints. *Animal* **1**, 1188-1197.

Colditz, I, Ferguson, D, Collins, T, Matthews, L, Hemsworth, P (2014a) A prototype tool to enable farmers to measure and improve the welafre performance of the farm animal enterprise: The unified field index. *Animals* **4**, 446-462.

Colditz, IG, Ferguson, DM, Collins, T, Matthews, L, Hemsworth, PH (2014b) 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.

DAFF (2014) 'Investigations in mortalities by the Australian Department of Agriculture, Fisheries and Forrestry.' Available at http://www.daff.gov.au/biosecurity/export/live-animals/livestock/regulatory-framework/compliance-investigations/investigations-mortalities [Accessed 24th September].

Department of Agriculture (2015) Exporter Supply Chain Assurance System. Department of Agriculture, Canberra, Australia. Available at http://www.agriculture.gov.au/SiteCollectionDocuments/biosecurity/export/live-animals/livestock/escas/escas-report.pdf.

Farmer, B (2011) Independent Review of Australia's Livestock Export Trade. Department of Agriculture, Fisheries and Forestry, Canberra, Australia.

Fleming, PA, Clarke, T, Wickham, SL, Stockman, CA, Barnes, AL, Collins, T, Miller, DW (2016) The contribution of Qualitative Behavioural Assessment to livestock welfare assessment. *Animal Production Science* **In Press, Accepted Oct 2015**,

Goddard, P (2011) Welfare assessment in sheep. *In Practice* **33**, 508-516.

Green, TC, Mellor, DJ (2011) Extending ideas about animal welfare assessment to include 'quality of life'and related concepts. *New Zealand Veterinary Journal* **59**, 263-271.

Jago, J, Fisher, A, Le Neindre, P (2000) Animal Welfare and Product Quality. In 'Biological Resource Management Connecting Science and Policy.' (Eds E Balázs, E Galante, J Lynch, J Schepers, J-P Toutant, D Werner, PATJ Werry.) pp. 163-171. (Springer Berlin Heidelberg:

Keeling, L (2009) 'Positive affective states and positive animal welfare, Proceedings of the XXXI International Ethological Conference.' Rennes, France.

Llonch, P, King, EM, Clarke, KA, Downes, JM, Green, LE (2015) 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. *The Veterinary Journal* **206**, 289-297.

Main, DCJ, Kent, JP, Wemelsfelder, F, Ofner, E, Tuyttens, FAM (2003) Applications for the methods of on-farm welfare assessment. *Animal Welfare* **12**, 523-528.

Main, DCJ, Webster, AJF, Green, LE (2001) Animal welfare assessment in farm assurance schemes. *Acta Agriculturae Scandinavica, Section A-Animal Science* **51**, 108-113.

Mason, G, Rushen, J (2008) Sterotypic behaviour in captive animals. In 'Stereotypic Animal Behaviour: Fundamentals and Applications to Welfare.' (Eds G Mason, J Rushen.) pp. 325-356. (CABI Publishing: Wallingford UK)

Mellor, D, Beausoleil, N (2015) Extending the five domains model for animal welfare assessment to incorporated positive welfare states. *Animal Welfare* **24**, 241-253.

Mellor, D, Webster, J (2014) Development of animal welfare understanding drives change in minimum welfare standards. *Scientific and Technical Review OIE* **33**, 121-130.

MLA (2014) Australian livestock export industry statistical review 2013-14. Meat and Livestock Australia.

MLA (2015a) Australian livestock export industry statistical review FY 2014-15. Meat & Livestock Australia Limited, Sydney, Australia.

MLA (2015b) 'Livestock Global Assurance Program.' Available at http://www.livestockglobalassurance.org/

OIE (2015) 'Overview.' Available at http://www.oie.int/animal-welfare/improved-animal-welfare-programme/

Phythian, C, Cripps, P, Grove-White, D, Jones, P, Michalopoulou, E, Duncan, J (2013) Observing lame sheep: evaluating test agreement between group-level and individual animal methods of assessment. *Animal Welfare* **22**, 417-422.

Phythian, C, Cripps, P, Michalopoulou, E, Jones, P, Grove-White, D, Clarkson, M, Winter, A, Stubbings, L, Duncan, J (2012) Reliability of indicators of sheep welfare assessed by a group observation methods. *The Veterinary Journal* **193**, 247-263.

Pines, M, Petherick, C, Gaughan, JB, Phillips, C (2004) Developing alternative methods of measuring animal welfare on ships. Stage One: Survey of Industry Opinion. Meat & Livestock Australia.

Rius-Vilarrasa, E, Bünger, L, Maltin, C, Matthews, KR, Roehe, R (2009) Evaluation of Video Image Analysis (VIA) technology to predict meat yield of sheep carcasses on-line under UK abattoir conditions. *Meat science* **82**, 94-100.

Rousing, T, Bonde, M, Sorensen, JT (2001) Aggregating welfare indicators into an operational welfare assessment system: A bottom-up approach. *Acta Agriculturae Scandinavica, Section A, Animal Science* **30(S)**, 53-57.

Sandøe, P, Simonsen, HB (1992) Assessing animal welfare: Where does science end and philosophy begin? *Animal Welfare* **1**, 257-267.

Sevi, A (2009) Animal-based measures for welfare assessment. *Italian Journal of Animal Science* **8**, 904-911.

Widowski, TM, Rushen, J, Tuyttens, FAM, Veissier, I (2012) Implementing animal welfare assessments at farm and group level: introduction and overview. *Animal Welfare* **21**, 305-306.

Appendices

Appendix 1: Animal-based measure that are direct indictors of animal welfare

Mortality

Mortality is an indication of a poor quality of life for the animal and the presence of disease, injury or lack of care (von Keyserlingk *et al.* 2009) which have resulted in death. Animals and the industry benefit from reduced mortality rates. Assessing animal welfare through other indicators, before animals die, would greatly reduce the suffering for the animals, and the economic loss to the industry.

How is mortality measured?

Mortality is measured by counting the number of animals that have died. However, mortality should be measured as an incidence measure, and not just as a count; therefore numerator and denominator information about the group is vital. Post mortems are important to determine cause of death, and therefore actions that need to be taken to prevent the spread of any diseases, or to change management plans to increase the welfare of the animals and reduce any further deaths.

Relevance for the LEI

This is one of the most important welfare measures in the LEI because mortality is an indicator of the poorest welfare.

Morbidity and health

The disease and health status of the animals can indicate whether the animal is in a state of poor welfare (Segner *et al.* 2012). There is an economic cost to treating sick animals and removing the animals from the export chain if required. Therefore preventing the spread of disease and health issues have benefits for animals and the industry.

Poor health can be a result of physical injury, poor housing, and poor management. Assessments of the incidence of illness can provide useful information. For example, an increase in calf morbidity was used to identify that the large group sizes were a hazard for the welfare of group-housed calves (Svensson *et al.* 2003).

How is it measured?

If an individual animal can be subjected to a detailed physical examination then it should be possible to identify that the animal is unwell and identify a candidate list of differential diagnoses. It may not be possible to identify a specific diagnosis unless the condition presents with pathogenic signs. It is often possible to identify a syndrome.

If individual animals cannot be subjected to a detailed physical exam, then observation of individual or groups of animals will be necessary.

Parameters of ill health that can be measured are:

- what is the problem
- number of animals with issue or indictors of problem
- severity of problem and frequency or occurrence (and reoccurrence)
- duration of problem

Most of this does not require handling of the animals, and the information can be obtained through direct observation. However, some animals will react to the presence of an observer by

becoming alert and watchful. In this situation, it may be difficult to identify all sick individuals, let alone determine what the syndrome might be or the specific condition.

Relevance for the LEI

This is another important welfare indictor in the LEI because health status is an indicator of poor welfare for the animal in question, and a welfare risk for other animals. Morbidity may be best represented as syndromes rather than specific conditions.

Physiology

Body temperature

Body temperature is an indicator of the onset or degree of thermal stress in an animal (Silanikove 2000), and can also be used to indicate the presence of disease (pyrexia) and stress. As environmental temperature and humidity increase, core body temperature can increase. Livestock rely on their respiration to cool down, but if they cannot shed heat effectively, they can succumb to heat stress. This usually occurs when the environmental conditions do not cool down at night. Increases in heat production in the absence of physical activity, disease, increases in environmental temperature, humidity or increased diet reflect increased activity of the sympathetic nervous system due to the presence of a stressor (Sjaastad *et al.* 2003). For example, core body temperature of sheep increases during transport and remains elevated for several hours (Parrott *et al.* 1999; Ingram *et al.* 2002; Beatty *et al.* 2008).

Fluctuations of 0.5–1.0 °C in core body temperature over a 24 hour period are common (Sjaastad *et al.* 2003), and the body temperature of diurnal animals, such as livestock, is lowest at night and early in the morning and increases throughout the day. Adverse temperature and weather events can alter the circadian rhythm (Piccione and Caola 2003). These circadian patterns must be taken into account when using body temperature as an indicator of welfare, and careful selection of sampling time and number of samples to be taken needs consideration. Cold conditions, such as experienced by livestock during severe northern winters, are also a welfare risk, especially for animals transported from warmer southern climates.

How is body temperature measured?

Body temperature of animals can be measured at a specific time point with a standard rectal thermometer; however multiple readings of the same animal, in order to account for circadian patterns, require repeated handling. Remote continuous temperature monitors are available but need to be implanted into the animal, and unless the implantable monitors have a transponder, data from the implantable monitors is unavailable until the monitor is retrieved, usually post mortem. Implantable monitors are often costly and this may be prohibitive when monitoring thousands of animals. These would be useful for research purposes. There is increasing research on the use of remote sensors for body temperature e.g. Martinez *et al.* (2006).

Relevance for the LEI

Heat stress is a problem in the LEI, as is stress due to transport and novelty. Body temperature is useful as a diagnostic tool to determine the presence of heat stress or fever. However, it needs to be used in conjunction with other measures, such as respiration rate and character, to provide a clearer image of the welfare problem. Body temperature is only likely to be measured on the occasional individual animal (i.e. sick pen) because it requires restraint of an individual. However, core body temperature should be measured on necropsy in as many cases as possible to aid in post-mortem diagnosis.

Heart rate (HR) and heart rate variability (HRV)

Heart rate (HR) and heart rate variability (HRV) are indicators of the emotional response of an individual to a short-term problem, and can increase in anticipation to, and during, an event. HR can also decrease in response to an emotional response (Broom and Johnson 1993), while HRV tends to increase. HR can change during isolation, transport, the presence of a human or dog, or a change in environment such as a new location or entering a new flock/herd (Baldock and Sibly 1990; Schmidt *et al.* 2010). The benefit of measuring HR during a stress response is that HR can change within 1 or 2 heart beats (von Borell *et al.* 2007). Baldock and Sibly (1986) found that HR can vary within and between individuals, finding that during normal undisturbed behaviour the HR of sheep had a range of 17 beats per minute (bpm), while between individuals it varied by 15 bpm. With such a large range within and between individuals, and the possibility of not detecting changes in actual HR, careful consideration is needed when interpreting HR data. Therefore, heart rate variability (HRV) is often used and is measured by determining the constantly changing temporal distance between succeeding heart beats (R-R intervals) (Mohr *et al.* 2002). Additionally, a stressor may influence both the sympathetic and parasympathetic nervous systems which can result in no measurable changes in HR, and the overall effects of a change in HR are short lived and can be missed if not measured at the correct point in time.

Désiré *et al.* (2004) found that HRV of lambs was increased in the presence of a novel object but did not find an increase in HR. Désiré *et al.* (2004) suggests that increased vagal activity resulted in increased HRV but simultaneous activation of the sympathetic nervous system prevented the HR from increasing. Changes in HRV have also been found in horses and calves under stress (Mohr *et al.* 2002; Visser *et al.* 2002), and during transport (Ohmura *et al.* 2006). HRV can differ within and between individual animals depending on their temperament or the environmental factors influencing their response to a stressor.

How are HR and HRV measured?

HR can be measured immediately using a stethoscope over the heart, or by using the pulse, which requires handling of the animal, which in turn can affect HR. Alternatively, heart rate monitors can be attached via harnesses, while implantable HR loggers are also now available. Infrared thermography is portable and animal restraint is minimal or not necessary, but needs to be used out of direct sunlight and wind and more research is required into its use for livestock.

HRV is calculated from measures of heart rate, by determining the constantly changing temporal distance between consecutive heartbeats. The most useful measure of HRV is the formula of standard deviation (SDNN) which can be applied to durations of individual intervals (Malik 1997) and has been used as an indicator of stress in farm animals (Korte *et al.* 1999; Mohr *et al.* 2002).

Relevance for the LEI

HR and HRV are too variable and can be affected by the act of measuring it. Remote methods for monitoring may have relevance for controlled situations.

Hormones

Probably the most common physiological measurement of stress is the activation of the hypothalamic-pituitary-adrenal (HPA) axis. The HPA axis consists of the hypothalamus, the pituitary gland and the adrenal glands, and it is a major part of the neuroendocrine system that controls reactions to stress.

HPA activity can be determined by measuring corticotropin-releasing hormone (CRH), adrenotcorticotropic hormones (ACTH), plasma cortisol concentration, adrenaline and insluin which enables an animal to respond to stress (Nwe *et al.* 1996). ACTH and cortisol have been shown to increase during transport in goats (Nwe *et al.* 1996), sheep (Orihuela *et al.* 2002) and cattle (Kenny and Tarrant 1987; Ramin *et al.* 2007).

Increases in HPA activity has also been seen in response to the presence of humans (Hargreaves and Hutson 1990), during physical restraint (Jephcott *et al.* 1986), in response to the anticipation of food (Stull and Rodiek 1988), during sexual excitement (Colborn *et al.* 1991), or exercise (Mason *et al.* 1973), and are also influenced by sex and age (Van Cauter *et al.* 1996), novelty of the situation (Pfister 1979), experience (Mormede *et al.* 2007), and method of sampling (De Silva *et al.* 1986) and after they were handled (Hemsworth *et al.* 1986). Therefore, context needs to be considered when interpreting hormone concentrations.

Another issue with interpreting HPA axis hormones is that even though glucocorticoid release occurs a few minutes after the start of a stressful event and persists for about an hour after the end of the stressor (Mormede *et al.* 2007), plasma cortisol concentration can take 10 minutes to reach its peak after the start of a stressor (Kent and Ewbank 1983; Lay *et al.* 1992). Therefore, it is easy to miss the response of the HPA axis to a stressor if the measurements are not carried out at the correct time. Finally, long term stressors can down regulate the HPA axis, and cortisol can return to baseline despite the animal having not adapted to the stress (Fisher *et al.* 2002).

How are hormones measured?

Stress hormones can be measure in blood, saliva, hair and faeces, which all require some degree of handling of the animal during collection. A blood sample can indicate hormone levels at a specific point in time, whereas results from a faecal or hair sample cannot be time specific. Validation of hormone concentrations is required for each species, which is crucial for accurate interpretation of the results.

Relevance for the LEI

Animals need to be restrained to collect a sample, which is then sent away for testing. This can be costly and does not provide immediate results. Additionally, other measures need to be used in conjunction to provide enough information for correct interpretation.

Haematology

Haematological variables can be used to assess stress responses in animals, as well as immune function and susceptibility to disease. Kent and Ewbank (1983) and Ramin *et al.* (2007) found that overall white blood cell (WBC) numbers increased in calves and cattle during transport. Increases in monocyte and neutrophil numbers, and decreases in lymphocyte and eosinophil numbers, and therefore increases in the neutrophil:lymphocyte ratio (N:L) also accompany a stress response (Kent and Ewbank 1983; Cole *et al.* 1997; Jones and Allison 2007), and have been observed in animals during transport (Murata *et al.*, 1987; Nwe *et al.*, 1996). Haematocrit also changes with stress and has been shown to decrease in cattle after transport (Ramin *et al.*, 2007).

Animals can have a reduced immunity if there is high activity of the adrenal cortex (e.g. in response to a stressful situation) (Broom, 1991). Immune measures (e.g. interleukins, interferons, acute phase proteins) can provide a warning of decreased resistance to disease, and therefore an indicator of welfare.

Haematological variables can differ between animals of the same breed due to sex, age, physical activity, posture, nutritional status, dehydration, blood loss, pregnancy, lactation state, altitude, and emotional state (Hall and Bradshaw, 1998; Sjaastad *et al.*, 2003; Turner and Hodgetts, 1959), and therefore need to be interpreted in light of these other factors.

How are haematology variables measured?

Blood sampling is required to measure haematological variables. Any stressful stimulus, such as handling and drawing a blood sample, can activate the sympathetic nervous system to a varying degree causing mobilisation of RBC or WBC

Relevance for the LEI

Animals need to be restrained to collect a sample for testing. This can be costly and may not provide immediate results. Additionally, other measures need to be used in conjunction to provide enough information for correct interpretation.

Eating – rumination rate

Rumination is essential for digestion and to maintain the movement of material along the digestive tract. Reductions in rumination are associated with stress: cattle with high levels of cortisol spend less time ruminating (Bristow and Holmes, 2007), and rumination decreases with increasing environmental temperature and humidity (Paranhos da Costa *et al.*, 1992). However, there are many factors that can affect rumination in livestock and it is difficult to determine the cause of any decreases in rumination. For example, rumination will also decrease with feed restriction (Galvani *et al.*, 2010), to which animals are often subjected during transport as part of the LEI. Additionally, rumination can vary between individuals and with observation methods.

How is it measured?

Rumination rate is measured through direct observation of the animals and their jaw movements. Automatic measuring is available; however, the animal needs to wear a harness fitted with a counter that measures jaw movements, which requires handling of the animal and is costly to fit onto thousands of animals.

Relevance for the LEI

Rumination is quick and easy to observe and can provide an indication of evidence of feed consumption and stress. Rumination is best observed in undisturbed animals at rest, and may be best observed as a group measure. However, this measure needs to be used in conjunction with other measures to provide a picture of the overall welfare issue.

Weight and body condition score (BCS)

Weight and body condition score (BCS) can provide information as to whether animals are emaciated, indicating a degree of inappetence, or over-fat. Additionally, the physiological response to stress varies with differing levels of adipose tissue (Tilbrook and Clark 2006). Changing BCS can also be stressful and have adverse effects on animals. Tilbrook *et al.* (2008) found that fat ewes have greater stress-induced concentrations of ACTH and cortisol than lean ewes. During an intensive study of sheep transport by sea, Richards *et al.* (1989) found that sheep which died of inanition had greater reserves of body fat than sheep that died of other causes.

Animals that encounter calorie-restriction have greater baseline corticosterone and increased insulin concentrations than non-restricted animals, indicating activation of the HPA axis and greater stress levels compared to calorie-abundant animals (Vandermeerschen-Doise *et al.* 1983; Jahng *et al.* 2007; Tomiyama *et al.* 2010). Strack *et al.* (1997) found that the HPA response to stress was diminished in animals with increased calorie intake, suggesting that there is less need for HPA axis activity if there are easily available energy sources. This indicates that biochemical and hormonal changes occurring in sheep with increasing and decreasing BCS are more important than whether an animal is fat or thin.

BCS can also indicate an increased risk of heat stress, by affecting the animals' physiological capacity to manage thermal load. Animals with a lower BCS should be able to tolerate higher temperatures than animals with a high BCS; animals with a low BCS may be less able to cope with the cold. Dikman *et al.* (2011) showed that heavy and light Holstein feedlot cattle behaved differently in a hot environment, with the light cattle spending more time feeding, drinking and ruminating and the heavy cattle spending more time standing, lying and eliminating. The welfare of heavy animals is impacted negatively when ambient temperature is high.

Body weight in ruminants can fluctuate after feed and water intake, and can vary by a few kilograms based on whether the rumen is empty or full. However, measuring weight is less labour intensive than BCS and has less measuring errors. BCS can vary between measurers, and there may not be any consistency within or between measurers. However, very low values will represent emaciation and very high values will reflect obesity. Animals will naturally lose and gain body condition throughout the year with changing seasons and feed availability. Therefore BCS can be used as an immediate tool to assess condition as well as a measure of how condition changes over time (e.g. on entry and exit to a feedlot).

How are weight and body condition measured?

Weight is measured by weighing the animals using walk over scales. There is ongoing research into making automated systems for measuring BCS. BCS is measured by palpation of the backbone and short ribs, and/or measuring fat depth at the P8 site; this requires handling and scoring each individual.

Relevance for the LEI

ASEL state the minimum and maximum weight and BCS for animals entering the LEI. It is important for the welfare of the animals to follow these standards and monitor weight and BCS.

Reproductive efficacy

Hormones that can be affected by stress may also have a key role in normal body function (e.g. reproduction), and stress may alter the hormone signal or release and prevent normal function (Smith and Dobson 2002). Oestrous behaviour is reduced at high stocking densities, during transport and isolation (Dwyer and Bornett 2004). Transport of ewes in the follicular phase of their cycle can reduce LH pulse frequency and amplitude, and this disruption in gonadotrophin secretion will have a negative effect on fertility (Dobson *et al.* 1999). Chronic stress can result in a decrease in the number of ewes lambing and impair maternal behaviour (Knight *et al.* 1988).

How is reproductive efficiency measured?

Reproductive efficacy can be measured by calculating the percentage of females in oestrus, and the number of live born. These are common measures and do require handling of the animals.

Relevance for the LEI

This indicator is only relevant for breeding animals, and data is only available some time after the animals have arrived at their export destination.

Pregnancy status

There is a welfare risk to animals if they are transported during late stages of pregnancy. Transport of pregnant cattle for journeys longer that two days may increase the risks of clinical ketosis and other metabolic diseases (Glawischnig *et al.* 1972). There are also difficulties to administer veterinary care to pregnant animals under space-restricted conditions. The Farmer Report indicates that this is an issue for rangeland cattle (Farmer 2011). Additionally, pregnant animals in LEI may have a lowered heat stress threshold due to the increased metabolism during pregnancy, along with a decreased capacity to respond to thermal load, increasing their susceptibility to heat stress. Pregnant animals may also have different nutritional requirements not met by feeder diets, and can also suffer from complications related to disease and giving birth under suboptimal conditions of space and hygiene.

How is pregnancy status measured?

Pregnancy testing can determine an animal's physiological state.

Relevance for the LEI

Pregnant animals should not be sourced as feeder/slaughter animals in the LEI and pregnancy status is therefore already monitored as a measure of compliance.

Meat quality and yield

Meat quality can decline with both physical and emotional stress, such as that experienced during transport or from mixing unfamiliar animals together.

Evidence as a welfare measure

Glycogen is required for good meat quality; however, if an animal is stressed, glycogen stores can be depleted. This leads to a decline in acidification of the meat, and the resultant pH of the meat is much higher than ideal, which can lead to an increased risk of spoilage and an abnormal colour which can be difficult to market (Warriss 1990). Feed and water withdrawal can lead to a decrease in yield, as well as increasing time for which animal are transported (Warriss 1990). Bruising is another issue that can lead to a decline in meat yield. Bruised meat looks unsightly and is usually trimmed resulting in a decrease in carcass yield (Warriss 1990). Bruising can occur at any point along the livestock export process.

How is it measured?

Meat quality is usually measured post mortem; however biopsies can be done of muscles on live animals. Parameters to indicate meat quality include marbling, colour (meat and fat), eye muscle area, and muscle pH.

Relevance for the LEI

This measure is usually obtained post-mortem so provides only retrospective information for the animals directly tested. However, combined with environmental indicators, it can provide information as to the consequences of adverse events or management.

Respiration rate (RR) and panting

Respiration rate (RR) can indicate the presence of respiratory disease or heat stress. RR can increase with stress, excitement, disease (e.g. increased respiration rates noted in livestock with pneumonia; Martin 1996) and heat stress, whereby animals increase RR to increase evaporative heat loss (Silanikove 2000).

How is respiration rate measured?

RR and character can be observed and does not require handling of the animal.

Relevance for the LEI

Both heat stress and respiratory disease are problems for the LEI. Heat stress can be quantified based on RR, i.e. low: 40–60 breaths per min, medium high: 60–80, high: 80–120, severe heat stress: above 150 breaths per min in cattle, and above 200 in sheep (Silanikove, 2000). Panting score can be described or scored based on additional signs of open mouth or tongue protrusion.

Acid-base disturbances

The respiratory system assists in maintenance of normal blood pH by altering the rate of CO_2 removal. Slower deeper breathing can result in respiratory alkalosis (Hales and Webster, 1967). However, when RR is high, CO_2 is eliminated faster than the tissues produce it; therefore blood pCO_2 decreases, altering the balance between carbon dioxide and bicarbonate, which is important in maintaining normal pH (Robinson, 2002). Animals under continued heat stress use respiratory mechanisms for heat loss and so cannot reduce their RR in response to changes in blood CO_2 concentrations; therefore bicarbonate is excreted from the kidneys to normalise the ratio of CO_2 to bicarbonate (Robinson, 2002). Excessive loss of bicarbonate can lead to metabolic

acidosis. Both cattle (Beatty, 2005) and sheep (Stockman, 2006) developed a rebound metabolic acidosis after prolonged exposure to high heat and humidity.

How is acid-base disturbance measured?

Blood gas and pH is measured using a blood sample, requiring handling of the animal, which can alter respiratory character and therefore cause an acute change in acid-base values if the animal is stressed. Portable analysing machines are available to test blood immediately after collection. This can be costly. Additionally, other measures such as time of day and environmental temperature need to be used in conjunction to provide enough information for correct interpretation.

Relevance for the LEI

Acid-base disturbances can indicate the duration and severity of accumulated heat load in heat stress but are complicated by other factors, which must be considered in interpretation. Blood sampling requires handling of animals.

Behaviour

Behaviour is the outward expression of the culmination of all physiological processes at that time and includes "the expression of emotions" (Darwin, 1872, cited in (Dawkins 2004)). When behaviour differs from the norm it may indicate that all is not well with the animal. Conversely, behaviour can indicate a positive welfare state. Behavioural observations can vary in importance, and the significance of behaviour is determined by the observer's evaluation of the context in which it occurs (Paul *et al.* 2005). Behavioural assessments of animals are a useful tool available to stockmen (Kent 1997), especially when evaluating large numbers of animals. Since animal welfare includes the expression of both physical and psychological aspects, understanding the subjective experience of animals through their behaviour is a logical first step in welfare assessment. Assessing the behaviour of an animal is done through visual observation and is non-invasive and non-intrusive (Dawkins 2004), and usually does not require specific equipment or training.

Ethograms

Ethograms are a count of specific behaviours that can be used to detect the occurrence or prevalence of abnormal behaviour. Comparing time budgets of behaviours when an animal is in a more natural state with those from another situation may help us understand the impact of any production system on the animal. For example, recording the number and duration of animals lying can indicate whether space and comfort are sufficient (Fisher *et al.* 2003; Schütz *et al.* 2015). In addition, social relationships are an integral part of most mammalian species and play is an indicator of positive welfare because animals are motivated to play if all of their primary needs are met, such as food availability and thermal comfort; while illness, injury and insufficient food supply are associated with the absence of play behaviour (Napolitano *et al.* 2009).

How are ethograms measured?

The frequency of specific behaviours, such as resting, play, vocalisations, ruminating, aggression, investigating, grooming, feeding, drinking and mounting are documented over time. This can be done by directly observing animals, or later by video analysis. However, ethograms do not always incorporate the emotional state of the animal, and measuring, for example, the activity level of an animal does not indicate whether that animal is highly active because it is anxious or because it is curious.

Relevance for the LEI

Ethograms are an easy measure that be carried out by stockpersons within the industry, provided they are aware on what type of behaviour they are looking for. Ethograms can give an indication whether standards, such as stocking rate, are appropriate for the animals in question. Specific abnormal behaviour can be detected using ethogram observations, which can result in removal of animals from a pen, and leads to better welfare although it can be time consuming.

Qualitative Behavioural Assessment (QBA)

Qualitative Behavioural Assessment (QBA) can indicate '*how'* the animal is behaving rather than what it is doing, and does this by looking at how the animal interacts with its environment (Wemelsfelder *et al.* 2001).

Evidence as a welfare measure

Qualitative behavioural assessment (QBA) is based upon the integration by the observer of many pieces of information from the animal (Wemelsfelder *et al.* 2000; Wemelsfelder *et al.* 2001). QBA is a dynamic process and the assessment is not just a snapshot in time but can be done over any time period (Wemelsfelder *et al.* 2000; Wemelsfelder *et al.* 2001). This allows QBA to also capture fluctuations in the behaviour of animals; for example, a ewe that has lost its lamb may be said to be 'agitated' and 'distressed' but when she has found her lamb she may be 'calm' and 'relaxed' (Wemelsfelder *et al.* 2001). QBA focuses on the whole animal, and behaviour is no longer just a physical movement but is evaluated in a larger context with expressive and psychological quality that assesses both positive and negative emotional states (Wemelsfelder 1997, 2007).

There is high inter-observer reliability (i.e. observers achieved significant agreement in their assessment behaviour), and observers could repeat their assessment with high accuracy (Fleming *et al.* 2016). QBA has been used for behavioural assessment of cattle, sheep and goats (reviewed by Fleming *et al.* 2016). There are also meaningful relationships between the qualitative and quantitative behavioural measures, and correlations with relevant physiological parameters.

How is QBA measured?

QBA allows the use of descriptors that have expressive connotations (e.g. 'calm', 'anxious, 'timid, and 'confident') and so it can be used to assess how an animal is experiencing a situation and directly evaluate its welfare (Wemelsfelder and Lawrence 2001). Terms incorporate the dynamic and expressive nature of the behaviour, and their use allows people with a less scientific vocabulary to describe what they see in terms they can understand (Wemelsfelder 1997). The statistical analysis of the data generated disregards the anthropomorphic connotations and sorts the terms into a relative rating between individuals or groups. No training is necessary to use QBA; however, an understanding of the statistical methods and interpretation of the results is needed. QBA can be performed using video footage collected of animals, or during live observation of the animals.

Relevance for the LEI

QBA can be used on all species and in all areas of the LEI supply chain.

Stereotypy

Stereotypical behaviour indicates that an animal is either not coping or is attempting to cope with its environment/situation. Stereotypical behaviour, such as bar-biting, tongue-rolling, and route-tracing, are a repeated sequence of movements that appear to have no obvious purpose, and often occur in animals that lack control of their environment, especially in animals that are

frustrated, threatened or bored (Broom 1991). Some stereotypies may help animals to cope with their environment; however, there is little evidence to support this and therefore stereotypic behaviour may just be a useless waster of energy (Broom 1991).

How are stereotypies measured?

In order to determine whether an animal is displaying stereotypic behaviour, it is important to understand what normal behaviour is for a species and to observe individual animals frequently. This can be time consuming and often difficult when housing thousands of animals for export.

Relevance for the LEI

Stereotypical behaviour is common in confined animals, and can be used to indicate boredom in feedlots and during sea transport. Enrichment to the environment can improve animal welfare.

Emotional state

Emotions can be measured by physical responses to salient stimuli, such as the increased HR and perspiration accompanying fear. Emotion is the psychological and physiological reaction of an individual's state of mind when interacting with biochemical (internal) and environmental (external) influences and is associated with mood, temperament, personality, disposition and motivation (Myers 2004). It is believed that animals in a negative state of mind will show enhanced reaction to a threatening stimuli (Mendl *et al.* 2009). Paul *et al.* (2005) believe that measuring emotional reactivity in animals has advantages over interpreting physiological (such as hormone concentrations) and behavioural (such as ethograms) measurements, because emotional reactivity is based on how a person might feel in a similar situation. However, not all animals in a negative state of mind will have enhanced reactions to negative stimuli; some animals may become less reactive. Exposing animals to a novel environment is known to lead to changes in emotional responses, such as fear or stress reactions (Stephens and Toner 1975; Moberg and Wood 1982; Boissy 1995; Désiré *et al.* 2004). Novelty can be a new object, a new type of feed, or a new experience, such as shearing or transport.

How is emotional state measured?

Emotions cannot be directly measured in animals; however, approach and avoidance behaviour, freezing, attacking and exploratory behaviour can be used to gauge how unpleasant or pleasant a stimulus is (Paul *et al.* 2005). Vocal and facial expressions can also indicate emotions (Watts and Stookey 2000); white eye exposure in cattle (widened eyes showing the sclera of the eye) can indicate a level of frustration (Sandem *et al.* 2002). Posture of head, tail and ears can indicate emotion and pain (Rutherford 2002; Fitzpatrick *et al.* 2006).

Relevance for the LEI

Measuring the emotional state in animals needs carefully designed methodology, and may not be practical in the LEI.

Table A1. Animal-based measure that are direct indictors of animal welfare

▒ reflects a welfare risk for LEI ● practical measure ▨ Currently used in LEI	Loading[a]	Truck	Ship	Plane	Feedlot (Aus)[b]	Feedlot (OS)	Breeder (OS)	Slaughter	Requirements: Trained personnel[c]	Requirements: Equipment[d]	Requirements: Threshold[e]	Practicality of measurement: Animal Handling[d]	Practicality of measurement: Invasiveness[f]	Practicality of measurement: Cost[g] (above operating costs)	Practicality of measurement: Time[h]	Notes
Body temperature			●		●	●	●		TS/V	Y	Outside normal	Y	H	$	SI	
Heart rate			●		●	●	●		TS/V	N	Outside normal	Y	H	X	SI	
Heart rate variability			●		●	●	●		TS/V	Y	Outside normal	Y	H	$$$	LD	Animal needs to wear monitor
Hormones / haematology			●		●	●	●	●	TS/V	Y	Outside normal	Y	H	$$$	MD	Environmental conditions and stress can affect blood samples and results
Respiration rate / panting	●	●	▨		●	●	●	●	N	N	Outside normal	N	N	X	SI	
Acid-base disturbances			●		●	●	●	●	TS/V	Y	Outside normal	Y	H	$$$	MI	Environmental conditions can affect blood samples and results
Physiological status	●	●	●	▨	●	●	●	●	TS/V	Y	ASEL	Y	M	$$$	MI	
Digestion	●	●	●	▨	●	●	●	●	N	N	NE	N	N	X	MI	
BCS			▨		▨	●	●	●	TS	N	ASEL	Y	L	X	SI	
Weight			●		▨	●	●	●	N	Y	ASEL	Y	L	$	SI	
Reproductive efficacy							●		N	N	NE	Y	L	X	LI	
Meat quality / yield								●	TS	Y	MSA	N	N/A	$$$	LD	Only provides retrospective results
Morbidity & health:																
Parasites	▨		▨		▨	●	●	●	TS/V	N	ASEL	Y	L	X	MD	Inspection of skin or collection of faeces
Injury / wounds	▨		▨		▨	●	●	●	TS/V	N	ASEL	N	L	X	SI	

▒ reflects a welfare risk for LEI ● practical measure ▨ Currently used in LEI	Loading[a]	Truck	Ship	Plane	Feedlot (Aus)[b]	Feedlot (OS)	Breeder (OS)	Slaughter	Requirements			Practicality of measurement				Notes
									Trained personnel[c]	Equipment[d]	Threshold[e]	Animal Handling[d]	Invasiveness[f]	Cost[g] (above operating costs)	Time[h]	
Infection	●		●		●	●	●	●	TS/V	Y	ASEL	Y	H	$$$	MD	Costly and time consuming only if blood test required
Lameness	●		●		●	●	●	●	TS	N	ASEL	N	N	X	SI	
Pain	●		●		●	●	●	●	TS/V	N	NE	N	N	X	SI	
Sneezing	●	●	●	●	●	●	●	●	N	N	NE	N	N	X	SI	
Coughing	●	●	●	●	●	●	●	●	N	N	ASEL	N	N	X	SI	
Nasal mucous	●		●		●	●	●	●	N	N	ASEL	N	N	X	SI	
Faeces structure	●		●		●	●	●	●	TS/V	N	ASEL	N	N	X	SI	
Downers	●	●	●		●	●	●		N	N	ASEL	N	N	X	SI	
Behaviour:																
Emotional state	●	●	●	●	●	●	●	●	N	N	N/A	N	N	X	MI	
Ethograms	●	●	●	●	●	●	●	●	TS	N	N/A	N	N	$	LD	May require multiple observations over time, and statistical analysis
QBA	●	●	●	●	●	●	●	●	TS	Y	N/A	N	N	$	MD	Statistical program required Repeated observations are required
Stereotypy			●		●	●	●		N	N	N/A	N	N	X	SI	May require multiple observations over time
Mortality	●	●	●	●	●	●	●		N/V	N	ASEL	N	N	$$	MI	Vet required for post mortem

Key for Appendix Tables:

[a] includes unloading and holding yards

[b] includes sourcing animals

[c] V = Vet, TS = Trained Stockperson, TA = Trained Assessor, N = None

[d] Y = Yes, N = No

[e] NE = none established

ASEL = Australian Standards for the Export of Livestock

MO 43 = Australian Government Marine Order 43 (Cargo and cargo handling – livestock) 2006

LAR = International Air Transport Association, Live Animal Regulations

LTL = Australian Animal Welfare Standards and Guidelines Land Transport of Livestock (except WA)

ESCAS = Exporter Supply Chain Assurance Scheme

S = scientific recommendations

COP = Code of practice

ASDWA = Australian Sheepdog Worker's Association animal welfare code

OIE = Office International des Epizooties

MLA = Meat and Livestock Australia

N/A = not applicable

[f] L = Low, M = medium, H = High, N = non-invasive

[g] $$$ = high, $$ = medium, $ = low, X = no cost

[h] S = <1 minute, M = <10 minutes, L = >10 minutes, I = Instant results, D = Delayed results

Appendix 2: Environmental-based measures that indicate welfare risk for animals

2a: On ship

The welfare of animals is dependent upon the environment and how animals interact with their environment. Environmental conditions can vary greatly throughout the live export process, with both cool and hot climates in Australia throughout the year, and hot, often humid conditions in export destinations, such as the Middle East, and extremely cold environments in northern winters. On board ship, temperature is often high as result of environmental temperature and the production of body heat from the livestock on-board. Humidity is also high as a result of environmental humidity plus moisture from livestock (MAMIC 2001). Environmental conditions can indicate a risk to welfare, and some thresholds exist for temperature, humidity and ammonia, above which it is considered that the conditions post a health and welfare risk to the animals.

Ventilation

Ventilation serves to maintain environments appropriate to the physiological needs of livestock (MAMIC 2001). Ventilation is important to remove air pollutants (such as ammonia and carbon dioxide, and dust) and maintain air quality. Ventilation in feedlots and on trucks is usually by natural means, whereas on board ship and aeroplane, ventilation is by mechanical means.

Ammonia

High ammonia concentrations can irritate the eyes causing conjunctivitis, and upper respiratory tract leading to coughing (particularly on hot days) and rapid breathing. The small airways of the lower respiratory tract become inflamed after exposure to ammonia (Costa *et al.* 2003). Environmental conditions in Australia, on board ship, and in the Middle East and Asia are favourable for ammonia gas production. Frequent changing of bedding and adequate ventilation can bring fresh air and remove ammonia gas (Costa *et al.* 2003); however, low air turnover and ventilation dead spots can be issue on board ships (MAMIC 2001), and it can be impractical and stressful to the animals to frequently hose down ship pens, therefore careful management of the pad is required.

Temperature and humidity

Livestock are sensitive to environmental temperature and humidity, and high temperatures and humidity, and prolonged time spent in these conditions, result in accumulated excessive heat load, which can be fatal for the animal (Stockman *et al.* 2011).

Noise

All animals can be stressed by noise, such as banging gates, machinery, people yelling and dogs barking (Grandin 1980). Sudden and unexpected sounds elicit the fear response in livestock and can cause animal to baulk (Waynet *et al.* 1998). Noise may affect the time it takes to move animals from one location to another, and how easy the animals are to move.

Smell

Livestock are able to detect other livestock that are stressed from the smell of their urine and faeces, and can also detect stress in blood at the point of slaughter (Boissy *et al.* 1998).

Lighting

Lighting is important to be able to inspect animals at all points along the livestock export supply chain. Lighting should be uniform wherever possible because animals can baulk when moving from a well lit area to a dark area.

Shade

Tucker *et al.* (2007a) found that dairy cattle spent significantly more time under shade with high levels of protection from solar radiation (50 % - 90 %) compared to shade with low levels of protection from solar radiation (25 %), and as average ambient temperature increased, so did total use of the 50 % and 90 % shade structures. Tucker *et al.* (2007a) also reports that cows with more protection from solar radiation had lower body temperature. Sheep use shade if it is available, otherwise they stand about in groups, shading their heads under the flanks or between the hind legs of adjacent lambs rather than lying down (Schreffler and Hohenboken 1980). Cattle seek shade when the weather is hot (Blackshaw and Blackshaw 1994). It is clear that shade is important for livestock, especially in climates with high solar radiation and high temperatures.

Shelter

Livestock in the LEI can experience extremes of weather with temperatures ranging below 0^{o}C to above 46^{o}C in Australia (Bureau-of-Meterology 2014) and above 50^{o}C in the Middle East (Hasanean 2014). In addition to the hot temperatures, livestock can also encounter rain, wind and dust storms. Livestock seek to reduce the amount of body surface area available to the elements when the temperature is low or weather conditions are adverse (Tucker *et al.* 2007b). Animals will also seek shelter from high solar radiation, while cattle housed in feedlots in Europe during the winter may require some shelter from the extreme cold. In all climates, shelter construction is important to limit the build-up of faeces and urine, which can contribute to adverse environmental conditions, such as increased local humidity and ammonia.

How are environmental conditions measured?

Ventilation on ship is measured calculating the rate of air exchange based on supply airflow rate to the pen/deck space volume (MAMIC 2001). Ammonia concentration in the environment can be measured using an ammonia meter. Temperature and humidity are measured using various thermometers and loggers, which can provide an immediate reading or be downloaded and analysed retrospectively; wet bulb temperature is a commonly used measure incorporating dry bulb temperature and humidity, while other environmental indices may be useful in situations where radiation and air flow also impact on thermal load. Noise is measured using a decibel meter. Lighting can be measured using a light meter, and direct observation of an area to determine uniform lighting. Shade and shelter can be measured be determining area of shade and shelter required for the stocking rate; degree of shade can be measured using infrared thermometers.

Relevance for the LEI

Environmental factors influence the welfare of animals during shipping, and they can be measured and controlled, so they are highly relevant for the LEI.

2b: Land transport

Transport is recognised as a stressful experience among animals (Fraser 1979; Das *et al.* 2001). Sartorelli *et al.* (2003) found that transport was more stressful than isolation in sheep.

Driving conditions, balance and slipping/falling

Acceleration, braking, cornering, stopping, gear changes, uneven road surface and vibrations affect the movement of the vehicle and in turn the ability of the animals onboard to maintain their balance and posture (Cockram *et al.* 2004). Cockram *et al.* (2004) found that more than 80 % of the losses of balance of sheep during a number of experimental transport trips could have been caused by a driving event. Sheep had fewer losses of balance, increased lying behaviour, more rumination and fewer disturbances on a motorway journey compared with single carriageway driving, and that this was most likely due to fewer driving events occurring on the

motorway (Cockram *et al.* 2004). Some of the above driving events can occur together, e.g. acceleration and gear changing, or braking and cornering, and the chances of an animal losing its balance increases with two or more events occurring simultaneously. Ruiz-de-la-Torre *et al.* (2001) found that sheep had greater concentrations of cortisol and increased heart rate when they were transported with frequent changes in acceleration compared with smooth roads with few changes in acceleration.

Journey Plan

A journey plan is important to maximise the welfare of livestock during transport, including during lairage, loading and unloading. There are a number of factors to consider in a journey plan:

- *Fit to load* - Animals must be fit to load to enter the livestock export supply chain. If an animal is already compromised in its welfare with existing injury or disease then it is a further welfare risk to expose them to additional stressors such as transport. If an animal becomes sick or injured during transport, protocols and provisions should be in place to deal with those animals.
- *Journey time* – Livestock will usually lose weight during land transport (which increases with increasing journey length) due to feed and water restrictions, which can cause hunger and dehydration, as well as experience fatigue on longer journeys (Villa *et al.* 2009).
- *Weather* - Extremes of thermal environment can cause stress to livestock, especially if a vehicle will be stationary for any period of time, because lack of sufficient air flow to limit increases in temperature, are often encountered on stationary vehicles loaded with animals (Fisher *et al.* 2005).

How are the effects of land transport measured?

Driving conditions can be measured by direct observation or the use of an accelerometer in the vehicle. Balance, slipping and falling can also be measured by direct observation or by analysis of video footage collected at the commencement of a journey. Journey plans should be completed and available for inspection. Numbers of injuries and animals affected can be assessed at unloading.

Relevance for the LEI

Injuries during land transport are of economic and welfare concern both immediately, and because of the impact on subsequent performance of the animals throughout the export chain.

Appendix 2c: Facilities specific based measures that indicate welfare risk for animals

The design, construction and hygiene of facilities are important to reduce the risk of injury and spread of disease, and promote the well-being of animals by allowing species-characteristic behaviour and preventing injury and disease (Tuyttens 2005). Design of pens, yards and races are important to ensure that animals are safe from predators and the animals cannot escape. Design is also important to ensure that animals are easily moved from one location to another with minimal stress.

Evidence as a welfare measure

Carrier design

Ventilation is important to remove ammonia and carbon dioxide and provide fresh air to the animals, as well as maintain a comfortable thermal environment. Poor suspension can result in excessive vibrations which can lead to muscle fatigue, physical stress and an increased fear reaction in livestock (Van De Water *et al.* 2003). Livestock are prone to slipping and falling during transport so non-slip flooring is essential to reduce and/or prevent slipping and falling. In

addition, cattle rarely alter their position during transport, and prefer to align their bodies at right angles to the direction of travel, possibly to improve balance (Tarrant 1990), therefore vehicles should allow for animals to orient themselves in a way beneficial for their welfare.

Ramp/race, holding yard and pen condition and design

Unloading chutes should be wide and straight to provide a clear, unimpeded path, and allow cattle to walk in single file (Grandin 1980) and sheep to walk side by side to maximise social needs (Fraser and Broom 1990). Loading chutes should have high, solid sides to prevent animals from seeing out and a narrow curved single file chute is the most efficient (Grandin 1980). Ramp incline should be tailored to each species. Straight raceways can cause animal to baulk because they perceive a dead end up ahead (Grigor *et al.* 1998). Additionally all species of animals may baulk and refuse to move when they see things in the race that scare them such as sparkling reflections, dangling chains, moving people or equipment, shadows or water dripping, or even air blowing down the race into the faces of approaching animals (Grandin 1996). Animals also baulk and may refuse to enter a dark place. They have a tendency to move from a darker place to a brighter place (Grandin 1996). Shields can be installed to prevent animals from seeing moving people or moving objects up ahead and adding a light to illuminate a race entrance or moving a lamp to eliminate a sparkling reflection will often improve animal movement (Grandin 1996). Round yards can help prevent animals running in fences and crowding in corners.

A floor surface that is too rough can cause wear of hooves and grazes on other parts of the body, while other floors may be too slippery and cause animals to fall. Floors need to be easy to clean to prevent the spread of disease, and allow for urine and faeces to be eliminated without too much build up.

Hygiene of facilities

The stress of transport can cause some animals, already infected by disease, to shed large numbers of pathogens, which will contaminate the vehicles and general lairage environment (including races and ramps) (Collins and Wall 2004). Therefore sanitation of trucks, ships and aeroplanes, and races and yards is important to prevent the spread of diseases from one group of animals to another. Flow and mixing of animals through facilities should also be considered, to limit the exposure of naïve animals entering the facility to pathogens shed by stressed animals on exit.

How is it measured?

Design and condition of facilities can be measured against set standards developed for the LEI. Hygiene can be assessed by observation and strategic sampling for pathogen load, as well as by outcome measures, such as the incidence and prevalence of infectious diseases.

Relevance for the LEI

Appropriate design and construction of facilities can increase productivity and reduce welfare risks.

Table A2. Environmental-based measures that indicate welfare risk for animals

▒ reflects a welfare risk for LEI ● practical measure ▨ Currently used in LEI	Loading[a]	Truck	Ship	Plane	Feedlot (Aus)[b]	Feedlot (OS)	Breeder (OS)	Slaughter	Requirements			Practicality of measurement				Notes
									Trained personnel[c]	Equipment[d]	Threshold[e]	Animal Handling[d]	Invasiveness[f]	Cost[g] (above operating costs)	Time[h]	
Ventilation		▨●	▨●	▨●	▒●	▒●	▒●	▒●	N	Y	MO 43 (Ship) LAR (plane) LTL (truck)	N	N	$	MI	
Ammonia			▨●	▨●	▒●	▒●	▒●		N	Y	S	N	N	$	MI	
Temperature & humidity	▒●	▒●	▨●	▨●	▒●	▒●	▒●	▒●	N	Y	S	N	N	$	MI	
Weather	▒●	▒●	▨●	▨●	▒●	▒●	▒●		N	Y	NE	N	N	$	MI	Needs to be measured at multiple locations and at multiple time points
Noise	▒●	▒●	▒●	▒●	▒●	▒●	▒●	▒●	N	Y	NE	N	N	$	MI	
Smell	▒●	▒●	▒●	▒●	▒●	▒●	▒●	▒●	N		NE	N	N	$	MI	
Lighting	▒●	▒●	▨●	▨●	▒●	▒●	▒●	▒●	N	Y	MO 43 (Ship) LAR (plane)	N	N	$	MI	
Shade	▒●				▒●	▒●	▒●		N		NE	N	N		MI	
Shelter	▒●	▒●			▒●	▒●	▒●	▒●	N		NE	N	N		MI	

Table A2 cont... Transport specific based measures that indicate welfare risk for animals

▒ reflects a welfare risk for LEI ● practical measure ⧅ Currently used in LEI	Loading[a]	Truck	Ship	Plane	Feedlot (Aus)[b]	Feedlot (OS)	Breeder (OS)	Slaughter	Requirements			Practicality of measurement				
									Trained personnel[c]	Equipment[d]	Threshold[e]	Animal Handling[d]	Invasiveness[f]	Cost[g] (above operating costs)	Time[h]	Notes
Driving conditions		●	●	⧅					N	Y	LTL (truck)	N	N	$	LD	Accelerometers and video cameras can be used instead of direct observation, and analysed post journey
Balance		●	●	●					N	N	NE	N	N	$	LI	
Slipping/ falling	●	●	●	●					N	N	NE	N	N	$	LI	
Journey/ loading plan	●	⧅	⧅	⧅					TS	N	ASEL (land transport)	N	N	X	LI	Air transport loading plan only required for **cattle** over 650 kg

Table A2 cont... Facilities specific based measures that indicate welfare risk for animals

▒ reflects a welfare risk for LEI ● practical measure ▨ Currently used in *export industry*									Requirements			Practicality of measurement				
	Loading[a]	Truck	Ship	Plane	Feedlot (Aus)[b]	Feedlot (OS)	Breeder (OS)	Slaughter	Trained personnel[c]	Equipment[d]	Threshold[e]	Animal Handling[d]	Invasiveness[f]	Cost[g] (above operating costs)	Time[h]	Notes
Carrier/crate/pen conditions & design		●	▨	▨	●	●	●		AI	N	MO 43 (ship) LAR (plane)	N	N	X	LI	
Hygiene of carrier/crates		●	●	●					TS	Y	NE	N	N	$	LD	Samples required for analysis of microbes
Race/ramp design & condition	●	●	●	●				●	TS	N	NE	N	N	X	LI	
Design & condition of holding yards	●							●	TS	N	NE	N	N	X	LI	

Appendix 3: Resource-based measures that indicate welfare risk for animals

Access to clean feed and water

Livestock in a production system rely on the provision of certain resources, such as food, water, bedding and enrichment, as well as the quality and quantity of such resources. Lack of water can indicate a risk of dehydration, while a lack of feed can indicate a risk of loss of body condition and inappetence. Conversely, too much or the wrong type of feed can result in bloat.

Highly motivating behaviours, such as feeding, are rewarding and therefore being deprived of them is a severe stressor (Boissy *et al.* 2007). Finding and consuming feed and water is an appetitive behaviour (an instinctive physical desire) and has been associated with high arousal positive motions (Keeling 2009). If feed is not available then self-rewarding behaviour may manifest, such as increased locomotion, sexual activity or self-grooming (Boissy *et al.* 2007).

Adequate nutrition is not only necessary for healthy growth and function of animals but can have an influence on the temperament and emotionality of animals. Hernshaw and Morris (1984) found that cows given a medium level of nutrition were rated as less calm and still than cows given a high or low level of nutrition.

Deficiencies can also affect the health and welfare of animals; selenium/Vitamin E deficiency results in white muscle disease, iron deficiency has been associated with reduced emotional response (Barsideh *et al.* 1995) and zinc deficiency associated with an increase in emotionality (Black 1998).

Feed and water troughs often contain faeces that contaminate the feed and water with a number of disease causing organisms (Collins and Wall 2004). Animals may be exposed to high pathogen load, or may be reluctant to feed and drink from unhygienic feed and water troughs leading to dehydration and hunger.

How is access to clean feed and water measured?

Access to feed and water can be recorded through comparison of numbers of animals with linear meters of available trough space. Consumption is usually measured on a group level and averaged for individual animal by the difference between the volume of feed and water given and the volume remaining after a specific period of time. If feed and water is given *ad libitum*, RFID technology can be used to log individual animal activity at troughs, although this will not give actual consumption values. Hygiene of feed and water troughs can be measured by sampling the contents for pathogens.

Inappetence is a cause of mortality in sheep. If animals that are not eating sufficiently can be identified before they undergo long distance transport, mortality rates may be reduced. Existing requirements in the LEI are to provide adequate nutrition and potable drinking water (ASEL and MO43). These existing regulatory measures could be developed as a resource-based welfare indicator that could include trough space and access, quality and availability, consumption, and hygiene.

Time off feed and water, and time to resume feeding and drinking

Feed and water withdrawal (FWD) can increased risk of dehydration, alter rumen fermentations, blood chemistry and activate the HPA axis (i.e. stress response). Short-term food deprivation is detrimental to ruminants (Cole and Hutcheson 1988), and transport can further exacerbate the adverse effects of fasting. This is possibly due to changes in rumen fermentation and blood chemistry (Crookshank *et al.* 1979). Hogan *et al.* (2007) found that FWD is associated with sheep having increased concentrations of plasma cortisol.

FWD differentially affects animals depending on their species, age, physiological state, and pre-transport access to feed and water (Fisher *et al.* 2009). Journey conditions can also influence how

animals cope with FWD during transport. Cold conditions, such as during a period of decreasing day length (July/winter) can exacerbate the effects of feed withdrawal because animals are mobilising energy reserves to maintain body temperature, while hot conditions, such as during a period of decreasing day length (January/summer) can increase the risk of dehydration (Fisher *et al.* 2009).

Animals arriving at a feedlot or on board ship have undergone some degree of stress through transportation to each location. A study by Barnes *et al.* (2013) found that it took five days for at least 97 % of sheep to spend more than 30 minutes a day at feed troughs at an pre-embarkation registered feedlot. Disturbances to the animals along the livestock export supply chain can interrupt feeding patterns. There is potential for some animals never to return to feeding; however, more research is required in this area.

How is time off feed/water measured?

Time off feed and water is measured from the time animals are mustered at their origin before transport. Time to resume feeding and drinking can be measured by direct observation of animals, or by using RFID technology to log activity of individual animals at the troughs.

Relevance for the LEI

More research is required to identify the effects of FWD which is directly relevant to the LEI.

Table A3. Resource-based measures that indicate welfare risk for animals

▒ reflects a welfare risk for LEI ● practical measure ▨ Currently used in LEI	Loading[a]	Truck	Ship	Plane	Feedlot (Aus)[b]	Feedlot (OS)	Breeder (OS)	Slaughter	Requirements			Practicality of measurement				
									Trained personnel[c]	Equipment[d]	Threshold[e]	Animal Handling[d]	Invasiveness[f]	Cost[g] (above operating costs)	Time[h]	Notes
Access to feed			▒●	▒●	▒●	●	●		N	N	ASEL	N	N	X	MI	
Feed consumption			▒●		●	●	●		N	Y	NE	N	N	X/$$$	LD	Weighed and measured, or automated tracking of animals required if fed *ad libitum*.
Access to water		▒●	▒●	▒●	▒●	●	●		N	N	ASEL	N	N	X	MI	
Water consumption			▒●		●	●	●		N	Y	NE	N	N	X/$$$	LD	Volume measured, or automated tracking of animals required if *ad libitum* supply.
Time off feed and water	▒●	▒●		▒●				▒●	N	N	ASEL (water only)	N	N	X	LI	
Time to resume feeding & drinking			▒●		▒●	●	●		N	N	NE	N	N	$/$$$	LD	Can be done by direct observation or automated tracking
Hygiene of feed and water troughs			▒●	▒●	▒●	●	●		N	Y	NE	N	N	$	LD	Samples required for analysis of microbes

Appendix 4: Management based measures that indicate welfare risks for animals – Animal management

Appropriate management of animals can indicate a reduced risk of poor welfare.

Appropriate sourcing (including breed, genotype, size, age)

The response of livestock to environmental conditions can vary with breed, for example, *Bos taurus* cattle have a lower heat stress threshold than *Bos indicus* cattle (MAMIC 2001). Animals with increased body fat, increased skin rolls and long wool length (in sheep) are also at higher risk of excessive accumulated heat load under hot and humid environmental conditions. Horned cattle, goats and sheep can cause injury to themselves, other animals, and stockman. Time of year that certain types of animals are sourced is also important. Norris and Richards (1989) found that death rates aboard ships were greater in the second half of the year. These findings were confirmed in a later study by Higgs *et al.* (1991), who found shipboard deaths doubled between April and August and that, of the inappetent sheep, fatter sheep had greater death rates than thin sheep. There is a property of origin effect on mortality risk, and Norris et al. (1989) found that half the shipboard sheep mortalities occurred in 25% of 133 lines of sheep in the 5 cohorts studied; there are also current restrictions regarding the sourcing of pastoral animals for live export at certain times of year.

Mixing

Mixing of unfamiliar animals together is often stressful because animals need to establish new associations and hierarchy, which can result in aggressive behaviour. Goats, for example, establish a hierarchy within the herd, and mixing of unfamiliar animals alters the social hierarchy causing an increase in aggressive behaviour (Andersen and Bøe 2007) which can decrease 24 h after mixing (Alley and Fórdham 1994). If stress is severe, and animals are subjected to increased pathogen exposure from mixing, then animals may be at a higher risk of morbidity and mortality.

Stocking rate

Sufficient space is needed for animals to move about, stand up, lie down, and access feed and water supplies, as well as access jets of supply air. High stocking rates can contribute to increased environmental temperature and humidity, and air pollutants such as ammonia and carbon dioxide, especially during transport. During transport, overloading and underloading can increase bruising, lower carcass weight and increase the risk of injury for animals (Eldridge and Winfield 1988). For example, if loading density is too low, especially in trucks, animals are forced to continuously balance and frequently fall; however, if loading density is too high, animals that do fall may be unable to stand again (Cockram *et al.* 1996; Hall and Bradshaw 1998). In feedlots, inappropriate stocking rate can leading to crowding. Crowding occurs when animals are forced into the personal spaces of others, and can result in aggression which animals are unable to find space to move away from. This can cause injury and stress to the animals.

Vaccination status

Vaccinations are important for herd or flock health, because they can help prevent common endemic livestock diseases, leading to improved animal health, welfare and productivity.

Isolation/separation

Isolation and separation from familiar animals are psychological stressors for animals (Watts and Stookey 2000; Carbajal and Orihuela 2001). However, isolation and separation may be necessary if an animal is suspected of having a disease that is easily transmitted to other animals.

Hospital pen

Hospital pens are used to segregate animals with injury or disease (that can be treated without further compromising the welfare of the animal) from other animals, to maximise the welfare of the injured/diseased animal welfare by protecting them from others, and the welfare of the rest of the herd/flock by preventing the spread of disease.

Previous experience

An animal's previous experience and learning can affect how it will react to a particular event (Grandin 1997; Hicks *et al.* 1998). An animal which is familiar with a situation may have reduced physiological reactivity compared to an animal encountering it for the very first time (Pfister 1979). An animal may always remain 'calm' or 'flighty' but the degree to which the animal shows these traits may alter depending on its previous experience. For example, taming may reduce the behavioural and physiological reaction of a flighty animal, but it does not necessarily change its temperament (i.e. the fact that it is a flighty animal compared to calmer animals). Differences between the basic predispositions of individuals in a group of animals will still be reflected in differences in their behavioural responsiveness whatever their experience.

Traceability

Traceability of individual animals and of herds/flocks is important for disease control and animal welfare. If an animal or group of animals is determined to be the source of a disease outbreak, it is essential to know where those animals have been, which other animals they have come into contact with, and their current location. This is important to safeguard the spread of disease and the welfare of animals at risk from the disease.

Rejections

Animals must be deemed fit-to-load prior to embarking on any transport. Animal welfare is already compromised during transport due to stress and any animals with increased susceptibility, such as those with evidence of disease, injury or other health issue, should not be transported.

Slaughter method

The method in which animals are killed can affect their welfare (and meat quality). Welfare requirements dictate that animals should be insensible to noxious, potentially painful, stimuli during slaughter (Anon 2011). Pre-slaughter stunning is used to induce rapid desensitisation of animals to the pain of slaughter, which renders them unconscious which also reduces the reflexes which occur when the throat is cut that can results in injury to both animal and abattoir personnel (Anon 2011). In some religions, stunning is not acceptable, and others only permit stunning if it is reversible (i.e. the animal can potentially regain consciousness) because they believe the throat cut should be the cause of death (Anon 2011). Restraint of the animal during slaughter is also a welfare concern, with higher cortisol levels, indicating a higher degree of stress, cattle inverted prior to slaughter compared to cattle that remained standing prior to slaughter (Dunn 1990). ESCAS has collated information on pre-slaughter stunning (Department of Agriculture 2015) which promises to make substantial differences to public perception.

Time at feedlot

Livestock need to acclimatise to potentially unfamiliar feed that they encounter at domestic export feedlots before being transported overseas. Based on research by (Barnes *et al.* *N 2013; Barnes *et al.* Unpublished) it takes five days for at least 97 % of sheep to eat for more than 30 minutes a day at an export feedlot. This is supported by Chapple *et al.* (1987) who found that sheep previously kept on pasture took up to 3 days to start to eat hay when penned inside.

Therefore it is important to allow this time for livestock to acclimatise. Under hot environmental conditions, animals may accumulate heat load over time, and therefore longer time in such conditions brings a greater risk of succumbing to fatal heat stress. Therefore, it is important to acknowledge the limitations of the animals in their environment.

Use of electric prods and dogs

The current from an electric prod is enough to cause pain in animals, which stimulates movement away from the pain, and therefore towards the direction the stockperson intended to move the animals. Many argue that the use of prods is harmful to animals, while others argue that it is short term pain that is quickly forgotten.

Dogs are efficient in moving livestock from one location to another; however they can cause injury to livestock by hock and tail biting and may cause fear in the stock.

How are animal-based management issues measured?

Animal management based measures can be compared to existing standards to determine compliance.

Relevance for the LEI

All of the above animal management measures are defined in ASEL and therefore are relevant to the LEI.

Table A4. Management-based measures that indicate welfare risks for animals – Animal management

▒ reflects a welfare risk for LEI ● practical measure ⧅ Currently used in LEI	Loading[a]	Truck	Ship	Plane	Feedlot (Aus)[b]	Feedlot (OS)	Breeder (OS)	Slaughter	Requirements			Practicality of measurement				
									Trained personnel[c]	Equipment[d]	Threshold[e]	Animal Handling[d]	Invasiveness[f]	Cost[g] (above operating costs)	Time[h]	Notes
Sourcing of animals	●	●	●	●	●	●	●	●	TA	N	ASEL	Not required for inspection of management practices	None	$ Cost for inspection of industry	LD	
Mixing	●	●	●	●	●	●	●	●	TA	N	ASEL					
Stocking rate	●	●	●	●	●	●	●		TA	N	ASEL					
Vaccination status					●	●	●		TA	N	NE					
Isolation/ separation	●	●	●	●	●	●	●	●	TA	N	ASEL					
Hospital pen			●		●	●	●		TA	Y	MO 43 (ship only)					
Previous experience	●	●	●	●	●	●	●	●	TA	N	NE					
Traceability (individual)	●	●	●	●	●	●	●	●	TA	Y	ASEL ESCAS					Only applicable for **cattle** ESCAS – no foreign jurisdiction
Traceability (flock/herd)	●	●	●	●	●	●	●	●	TA	Y	ASEL ESCAS					Applicable to cattle, sheep and goats ESCAS – no foreign jurisdiction
Rejections	●	●	●	●					TA	N	ASEL					
Slaughter method								●	TA	Y						
Time at feedlot					●	●			TA	N	ASEL (Aus only)					
Electric prod use	●	●	●	●	●	●	●	●	TA	N	ASEL COP					Standards for loading and transport only
Use of dog	●	●			●	●	●		TA	N	ASEL ASDWA					ASEL for loading and transport only ASWA for general dog use

Appendix 5: Management based measures that indicate welfare risks for animals – Industry management

Industry management based measures can indicate a reduced risk of animal welfare if the industry complies with regulations.

Evidence as a welfare measure

License and Accreditation

A license is important to ensure that the owner of the export business has not been convicted of any crime that is detriment to the livestock industry (such as animal cruelty), and is financially able to operate within the industry. Accreditation implies that the industry has goals, and that exporters who are part of the accreditation program meet nationally endorsed standards in the profession. Accreditation is a form of assessment and evaluation that can lead to improvements. Licensing and accreditation can improve animal welfare standards by holding people/companies accountable for their actions. This is especially important if the welfare risk does not meet the requirements for it to be punishable under the Animal Welfare Act.

Assurance schemes

Assurance schemes have become popular in the UK to address the public concern for animal welfare. There are multiple different farm assurance schemes in the UK; however, consumers are confused by the information generated from these different schemes (Anon 2012). Many of these schemes use multiple indicators to determine farm animal welfare, including the RSPCA Freedom Food Scheme. However, a review of dairy cattle farms both within (28 farms) and outside (25 farms) the RSPCA scheme was performed in the winter of 2000/2001 and the farms in the scheme had better results for 12 welfare indicators, however, they had poorer welfare for 8 welfare indicators. This highlights the need for well designed, implemented, and monitored welfare schemes that are adjusted where appropriate. Australia appears to be the only country with an assurance scheme (ESCAS) for the LEI; however, it only covers animals destined for slaughter and does not cover animals exported for breeding purposes (DAFF 2014a). ESCAS assures that animals will be handled according to OIE standards in the importing country, can be traced throughout the process, and requires independent audits to be carried out.

Auditing and compliance

Auditing of each part of the livestock export chain is important to determine compliance with the relevant standards, regulations, codes of practice and Acts, including the OIE, which indicate a standard of animal welfare acceptable within the industry (see Fig. 4).

The OIE expects that member countries will adopt domestic animal welfare standards and regulations that are consistent with the requirements of the OIE's animal welfare standards. Australia's domestic standards are generally consistent with, but often higher than OIE standards for land, sea and air transport and slaughter. The OIE standards are encouraging developing nations to adopt reasonable animal welfare practices. The OIE standards are not mandatory, and though many of the countries that Australia exports to are members of the OIE, they do not have to follow the standards set out by the OIE.

Documentation and Reporting

Documenting and reporting data is important for compliance with regulations, and is useful to indicate animal welfare issues so that problems can be identified and rectified quickly.

Stockmanship

Since animal welfare is directly influenced by the animal's emotional perception of its environment, human factors can influence our behaviour towards animals and their response

towards us (Boivin *et al.* 2003). Hemsworth (2003) showed that the behaviour of stockpersons towards animals was influenced by their attitudes (whether they describe animals as positive or negative, whether they felt it important to pet or talk to the animals or, conversely, to hit or shout at them) and personality (whether they were introvert/extrovert or confident/unconfident). Handling methods are important for ease of movement of livestock, increased productivity, and increased health and safety. Understanding the behaviour of livestock is an important part of good stockmanship and improves the ability to move stock with minimal stress and force (low stress stock handling). Poor handling can result in bruising, injury, poor meat quality and mortality.

Standard operating procedures

Standard operating procedures (SOP) are intended to ensure the quality and integrity of work carried out. SOPs can:

- maximise the well-being of animals
- reduce variability between staff and generate a more cooperative team approach
- ensure tasks are completely properly, to the standard required and that nothing is missed
- provide an opportunity to evaluate staff performance as well as evaluate and develop the procedures themselves
- protect staff from potential injuries (i.e. the correct procedure to lift heavy items)
- protect the environment (i.e. proper handling of chemicals and waste, e.g. manure)

How are industry-based management issues measured?

Industry management based measures can be compared to existing standards and regulations to determine compliance.

Relevance for the LEI

Given the risk of prosecution from non-compliance with animal welfare standards and regulations, it is in the interest of the LEI to measure compliance within the industry.

Table A5. Management-based measures that indicate welfare risk for animals – Industry management

▒ reflects a welfare risk for LEI ● practical measure ▨ Currently used in LEI	Loading[a]	Truck	Ship	Plane	Feedlot (Aus)[b]	Feedlot (OS)	Breeder (OS)	Slaughter	Requirements: Trained personnel[c]	Requirements: Equipment[d]	Requirements: Threshold[e]	Practicality of measurement: Animal Handling[d]	Practicality of measurement: Invasiveness[f]	Practicality of measurement: Cost[g] (above operating costs)	Practicality of measurement: Time[h]	Notes
License	●	●	●	●	●	●	●	●	TA	N	ESCAS	Not required for inspection of industry	None	$ Cost for inspection of industry	LD	
Accreditation	●	●	●	●	●	●	●	●	TA	N						
Assurance schemes	●	●	●	●	●	●	●	●	TA	N	ESCAS					
Auditing	●	●	●	●	●	●	●	●	TA	N	ESCAS					
Compliance	●	●	●	●	●	●	●	●	TA	N	ASEL ESCAS LTL MO 43 LAR COP OIE					
Reporting/ documentation	●	●	●	●	●	●	●	●	TA	N	ASEL					
Stockmanship	●	●	●	●	●	●	●	●	TA	N						
Standard operating procedures	●	●	●	●	●	●	●	●	TA	N	Livecorp/ MLA					SOP for **cattle** (slaughter and breeder), **goats** (breeder) and **sheep** (slaughter) in overseas markets

References for Appendices

Alley, JC, Fórdham, RA (1994) Social events following the introduction of unfamiliar does to a captive feral goat (*Capra hircus* L.) herd. *Small Ruminant Research* **13**, 103-107.

Andersen, IL, Bøe, KE (2007) Resting pattern and social interactions in goats - The impact of size and organisation of lying space. *Applied Animal Behaviour Science* **108**, 89-103.

Anon (2011) Effect of slaughter method on animal welfare and meat quality. Meat Industry Services Available at http://www.ampc.com.au/site/assets/media/Factsheets/Livestock-Animal-Health-Welfare-Transport-Biosecurity/MTU_2011_Effect-of-slaughter-method-on-animal-welfare-and-meat-quality.pdf.

Anon (2012) Farm assurance schemes & animal welfare: How the standards compare. Compassion in World Farming & OneKind, United Kingdom. Available at http://www.onekind.org/uploads/publications/120323-farm-assurance.pdf.

Baldock, NM, Sibly, RM (1986) Effects of management procedures on heart-rate in sheep. *Applied Animal Behaviour Science* **15**, 191-191.

Baldock, NM, Sibly, RM (1990) Effects of handling and transportation on the heart rate and behaviour of sheep. *Applied Animal Behaviour Science* **28**, 15-39.

Barnes, A, Wickham, S, Admiraal, R, Miller, DW, Collins, T, Fleming, PA (Unpublished) Detecting at-risk sheep at feedlots using radio tracking technology.

Barnes, AL, Wickham, SL, Miller, DW, Fleming, PA, Collins, T, Stockman, C (2013) Inanition tracking in pre-embarkation feedlots. In Proceedings of the Australian Sheep Veterinarian Annual Conference. Albany, WA pp 94-99.

Barsideh, O, Burright, RG, Donovick, PJ (1995) Dietary iron and exposure to lead influence susceptibility to seizures. *Psychological Reports* **76**,

Beatty, DT (2005) Prolonged and continuous heat stress in cattle: Physiology, welfare and electrolyte and nutritional interventions. Murdoch University.

Beatty, DT, Barnes, AL, Fleming, PA, Taylor, E, Maloney, SK (2008) Effect of fleece on core and rumen temperature in sheep. *Journal of Thermal Biology* **33**, 437-443.

Black, MM (1998) Zinc deficiency and child development. *AMerican Journal of Clinical Nutrition* **68**, 464S-469S.

Blackshaw, JK, Blackshaw, AW (1994) Heat stress in cattle and the effect of shade on production and behaviour: a review. *Australian Journal of Experimental Agriculture* **34**, 285-295.

Boissy, A (1995) Study of fear and fearfulness in animals: a critical review. *Quarterly Review of Biology* **70**, 165-191.

Boissy, A, Manteuffel, G, Jensen, MB, Moe, RO, Spruijt, B, Keeling, LJ, Winckler, C, Forkman, Bo, Dimitrov, I, Langbein, J, Bakken, M, Veissier, I, Aubert, A (2007) Assessment of positive emotions in animals to improve their welfare. *Physiology & Behaviour*

Boissy, A, Terlouw, C, Le Neindre, P (1998) Presence of Cues from Stressed Conspecifics Increases Reactivity to aversive Events in Cattle:Evidence for the Existence of Alarm Substance in Urine. *Physiology and Behaviour* **63**, 489-495.

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

Bristow, DJ, Holmes, DS (2007) Cortisol levels and anxiety-related behaviors in cattle. *Physiology & Behavior* **90**, 626-628.

Broom, DM (1991) Animal welfare: concepts and measurement. *Journal of animal science* **69**, 4167-75.

Broom, DM, Johnson, KG (Eds DM Broom, KG Johnson (1993) 'Stress and Animal Welfare.' (Kluwer Academic Publishers: Dordrecht)

Bureau-of-Meterology (2014) 'Climate statistics for Australian locations.' Available at http://www.bom.gov.au/climate/averages/tables/cw_009194_All.shtml [Accessed 23rd September].

Carbajal, S, Orihuela, A (2001) Minimal Number of Conspecifics Needed to Minimize the Stress Response of Isolated Mature Ewes. *Journal of Applied Animal Welfare Science* **4**, 249-255.

Chapple, RS, Wodzicka-Tomaszewska, M, Lynch, JJ (1987) The learning behaviour of sheep when introduced to wheat. I. Wheat acceptance by sheep and the effect of trough familiarity. *Applied Animal Behaviour Science* **18**, 157-162.

Cockram, MS, Baxter, EM, Smith, LA, Bell, S, Howard, CM, Prescott, RJ, Mitchell, MA (2004) Effect of driver behaviour, driving events and road type on the stability and resting behaviour of sheep in transit. *Animal Science* **79**, 165-176.

Cockram, MS, Kent, JE, Goddard, PJ, Waran, NK, McGilp, IM, Jackson, RE, Muwanga, GM, Prytherch, S (1996) Effect of space allowance during transport on the behavioural and physiological responses of lambs during and after transport. *Animal Science* **62**, 461-477.

Colborn, DR, Thompson Jr, DL, Roth, TL, Capehart, JS, White, KL (1991) Responses of cortisol and prolactin to sexual excitement and stress in stallions and geldings. *Journal of Animal Science* **69**, 2556-2562.

Cole, DJ, Roussel, AJ, Whitney, MS (1997) Interpreting a bovine CBC: Evaluating the leukon and acute phase proteins. *Veterinary Medicine* **92**, 470-478.

Cole, NA, Hutcheson, DP (1988) Influence of protein concentration in prefast and postfast phosphorus intake of steers and nitrogen and phosphorus metabolism of lambs. *Journal of Animal Science* **66**, 1764-1777.

Collins, JD, Wall, PG (2004) Food safety and animal production systems: controlling zoonosis at farm level. *Rev. sci. tech. Off. int. Epiz.* **23**, 685-700.

Costa, N, Accioly, J, Cake, M (2003) Determining critical atmospheric ammonia levels for cattle, sheep and goats - a literature review. Available at https://livecorp.com.au/sites/default/files/rd_report/project_file/live.0218_determining_critical_atmospheric_ammonia_levels_for_cattle_sheep_and_goats_-_a_literature_review.pdf.

Crookshank, HR, Elissalde, MH, White, RG, Clanton, DC, Smalley, HE (1979) Effect of transportation and handling of calves upon blood serum composition. *Journal of Animal Science* **48**, 430-435.

DAFF (2014) 'Exporter Supply Chain Assurance System (ESCAS) ' Available at http://www.agriculture.gov.au/biosecurity/export/live-animals/livestock/information-exporters-industry/escas [Accessed 9th October].

Das, KS, Srivastava, BB, Das, N (2001) Standing orientation and behaviour of goats during short-haul road transportation. *Small Ruminant Research* **41**, 91-94.

Dawkins, MS (2004) Using behaviour to assess animal welfare. *Animal Welfare* **13**, S3-S7.

De Silva, M, Kiehm, DJ, Kaltenbach, CC, Dunn, TG (1986) Comparison of serum cortisol and prolactin in sheep blood sampled by two methods. *Domestic Animal Endocrinology* **3**, 11-16.

Department of Agriculture (2015) Exporter Supply Chain Assurance System. Department of Agriculture, Canberra, Australia. Available at http://www.agriculture.gov.au/SiteCollectionDocuments/biosecurity/export/live-animals/livestock/escas/escas-report.pdf.

Désiré, L, Veissier, I, Despre's, G, Boissy, A (2004) On the way to asess emotions in animals: Do lambs (Ovis aries) evaluate an event through its suddenness, novelty, or unpredictability? *Journal of Comparative Psychology* **118**, 363-374.

Dikman, S, Ustuner, H, Orman, A (2011) The effect of body weight on some welfare indicators in feedlot cattle in a hot environment. *International Journal of Biometeorology* **56**, 297-303.

Dobson, H, Tebble, JE, Phogat, JB, Smith, RF (1999) Effect of transport on pulsatile and surge secretion of LH in ewes in the breeding season. *Journal of Reproduction and Fertility* **116**, 1-8.

Dunn, CS (1990) Stress reactions of cattle undergoing ritual slaughter using two methods of restraint. *The Veterinary Record* **126**, 522-525.

Dwyer, CM, Bornett, HLI (2004) Chronic stress in sheep: assessment tools and their use in different management conditions. *Animal Welfare* **13**, 293-304.

Eldridge, G, Winfield, C (1988) The behaviour and bruising of cattle during transport at different space allowances. *Australian Journal of Experimental Agriculture* **28**, 695-698.

Farmer, B (2011) Independent Review of Australia's Livestock Export Trade. Department of Agriculture, Fisheries and Forestry, Canberra, Australia.

Fisher, A, Verkerk, GA, Morrow, CJ, Matthews, LR (2002) Ther effects of feed resirtiction and lying deprivation on pituitary-adrenal axis regulation in lactating cows. *Livestock Production Science* **73**, 255-263.

Fisher, AD, Colditz, IG, Lee, C, Ferguson, DM (2009) The influence of land transport on animal welfare in extensive farming systems. *Journal of Veterinary Behavior: Clinical Applications and Research* **4**, 157-162.

Fisher, AD, Stewart, M, Duganzich, DM, Tacon, J, Matthews, LR (2005) The effects of stationary periods and external temperature and humidity on thermal stress conditions within sheep transport vehicles. *New Zealand Veterinary Journal* **53**, 6-9.

Fisher, AD, Stewart, M, Verkerk, GA, Morrow, CJ, Matthews, LR (2003) The effects of surface type on lying behaviour and stress responses of dairy cows during periodic weather-induced removal from pasture. *Applied Animal Behaviour Science* **81**, 1-11.

Fitzpatrick, J, Scott, M, Nolan, A (2006) Assessment of pain and welfare in sheep. *Small Ruminant Research* **62**, 55-61.

Fleming, PA, Clarke, T, Wickham, SL, Stockman, CA, Barnes, AL, Collins, T, Miller, DW (2016) The contribution of Qualitative Behavioural Assessment to livestock welfare assessment. *Animal Production Science* **In Press, Accepted Oct 2015**,

Fraser, AF (1979) The nature of cruelty to animals. *Applied Animal Ethology* **5**, 1-4.

Fraser, AF, Broom, DM (1990) 'Farm animal behaviour and welfare.' (CAB International: Wallingford, Oxon)

Galvani, DB, Pires, CC, Wommer, TP, Oliveira, F, Santos, MF (2010) Chewing patterns and digestion in sheep submitted to feed restriction. *J Anim Physiol Anim Nutr (Berl)* **94**, e366-73.

Glawischnig, E, Fehr, P, Schittmayer, F (1972) 'Studies on the influence of length of transport and care of animals in transit on the incidence of liverdisease in heifers far advanced in pregnancy, Proceedings of the VII International Meeting on Diseases of Cattle, World Association of Buiatrics.' London.

Grandin, T (1980) Observations of cattle behaviour applied to the design of cattle-handling facilities. *Applied Animal Ethology* **6**, 19-31.

Grandin, T (1996) Factors which impede animal movement in slaughter plants. *Journal of American Veterinary Medicine Association* **209**, 757-759.

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

Grigor, PN, Goddard, PJ, Littlewood, CA, Deakin, DW (1998) Pre-transport loading of farmed deer: Effects of previous overnight housing environment, vehicle illumination and shap or loading race. *The Veterinary Record* **142**, 235-238.

Hall, SJG, Bradshaw, RH (1998) Welfare Aspects of the Transport by Road of Sheep and Pigs. *Journal of Applied Animal Welfare Science* **1**, 235 - 254.

Hargreaves, AL, Hutson, GD (1990) Some effects of repeated handling on stress reponses in sheep. *Applied Animal Behaviour Science* **26**, 253-265.

Hasanean, HM (2014) 'Middle East Meteorology.' Available at http://www.eolss.net/sample-chapters/c01/e6-158-19.pdf [Accessed 3rd October].

Hemsworth, PH (2003) Human-animal interactions in livestock production. *Applied Animal Behaviour Science* **81**, 185-198

Hemsworth, PH, Barnett, JL, Hansen, C (1986) The influence of handling by humans on the behaviour, reproduction and corticosteroids of male and female pigs. *Applied animal behavioural science* **15**, 303-314.

Hernshaw, H, Morris, CA (1984) Genetic and environmental effects on a temperamnt score in beef cattle. *Australian Journal of Agricultural Research* **35**,

Hicks, TA, McGlone, JJ, Whisnant, CS, Kattesh, HG, Norman, RL (1998) Behavioral, endocrine, immune, and performance measures for pigs exposed to acute stress. *Journal of Animal Science* **76**, 474-483.

Higgs, ARB, Norris, RT, Richards, RB (1991) Season, age and adiposity influence death rates in sheep exported by sea. *Australian Journal of Agricultural Research* **42**, 205-214.

Hogan, JP, Petherick, JC, Phillips, CJ (2007) The physiological and metabolic impacts on sheep and cattle of feed and water deprivation before and during transport. *Nutrition Research Reviews* **20**, 17-28.

Ingram, JR, Cook, CJ, Harris, PJ (2002) The effect of transport on core and peripheral body temperatures and heart rate of sheep. *Animal Welfare* **11**, 103-112.

Jahng, JW, Kim, JG, Kim, HJ, Kim, B, Kang, D, Lee, J (2007) Chronic food restriction in young rats results in depression- and anxiety-like behaviours with decreased expression of serotonin reuptake transporter. *Brain Research* **1150**, 100-107.

Jephcott, EH, McMillen, IC, Rushen, J, Hargreaves, A, Thorburn, GD (1986) Effects of electro-immobilisation on ovine plasma concentrations of beta-endorphin/beta-lipotrophin, cortisol and prolactin. *Research in Veterinary Science* **41**, 371-377.

Jones, M, Allison, R (2007) 'The ruminant complete blood count - evaluation and interpretation, CanWest Veterinary Conference.' The Fairmont Banff Springs Hotel, Banff, Alberta, October 13-16, 2007.

Keeling, L (2009) 'Positive affective states and positive animal welfare, Proceedings of the XXXI International Ethological Conference.' Rennes, France.

Kenny, FJ, Tarrant, PV (1987) The physiological and behavioural responses of crossbred Friesian steers to short-haul transport by road. *Livestock Production Science* **17**, 63-75.

Kent, J (1997) Stress in transported sheep. *Comparative Haematology International* **7**, 163-166.

Kent, JE, Ewbank, R (1983a) The effect of road transportation on the blood constituents and behaviour of calves. I. Six months old. *British Veterinary Journal* **139**, 228-235.

Kent, JE, Ewbank, R (1983b) The effect of road transportation on the blood constituents and behaviour of calves. I. Six months old. *British Veterinary Journal* **139**, 228-235.

Knight, TW, Hall, DRH, Lynch, PR, Hockey, HUP (1988) Effects of pre-joining shearing, stress, pasture allowance, and haemoglobin type on reproductive performance of Romney and Marshall Romney ewes. *New Zealand Journal of Agricultural Research* **31**, 249-258.

Korte, SM, Ruesnik, W, Blokhuis, HJ (1999) Heart rate variability during manual restraint on chicks from high- and low-feather pecking lines of laying hens. *Physiology & Behaviour* **65**, 649-652.

Lay, DC, Jr., Friend, TH, Bowers, CL, Grissom, KK, Jenkins, OC (1992) A comparative physiological and behavioral study of freeze and hot-iron branding using dairy cows. *Journal of animal science* **70**, 1121-1125.

Malik, M (1997) Time-Domain Measurement of Heart Rate Variability. *Cardiac Electrophysiology Review* **1**, 329-334.

MAMIC (2001) Investigation of the Ventilation Efficacy on Livestock Vessels. Meat and Livestock Australia, North Sydney, NSW, Australia. Available at https://www.livecorp.com.au/sites/default/files/rd_report/project_file/sbmr.002_-_investigation_of_the_ventilation_efficacy_on_livestock_vessels.pdf.

Martin, WB (1996) Respiratory infections of sheep. *Comparative Immunology, Microbiology and Infectious Diseases* **19**, 171-179.

Martinez, A, Schoenig, S, Andresen, D, Warren, S (2006) 'Ingestible Pill for Heart Rate and Core Temperature Measurement in Cattle, Engineering in Medicine and Biology Society, 2006. EMBS '06. 28th Annual International Conference of the IEEE.' Aug. 30 2006-Sept. 3 2006.

Mason, JW, Hartley, LH, Kotchen, TAM, Mougey, EH, Ricketts, PT, Jones, LGC (1973) Plasma Cortisol and Norepinephrine Responses in Anticipation of Muscular Exercise. *Psychosom Med* **35**, 406-414.

Mendl, M, Burman, OHP, Parker, RMA, Paul, ES (2009) Cognitive bias as an indicator of animal emotion and welfare: Emerging evidence and underlying mechanisms. *Applied Animal Behaviour Science* **118**, 161-181.

Moberg, GP, Wood, VA (1982) Effect of differential rearing on the behavioral and adrenocortical response of lambs to a novel environment. *Applied Animal Ethology* **8**, 269-279.

Mohr, E, Langbein, J, Nürnberg, G (2002) Heart rate variability: A noninvasive approach to measure stress in calves and cows. *Physiology & Behavior* **75**, 251-259.

Mormede, P, Andanson, S, Auperin, B, Beerda, B, Guemene, D, Malmkvist, J, Manteca, X, Manteuffel, G, Prunet, P, van Reenen, CG, Richard, S, Veissier, I (2007) Exploration of the hypothalamic-pituitary-adrenal function as a tool to evaluate animal welfare. *Physiology & Behaviour*

Murata, H, Takahashi, H, Matsumoto, H (1987) The effects of road transportation on peripheral blood lymphocyte subpopulations, lymphocyte blastogenesis and neutrophil function in calves. *British Veterinary Journal* **143**, 166-174.

Myers, DG (2004) Theories of emotion. In 'Psychology.' (Worth Publishers: New York, NY)

Napolitano, F, Knierim, U, Grasso, F, De Rosa, G (2009) 'Positive indicators of cattle welfare and their applicability to on-farm protocols.'

Norris, RT, Richards, RB (1989) Deaths in sheep exported by sea from Western Australia - analysis of ship master's reports. *Australian Veterinary Journal* **66**, 97-102.

Norris, RT, Richards, RB, Dunlop, RH (1989) An epidemiological study of sheep deaths before and during export by sea from Western Australia [live exports]. *Australian veterinary journal* **66**, 276-279.

Nwe, TM, Hori, E, Manda, M, Watanabe, S (1996) Significance of catecholamines and cortisol levels in blood during transportation stress in goats. *Small Ruminant Research* **20**, 129-135.

Ohmura, H, Hiraga, A, Aida, H, Kuwahara, M, Tsubone, H, Jones, JH (2006) Changes in heart rate and heart rate variability in Thoroughbreds during prolonged road transportation. *American Journal of Veterinary Research* **67**, 455-462.

Orihuela, A, Sanchez-Mejorada, H, Toledo, M (2002) Effect of short transport during di-oestrus and pro-oestrus on cortisol levels and oestrous behaviour of sheep. *Journal of Agricultural Science* **138**, 93-96.

Paranhos da Costa, MR, da Silva, R, de Souza, R (1992) Effect of air temperature and humidity on ingestive behaviour of sheep. *International Journal of Biometeorology* **36**, 218-222.

Parrott, RF, Lloyd, DM, Brown, SN (1999) Transport stress and exercise hypothermia recorded in sheep by radiotelemetry. *Animal Welfare* **8**, 27-34.

Paul, ES, Harding, EJ, Mendl, M (2005) Measuring emotional processes in animals: the utility of a cognitive approach. *Neuroscience and Biobehavioural Reviews* **29**, 469-491.

Pfister, HP (1979) The glucocorticosterone response to novelty as a psychological stressor. *Physiology & Behavior* **23**, 649-652.

Piccione, G, Caola, G (2003) Influence of shearing on the circadian rhythm of body temperature in the sheep. *Journal of Veterinary Medicine Series A Physiology, Pathology, Clinical Medicine* **50**, 235-240.

Ramin, AG, Asri-Rezaie, S, Mohammadi, D (2007) Influence of the short-term road transport stress on blood parameters in cows. *Medycyna Wet* **63**, 1311-1315.

Richards, RB, Norris, RT, Dunlop, RH, McQuade, NC (1989) Causes of death in sheep exported live by sea. *Australian Veterinary Journal* **66**, 33-38.

Robinson, NE (2002) Hemostasis. In 'Textbook of veterinary physiology.' (Ed. JG Cunningham.) pp. 516-544. (W. B. Saunders Company: St Louis)

Ruiz-de-la-Torre, JL, Velarde, A, Manteca, X, Diestre, A, Gispert, M, Hall, S, J. G., Broom, DM (2001) Effects of vehicle movements during transport on the stress responses and meat quality of sheep. *Veterinary Record* **148**, 227-229.

Rutherford, KMD (2002) Assessing pain in animals. *Animal Welfare* **11**, 31-54.

Sandem, AI, Braastad, BO, E., BK (2002) Eye white may indicate emotional state on a frustration-contentedness axis in dairy cows. *Applied Animal Behaviour Science* **79**, 1-10.

Sartorelli, P, Spagnolo, S, Paltrinieri, A, Giordano, A, Comazzi, S (2003) The effect of natural and pharmacological stressors on sheep: haematological, biochemical and granulocytic functional changes. *Veterinary Research Communications* **27**, 723-726.

Schmidt, A, Biau, S, Möstl, E, Becker-Birck, M, Morillon, B, Aurich, J, Faure, JM, Aurich, C (2010) Changes in cortisol release and heart rate variability in sport horses during long-distance road transport. *Domestic Animal Endocrinology* **38**, 179-189.

Schreffler, C, Hohenboken, WD (1980) Circadian behaviour, including thermoregulatory activities, in feedlot lambs. *Applied Animal Ethology* **6**, 241-246.

Schütz, KE, Huddart, FJ, Sutherland, MA, Stewart, M, Cox, NR (2015) Effects of space allowance on the behavior and physiology of cattle temporarily managed on rubber mats. *Journal of Dairy Science* **98**, 6226-6235.

Segner, H, Sundh, H, Buchmann, K, Douxfils, J, Sundell, K, Mathieu, C, Ruane, N, Jutfelt, F, Toften, H, Vaughan, L (2012) Health of farmed fish: its relation to fish welfare and its utility as welfare indicator. *Fish Physiology and Biochemistry* **38**, 85-105.

Silanikove, N (2000) Effects of heat stress on the welfare of extensively managed domestic ruminants. *Livestock Production Science* **67**, 1-18.

Sjaastad, OV, Hove, K, Sand, O (2003) 'Physiology of domestic animals.' (Scandinavian Veterinary Press: Oslo)

Smith, RF, Dobson, H (2002) Hormonal interactions within the hypothalamus and pituitary with respect to stress and reproduction in sheep. *Domestic Animal Endocrinology* **23**, 75-85.

Stephens, DB, Toner, JN (1975) Husbandry influences on some physiological parameters of emotional responses in calves. *Applied Animal Ethology* **1**, 233-243.

Stockman, CA (2006) The physiological and behavioural responses of sheep exposed to heat load within intensive sheep industries. Murdoch University.

Stockman, CA, Barnes, AL, Maloney, SK, Taylor, E, McCarthy, M, Pethick, D (2011) Effect of prolonged exposure to continuous heat and humidity similar to long haul live export voyages in Merino wethers. *Animal Production Science* **51**, 135-143.

Strack, AM, Akana, SF, Horsley, CJ, Dallman, MF (1997) A hypercaloric load induces thermogenesis but inhibits stress responses in the SNS and HPA system. *Am J Physiol Regul Integr Comp Physiol* **272**, R840-848.

Stull, CL, Rodiek, AV (1988) Responses of blood glucose, insulin and cortisol concentrations to common equine diets. *The Journal of Nutrition* **118**, 206-213.

Svensson, C, Lundborg, K, Emanuelson, U, Olsson, S (2003) Morbidity in Swedish dairy calves from birth to 90 days of age and individual calf-level risk factors for infectious diseases. *Preventative Veterinary Medicine* **58**, 179-197.

Tarrant, PV (1990) Transportation of cattle by road. *Applied Animal Behaviour Science* **28**, 153-170.

Tilbrook, AJ, Clark, IJ (2006) Neuroendocrine mechanisms of innate states of attenuated responsiveness of the hypothalamo-pituitary adrenal axis to stress. *Frontiers in neuroendocrinology* **27**, 285-307.

Tilbrook, AJ, Rivalland, EAT, Turner, AI, Lambert, GW, Clarke, IJ (2008) Responses of the hypothalamopituitary adrenal axis and the sympathoadrenal system to isolation/restraint stress in sheep of different adiposity. *Neuroendocrinology* **87**, 193-205.

Tomiyama, AJ, Mann, T, Vinas, D, Hunger, JM, DeJager, J, Taylor, SE (2010) Low calorie dieting increases cortisol. *Psychosomatic Medicine* **72**, 357-364.

Tucker, CB, Rogers, AR, Schultz, KE (2007a) Effect of solar radiation on dairy cattle behaviour, use of shade and body temperature in a pasture-based system. *Applied Animal Behaviour Science* **109**, 141-154.

Tucker, CB, Rogers, AR, Verkerk, GA, Kendall, PE, Webster, JR, Matthews, LR (2007b) Effects of shelter and body condition on the behaviour and physiology of dairy cattle in winter. *Applied Animal Behaviour Science* **105**, 1-13.

Turner, AW, Hodgetts, VE (1959) The dynamic red cells storage function of the spleen in sheep. *Australian Journal of Experimental Biology* **37**, 399-420.

Tuyttens, FAM (2005) The importance of straw for pig and cattle welfare: A review. *Applied Animal Behaviour Science* **92**, 261-282.

Van Cauter, E, Leproult, R, Kupfer, DJ (1996) Effects of gender and age on the levels and circadian rythmicity of plasma cortisol. *Journal of Clinical Endocrinology & Metabolism* **81**, 2468-2473.

Van De Water, G, Heylen, T, Swinnen, K, Geers, R (2003) The impact of vertical vibrations on the welfare of calves. *Dtsch Tierarztl Wochenschr* **110**, 111-4.

Vandermeerschen-Doise, F, Bouchat, JC, Bouckoms-Vandermeir, M-A, Paquay, R (1983) Effects of long-term *ad libitum* feeding on plasma lipid components and blood glucose, β-hydroxybutyrate and insulin concentrations in lean adult sheep. *Reproduction Nutrition Development* **23**, 51-63.

Villa, PD, Marahrans, M, Calvo, AV, Di Nardo, A, Kleinschmidt, N, Alvarez, CF, Truar, A, Di Fede, E, Otero, JL, Müller-Graf, C (2009) Project to develop animal welfare risk assessment guidelines on transport. Technical Report for the European Food Safety Authority.

Visser, EK, van Reenen, CG, van der Werf, JTN, Schilder, MBH, Knaap, JH, Barneveld, A, Blokhuis, HJ (2002) Heart rate and heart rate variability during a novel object test and a handling test in young horses. *Physiology & Behaviour* **76**, 289-296.

von Borell, E, Langbein, J, Després, G, Hansen, S, Leterrier, C, Marchant-Forde, J, Marchant-Forde, R, Minero, M, Mohr, E, Prunier, A, Valance, D, Veissier, I (2007) Heart rate variability as a measure of autonomic regulation of cardiac activity for assessing stress and welfare in farm animals — A review. *Physiology & Behaviour* **92**, 293-316.

von Keyserlingk, MAG, Rushen, J, de Passillé, AM, Weary, DM (2009) Invited review: The welfare of dairy cattle—Key concepts and the role of science. *Journal of Dairy Science* **92**, 4101-4111.

Warriss, PD (1990) The handling of cattle pre-slaughter and its effects on carcass and meat quality. *Applied Animal Behaviour Science* **28**, 171-186.

Watts, JM, Stookey, JM (2000) Vocal behaviour in cattle: the animal's commentary on its biological processes and welfare. *Applied Animal Behaviour Science* **67**, 15-33.

Waynet, DF, Stooley, JM, Schwartzfopt, US, Watts, JM, Waltz, CS (1998) The response of beef cattle to noise during handling. *Applied Animal Behaviour Science* **62**, 27-42.

Wemelsfelder, F (1997) The scientific validity of subjective concepts in models of animal welfare. *Applied Animal Behaviour Science* **53**, 75-88.

Wemelsfelder, F (2007) How animals communicate quality of life: the qualitative assessment of behaviour. *Animal Welfare* **16(S)**, 25-31.

Wemelsfelder, F, Hunter, TEA, Mendl, MT, Lawrence, AB (2000) The spontaneous qualitative assessment of behavioural expressions in pigs: first explorations of a novel methodology for integrative animal welfare measurement. *Applied Animal Behaviour Science* **67**, 193-215.

Wemelsfelder, F, Hunter, TEA, Mendl, MT, Lawrence, AB (2001) Assessing the 'whole animal': a free choice profiling approach. *Animal Behaviour* **62**, 209-220.

Wemelsfelder, F, Lawrence, AB (2001) Qualitative assessment of animal behaviour as an on-farm welfare-monitoring tool. *Acta Agriculturae Scandinavica, Section A, Animal Science* **51**, 21-25.