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ANIMAL WELFARE

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Cataloguing Land Transport Science and Practices in Australia

Abstract

A review was undertaken to catalogue livestock land transport science and practices in Australia. The aim of the report was to review advances in science, in comparison with developments in transport practices. The development of how the livestock transport industry operates (practices), and the standards to which it is deemed to operate (codes and QA) have not occurred as a simple linear process following scientific research and discovery. In most cases, the practices have arisen through experience, and the codes and the science have either followed in time, or provided support to what is done. Nevertheless, in many areas, there was good alignment between current scientific knowledge and the ways in which land transport of livestock was undertaken. The conclusions of this review are that there are no substantive contradictions between the science of land transport of livestock under Australian conditions, and the current practices. There are however areas where the science is incomplete, where the knowledge of what occurs in Australia is incomplete, and gaps between what is known as good practice and what may occur in practice. It is recommended that these gaps are addressed through targeted research, industry benchmarking and QA standards. An index is provided at the end of this report to be able to quickly match practices with the science.

Executive Summary

The livestock transport practices and conditions in Australia are markedly different to those in many other countries. Because of animal welfare interest in the topic of livestock transport, it is important to ensure that the way in which livestock are transported within Australia conforms to current scientific knowledge on appropriate welfare practices. A review was undertaken to catalogue livestock land transport science and practices in Australia. The aim of the report was to review advances in science, in comparison with developments in transport practices. Additional aims were to detail where there are gaps and inconsistencies between the science and current industry best practice, and codes of practice, standards and quality assurance, and provide recommendations for improvements.

The development of how the livestock transport industry operates (practices), and the standards to which it is deemed to operate (codes and QA) have not occurred as a simple linear process following scientific research and discovery. In most cases, the practices have arisen through experience, and the codes and the science have either followed in time, or provided support to what is done. In some areas there is little or no scientific data to support or contradict a practice. Nevertheless, in many areas there was good alignment between the state of scientific knowledge and the ways in which land transport of livestock was undertaken in Australia. Furthermore, areas in which previous practices and codes have fallen short of the available science have been corrected, such as the original stocking densities for cattle in the 1983 Code.

Fitness to travel- There has not been extensive scientific research on what constitutes fitness to travel in livestock. Appropriately, the knowledge in this area is based more on clinical know-how, years of practical experience and common sense. The most important recent development has been in the production and widespread distribution of the “Fit to Load” booklet. This will help practices become more aligned with industry knowledge, however even this guide is incomplete with respect to curfews and young livestock.

Pre-transport curfew - This area represents one of the key knowledge gaps within Australian livestock transport. There is a lack of scientific data to support the views from livestock transporters that pre-transport curfews facilitate improvements in the capacity of cattle and sheep to cope with transport.

Loading and unloading - There is alignment between the science and industry knowledge in this area, in that the scientific results demonstrate the relative stressfulness of these components of the transport process, emphasizing the importance of good loading facilities and handling. Similarly, this is backed by industry awareness of the importance of good handling practices and loading facilities, but in practice, these facilities are not always present.

Stocking density - In general, stated industry practice follows the welfare code guidelines for stocking density. The stocking densities in the Cattle Transport Code are in relatively good alignment with the results of research. In contrast, there has been little direct research under Australian conditions on stocking densities for sheep. The values in the Australian codes represent space allowances for sheep at the lower end or just below the conclusions on appropriate space allowance from European studies. However, the European values are based on a perceived need for the animals to lie down on longer journeys. Therefore, for sheep, the question of stocking density is also related to that of transport duration and the question of the real or perceived need of sheep to lie down on longer journeys. Under Australian conditions, the issue of appropriate transport duration for sheep is currently being examined by the MLA research project AHW.055.

Transport duration - There is little scientific data on the welfare of cattle and sheep when they are transported at durations close to the current code maximums (48 hours for cattle and 38 hours for sheep under the revised draft code) under Australian conditions. Accordingly, it is not possible to compare the science, codes and industry practice until further research has been undertaken. Two key MLA projects that will inform this issue are currently underway: AHW.055 “Animal Welfare Outcomes of Livestock Road Transport Practices”, which will measure the welfare of cattle transported for set durations up to the code maximum, and AHW.125 “Assessing long distance livestock land transport practices in Australia to benchmark animal health and welfare outcomes”, which will provide some information on the relative duration of transport events in commercial practice.

Vehicle design - The design of Australian livestock transport vehicles has been largely driven by industry practical experience, with science essentially confirming the usefulness of some key features. It would appear that the design of vehicles used is now well-suited to Australian conditions and practices, as within the literature, and in discussion with industry, there were no major design issues identified as causing animal welfare problems in the current environment. However, it should be noted that the occasional protrusion of heads and legs from vehicles transporting sheep can present problems and creates public concern where the journey is through towns and cities.

Key Gaps and Recommendations

Quantifying the benefits of pre-transport curfews is recognized as a significant knowledge gap. The fundamental questions of whether they are necessary in the context of enabling animals to better adapt to transport and if so, how long should cattle and sheep be deprived of feed and/or water prior to transport after taking into consideration their condition, nutritional background and transport duration, requires immediate attention. The critical issue of pre-transport curfews was recently reviewed by MLA (LIVE 122A ~ Investigating feed and water curfews for the transport of livestock within Australia - a literature review) and the recommendations identified in that review will be influential in any future research of the effects of pre-transport curfews in livestock. Furthermore, the results of current research (MLA Project AHW.055 ~ Animal Welfare Outcomes of Livestock Road Transport Practices) will, in part, address this knowledge gap. However, it is recommended that additional research into the development of pre-transport curfew best practice needs to be considered.

There was clear convergence between the scientific knowledge and industry support for the need for well designed loading facilities, particularly on properties of origin. On-farm loading facilities were reported as being highly variable, with substandard facilities raising concerns about poorer or more difficult handling, and risks to animal welfare. Consideration should be given to methods of improving this issue by removing or replacing problem yards and loading facilities. This also has obvious implications for animal welfare on-farm, and could be encouraged through incorporation of suitable standards into on-farm quality assurance systems, along with good practices for handling livestock.

A similar gap concerns the current inability under some circumstances to be certain that livestock are not exceeding the maximum water deprivation period during transport events. Although there are moves through NVD and journey plan provisions to capture data on when animals were loaded and/or last received access to water, the failure to follow this through repeated transport events could present a problem, such as when animals are transported to a saleyard, sold and then transported out that evening.

Australia has a good record of continuous improvement in livestock transport vehicles and methods, and although there has not been a strong level of alignment in the past between the conduct of research and improvements in practices, this is now being addressed in several areas, including current research commissioned by MLA, and overarching developments in Australian welfare codes and standards, as part of the Australian Animal Welfare Strategy.

Contents

1 Background

The land transport of livestock via road and rail is an essential element of Australian livestock production systems. Livestock may be transported within properties, between properties and between a property and saleyard, abattoir, feedlot and pre-export assembly depot. Livestock can be transported to growing and finishing properties, markets or to make best use of seasonal conditions. Because of Australia's relatively large size by international standards and its unique climate, the Australian transport industry has successfully evolved as a consequence of scientific research and local industry knowledge. Given the increasing importance for industry to demonstrate its competency in the land transport of livestock, it is fitting to compile and document the related scientific research in Australia and overseas alongside the current best practice in Australia.

2 Project Objectives

Within one month of the project commencing and with a focus on animal welfare:

1. Prepare an initial, broad review focussing on the scientific and practical advancements over the last 30 years in the Australian livestock transport industry, which is suitable both as a scoping paper and as a public relations discussion paper. By May 2006, with a focus on animal welfare:

2. Compile a comprehensive and chronological reference document of the advances in Australian and international science and the on-ground changes in practical know-how and implementation related to the land transport of livestock in Australia.

3. Describe how this science has been incorporated into current best practice as contained in the relevant codes of practice, standards and current best industry practice and the improvements in animal welfare with these changes over time. This objective will as a minimum address the following codes of practice:

- Model Code of Practice for the Welfare of Animals: Land Transport of Cattle, SCARM Report 77 (1999).
- Model Code of Practice for the Welfare of Animals: Rail Transport of Cattle, SCARM Report 77 (1983).
- Model Code of Practice for the Welfare of Animals: Road Transport of Livestock (1983).
- TruckCare.
- Queensland Rail Stockcare.

The review will comprehensively address the following issues if not done so as part of the above:

- Fitness of livestock to travel,
- Loading and unloading,
- Transport design,
- Time off feed and water,
- Loading density,
- Rest before, during and after transport.

4. Detail where there are gaps and inconsistencies between the science and codes of practice, standards and current best industry practice.

5. Based on the science and industry knowledge, recommend where existing codes of practice, standards and current best industry practice can be improved.

3 Methodology

A thorough search was conducted of available scientific databases for relevant research papers pertaining to the land transport of livestock, specifically, cattle, sheep and goats. Also included for the search were current codes of practice, standards and quality assurance schemes as well as unpublished scientific literature and published anecdotal information. Copies of all identified relevant material were obtained.

A literature review was then undertaken to highlight the key findings of the available material which was then compiled into a report by the project team.

A bibliography was created in an electronic format from all reference material reviewed in the report.

Also, all relevant information revealed in the search has been placed in an electronic database in PDF format for MLA.

QDPI&F undertook industry interviews and liaison with a wide cross-section of industry stakeholders. See Appendix 2- Industry contacts. QDPI&F contacted a number of known key players in the various sections of the livestock transport industry dating back to the 1950's. These included transport companies, owner/drivers, drivers, manufacturers and senior management staff in all of the above areas. All participants were initially contacted by phone or personal visit to ascertain a willingness to cooperate and participate in the project. There were no objections. Some of those contacted also suggested other industry people they felt could offer additional valuable information and insights for the project.

A basic set of questions was sent to all participants along with an early draft of the chronological events to act as both a memory jogger and to also get verification on information already catalogued.

Face to face interviews were held with key cattle and sheep transporters in all states except Victoria and Tasmania. Some major stockcrate manufacturers from Queensland, NSW and WA were also interviewed in the same manner. These personal interviews proved particularly useful as additional information was extracted that would have otherwise been overlooked.

All participants were sent an electronic or faxed copy of a near final draft to ensure that their contributed information had been correctly recorded. Not everyone replied, but those who did were more than happy and felt it was a fair and true representation of events.

4 Results and Discussion

4.1 Introduction

Because of the extensive nature of Australian livestock production, there has always been a need to move animals to central points, whether these be saleyards, feedlots, other properties, abattoirs or ports of embarkation for live export. Although animals were originally moved on foot, particularly since the late 1920s, there has been an increasing use of mechanised transport by road and rail. Today the vast majority (estimated at 95%) of animals are moved by road. The progress of the livestock transport industry in Australia has been driven by economic forces, supported largely by the implementation of practical development and know-how. The competitive nature of the industry has accelerated the adoption of practices and facilities that improve efficiency, and this has also benefited animal welfare through improvements in animal loading and unloading systems, and in stock crate designs that minimise bruising. This review highlights the developments since 1970 in livestock transport within Australia, in terms of scientific research, the development of new practices that enhanced livestock welfare, and the formation of animal welfare codes and quality assurance schemes such as TruckCare and Livestock Production Assurance (LPA). The review extensively covers scientific research on livestock welfare during land transport that has occurred internationally.

The livestock transport practices and conditions in Australia are markedly different to those in other countries. Long distances, heat and dust are regular features of livestock road transport in Australia, particularly for cattle in northern Australia. Despite this, and the significant reliance on road transport to service the cattle and sheep industries, the overall research effort exploring the welfare outcomes of our transport practices has not been extensive.

Most previous Australian research was conducted during the 1980s. In the majority of these studies, the impact of transport stress was measured in terms of either loss in product mass (e.g. weight loss) or product quality (e.g. incidence of bruising and/or high ultimate pH meat or dark cutting).

It is important to recognize that the parameters of muscle bruising and meat pH, whilst important in terms of productivity, do not necessarily convey a complete picture of animal welfare. This typically requires a more detailed evaluation of both behavioural and physiological responses.

More recently, research funded by MLA/LiveCorp has examined some of the effects of long transport duration for export cattle. Parker et al. (2003b) contrasted the effects of 0 hours food and water deprivation (FWD), 60 hours FWD and 12 hours FWD followed by 48 hours of transport in Bos indicus cattle. They were primarily focused on the compensatory mechanisms associated with the maintenance of acid-base balance during long duration transport, which is of relevance to the blood biochemical components of an animal's welfare.

Currently, new research has been commissioned by MLA to specifically investigate the welfare outcomes of road transport practices with the emphasis on transport duration and the interaction between curfew duration and transport duration in both cattle and sheep (AHW.055). The results from the cattle transport duration study will be published in 2006, with preliminary results provided to industry indicating that healthy cattle that have not had restricted access to food or water prior to transport can tolerate transport up to 48 hours (the Code maximum) without any major compromise to their welfare.

4.2 Fitness of livestock to travel

There is a lack of published scientific literature on the impact of fitness on the welfare of livestock during land transport. "Fitness" in this context means being of appropriate health and vigour. Common sense would suggest that animals in poor condition, such as drought affected animals, would not have the same capacity to cope with extended transport durations, but this has not been scientifically investigated outside the confines of practical experiences of transporting drought-affected stock.

Under the codes of practice for the welfare of cattle, sheep and goats during transportation (MCOP 1999; MCOP 1983a), the owner or agent is responsible for selecting only fit and healthy animals for travel. It is advised that animals should be rejected for travel if they are sick, injured or weak, or in late pregnancy. Exceptions include transportation for veterinary treatment of ill or injured animals, transport over a short distance for humane destruction or during salvage operations, e.g. relocation from a drought area. Additionally, it is recommended that only animals judged capable of surviving the journey should be transported. The code states that humane and effective arrangements should be made for the care of animals unsuitable for loading and provides recommended methods for humane destruction if necessary. Pre-transport preparation with a 12-24 hour rest period, with the provision of food and water, is recommended before loading. Additionally, specific recommendations are given for managing other classes of cattle, such as calves, lactating dairy cows and injured or weak animals.

A publication has recently been developed designed to provide pictorial representation of the MCOP requirements in relation to preparation of stock and determining fitness for transport. Meat & Livestock Australia, along with state and federal governments and several livestock industry organisations, developed the guide, 'Is it fit to load?' (MLA 2006), for livestock producers, agents and transporters and others in the supply chain to assist them with determining whether animals are in a fit state to travel. The guide uses pictures and simple explanations of those conditions which are described but not shown in transport codes of practice, to allow people to quickly decide whether an animal is unfit for transport. The guide states that an animal is fit to travel if it:

- Can walk normally, bearing weight on all four legs.
- Is not suffering from any visible disease or injury that could cause it harm during transport.
- Can keep up with the mob both at loading and unloading.
- Can see out of at least one eye.
- Is NOT in late pregnancy (ewes more than 4 months and cows more than 8 months pregnant).

The guide advises that if the animal is assessed as unfit for transport, it should be treated if possible, or destroyed humanely.

A voluntary quality assurance program, TruckCare has been developed by the Australian Livestock Transporters Association (ALTA). TruckCare enables drivers to understand their responsibility for ensuring only those animals that are fit for travel are transported. TruckCare encourages the establishment of standards and documentation for selecting and handling of livestock for transport. The recently launched Livestock Production Assurance program by MLA (LPA, 2006) includes requirements on loading facilities, handling practices and suitability of vehicles for transport, and is covered in more detail in Section 4.9.

A survey of mortality among cattle transported by rail in Queensland in the late 1970s (Tobin, 1981), revealed a mortality rate of 0.36%. Cattle, particularly older cows that were in poor body condition at the start of a journey were at greater risk of death.

4.2.1 Pre-transport therapies

The provision of electrolyte solutions to livestock prior to and subsequent to transport are reported to maintain electrolyte balance and in doing so, potentially reduce dehydration and weight loss associated with transport (Schaefer et al. 1997). The efficacy of commercial electrolyte products has been evaluated in Australia but unfortunately there is very little published data. The evidence from unpublished research (Burrow et al. 1998) tends to align with the key conclusions of others (Parker et al. 2003b; Parker et al. 2003a) that electrolyte supplementation had little to no effect on reducing liveweight loss in transported cattle. The findings of research conducted by Anne Barnes at Murdoch University, WA, investigating the use of electrolytes in heat stress conditions, such as during live export, have been inconclusive (Barnes, personal communication).

In relation to the effects of long transport duration, (Parker et al. 2003b) contrasted the effects of 0 hours food and water deprivation (FWD), 60 hours FWD and 12 hours FWD followed by 48 hours of transport in Bos indicus cattle. The transported cattle were able to maintain their blood acid-base within normal ranges. Moreover, plasma electrolyte concentrations were not different between the three treatments. They concluded that in view of this, the provision of electrolyte solutions rather than water alone was unlikely to be more effective in resolving the dehydration associated with long-term transport. This view was further reinforced in a subsequent study in sheep (Parker et al. 2003a). Although they concluded that there was no major advantage of electrolytes per se over the provision of water alone, the advantage of electrolytes may relate to the enhanced palatability of the water, resulting in increased consumption before loading. Other additives such as sugar-based supplements may also enhance water palatability. This may be advantageous for cattle in unfamiliar yards and drinking systems to ensure adequate water intake before transport and reduce the chance of dehydration. However, it should be noted that excessive drinking immediately prior to transport is undesirable, as industry experience is that animals are more likely to go down during the journey.

4.3 Loading and unloading

Loading is reported to be the most stressful period during transport. In general, studies report that livestock show an increase in plasma cortisol concentration during loading, with a gradual decline over the next few hours, suggesting that animals adapt to the transport procedure (Agnes et al. 1990; Knowles et al. 1995; Trunkfield & Broom 1990; Warriss et al. 1995); AHW.055 Pettiford et al, in prep.). Body temperature has been shown to increase significantly during loading in cattle (Tennessen et al. 1984); AHW.055 Pettiford, et al, in prep). Studies in sheep report increased cortisol in response to loading (Broom et al. 1996; Knowles et al. 1995; Hall et al. 1999). Other physiological responses to loading include increased glucose (Knowles et al. 1995) and prolactin, and decreased osmolality and haematocrit (Broom et al. 1996). The pattern of increased cortisol in response to loading was also reported in goats (Kannan et al. 2000).

In contrast, other studies have reported no effect of loading on the plasma cortisol concentration of sheep (Cockram et al. 1996; Parrott et al. 1998a). (Parrott et al. 1998a) reported an increased heart rate, but no cortisol or catecholamine response and a small prolactin response to loading. The result may have been due to the very careful loading practices used in the study, with only 3 sheep loaded at a time in an unhurried manner. Similarly, cattle showed no cortisol response to loading, and only an increase in heart rate associated with the physical exertion of walking up a ramp (Kenny & Tarrant 1987).

In general, loading has been shown to be more stressful than unloading, with more adverse effects on the animal's welfare (Maria et al. 2004). Unloading does not appear to produce a significant stress response with no increase in cortisol or body temperature reported in cattle (Warriss et al. 1995); AHW.055 Pettiford et al, in prep.) or sheep (Broom et al. 1996). A method of subjectively scoring the loading and unloading procedures was developed by (Maria et al. 2004).

There is some evidence that calves habituate to the novelty and stress of loading and transport (Jacobson & Cook 1998). Similarly, in sheep, cortisol increased in response to loading in the first part of a two-stage journey but was markedly reduced in response to the second loading, following a 1 hour rest stop (Parrott et al. 1998b). In contrast, when the rest period was for 6 hours, loading on a second occasion did stimulate cortisol release (Broom et al. 1996).

Many factors contribute to the stress of loading and unloading, including physical exertion, a novel environment, noise and the effects of contact with people during handling. Considering these factors, and that experimental studies were conducted under different conditions and on different classes of animals, it is not surprising that there is some inconsistency in the reports of sheep and cattle responses to loading and unloading. Notwithstanding this, the weight of evidence would suggest that loading elicits a pronounced acute stress response.

Animals may be managed with minimal contact with humans so that even the slightest contact can initiate a substantial fear response. (Grandin 1997) suggests that previous experience may affect an animal's fear response and may be responsible for the variable results reported in transport studies. For example, extensively reared animals may experience more psychological fear during loading than intensively reared animals. In a study using steers that were not familiar with human contact, handling during loading was associated with an increased cortisol response, which was suggested to be more disturbing than the truck ride itself (Tennessen et al. 1984). For extensively reared livestock, (Grandin 1997) suggests that rest stops where livestock are removed from the transport, may compromise welfare due to the stress associated with loading and unloading. It may therefore be beneficial to familiarize stock with human handlers on a regular basis to reduce the stress of handling.

The methods used during handling, loading and unloading may affect animal welfare. The use of an electric prodder on cattle at loading did not produce any additional physiological response than loading without an electric prodder (AHW.055 Pettiford, et al, in prep). However, any adverse effect of the electric prodder may have been masked and overridden by the significant stress response to loading. (Broom 2000) stated that the use of electric goads is inhumane and unacceptable as they are used to compensate for inadequately designed loading and handling facilities. (Wythes 1987) highlighted the importance of proper handling of livestock during loading and unloading to minimize bruising and stress of cattle. She noted the importance of the producer in determining loading strategies, including optimal time from yarding to loading, drafting on type, horn status and size, water and feed deprivation, handling procedures and training of stockmen. Inadequate loading methods were noted in a paper by (Tarrant 1990), who attributed difficulties at loading in commercial situations to be associated with overloading, with the last few cattle being driven forcefully on board.

The design of loading and unloading facilities is an important factor relating to the welfare of transported livestock. The minimum design standards for cattle loading and unloading facilities have been described by (Lapworth 1990). The Code of Practice for the Land Transport of Cattle (MCOP 1999) recommends that the design of facilities should support the tendency of cattle to follow each other, e.g. curved races with covered sides and clearly visible passageways and gates. The loading ramp should be appropriately constructed for the transport used. The top of the loading ramp should have a flat platform level with the truck deck. Ramps should be designed with an angle of less than 20° and should be constructed to minimize the risk of slipping by animals. Artificial light should be used when loading at night and it is preferable to have dry floors on the truck.

4.4 Effects of stocking density during transport on animal welfare

4.4.1 Cattle

There was no peer-reviewed published scientific research during the 1970s that measured the welfare responses of cattle to variations in stocking density during land transport. The initial research was published in 1988, with Australian-based research being among the first studies published. Graham Eldridge and colleagues at the Victorian Department of Agriculture conducted a series of experiments with heifers and steers at variations in stocking density during trucking (Eldridge & Winfield 1988; Eldridge et al. 1988).

In their first paper (Eldridge et al. 1988), the researchers conducted an initial experiment comparing the responses of 350-kg Angus x Shorthorn heifers trucked 135 km at either 0.9 or 1.2 m^2 per animal in group pens of 9 animals each. In a second experiment, heifers were trucked 31 km in a 2 x 2 factorial plan at two space allowances (0.8 and 1.0 m^2 per animal) and two pen sizes (8 and 16 m^2). In the final experiment, heifers were trucked 424 km at 0.89 or 1.14 m^2 per animal. Across all three experiments, heifers transported at the smaller space allowances recorded lower heart rates and fewer positional movements (defined as where an animal moved more than 1 m). (Eldridge et al. 1988) concluded that for the size of the heifers transported, the lower space allowances used in the studies were preferable. For comparison, the current Australian Code for the Land Transport of Cattle (MCOP 1999) recommends 0.86-0.98 m^2 for cattle of 300-350 kg bodyweight, suggesting that providing animals with more space than that recommended in the Code may not be of additional benefit.

In their second paper (Eldridge & Winfield 1988), the scientists trucked 400-kg Hereford steers for 360 km at space allowances of 0.89, 1.16 and 1.39 m^2 per animal in group pens. The study measured carcass weights, bruise score and bruise numbers, as well as the number of animals going down during transport. Heart rate was not measured. Only at 0.89 m^2 did animals go down, although both the 0.89 and 1.39 m^2 treatments resulted in significantly greater bruising than the space allowance of 1.16 m^2 per animal. The results of this paper would align with the current Australian Code for the Land Transport of Cattle (MCOP 1999) which recommends 1.05 m^2 for cattle of 400 kg bodyweight. Furthermore, it is revealing when these stocking densities are considered from an allometric perspective. Allometry is the dimensional calculation of area required by an animal based on a formula involving its bodyweight (Petherick 1983). At 287kg/m^2 (1.39 m^2 per animal), the animals would have had significant spare space, so it is not surprising that they moved around. At 460 kg/m^2 (1.16 m^2 per animal), they would have had just a little more room than the amount of space they occupy when standing, so would brace each other because there would be little spare space.

The first paper from the research of Tarrant, Kenny and colleagues in Ireland on stocking density was also published in 1988 (Tarrant et al. 1988). Heavy Friesian steers (600 kg) were trucked for 195 km at space allowances of 1.0, 2.0 and 3.0 m^2 in group pens. The study measured both behaviour and blood parameters including the stress hormone (cortisol) and muscle damage marker enzyme (creatine kinase - CK). The low space allowance of 1.0 m^2 was associated with significantly greater incidence of loss of balance and animals going down, and also resulted in the highest cortisol and CK measurements. The authors concluded that 1.0v m^2 per animal was insufficient for cattle of 600 kg. Allometrically this amount does not even allow the animals enough space to stand without some overlapping, so the results are perhaps not surprising. This figure compares to the current Australian Code for the Land Transport of Cattle (MCOP 1999) which recommends 1.47 m^2 for cattle of 600 kg bodyweight. Interestingly, in contrast to the results of Eldridge and colleagues, (Tarrant et al. 1988) found no disadvantage for the 3 m^2 compared with the 2 m^2 space allowance in their study. The authors speculated that this may have been due to the larger size of their animals. Other possible explanations may be differing vehicle flooring, road conditions or driving styles between the studies, although it is not possible to know if this was the case.

In a scientific review of cattle transport research published in 1990, Tarrant commented that recommended space allowances of cattle for transport varied widely, and then published the existing Australian recommendations in the review, before reviewing the work of Eldridge and his own research (Tarrant 1990). The Australian recommendations at the time were from the original Land Transport of Livestock Code (MCOP 1983b) and are reproduced below (Table 1).

Table 1. Loading density for cattle during road or rail transport in the original Model Code of Practice

Average weight (kg)	Floor area (m^2 per head)
250	0.70
300	0.74
350	0.78
400	0.87
450	0.99
500	1.06
550	1.14
600	1.23
650	1.35

(MCOP, 1983)

A subsequent paper based on experimental research on stocking density was published by (Tarrant et al. 1992). In this experiment, 600-kg Friesian steers were transported by road for 24 hours at space allowances of 1.08, 1.24 and 1.33 m^2 per animal in group pens. Cattle preferred to orient themselves perpendicular to the direction of travel. Orientation aligned along the axis of travel was next preferred, and diagonal orientations were strongly avoided. The cattle were most able to orient themselves appropriately at the 1.33 m^2 space allowance, and were least able to all achieve a preferred orientation at the 1.08 m^2 treatment. The researchers also recorded loss of balance events, animals going down, detailed blood measurements (cortisol, glucose, haematology, CK and total protein), and carcass bruising. The overall conclusion was that stress, bruising and loss of balance were all significantly increased by increasing stocking density, and that for 600-kg steers, space allowances below about 1.1 m^2 were unacceptable.

The next general review on road transport of cattle was published by (Knowles 1999). Regarding space allowance, the author commented that there was little experimental work on which to base recommendations for stocking density, and that most codes were based on practical experience. (Knowles 1999) then reviewed the work of Eldridge, Tarrant and colleagues in some detail, but also suggested that data from allometry may also be helpful. Allometry is the dimensional calculation of area required by an animal based on a formula involving its bodyweight (Petherick 1983) and suggests reasons why research findings indicate that certain space allowances result in unacceptable animal welfare, such as 1.0 m^2 for 600-kg cattle (Tarrant et al. 1988). (Randall 1993) published a paper suggesting that the minimum space allowance for cattle during transport could be calculated as 0.01W0.78, and this calculation largely aligns with the experimental results of studies on animal welfare outcomes of different space allowances.

In their chapter on cattle transport in the second edition of the book on livestock transport edited by (Tarrant & Grandin 2000), the authors essentially reviewed the papers covered in the preceding paragraphs.

A large experimental study examining space allowance for young calves transported by road was published by (Grigor et al. 2001). Male Holstein-Friesian calves (50 kg) were transported for 9 hours, including a mid-journey rest period of 1 or 12 hours. The space allowance treatments were 0.375 and 0.475 m^2 per animal, with a straw-bedded vehicle and sufficient space for all calves to lie down. The study measured a wide range of variables, including behaviour during transport, bodyweight, immunocompetence, heart rate and plasma osmolality, glucose, CK and cortisol. The authors concluded that both the space allowances used in the study were acceptable, as there were few differences in response between the two treatments.

Finally, the most recent paper published on stocking density for cattle during land transport was a result of the EU Framework CATRA Project (Honkavaara et al. 2003). The paper was focussed on duration (1 vs. 7 vs. 10 hours), however the vehicles used for the 7 and 10 hour durations had pens that contained only 1 to 2 animals, whereas the short journey vehicle had pens of 3 to 4 animals. The authors found that bruising was less for the 7 and 10 hour journeys and commented that this indicated that single animal pens were more desirable. However, because of the confounding effects of the design, this conclusion is not warranted, and there are no studies that robustly examine space allowance interactions with journey duration.

In conclusion, the research suggests that under Australian conditions, both too much space and insufficient space can be detrimental to cattle welfare during land transport. From the relatively limited literature, appropriate space allowances during road transport would be approximately 0.8-0.9 m^2 for 350-kg animals, 1.0-1.1 m^2 for 400-kg animals, and 1.1-1.2 m^2 for 600-kg animals. This compares to values in the Australian Model Code of Practice for the Land Transport of Cattle (MCOP 1999) which recommends 0.98 m^2 for 350-kg animals, 1.05 m^2 for 400-kg animals, and 1.47 m^2 for 600-kg animals. From these values it can be seen that the Code is closely aligned with Australian data for 350- and 400-kg animals, and is more generous in its recommended space allowance for 600 kg animals. However, this is probably reasonable, given the findings of (Tarrant et al. 1988). Further information is presented in Table 7 in Section 4.9.

4.4.2 Sheep

There are fewer papers examining the welfare responses of sheep transported on land at various stocking densities.

(Cockram et al. 1996) transported slaughter-weight lambs (35kg) by road for 12 hours at space allowances of 0.22, 0.27, 0.31, and 0.41 m^2 per animal. The lambs were described as "full-fleeced", which given their age (16 weeks) would indicate a reasonable amount of wool, but less that that of an unshorn year-old animal. The vehicle floor was bedded with wood shavings and sawdust. The study measured a comprehensive range of variables including animal behaviour during transport, heart rate, bodyweight and plasma cortisol, osmolality, total protein, betahydroxybutyrate and CK. Although the behavioural data showed that sheep transported at 0.22 m^2 spent less time lying down during transport than animals at the other space allowance treatments, there were no effects of space allowance on stress levels or biochemical markers of fatigue or injury. It should be noted that allometric data for sheep of this bodyweight indicate that the space occupied by a lying animal is 0.26 m^2. The authors concluded that 35-kg sheep could be transported for 12 hours at space allowances between 0.22 and 0.41 m^2 without showing major physiological changes. However, because of the reduced lying at 0.22 m^2, the authors commented that this space allowance could not be recommended for journeys greater than 3 hours, for which a space allowance of 0.27 m^2 was preferable. This paper highlights a disjunction between Australian and emerging European thoughts on the general topic of space allowance during transport. In Australia, animals are not transported in a way that encourages them to lie down during the journey, and animals that are down are viewed as at risk of being smothered or trampled and are encouraged to stand. In Europe, the ability of an animal to have sufficient space and bedding to lie down during transport is generally seen as a good thing, although there is little evidence of the magnitude of the direct benefits this produces. There have not been studies specifically examining the provision of lying for transported sheep under European conditions in relation to soiling of the fleece, and it is likely that if sufficient bedding is provided at the stocking densities used in Europe that fleece soiling would be minimal.

In a later UK-based study, (Knowles et al. 1998) transported shorn 40-kg lambs for 24 hours at 0.18, 0.20, 0.24 and 0.30 m^2 per animal during summer. The study focused on measuring physiological responses, including plasma CK, osmolality, total protein, glucose and betahydroxybutyrate. Behaviour measurements were conducted on lambs in lairage at the space allowances used in the transport. The study found that there were no physiologically detrimental effects of the higher space allowances used in the study. The authors expressed some concern at the reduced lying behaviour in lambs during separate lairage at the 0.18 and 0.20 m^2 space allowances, caused by insufficient space for all the animals to lie down, although the animal welfare impacts of this were not quantifiable.

In a second experiment published in the same paper (Knowles et al. 1998), fully-fleeced lambs (37 kg; wool length not specified) were transported for 24 hours at space allowances of 0.23, 0.25, 0.29 and 0.34 m^2 per animal during winter. The measurements recorded were the same as for the first experiment, and the results showed that the lambs transported at the lowest space allowance of 0.23 m^2 had significantly greater plasma CK concentrations, suggesting muscle damage or fatigue. (Knowles et al. 1998) commented that this stocking density was therefore unacceptable for woolled lambs of this size, but that the other values used were acceptable. The authors suggested that fleece length was a critical factor in the different findings between their two experiments, despite the underlying difference in seasons.

In a study conducted during a New Zealand summer, (Fisher et al. 2002) transported 35-kg lambs in half wool (20 mm) for 3 hours, punctuated by a 4 hour stationary period in the middle of the journey. The stationary period occurred in a large shed, in order to simulate the wind-less conditions on an enclosed deck on a roll-on roll-off ferry. The experiment measured the thermal conditions on board the multi-deck vehicles, comparing space allowance treatments of 0.20 and 0.26 m^2 per animal. During the moving periods of the experiment, the temperature-humidity index (THI) remained within acceptable limits for both treatments. However, during the stationary period, the THI for lambs at 0.20 m^2 increased to 91.0, compared with a peak of 84.9 for the animals at 0.26 m^2. The study indicated that a stationary period in summer during lamb transport represented a significant thermal welfare challenge for the animals if there was little or no air movement, and that this risk was mitigated at the lower stocking density. Although one could conceive a table of reduced stocking densities at higher ambient temperatures, the approach in Australia to welfare codes is not to be overly prescriptive, but instead to rely on the responsibilities of those in charge of animals to achieve good welfare outcomes within certain boundaries. Thus, it is currently the responsibility of the person in charge of the transported stock to alter journey factors depending on the class and condition of the animals, as well as the existing weather conditions.

In comparison with the results of these studies, the forthcoming Model Code of Practice for the Land Transport of Sheep (currently in final draft form) (PIMC 2006), and the current Australian Standards for the Export of Livestock: Standard 2 Land transport of livestock (DAFF 2005), have values of 0.19 m^2 for 30-kg sheep and 0.22 m^2 for 40-kg sheep (further information is presented in Table 8 in Section 4.9). These values are for sheep in half-wool and may be adjusted downwards for newly-shorn sheep and upwards for sheep in full wool, although by how much is not specified. Accordingly, it would appear that Australian space allowances are at the lower end of the values deemed as acceptable by the European studies, or just below these values, but with the caveat that the European conclusions were based on lying behaviour more than any physiological changes. In Australia, the lying of sheep during transport is seen as undesirable "going down". The issue of appropriate journey durations for sheep under Australian conditions (including stocking density) is currently being addressed by the MLA research project AHW.055.

Finally, a paper by (Warriss et al. 2003), examined not the response of sheep to different stocking densities, but the ability of human operators to accurately estimate the stocking density, based on different methods of calculation. The best method (in the absence of being able to measure a sample of body weights) was to obtain a girth measurement of a sample of the lambs, combined with counting lambs into each truck pen. For sheep, bodyweight (kg) = $([\text{girth (cm)} \times 0.0297] + 0.902)^3$ (Warriss & Edwards 1995).

4.4.3 Goats

Only one peer-reviewed scientific paper examining the effects of stocking density during transport of goats was identified. (Kannan et al. 2000) trucked 26-kg does for 2.5 hours at space allowances of 0.18 and 0.37 m^2 per animal in group pens. Measurements included plasma cortisol, glucose and CK. The results showed that transport per se was stressful to the goats, and that there were no significant effects of space allowance, apart from a trend for higher CK at a space allowance of 0.18 m^2. The study was conducted in the USA using domestic breeds of meat goats, and it is worth noting that the relatively short duration used may have masked effects of stocking density.

4.5 Effects of transport duration on animal welfare

4.5.1 Cattle

The initial published research examining the effects of transport duration on cattle originated from the Queensland Department of Primary Industries. Jennifer Wythes and colleagues (Wythes et al. 1981) transported beef cows by rail for 460, 870 or 2055 km, with the longest journey interrupted by a 27-hour unloaded rest stop for feed and water. The effective durations of actual transport were 19, 40, and approximately 40 + 40 hours. There were no differences between treatments in the amount of bodyweight lost, but cows on the two longer journey treatments had higher bruise scores at slaughter.

Other early Australian research similarly focused on production variables. (Smith et al. 1982) trucked slaughter-weight steers for 0, 3 or 12 hours and measured bodyweight changes and carcass bruising, as well as meat quality variables. The 0 hour groups (i.e. not transported) were feed and water-deprived. All animals had no feed or water from the commencement of the study until slaughter at 53 hours. There was no difference between treatments in bodyweights or bruising.

A survey investigation published by (Jarratt et al. 1982) on factors affecting mortality during rail transport of cattle in Queensland found that deaths increased from 0.08% for journeys less than 36 hours to 0.20% for journeys of 36 hours or more. However, because the 36-hour point was arbitrarily chosen, it is not possible to say if this was an inflection point in the mortality curve, or if the increased deaths were occurring mainly at some greater duration. Up to 5.5% of journeys lasted for 48 hours or more (i.e. beyond the current Code maximum).

In 1984, the known effects of cattle marketing and handling procedures (i.e. post-farm transport, methods of sale and handling and lairage at abattoirs) on bodyweight and carcass attributes were summarised in a paper by (Wythes & Shorthose 1984). The authors commented that a maximum journey stage duration of 36 hours for cattle was by then seen as an appropriate recommendation, unless the entire journey could be completed in a few more hours, based on industry practice and carcase weight and bodyweight data. Rest stops were recommended to be at least 12 and preferably 24 hours. A subsequent review by (Shorthose & Wythes 1988a) did not uncover any substantial new information.

A research paper by (Wythes et al. 1988) examined the effects of the duration of the rest period during extended transport on carcass weights and bruising in cattle. Cattle were transported by rail for 35 hours direct to an abattoir, or rested once or twice during the journey, with the cattle unloaded. The durations and timing of the rest periods were not specified, but the cattle rested once arrived 36 hours after the unrested cattle, and the animals rested twice arrived 60 hours after the unrested cattle. During the rest periods, the animals had access to water and feed. Animals that were transported directly to the abattoir for 35 hours had greater bruise scores than those rested once, but were not different from those rested twice. It would appear that although a rest period may have been beneficial to the animals under the rail transport conditions at the time, the handling of loading and unloading associated with two rest stops within the journey was not helpful to the animals' bruising. Animal bodyweight was not measured and there were no differences between treatments in carcass weights.

The early published European research on the effects of transport duration on cattle welfare focussed on calves. (Mormede et al. 1982) examined responses to transport in Friesian calves 1 month of age or less. The calves were subjected to a combination of saleyard and trucking procedures, in two treatments. The short journey treatment involved a short journey from farm to saleyard, a minimal stay in the saleyard and a 3-hour transport event (distance not specified), for a total event time (including the saleyard) of 13 hours. The long journey calves had the same journey from farm to saleyard, followed by a longer stay in the saleyard, followed by a road journey of 300 km (duration not specified), for a total event time of 22 hours. The longer time journey calves were more dehydrated, had a greater level of hypoglycaemia and a greater disease incidence over the following 3 weeks.

Subsequently, a series of three papers by Kent and Ewbank from the University of Liverpool examined transport duration in calves at three ages. In the first study ((Kent & Ewbank 1983), 6-month-old Friesian-cross calves were transported by road for 6 hours, or deprived of feed and water for an equivalent period. Transport per se was accompanied by significant increases in cortisol and white blood cell count and a gradual increase in haemoconcentration. However, the overall impact on the calves was most affected by a change in environment. Calves transported and returned to a new environment lost weight over a subsequent 3 week period, as did a non-transported group that was moved to the new environment. Transported calves returned to their home environment did not lose weight, which was also the case for control calves that remained in their home environment. In summary, transport caused short-term stress-induced changes, but medium-term stress-induced changes in measures such as bodyweight were a result of change in environment.

In a second study (Kent & Ewbank 1986a), calves 1 to 3 weeks of age were transported by road for either 6 or 18 hours. The calves had been fed on milk replacer and offered hay and concentrate pellets in the period before the experiment, and were able to lie down in the vehicle during the journey. There was no evidence of dehydration or hypoglycaemia resulting from either of the treatments. Plasma cortisol was not affected by journey duration, but did increase immediately after loading.

In the final paper (Kent & Ewbank 1986b), 3-month-old calves were transported for either 6 or 18 hours. The calves were fully weaned and able to lie down during the journey. The results showed that stress levels (cortisol) peaked within 10 minutes of the commencement of either journey, and that there was no evidence of dehydration, hypoglycaemia or muscle fatigue.

In the USA, (Cole et al. 1988) examined the responses of 200-kg young steers to fasting without transport, road transport for 12 hours and transport for 24 hours. Serum cortisol decreased during transport (presumably as the animals adapted) whereas creatine kinase showed a slight increase. The calves transported for 12 hours had a greater disease incidence than the 24-hour group during the 56-day feedlot period that followed, although this may be an anomalous result given that there is no apparent logical reason why shorter transport duration per se would result in more disease. There was no significant evidence that the 24-hour journey was detrimental to the welfare of the cattle compared with the 12-hour trip.

The review of cattle transport by (Tarrant 1990) did not examine journey duration specifically in terms of welfare, although there was discussion of the results of Australian and other research covered elsewhere in this review on the effects of fasting duration on changes in liveweight and meat attributes.

Cattle transport was examined in experimental studies by Warriss, Knowles and others at Bristol University during the latter part of the 1990s. In the first study (Warriss et al. 1995), 340-kg steers were transported by truck for 5, 10 or 15 hours. Detailed blood measurements included bodyweight, cortisol, CK, and indicators of hydration and metabolic status. The cattle were transported at a density of 1 m^2 per animal, which would not permit lying down, but would allow standing with a little spare space. There was no biochemical evidence that the 15-hour journey was any more stressful or problematic to the cattle than the 10-hour journey, although the authors commented that the 15-hour animals appeared more docile at unloading, possibly through tiredness. The conclusion of the researchers was that the 15-hour journey under good conditions was acceptable for animal welfare.

In a subsequent study (Knowles et al. 1999a), cattle (572 kg) were transported for 14, 21, 26 and 31 hours, including a rest stop of 1 hour after the first 14 hours of travel. The animals were transported at 1.55 m^2 space allowance, and the vehicle was bedded, permitting some lying behaviour during the journey, although not by all animals simultaneously. During the rest stop, the animals remained on the vehicle, but had access to water in accordance with European regulations. The detailed physiological measurements did not indicate any significant welfare compromise after 31 hours of transport, although plasma osmolality and urea concentration progressively increased, indicating a degree of (non-clinical) dehydration. Interestingly, the paper also showed that 42% of cattle failed to take a drink during the 1-hour rest stop on board the vehicle. It is not certain whether this would have been caused by lack of space allowance or unfamiliarity with the environment. Behavioural observations showed that 7 out of 15 monitored animals lay down after approximately 24 hours of transport. The interpretation of the authors was that 24 hours of transport may therefore be a suitable limit to avoid animal tiredness, although the physiological measures suggested that the 31 hour journey was not excessively physically demanding.

A review by (Knowles 1999), highlighted the likely inadequacy of a 1 hour rest period during an extended journey, and also cited papers discussed above as well as the finding of (Tarrant et al. 1992). In the study of (Tarrant et al. 1992), which was primarily focused on stocking density and is described in detail in the preceding section, 600-kg steers were transported for 24 hours. The review of (Knowles 1999) commented that the cattle transported for 24 hours by Tarrant and colleagues “suffered considerable dehydration”. This comment was not made in their paper by (Tarrant et al. 1992), and appears to be based on an increase of 13% in total plasma protein concentrations from 76.4 to 86.0 g/l. According to (Carlson et al. 1997), such a change in total plasma protein would represent approximately a 10% deficit in plasma volume, a moderate but significant level of dehydration, albeit recoverable within 24 hours if sufficient water were available. This discrepancy between the hydration changes in the study of (Tarrant et al. 1992) and those responses measured in other work is not easy to attribute.

The effects of overnight rest stops during an extended 3 to 4 day trucking journey for pregnant (day 190) cows was examined by (Fisher et al. 1999). Changes in bodyweight and blood biochemical variables were tracked through transport, and while overnight off-truck rest stops with water and hay were beneficial in terms of hydration and muscle fatigue, bodyweight and serum magnesium concentrations (important in pregnant bovines) declined throughout transport, suggesting that transport over a longer distance may have caused welfare problems for the cows.

In a field study of multiple transport journeys from 0.5 to 8 hours for slaughter-weight cattle in Germany, (Holleben et al. 2003) found that although longer journey lengths were associated with slightly more difficulty in unloading the cattle, animal stress responses in terms of heart rate were lower with increasing journey duration. The study collected data from 63 commercial livestock journeys involving 580 bulls, cows and heifers, with 206 of the animals fitted with heart rate monitors. It should be noted that heart rate data alone does not provide an overall assessment of animal stress and welfare during transport.

In Australia, MLA-funded research by Parker, Fitzpatrick and colleagues at James Cook University (Parker et al. 2003b) examined the responses of Bos indicus steers transported for 48 hours following a 12-hour period of feed and water withdrawal. It should be noted that the current maximum permissible Australian limit on transport duration of cattle as defined by water deprivation time is 48 hours (i.e. less than the duration of water deprivation used in this study). Detailed analyses of plasma acid-base balance, total protein and other variables revealed that the 48 hour journey duration resulted in a mild metabolic acidosis, presumably related to a loss in body water. The difference in total plasma protein between control and transported steers (64.1 vs. 78.6 g/l) would suggest that the trucked animals were just above the upper limit of the normal range for plasma protein (74.6g/l) (Kaneko et al. 1997), but were not severely dehydrated.

In summary, there is relatively little information that directly pertains to the current Australian Model Code of Practice for the Land Transport of Cattle (MCOP 1999). For calves 1 to 6 months of age, the Code sets a maximum limit of 24 hours. Given that the study of (Kent & Ewbank 1986b) did not identify problems with 18 hours of transport for 3-month-old calves, the Code value appears potentially reasonable, but without the support of directly relevant data. It should be noted that the beef industry does not commonly transport calves, in contrast to the transport of animals derived from dairying. The studies of (Warriss et al. 1995) and (Knowles et al. 1999a) suggest that there was little problem with transporting older cattle for 15 to 24 hours, but there is little data that directly relates to the Code value of 36 (extendable to 48) hours. The fact that a significant proportion of cattle transported by (Knowles et al. 1999a) did not drink during a journey of 31 hours (assuming they were able), combined with the blood data that suggested haemoconcentration but no clinical dehydration in the 31 hour group, would suggest that the 31 hour journey in this case was not problematic. Beyond this point, there is the study of (Parker et al. 2003b) in which 60 hours of water deprivation during transport caused clinical but not severe dehydration in *Bos indicus* steers.

4.5.2 Sheep

The scientific examination of the effects of transport duration on the welfare of sheep was detailed in four key papers between 1993 and 1996 by Knowles and colleagues from the University of Bristol.

In the first paper (Knowles et al. 1993a), the researchers examined the effects of 9 and 14 hours of road transport on 29-kg lambs. The measurements included animal behaviour during the journey, as well as plasma indicators of stress, fatigue and dehydration, including cortisol, CK, betahydroxybutyrate, total protein and glucose. There were no differences in the responses of the lambs to the two transport durations. The authors noted that after arrival, blood variables indicative of stress and changes in hydration had returned to pre-transport values by 24 hours, and bodyweight and metabolic indicators had recovered by 96 hours post-arrival.

The second study (Knowles et al. 1994) examined longer journey durations of 18 and 24 hours, including a crossing on a roll-on/roll-off ferry to France. The lambs were approximately 36 kg in weight, and an extended range of measurements included variables related to stress and metabolic state (cortisol, glucose, betahydroxybutyrate, free fatty acids and lactate), fatigue and muscle damage (CK) and dehydration (bodyweight, plasma osmolality, protein and albumin). The space allowance was 0.20 m^2 per animal. The study found that there was an increase in plasma osmolality after the 24 hour journey, but that the major changes caused by both treatments were in metabolic variables. There were no major differences in metabolic responses between the transport durations. On arrival, the lambs from both treatments were observed to be eating before drinking or resting.

In the third study (Knowles et al. 1995), 38-kg sheep were transported by truck for 3, 9, 15, 18 or 24 hours. The sheep were transported at a space allowance of 0.29 m^2 per animal, which the authors noted was sufficient to enable the animals to lie down. Metabolic and hydration measurements indicated that the sheep transported for 24 hours were not clinically dehydrated or metabolically compromised, while behavioural observations suggested that the sheep had adapted to the journey conditions by 9 hours after commencement. It is worth noting that in both (Knowles et al. 1994) and (Knowles et al. 1995), the authors commented that transport duration should be kept to a minimum from a welfare perspective, and that the studies represented best practice under ideal conditions, and thus the results should not be extrapolated to all sheep in all conditions. Furthermore, in (Knowles et al. 1995), the authors additionally suggested that transport at a stocking density that did not permit the animals to lie down comfortably could lead to greater problems. The animals in the study by (Knowles et al. 1995) remained standing for the first 4 hours, but then the majority lay down for the remainder of the journeys unless disturbed. Given that there was no contrast in the study between animals that were able to lie down and animals that were not able to lie down, it is difficult to conclude how much the restriction of lying per se during medium-longer distance transport represents a compromise to the animals' welfare. The results of (Knowles et al. 1995) would show that sheep would prefer to lie down if they are able and it is comfortable to do so during a longer journey, but we do not know the impact on animal welfare of longer journey durations when the sheep are not able to lie down, as is typically the case in Australia, where the provision and removal of bedding presents economic, environmental and practical difficulties, especially in multi-deck sheep transport vehicles. This issue is currently being addressed by the MLA research project AHW.055.

In the final study in the series (Knowles et al. 1996), 30-kg lambs were either 1) transported for 15 hours, unloaded and rested with feed and water for 2 hours and then trucked for a further 7 hours; or 2) transported for 24 hours, unloaded and rested with feed and water for 48 hours. The results showed that after a 15 hour journey, the 2 hour rest was of slight benefit in permitting decreases in CK and non-esterified fatty acids, suggesting some recovery in muscle status and metabolic responses. The rest period of 8 hours after the 24 hour journey was of greater benefit. Animals transported for 24 hours showed haemoconcentration indicative of some dehydration, however they were still primarily interested in eating on arrival.

Some information on the effects of extremes in transport duration can be gleaned from the work of (Cole 1995). In this study, although sheep were not transported, mature wethers were deprived of all feed and water for 3 days, and detailed body water measurements conducted. The wethers lost 5.7 litres of total body water, of which 1.6 litres was from the digestive tract. Total body water of control animals was 33.9 litres, and bodyweight was 72 kg. This indicates that the water-deprived wethers were approximately 10% dehydrated, which is clinically significant, although recoverable. Similar findings were obtained in a subsequent study also examining the effects of 3 days of water and feed deprivation (Cole 2000). It is the opinion of the authors of this review that a practice which routinely resulted in 10% dehydration in animals would not be regarded as acceptable in welfare terms by veterinarians.

A study by Don Broom and colleagues at Cambridge (Broom et al. 1996) collected blood samples via catheter every 30 minutes from sheep during a 15-hour road journey. The results showed that the major changes in stress hormone release occurred during the first 3 hours, while during the remaining 12 hours, the animals appeared to have adapted. Variables indicative of dehydration such as osmolality and haematocrit either declined or were unchanged during the journey.

A subsequent study by the Cambridge group (Hall et al. 1997) examined the rate of recovery in body weight in (untransported) sheep fed for 1 hour after 14 hours of feed and water deprivation. This study was clearly conducted in response to EU regulations requiring a rest stop of at least 1 hour after 14 hours of transport. The study found that sheep of various bodyweights lost on average 5.7% of their weight after 14 hours of deprivation. The 1 hour feeding period resulted in only a small alleviation of this loss, with hay consumption being slower than concentrates. The sheep drank just under one litre of water per animal during this period. The authors concluded that a 1 hour rest period was insufficient to allow for good welfare during transport, however one can not draw any conclusions about the appropriateness of the 14 hour period preceding, because no measurements were made of animal metabolic or hydration status. Realistically, much of the 5.7% weight loss would be gut contents, and all but very young or weakened sheep would not be metabolically compromised by this.

A final Cambridge paper (Parrott et al. 1998b) also examined the responses to extended transport and rest periods. Sheep (50 kg) were transported for 14 hours, followed by a 1-hour rest period and then a further 15.5 hours of transport. During the rest period, the sheep were unloaded and had access to feed and water. The results showed no increases in plasma osmolality and CK during the overall journey, indicating that the animals were not dehydrated or fatigued. Cortisol concentrations increased during the initial period of the journey and then declined. Very few animals drank during the 1 hour rest period, suggesting that if a rest period is used, it would need to be longer than 1 hour, although given that biochemical values remained normal throughout the journey, it is possible that the animals were not strongly motivated to drink during the rest period. Interestingly, (Parrott et al. 1998b) noted that their results, in conjunction with the results of an earlier paper on feed and water deprivation without transport (Parrott et al. 1996), suggested that sheep could tolerate periods of water deprivation of 31 to 48 hours without undue compromise to their welfare.

One point to note from all the European papers cited in this section is that there is no suggestion that any curfews were applied before transport.

There are two research papers from New Zealand that do not examine transport durations for sheep per se, but which provide some insight into the risk of thermal stress during various durations of stationary periods during road transport. (Lowe et al. 2002) tracked changes in temperature and hydration status of sheep that were exposed in climate chambers to a dry bulb temperature of 33°C at high humidity (THI ~90), with and without water deprivation. The results showed that the welfare of the sheep was not additionally adversely affected by water deprivation, but that extreme respiratory rates (250 breaths min-1) and very high body temperatures (40.5°C) occurred after 3 to 4 hours. Under New Zealand commercial sheep transport conditions, (Fisher et al. 2004) recorded that the THI in pens increased from ambient levels (e.g. 60) to high values (>75) when trucks were stopped, particularly when there was no natural airflow. On average the THI increased by 9.6 units per hour, suggesting that severe heat stress conditions (THI 90) would result after a stationary period of 50 minutes on a day of 30°C and 75% humidity. This would then result in severe animal distress after a further 3 hours (Lowe et al. 2002). It should be noted that the ventilation slots in New Zealand sheep transport vehicles are narrower than those used in Australia.

There were no peer-reviewed scientific papers examining the effects of land transport durations on the welfare responses of sheep that were identified from the Australian literature.

In summary, the studies of Knowles and colleagues suggest that transport of lambs (29-38 kg) under good practice for up to 24 hours does not present a major welfare problem. The draft Australian Model Code of Practice for the Land Transport of Sheep (PIMC 2006) has a maximum duration of 20 hours for animals less than 6 months of age, extendable to 28 hours. These values are also included in the Australian Standards for the Export of Livestock (DAFF 2005), and align with the results reviewed here. For mature sheep, the draft Code has a maximum time of 32 hours, extendable to 38 hours. There is little data examining these durations, although there is some indication from the results of (Parrott et al. 1996) and (Parrott et al. 1998b) that the hydration of the sheep will be clinically acceptable at these durations.

4.5.3 Goats

There were no papers identified that specifically examined the welfare responses of goats to transport duration.

A paper by (Kannan et al. 2002) examined the effects of depriving 35-kg does of feed (but not water) for up to 21 hours. There was some change in metabolic indicators, but no evidence of significant compromise. Interestingly, the stress responses were equally high at the beginning of the experimental period for both feed-deprived and control goats, indicating that the move to the experimental facility was the most potent stressor. There were no significant differences in stress responses between the treatments.

4.5.4 Rest plus feeding and watering during transport

There is considerable industry interest on whether there is value in allowing livestock to rest for some period during a transport journey (eg. >18 hours) compared with transporting them uninterrupted to their destination. The perceived benefits of a discontinuous long journey is that the rest period, especially if the livestock also have access to food and water, allows the animals to partially recover and therefore the cumulative psychological and physiological impacts of the journey are reduced. However, it also requires animals to endure an additional unloading and loading which are recognized as the main psychological stressors associated with transport (Knowles et al. 1995; Warriss et al. 1995); AHW.055 Pettiford et al in prep.). Moreover, there is no guarantee all animals will sufficiently rest, eat or drink when placed in novel yards and exposed to unfamiliar feed or watering facilities. Consequently, the additional psychological stress and extension in time between departure and arrival could negate any benefit of an in-transit rest period for some animals.

Most of the research investigating the benefits of in-transit rest periods has been conducted in Europe. Under the EU directive 91/628/EEC, (Council of the European Union 1991) a 1 hour rest break after 14 hours of transport before the resumption of transport (max 14 hours) is required for mature cattle and sheep. The animals typically remain on the transport vehicle and water (nipple drinkers) and adequate space for lying down is made available. Although water is available, not all cattle will drink, as shown in the study by (Knowles et al. 1999a) where 42 % of cattle did not consume water during the 1-hour rest period following 14 hours of transport. They concluded that a 1-hour rest stop with access to water was of limited value in terms of rehydrating the cattle, although potential unfamiliarity of the environment may also have been a factor. In a NZ study examining the effects of 3-4 days of transport on pregnant dairy cattle, (Fisher et al. 1999) showed that overnight rest stops were beneficial in terms of reducing dehydration and muscle fatigue. However, significant declines in liveweight and blood magnesium were still evident over the transport period. Other than this work, no other published data was found justifying the use of a mid-transport rest break for mature cattle. Anecdotal information would suggest that the break is more for the driver's benefit rather than for the cattle. The evidence in the following section would suggest that it takes a minimum of 24 hours for animals to recover satisfactorily from a journey of >24 hours. Therefore, short breaks even with access to water would appear to be of limited value on animal welfare grounds.

Typically, cattle and sheep can be transported over long distances in Australia. The utility of rest periods during and subsequent to long journeys on beef quality was investigated by (Wythes et al. 1988). In this instance, they studied the effects of rest (with access to feed and water) during a long rail journey (650 – 1000 km) and rest duration on arrival at the abattoir. They concluded that resting cattle during the course of a long journey resulted in a lower incidence of high ultimate pH values in the meat. Moreover, the combination of rest during transit and at the abattoir was additive with respect to ultimate pH.

There has been a considerable emphasis on the utility of mid-transport rest and feed breaks for young calves (< 1 month of age) (Grigor et al. 2001; Knowles et al. 1997). Young livestock are more vulnerable to transport stress which can predispose them to immunosuppression and disease. As a consequence, higher post-transport mortality rates have been reported in calves (Knowles 1995). The evidence from three separate UK studies would suggest that there was very little benefit in a rest break during transport and this is perhaps because calves spent 40-50% of their time lying during transport (Grigor et al. 2001; Knowles et al. 1999). Further, the provision of a glucose and electrolyte supplement during the 1 hour rest stop did not reduce the level of dehydration as determined by blood parameters (Knowles et al. 1999; Knowles et al. 1997). Given these results, (Knowles & Warriss 2000) advocate that mid-transport rest and/or feed stops be avoided as there are greater benefits in keeping the total transport time to a minimum if the journey is less than 24 hours.

In sheep, specifically lambs, (Knowles et al. 1998) recommended a minimum mid-transport rest period of 8 hours with access to water and food for journeys longer than 24 hours. This was based on an earlier study he and others (Knowles et al. 1996) had undertaken contrasting three transport treatments: (i) 24 hours of transport plus 48 of recovery, (ii) 22 hours of transport with a 2 hour rest period after 15 hours of transport and (iii) 34 hours of transport with a 8 hour rest period after 24 hours of transport. During post-transport recovery and the mid-transport rest breaks, the lambs had access to water and hay and a low protein concentrate. In contrast to the group transported continuously for 24 hours, 2 hours of rest allowed for some recovery but the differences were generally not significant with the exception of plasma NEFA and creatine kinase concentrations. For the group, rested for 8 hours during 34 hours of transport, the authors concluded that the rest allowed realimentation and rehydration before the final 10 hours of transport. This was most apparent for plasma NEFA concentration which returned to the pre-transport levels however, the same was not observed for the haemoconcentration measures. With the exception of plasma osmolality, these generally declined during the 8 hour rest period but the levels were still elevated relative to those observed pre-transport. Clearly, the animals had not completely rehydrated and therefore it is difficult to completely accept these conclusions. The inclusion of a fourth treatment where the lambs were transported continuously for 34 hours would have made for a more valid experimental comparison.

Summary

For journeys between 24 – 36 hours, the available evidence would indicate that the benefits of mid-transport rest periods are of negligible value in terms of animal welfare. There is more value in ensuring the journey is completed in the shortest time possible. There is a knowledge gap in terms of the relative animal welfare benefits of unloading and resting sheep and cattle for periods (and the duration of such periods) compared with transportation for 36 to 48 hours.

4.6 Effects of food and water deprivation during livestock transport

When livestock are transported, it is inevitable that there will be short to moderate periods of restricted access to food and water. This can occur during: mustering and assembly prior to transport, transport, and subsequent to transport when livestock are held in saleyards or abattoir lairage. Whilst food and water deprivation will normally occur at some point, in some cases, the period of deprivation can be substantially extended, particularly prior to transport, due to the requirements of transport operators and selling contract conditions set by livestock buyers and agents. Curfew is the generic term used in livestock industries for the practice of enforced food or food and water deprivation prior to transport, sale or slaughter. As used in general practice, the word “curfew” can thus refer to either combination of food and/or water deprivation. Curfews are typically 6 – 12 hours in duration and they are applied to reduce the gastrointestinal volume prior to transport, thus reducing the total amount of excreta in trucks and the level of faecal soiling on animals. Similarly, the application of curfews prior to marketing facilitates a more accurate realization of liveweight, and therefore value, at the point of sale. There is also the opinion among transporters that curfews reduce the amount of slipping and falling and animals “going down” on vehicles.

Food and water deprivation is just one of several stressors that apply to livestock transport and in this context, the physiological impacts are more apparent during longer journey durations. Relative to monogastric animals, ruminants (mature, healthy and non-lactating) can tolerate longer periods of food and water deprivation before it becomes of clinical concern. This capacity can be attributed to the rumen and its contents, which acts as a reservoir of nutrients and water to buffer against the restricted intake of food and water.

When considering the impact of food and water restriction on animal welfare, it has to be considered from two viewpoints. Firstly, what is the direct effect of food and water deprivation on animal welfare, and secondly, does the period of food and water deprivation affect the capacity of animals to cope with transport? For the purposes of this review, emphasis was given to studies examining short to moderate periods of deprivation (24 – 72 h) which are similar to those experienced by livestock during transport and marketing in Australia. This period of deprivation includes the mustering, assembling and processing of livestock prior to transport, the period of actual transport and any time without access to food and water, following arrival at their destination.

4.6.1 Direct effects of food and water deprivation in ruminants

4.6.1.1 Liveweight loss

The most obvious effect from food and water deprivation is a loss in liveweight (Table 2). The trend is typically exponential whereby the rate of liveweight loss is fastest during the initial 12 hours of food and water restriction and slower thereafter. (Shorthose & Wythes 1988b) summarized the results from 26 cattle studies to reveal average losses of 4, 6.5, 9 and 10.5 % in liveweight following 6, 12, 24 and 48 hours of food and water restriction (with or without transport). A similar pattern has been reported for sheep and lambs (Kirton et al. 1972; Knowles et al. 1995; Thompson et al. 1987) and goats (Kannan et al. 2002).The origin of the weight loss varies over the period of food and water deprivation. Typically in cattle, during the initial 24 – 48 hours of fasting, the majority of weight lost originates from excretion of gastrointestinal tract (GIT) contents and urine. In a study by (Phillips et al. 1991b), the combined weight of urine and faeces excreted accounted for 61 – 64 % of the total liveweight lost after 48 hours of food and water deprivation. In sheep, this proportion is much lower (Cole 1995). As the duration of food and water deprivation extends beyond 48 hours, tissue catabolism and dehydration increase in their contribution to liveweight loss. In their review,(Wythes & Shorthose 1984) stated that carcass weight loss, an indicator of tissue catabolism and dehydration, was typically not observed until after 24 hours of food and water deprivation in cattle. This period, before discernable changes in carcass weight loss are evident, can be extended up to 3 – 4 days when cattle have access to water during fasting (Kirton et al. 1972). For sheep and lambs, significant changes in carcass weight may be evident much earlier, within 12 hours of food and water deprivation (Kirton et al. 1972; Thompson et al. 1987).

The quantity and composition of the gut contents, particularly the water content, can affect the rate of passage through the gut and this in turn, will influence the rate and magnitude of weight loss during food and water deprivation (Wythes & Shorthose 1984). Climatic conditions can also be influential, as temperature can affect gut motility and urinary output. (Phillips et al. 1991a) reported that as the ambient temperature increased, the proportion of liveweight lost as excreta decreased.

Table 2: The effect of time off feed on percentage weight loss in cattle, sheep and goats

Time off feed (hours)	Cattle (weight loss %)	Sheep (weight loss %)	Goats (weight loss %)
3		1	
6	4		
7			2
9		4	
12	6.5		
14			5.5
15		8	
21			7
24	9	9	
48	10.5	12	

Shorthose & Wythes (1988); Thompson et al. (1987); Knowles et al. (1995); Kannan et al. (2002)

4.6.1.2 Rumen function

The results from the literature would suggest that the effects of periods of food and water deprivation on rumen function, specifically the microbial populations and activities, are equivocal (Cole & Hutcheson 1985; Galyean et al. 1981; Loerch & Fluharty 1999). Further exploration of these results and the possible reasons for the differences between studies is dealt with in more detail by Entwistle (Live.122A, 2006). One clear difference between the studies was the methodologies used to measure ruminal microbial activity.

4.6.1.3 Blood chemistry

There is a reasonable body of literature examining the effects of either food deprivation or food + water deprivation on blood hormones, metabolites and chemistry in ruminants. From these studies, there is a general trend of changes in key parameters, particularly those that are indicative of protein and fat catabolism and haemoconcentration/dehydration. These are summarized in Table 3. Changes in the total and differential leucocyte counts (indicator of immune response) during food deprivation have also been examined in cattle (Cole et al. 1988; Schaefer et al. 1990) and goats (Kannan et al. 2002). The results generally indicated that there are minimal changes in leucocyte numbers following food deprivation.

In general, food or food and water deprivation over varying periods up to 72 hours did not affect blood cortisol concentration in cattle (Galyean et al. 1981; Parker et al. 2003b; Walt et al. 1993), sheep (Horton et al. 1996; Warriss et al. 1995) and goats (Kannan et al. 2000) (see Table 3). Cortisol secretion is regulated by the HPA axis and it increases in response to a wide range of stressors but particularly those that are psychological in nature. The general lack of a cortisol response would suggest that food and water deprivation up to 72 hours was not overly psychologically stressful to ruminants.

Table 3: Typical response in selected blood parameters to food deprivation or food + water deprivation over varying periods up to 72 hours in ruminants

Blood Parameter	Indicator	Response to Food Deprivation or Food + Water Deprivation
Glucose	Carbohydrate metabolism	**Decrease** (may show slight increase initially up to 24 h)
NEFA	Lipolysis	**Increase**
Urea Nitrogen	Protein catabolism	**Increase**
Total protein	Haemoconcentration/dehydration	**Increase***
Albumin	"	**Increase***
Haematocrit or PCV	" & HPA activation (fear)	**Increase***
Haemoglobin	"	**Increase***
Osmolality	"	**Increase***
Cortisol	HPA activation (fear)	**Minimal change**
PCO_2	Blood-acid base balance	**Decrease**

Response during food + water deprivation. Food deprivation alone may only result in minimal changes to these parameters.
HPA hypothalamic-pituitary-adrenal axis WBC – White blood cell count

(From: (Cole et al. 1988; Galyean et al. 1981; Schaefer et al. 1988; Parker et al. 2003b; Phillips et al. 1991a; Walt et al. 1993) – Cattle; (Gaal et al. 1993; Horton et al. 1996; Knowles et al. 1995) – Sheep; (Kannan et al. 2000)– Goats)

4.6.1.4 Urine volume and chemistry

Reduced fluid intake causes pronounced changes in urine output and chemistry. Specifically, urine output declines with a commensurate decrease in sodium and chloride ion concentrations and an increase in nitrogen, specific gravity and osmolality (Igbokwe 1997; Carlson et al. 1997).

Summary

The associative effects of food and water deprivation for periods up to 72 hours are liveweight loss, dehydration, lipolysis and protein catabolism. These associations are generally not linear. The psychological stress associated with feed and water restriction appears quite small based on blood cortisol concentration. However, this should not be interpreted that the animals do not experience hunger or thirst.

4.6.2 Effect of pre-transport food and water deprivation on the response to transport

Paradoxically, it appears that the application of pre-transport curfews (i.e. periods of food and water deprivation on-farm prior to transport) was in part, predicated on animal welfare grounds. The anecdotal reports from livestock transporters are that cattle and sheep tend to travel better following pre-transport curfews. One of the primary benefits observed was the reduction in number of animals (primarily cattle) that lie down or lose their balance on the truck during the journey. The risk of bruising and injury increases considerably when animals go down (Tarrant & Grandin 2000) and drivers are required to encourage these animals back to their feet which in turn, may cause additional stress in both the downed animal and others in the truck. Regular stopping to attend to downed animals will also prolong the transport duration. One factor thought to contribute to the curfew mediated reduction in downer animals was the reduced volume of excreta on the truck floor and therefore reduced risk of slippage and falling.

There is very little published data corroborating these anecdotal views. (Gregory et al. 2000) in New Zealand undertook a study examining the effect of different pre-slaughter feeding treatments on the amount and consistency of excreta voided during transport. Pasture finished cattle were either: (i) fed hay for 48 hours, (ii) fed hay for 24 hours, (iii) fasted for 24 hours or (iv) not fasted (remained on pasture) prior to transport (2 hours) to the abattoir. The cattle had access to water during their pre-transport feeding treatments and in lairage. As expected, fasted cattle produced significantly less excreta than the non-fasted or hay fed groups. Their results also confirmed earlier observations (Bass & Duganzich 1980) that digesta tends to become more liquid over time of increasing food deprivation. However, the faeces from the non-fasted pasture cattle were significantly more liquid than the fasted group. Unfortunately, no behavioural observations were made during transport. These results confirm that non-curfewed cattle will not only produce more excreta during transport but it is also likely to be more liquid. Although not stated, it is presumed that the pasture conditions in the study by (Gregory et al. 2000) were typical of those in New Zealand (i.e. high quality, relatively lush temperate pasture). If so, one question that arises is whether these results are equally applicable when cattle are derived off poorer quality or drier Australian pastures.

Whilst the volume of excreta and indeed the design and construction of the stockcrate floor contribute to losses of balance and slippage, it is pertinent to highlight that stocking density and driving events (eg. braking, cornering) are also major factors in this context (Eldridge & Winfield 1988; Cockram et al. 2004; Tarrant et al. 1992).

No clear conclusions can be drawn with regard to the interaction between pre-transport food and water deprivation and the response to transport as there is a distinct lack of published data. The search only revealed three cattle studies that were relevant. In the study by (Gregory et al. 2000), described above, there were no differences in plasma cortisol or protein concentration at slaughter between the fasted and non-fasted groups. Urine sodium concentration was significantly higher in the fasted group suggesting that these cattle may have been more dehydrated. There was no data recorded on bruising or meat quality. Irish researchers (Earley et al. 2004) contrasted the treatments of 8 hours of fasting (with access to water) versus no fasting on the responses to 8 hours of road transport. Apart from a difference in liveweight lost after transport (9.4% fasted and 7.2% non-fasted), there were no or minimal differences in blood chemistry and haematology. Given this, they concluded that the combination of 8 hours of fasting and 8 hours of transport did not negatively impact on animal welfare. The salient point here is that cattle had access to water during the curfew period. (Jacobson & Cook 1997) compared different periods of pre-transport holding time (3, 8 and 20 hours) with and without access to feed (silage) prior to 2 hours of transport for bulls. They found that holding time and conditions affected the stress response to transport. The plasma cortisol levels were considerably higher prior to (46.5 – 60.7 nmol/l) and subsequent to transport (92.1 – 108.8 nmol/l) in the 3 hour group compared to the 8 and 20-hour groups (28.9 – 34.3 nmol/l pre-transport and 21.5 – 30.8 nmol/l post-transport). They concluded that pre-transport holding periods of <8 hours for bulls may be insufficient to allow adequate recovery from the process of mustering, and yarding.

In this context, transport operators have asserted that cattle that are curfewed prior to transport show less desire to lie down during transport. There is some limited evidence that supports this assertion. Lying behaviour during rail transport was particularly evident in a Queensland experiment when cattle consumed excessive volumes of water prior to the journey (J.Lapworth, personal communication). The excess consumption was due to the inclusion of sugars in the water.

Summary

There is a paucity of scientific data to support the anecdotal views from livestock transporters that pre-transport curfews facilitate improvements in the capacity of cattle and sheep to cope with transport. The application of pre-transport curfews will result in less excreta in trucks but it is not clear whether this reduces the amount of slippage and improves the ability of animals to maintain their balance during the journey.

4.6.3 Comparative physiological responses to similar periods of food and water deprivation or transport

There are a small number of investigations comparing the physiological effects of similar periods of food and water deprivation or transport in both cattle and sheep. The results from these studies are summarized in Table **4**.

In their review of research published prior to the 1980s, (Shorthose & Wythes 1988a) reported it was questionable whether the loss in liveweight or carcass weight due to transport was higher than that from food and water deprivation alone. In investigations since then, weight loss was higher following 48 hours of discontinuous transport in cattle (Phillips et al. 1991a), but in sheep the results were equivocal (Horton et al. 1996; Knowles et al. 1995). The percentage of weight loss as excreta was higher in transported cattle compared to those deprived of food and water for 48 hours.

On the basis of the limited number of studies presented in Table 4, it would also appear that the differences in the physiological responses to food and water deprivation compared to transport are negligible.

Collectively, these results seem counterintuitive given the additional psychological stress and physical demands that occur during transport. Psychological stress can induce diuresis (Parker et al. 2003a) and increased gastrointestinal tract motility. Therefore, it is reasonable to expect that liveweight losses might be higher during transport. The psychological stress associated with transport, based on changes in heart rate and plasma cortisol concentrations, is generally highest during loading and initial phases of transport (Eldridge et al. 1988; Warriss et al. 1995): AHW.055 Pettiford et al in prep.). Beyond that, animals generally habituate to the transport conditions. Consequently, the elevated stress response is not sustained over the entire journey and this may account for the equivocal results with regard to liveweight loss. The effort to maintain balance during transport would also be expected to incur increased muscular demands compared to that during food and water deprivation only. However, (Knowles et al. 1995) reported no difference in plasma creatine kinase levels. Creatine kinase is an enzyme associated with energy metabolism in muscle which is released following a change in the permeability or damage to muscle cell membranes and has been used as an indicator of muscle use/damage in transport studies (Knowles & Warriss 2000). Whilst useful, measurements of muscle glycogen depletion may be more informative in this context. This was measured in the experiment by (Knowles et al. 1999b) who found a small effect of transport up to 31 hours on the depletion of muscle glycogen concentration in cattle. In this instance, the decrease was only significant in two of the four muscles sampled. Finally, some care needs to be exercised with respect to the results of (Phillips et al. 1991a) as the cattle were not transported continuously over the 48-hour period.

Table 4: Summary of results from studies comparing the effects of food and water deprivation versus transport on physiological response in cattle and sheep

Reference	Treatments	Trygly. (mg/dL) or FFA (mmol/L)	Glucose (mg/dL)	Urea N (mg/dL)	Cortisol (g/dL)	Osmol. (mosmoles/ kg)	Total Protein (g/dL)	PCV (%)	pCO_2 (mm HG)
Cattle									
Galyean et al (1981)	0 h FWD	53.0^{a}	75.0^{ab}	25.7^{a}	3.13	290	6.7^{a}		
	32 h FWD$^{\#}$	46.3^{ab}	67.7^{a}	21.0^{ab}	3.83	297	8.3^{b}		
	32 h Transport	33.3^{b}	90.0^{b}	16.7^{a}	1.88	296	8.3^{b}		
Phillips et al (1991)	48 h FWD		93.0^{a}	No diff.			No diff.	No diff.	
	48 h Transport*		135.6^{b}						
Parker et al (2003)	0 h FWD						6.4		42.6
	60 h FWD						8.1		36.1
	12 h FWD + 48 h Transport						7.9		37.8

Sheep									
Knowles et al (1995)	24 h FWD	1283^{a}	61.4^{a}	28.4^{a}	2.99	291	6.8	37.6	
	24 h Transport	788^{b}	80.8^{b}	24.5^{b}	3.09	293	6.8	36.8	

[#]FWD – food and water deprivation. No diff. – least square means not reported due to non significant differences between the treatments (P>0.05)
Cattle were held in metabolism crates on the truck. Transport was not continuous (10 h transport + 14 h stationary + 8 h transport + 16 h stationary)

Trygly – tryglycerides, FFA – free fatty acids, urea N – urea nitrogen, Osmol – osmolality, PCV – packed cell volume and pCO_2 - partial pressure

Summary

The differences in the physiological responses to similar periods of food and water deprivation or transport are negligible based on the available evidence.

4.6.4 The impact of pre-transport curfews on ruminant welfare

Under the Australian Model Code of Practice for the Land Transport of Cattle (MCOP 1999), the maximum allowable transport duration is primarily determined by the maximum time that stock can be deprived of water. For mature dry cattle, the maximum duration is 36 hours. However, this can be extended to 48 hours if the animals are not displaying obvious signs of fatigue, thirst or distress and if the extension allows the journey to be completed within 48 hours. For mature healthy sheep, the draft maximum proposed time is 32 hours but this can be extended to 38 hours. These maximum durations also include any period of pre-transport curfew where access to water is restricted. Clearly, this would not apply to pre-transport curfews that allow access to water but not food.

For the majority of cattle, sheep and goats that are transported directly to slaughter within Australia, it is unlikely that the period of water deprivation will exceed the maximum limits under the code. One of the mitigating factors here is the availability of water during abattoir lairage. However, even with access to water, not all animals will drink. Limited access to watering facilities, unfamiliarity and neophobia all contribute to the variability in drinking behaviour in novel environments. This could account for the high proportion of directly consigned lambs in WA that were considered dehydrated at slaughter (Jacob et al. 2005).

However, for some marketing/transport pathways, it is likely that the maximum limit will be exceeded and therefore animal welfare may be compromised. It is also pertinent to highlight that under the current regulatory framework governing animal welfare in Australia, there are limitations with regard to the capturing of information that enables assessment of compliance with the code.

From an animal welfare perspective, curfews will elicit hunger and thirst and their expression will depend on curfew duration and the physiological condition of the animals prior to the commencement of the curfew. The emotional costs of hunger and thirst in livestock cannot be reliably quantified at this juncture. Consequently, we are reliant on quantifying the biological costs via physiological measurements. Physiologically, restricted food and water intake leads to altered metabolism, increased tissue catabolism and dehydration. Of these, dehydration is undoubtedly the most significant welfare concern. Transport or fasting studies where cattle were deprived of food and water up to 48 hours clearly show haemoconcentration indicating some level of dehydration (Parker et al. 2003b; Phillips et al. 1991a; Schaefer et al. 1990; Walt et al. 1993); AHW.055 Pettiford et al in prep.). However the level of dehydration even after 48 hours could not be classed as being of clinical concern. For example, in a recent Australian study (AHW.055 Pettiford et al in prep.) where cattle were transported for 48 hours (no pre-transport curfew), many of the key plasma measures (eg. osmolality, total protein, PCV) were still within normal expected physiological ranges. This outcome can be partly attributed to the ruminal reservoir of fluid which acts as a useful buffer during periods of water restriction (Knowles & Warriss 2000; Parker et al. 2003b). Unfortunately, the picture is less clear with regard to sheep and goats. Recent results by (Parker et al. 2003a) indicate that sheep may also be reasonably tolerant of considerable periods of water deprivation as reductions in urinary output were only evident after 72 hours of water deprivation.

There is insufficient scientific evidence to conclude that pre-transport curfew improves the capacity of ruminants to cope with transport. Clearly, this association requires research attention, as the results are central to any informed judgment of the impact of curfews on animal welfare during transport.

4.6.5 Recovery following transport

The rate of recovery following transport is clearly important with respect to animal welfare and productivity. This is generally indicated by the time it takes for the physiological and behavioural measures to return to their pre-transport levels. However, as always, some care needs to be applied here particularly if the pre-transport blood measures were affected by initial handling, movement and sampling of the animals which was evident in transport studies (Knowles et al. 1995) in lambs and (AHW.055 Pettiford et al in prep) in cattle.

Apart from associated transport effects, the rate of recovery will also be influenced by the conditions in the resting yards/pens, quality and composition of the feed and the capacity of the animals to adapt to the novel surrounds, feed type and watering facilities. For example, (Knowles et al. 1993b) reported that the recovery rates (increased liveweight gain and decrease in plasma free fatty acids) were more rapid in lambs that had prior experience with the feed source (hay) provided during post-transport recovery. Notwithstanding this, a general trend emerges in the recovery patterns following moderate to long transport durations (9 – 48 hours) in both cattle (Galyean et al. 1981; Knowles et al. 1999a; Knowles et al. 1999)b; AHW.055 Pettiford et al in prep.) and sheep (Knowles et al. 1993a; Knowles et al. 1996; Knowles et al. 1998). Generally after 24 hours, when animals have adequate space for rest and access to good quality water and feed, the physiological measures have or have nearly returned to their pre-transport levels. This is not always the case for some parameters such as liveweight which did not fully recover by 72 hours after cattle were transported for 31 hours (Knowles et al. 1999a) and 48 hours (AHW.055 Pettiford et al in prep). In calves, this time extended out to 7 days after 24 hours of transport (Knowles et al. 1999). (Knowles et al. 1995; Knowles et al. 1998) also reported that liveweight took longer than 24 hours to return to pre-transport levels in lambs transported for 24 hours. Similarly, there are study-specific exceptions to this general trend for some metabolic and dehydration markers. For example, in cattle transported for 31 hours, (Knowles et al. 1999a) reported that the dehydration indicators of plasma osmolality, total protein and albumin were at or near their pre-transport levels only after 72 hours of recovery.

Knowles and co-workers have also observed behavioural responses during 24 hours of post-transport recovery specifically, the frequency of lying, standing, eating and drinking behaviour over time in both cattle (Knowles et al. 1999a) and lambs (Knowles et al. 1995; Knowles et al. 1998). The behavioural responses were contrasted against those measured over 24 hours prior to the journey. On placement in their recovery pens, there was a compensatory increase in eating and drinking behaviour with a concomitant increase in standing during the initial post-transport recovery period in both cattle (Knowles et al. 1999a) and sheep (Knowles et al. 1995; Knowles et al. 1998). During the subsequent period up to 5-8 hours, the cattle and lambs generally spent more time lying relative to the pre-transport behavioural patterns. The resumption of normal patterns of behaviour was quite rapid in the earlier sheep study (Knowles et al. 1995), whilst in the latter (Knowles et al. 1998), the sheep were lying more, even after 24 hours of recovery. In cattle, (Knowles et al. 1999a) reported 3 bouts of increased feeding and/or drinking behaviour; during the initial hour, after 8 and 16-20 hours of recovery. When cattle were transported over a longer duration of 48 hours, the desire to lie down was significantly greater in the initial 3 hour recovery period compared to that observed in cattle transported 12 hours (AHW.055 Pettiford et al in prep.). Although there were differences between the replicate groups in this study, the differences in lying behaviour between the two transport duration treatments were less apparent during hours 3 to 6 of recovery.

Summary

After 24 hours of post-transport recovery with access to food and water, most physiological measurements returned to pre-transport levels in both cattle and sheep transported over moderate to long durations. Longer periods of recovery are required (e.g. 72 hours) for other variables such as liveweight, some metabolic blood parameters and behaviour to return to levels or patterns observed prior to transport.

4.7 Design of vehicles

4.7.1 Knowledge gaps in Australian Transport practices (vehicle design)

It has been recognised for more than 30 years that features of vehicle design that influence the welfare of sheep and cattle during transport include vibration, ventilation, headroom, pen size, construction materials, material fixation methods, fittings and flooring. Nonetheless, there are very few scientific publications providing data that demonstrate the improvement in welfare outcomes resulting from the substantial improvements in vehicle design that have occurred in this interval. Detailed descriptions of good stock crate design are provided on the websites of some State Departments of Primary Industries:

http://www2.dpi.qld.gov.au/beef/2437.html

http://www.dpi.wa.gov.au/mediaFiles/lic_RAG2StabOnRoadPerMultiJune2002.pdf

http://www.dpi.vic.gov.au/dpi/nreninf.nsf/childdocs/-89E7A8DAFEA417624A2568B30004C26A-B49A42716C4DB484CA256BC70081154C-7D429F62927388D64A256DEA0027A0BC-080B811B7208E8CACA256BCF000BBE83?open

http://www.pir.sa.gov.au/byteserve/agriculture/livestock/downloads/draft_land_transport_of_sheep_v28.pdf

http://www.dse.vic.gov.au/dpi/nreninf.nsf/9e58661e880ba9e44a256c640023eb2e/e037bd5021efd11aca256f0f0080e65f/$FILE/AG0062.pdf

4.7.2 Australian research

An important research focus was the improvement of stock crate design with particular emphasis on minimizing dust intake while still maintaining adequate ventilation. (Town & Lapworth 1990) used a wind tunnel to study air movements around a road train (multi-trailer truck) used for cattle transport. The crates were modified by fitting a solid floor to the lower deck and filling in the gaps between the trailers with canvas in an effort to improve the internal environment by reducing dust levels when travelling on unsealed roads. The research showed that not completely blanking the front of the trailer to air passage reduced the negative pressure otherwise formed at this point, and that it is this negative pressure that can suck dust forward through the vehicle under Australian conditions. (Lapworth 1990) also proposed standards for loading and unloading facilities to minimize stress and injury. Recommendations included, the height, slope, width, step design, material specifications, catwalks, ladder position, pier depth, bumper rails and aprons for single and double deck loading ramps. The paper outlined the specifications and animal welfare advantages of well-designed side-loading double-decked loading ramps for cattle. These designs are now common in facilities throughout Australia where commercial numbers of cattle are transported. The general advances in road transport of livestock during the 1970s and 1980s are outlined by (Lapworth 1986), highlighting the development of stock crate designs which minimised bruising through the incorporation of minimum door widths (900 mm minimum), low profile trailer floor heights (1170mm standard), recessed gate catches, sheeted sides and the removal of obstacles which may damage animals in transit. Contemporary designs such as those provided by QDPI (http://www2.dpi.qld.gov.au/beef/2437.html) incorporate these early recommendations of Lapworth.

(Eldridge & Hollier 1982) noted that there was little uniformity in stock crate design in tray body trucks delivering stock to regional sales in Victoria, and(Lapworth 1986) noted that this class of vehicle might be difficult to improve due to the multiple uses that farm trucks are put to and reliance of many farmers on their own skills for building livestock crates. Mechanisms for regulating the design of such crates do not appear to have been explored. (Eldridge et al. 1988) found that change in heart rate and movement of stock were less in small pens at the lower space allowance per animal (higher density) examined in their study. Both larger pens and more space per animal resulted in higher heart rates and more movement of animals during transport. At around the time this study was undertaken, volume loading was introduced in Queensland (Lapworth 1987). The prior practice of restricting the gross mass of vehicles, which resulted in variable space allowances, was replaced by loading stock to their optimal space allowance irrespective of gross vehicle mass (See Section 4.8). To be eligible for volume loading, vehicles needed to comply with specifications for gross vehicle mass, stock crate dimensions, brakes, tyres, suspension and trailer stability. Volume loading provided welfare outcomes for cattle by permitting pens to be filled to the optimal density thereby reducing bruising and slippage in loose packed pens.

4.7.3 International research

International research has identified the importance of road surface, tyre pressure and vehicle load on vibration during transport of livestock (Grandin 1994; Stevens & Camp 1979; Wikner et al. 2003). An increased transmission of truck vibrations to cattle increases their likelihood of movement and loss of balance. Cattle regularly experience minor loss of balance during transport and consequently shift their footing to regain balance (Kenny & Tarrant 1987). While minor loss of balance is not significant it is related to the risk of irreversible loss of balance resulting in cattle going down onto the floor. (Tarrant 1990). Loss of balance is influenced by cornering, braking, acceleration, gear change and swaying of the truck. While driving skills are an important cause of these events, improvements in truck design (e.g. air suspension, improved transmissions) are likely to help reduce their frequency and the magnitude of their impact. Airbag suspensions were first introduced in Australia in 1989 (See Section 4.8) and current experience of their effectiveness differs. In the late 1990s there was a gradual increased adoption of air suspension on commercial livestock transport vehicles. It is currently estimated to be installed on about 60% of trucks in Australia. This system is not popular in the harder and more extensive regions and has generally only been adopted in areas where the road conditions are good. Operators in the more extensive areas where conditions are more severe have continued using spring suspension as they are less prone to breakdown. They also believe that animals have an easier ride under rough conditions on steel springs (Honkavaara 2003) identified three phases in improvements in vehicle design in Finland with third generation vehicles introduced in 2000 providing good welfare outcomes for cattle transported 8 – 14 hours. However, these developments are not particularly relevant to Australia, given that the second and third phase designs contained only one or two animals per pen.

In the UK, the Department for the Environment, Food and Rural Affairs (DEFRA) has financed a number of scientific research projects on road transport of farm animals. Some important outputs of these projects include:

(i) The development of guidelines for "Guidance on Welfare of Animals (Transport) 2004" (http://www.defra.gov.uk/animalh/welfare/farmed/transport/wato-guidance.pdf),

(ii) "A guide to best practice for vehicle ventilation" (http://www.defra.gov.uk/animalh/welfare/farmed/transport/ventilation.pdf) and

(iii) "Guide to the ventilation of livestock during transport" (http://www.aata-animaltransport.org/Publications/research/Mitchell_Ventilation_guide_mitchell.pdf).

While the principles outlined below identified from this research have general relevance applicability of design specifications to Australian conditions can not be assumed as input variables such as class of stock, condition of stock, prior environmental experiences of sock, and genetics of stock can all influence the welfare outcomes of transport under Australian conditions. Thus research on welfare outcomes of transport of livestock under Australian conditions is needed to firstly avoid the inappropriate application of UK standards to Australian conditions and secondly to provide data under Australian conditions of the welfare outcomes of our practices.

Recommendations on best practice for vehicle ventilation arising from this research have been summarised by DEFRA as follows.

Summary of main recommendations from DEFRA research on vehicle ventilation to livestock producers in the UK (From "A guide to best practice for vehicle ventilation")

* Air movement amongst the animals is essential to remove (a) heat and moisture generated by the animals and (b) airborne pollutants (dust and gases).
* Avenues of heat exchange for the animals are:
  Convection - transfer by flow of air
  Radiation - transfer by emission of heat
  Conduction - transmission by contact with another surface
  Evaporation - transfer by evaporation of water e.g. by panting or sweating.
* High temperatures combined with high humidities will cause severe heat stress in transported livestock.
* It is essential to control both the "on-board" temperature **AND** humidity.
* The ventilation system of the vehicle must be able to dissipate both the heat and moisture loads.
* If deep body temperature falls the animals may become **HYPO**thermic.
* If deep body temperature rises the animals may become **HYPER**thermic.
* Animals will generally tolerate a greater fall than rise in body temperature.

* Reduce the risk of heat and cold stress by controlling the environment on the vehicle.
* Inspect the animals regularly and recognise the signs of thermal stress.
* Where possible use rectal temperature to determine if thermal stress is present.

* On a moving vehicle, the external pressure field generated by the vehicle movement promotes air to enter at the rear grilles, move forward within the container over the animals and leave through the front air apertures.
* The net effect is that air within the container is moving in the **same direction** as the vehicle.
* Parking vehicles at right angles to the wind direction (where possible) can be used to allow air flow amongst the animals during hot weather.
* The success of any mechanical ventilation systems depends upon:
  - Understanding the requirements of the animals and the consequences of inadequate or excessive ventilation on the welfare of the animals.
  - Ensuring that the airflow passes over all the animals.
  - Having defined inlets and outlets at specific locations on the vehicle.
  - Providing sufficient ventilation for all the animals throughout the entire transport period.
  - Controlling the ventilation rate to maintain stable and acceptable thermal, humidity and ammonia conditions around all the animals.
  - Adjusting the ventilation to changes in ambient conditions.
  - Optimising the system design and operation to reduce running costs.

Active mechanical ventilation systems are not used in sheep or cattle transport vehicles in Australia. A decision to investigate the merits of such systems in Australia should not be driven by their use elsewhere but by evidence of heat stress or inadequate ventilation in current Australian vehicle designs and transport practices. If heat stress or inadequate ventilation were found to be problems with current vehicle designs and transport practices, mechanical ventilation systems might be but one potential solution for that issue.

Research by Kettlewell and colleagues (Kettlewell et al. 2001) at Silsoe Research Institute, Bedford England have investigated the impact of mechanical (active) ventilation on conditions within stock crates. Active mechanical ventilation was found to reduce the risk of excessive temperature humidity index (THI) during transport and while livestock transports are stationary. The design recommended by this research is to install extraction fans at the head board with air vents in the tail board to reinforce the natural rear to front movement of air within a stock crate while it is in forward motion. The value or suitability of mechanical ventilation of stock crates on sealed or unsealed roads under Australian environmental conditions does not appear to have been investigated, although it is important to note that enclosed crates are more common on livestock transporters in the EU than Australia (see Figure 1). New Zealand research identified that lack of airflow in stationary vehicles carrying sheep could result in excessive This particularly when the vehicle was confined to the hold of a vehicle ferry for inter-island transport while stationary (Fisher et al. 2004; Fisher et al. 2002).

Figure 1. A European livestock transport vehicle illustrating the direction of natural ventilation. Some crate designs used in Australia have comparable ratios of solid walling to open areas, although Australian vehicles have more air inlets at the level of the feet of the animals, which may provide better air movement under Australian climatic conditions and reduce humidity build up from moisture from faeces and urine on the deck.

A catalogue of DEFRA funded livestock transport projects is included as an appendix (See Appendix 3- DEFRA research projects on livestock transport). Summaries of the outcomes of completed projects do not appear to be publicly released. The striking feature is the breadth of issues under investigation and the magnitude of investment by DEFRA in transport of farm animals. A summary and guidance document of the DEFRA UK Welfare of Animals (Transport) Order 1997 (WATO 1997) is provided in the references.

4.8 Advances in practices in Australian livestock transport

Table 5 presents a chronological review of the major changes and developments in livestock transport practices in Australia from the late 1950's. This information was collated following interviews with the industry reference group, as outlined in Section 3.

Table 5. Changes in Australian livestock transport practices and associated benefits for animal welfare

Year- 1950 onwards	Changes	Welfare Benefits
1952/53	Qld – Road trains for cattle (single deck) started in Longreach using a 34' semitrailer and an 18' dog trailer. A road train is a combination road vehicle consisting of a prime mover towing two or more trailers.	Transport larger mobs quicker and with less stress particularly in day time and at end of season when feed and water on stock routes were a limiting factor
1954	Qld – Road train configuration changed to a 20' body truck with a 30' dog trailer to fit in with carrying enough animals to fill 1.5 N class rail wagons.	As above – also maintain a consistency between road and rail on number transported per vehicle
1956	Start of road trains in North Queensland and the Northern Territory– Buntine (NT) & Wright (Mt Isa, Qld) The use of road trains enabled bigger mobs of cattle to be shifted from one place to another in a much shorter time period. They were particularly useful in times of drought or local feed shortages. The advent of road trains saw the demise of droving.	As for 1952/53
1960	Qld – Road train configuration using a 20' body truck with two 34' dog trailers. A road train configuration consisting of a semi trailer and two semi trailer dogs was not encouraged by the Queensland Transport Department at the time. Transporters considered it a better unit and did use this configuration.	As for 1952/53
1968	40' trailer (12,200mm) first used in Queensland.	
1969	First 3 x 2 deck convertible crates built in NSW. They were 2,640mm high, 11,000 long and 2,440 wide. See Figure 3.	Reduce stress Move bigger mobs more quickly
1969	First trailer built with 1.5 decks (bottom deck full length and top deck only half length over the rear of the trailer.	

1970	WA – Sheep crates with three fixed decks first manufactured in the late 1970s Fixed decks have fewer moving parts, and are easier on both sheep and operator.	Reduce stress and injury to animals Move bigger mobs more quickly Less work for the driver and Less protrusion to cause injury to animals
1970	Several Freuhauf stock crates were imported and used in northwest NSW and QLD. These stock crates had a series of holes along the sides to allow airflow (ventilation). However, they were hot in summer and cattle did manage to get horns and feet caught in the holes causing injury. In the main, these crates did not gain popular support and most were phased out within 10 years.	Thought to reduce stress and injury – not always true
1971	Double deck road trains introduced. These road trains were a double deck body truck as the power source and two single deck trailers.	Move bigger mobs more quickly over long distances
1971	Changed from 34' to 35' trailer length (10370mm to 10675mm).	
1972	Queensland sheep carriers begin changeover from 8 half width pens to 4 or 5 full width pens. This change gave sheep the ability to move more with the pen to better align themselves when travelling.	Less stress on sheep as can move around more to get more comfortable during transit.
1972	Some operators in Queensland try using full width internal loading ramps for cattle. Some felt the extra width did not give animals enough support when exiting from the top deck and have stayed with a half width ramp.	Easier, quicker loading/unloading Reduce stress and injury
1972	QLD began using 2 x 3 convertible stock crates. One operator felt that a fixed 3 deck crate is better for sheep as there is a greater deck clearance and therefore better airflow within the pens.	Reduced stress during transit
1973	The use of step deck trailers became more common. These stock crates had reduced internal clearance at the front of the bottom deck. Small cattle had to be penned in this area to ensure that they would not rub on the floor above.	Reduced stress and injury Allow separate penning of smaller animals

1975	SA – The first double deck stock crates were used to transport animals, subsequently coming into common usage.	
1975	NT Rail transport of livestock from Larrimah to Darwin ceased mainly due to road trains taking cattle direct to Katherine meatworks or Darwin. Livestock trucking yards on this line were originally built about 1964. Figure 2 shows typical livestock rail wagons of the period.	Road could do quicker with less loading/unloading Reduced stress and risk of injury during these processes
1976	NSW – Changed from 8 pens per deck on a sheep crate to 4 by removing the centre longitudinal division. This allowed more space per pen for the sheep to move in. This change was not common practice in SA or WA, which in the main still retain the longitudinal division (8 pens per deck).	Reduced stress Animals better able to align themselves to cope within transit movement
1976	40' trailer (12,200mm) accepted by industry as the standard length.	Reduced stress Bigger mobs moved quicker
1977	Formation of the Livestock Transporters Association (LTA) in Western Australia, followed later by Queensland, then South Australia, New South Wales, Victoria and Tasmania. The formation of the LTA gave livestock transporters a unified voice to improve all aspects of their industry. They were able to present a unified case to negotiate for regulatory charges to improve animal welfare, get better roads, improve vehicle dimensions and carry more animals in a safer manner.	LTA better able to lobby for changes to improve transport regulations Also resulted in improved conditions for animals in transit
1977	Manufacturers began replacing wooden sides (boards & plywood) with metal sheeting. This made the trailers lighter and easier to maintain.	Reduced stress and injury
1978/79	Transporters began to see the animal welfare benefits of easier loading/unloading. Cattle would travel better and presented for sale looking fresher. First over or under double deck loading ramp (DDLR) installed at Dalby in Qld at	Faster safer loading/unloading Less stress reduced injuries

	the expense of the transport operator. See Figure 7.	
1978/79	A survey was initiated to determine the reasons for an increase in stock losses during rail transit. The outcomes of the survey resulted in a significant reduction of losses during rail transport, changes to Qld Rail's livestock management procedures and improved pre-transport management at rail trucking facilities.	Improved for transport management Reduced losses, less stress and injury
1978	First of low profile trailers for livestock in NT. The lead trailer was a step deck which only allowed for a single deck on the front of the trailer and would pull two single decks behind. These stock crates had wooden slatted sides on the outside. The early crates had a bottom deck clearance of 1578mm and a top deck clearance of 1400mm which meant that smaller cattle had to be drafted out to go in the top decks.	Reduced rollover accidents Reduced stress injury and stock losses
1978	The first through loading system (top deck only) was used in the Cloncurry area. Through loading enables the animals to move from one trailer into the other in continuous flow during the loading process. See Figure 5.	Quicker loading/unloading Reduced stress and injury
1978	WA rail ceased operation about 1978/80. This was mainly because of cost, other logistical issues and potential animal welfare problems.	
1979	The first through load system for road transport trialled in the Mt Isa area. Initially the through loading was only fitted to the top deck. This innovation designed and fitted by a transport operator markedly reduced time taken to load/unload animals. There was also a noticeable reduction in injuries.	Reduced loading/unloading times. Less stress and injury to animals
1980	The first double deck through loading system (both decks) was installed on road trains in the Cloncurry and Mt Isa areas. This reduced the time taken to load/unload stock and reduced stress by eliminating the need for multiple truck movements during the loading/unloading process.	As above Cattle appeared to travel better where this system was fitted

1980	A survey on "Attitude of Stockcrate Manufacturers to the imposition of standards on their industry" was undertaken as an initial step to achieving consistent and animal-friendly stockcrate design in commercial transport vehicles. The survey gauged the attitude of industry (particularly stock crate manufacturers) to modification to stock crate design in the interests of improved animal welfare. Any modifications would have to be structurally sound under harsh conditions and fit within existing government regulations. The work was submitted as a Postgraduate Diploma in Agricultural Extension at Hawkesbury Agriculture College by John Lapworth of QDPI.	Created awareness of need and benefits from improved animal friendly designs
Early 1980s	Industry-funded project conducted by Graeme Eldridge and colleagues of Vic DPI on cattle stocking density and behaviour during transit. This trial used onboard cameras on a single deck trailer to show the behaviour of cattle during transit, how they reacted to various events and the effects these events had on the animal and subsequent carcass quality.	This research lead to improving driving techniques and loading to reduce stress and injury
1980 (Onward)	An extension program began in Queensland that encouraged the use of DDLR at saleyards, abattoirs, pastoral companies and properties with large annual turnover of animals. This resulted in the increased adoption (installation) of DDLR.	Reduction of stress and injury Through loading enabled cattle to walk between trailers and required less vehicle movement during loading/unloading
1981	Study tour undertaken by John Lapworth of USA Canada & NZ transport industries and trailer manufacturers. (A Churchill Fellowship Grant and MLA funded). This study highlighted the comparative differences in technology between North America and Australia. It showed that in many areas Australian livestock transporters were equal to if not ahead of North America. This was particularly the case in terms of design features to reduce injury and heat stress. Our Doubledeck trailers with straight decks had significantly less bruising points and the top deck was cooler as there is no roof.	Continued effort to make the inside of crates safer by designing to remove structures likely to cause injury.

1981	LTAQ formed at a meeting in Roma. This association was formed so that livestock transporters as a unified group could have useful dialogue with Government to change and or implement new regulations to the betterment of the livestock industries and animal welfare.	As a group they were able to lobby for changes in the transport system
1981/82	Industry survey conducted by QDPI of truck and trailer manufacturers to compile a dimensional list to assist in the development of consistent standards and the argument for volume loading. The data focussed on Queensland, but also included other manufacturers across Australia. It took until 1983 for volume loading to be implemented by government. The results of the survey allowed Government, manufacturers and transporters to determine design changes that would enhance vehicle safety, improve animal welfare and contain costs in both vehicle manufacture and the transport of animals.	Regulatory changes (Volume loading) meant cattle were loaded at safer densities and had less holdup during transit
1982	Government assist tour of Queensland to increase membership of LTAQ. The benefits to industry in terms of potential improvements in animal welfare and economic returns prompted the Primary Industries Department of the Queensland Government to assist the association. With increased membership and a strong unified stance industry adopted improvements to animal welfare in a more timely and economic manner.	Better able to increase adoption of improved transport designs that enhanced animal welfare
1982	NT - The doubledeck loading bank was built at the Elliot Dip. This yard was a dipping yard for tick control to allow NT cattle to go to Queensland.	Easier and quicker loading/unloading Less stress and injury
1982/83	WA - The rail service from Perth to Port Augusta ceased carrying livestock.	
1982 onwards	Design blueprint for DDLR provided free to producers, saleyards, and abattoirs The supply of this ramp plan assisted in the widespread industry adoption and installation of DDLR particularly at processing plants, saleyards and feedlots.	Assist in adoption of new technology to ensure a smooth, bruise free interface between loading ramp and trailers

1983	LTAQ agree to Minimum Design standards for double deck livestock trailers, which included standards that improved animal welfare through minimisation of bruising and reducing other stressors These standards gave industry and transporters a platform from which to continue the momentum for improving stock crate design, particularly in the interest of animal welfare. Other spin offs were: - Improved driver safety when handling animals - A set of Government regulations that the livestock transport industry could work within. - Reduced levels of damage to animals presented at processing plants A heightened awareness of the benefits of good animal welfare for all sectors of the livestock industry.	Minimum design standards agreed to so that bruising and injuries occurring in transit would be minimised
1983	The use of wide interior gates (2/3 to 3/4 trailer width) began to be commonly used in QLD. This reduced bruising and other animal injury by largely preventing animals from jamming in the internal gateway. The common use of these wide gates did not become widespread in S.A. until the early 1990's.	Improve the adoption of design standards in trailers to improve overall animal welfare Reduce or eliminate animals jamming in internal gateways. Stress, bruising and injury reduction
1983	Volume loading approved by Qld State Government. This was the first state to do so. The approval of volume loading significantly improved the welfare of animals in transit. The need for vehicles to be stopped and weighed was eliminated if the vehicle specification met desired Government regulated standards. Injury and stress incurred by animals during this weighing process no longer occurred. The weighing process also caused damage to some vehicles that in some cases increased the stress on	Reduced stress and injury in transit. Fewer forced in transit inspections

	animals through increased transit times. Currently, all jurisdictions except NSW accept volume loading.	
1983 onwards	LTAs were actively involved in the drafting of National Animal Welfare Codes of Practice for the various species commonly moved by road transport. Their active participation in this process helped to create an ongoing awareness of the need for and the benefits accrued from adopting policies that included good animal welfare practices. Also the involvement of LTA members and executives ensured that practical workable solutions were the outcomes for the future.	Overall animal welfare benefits Now encoded and could be used to prosecute or defend
1984	National meeting at Corowa to discuss the standardisation of laws and regulations for livestock transport and the problems associated with the various dimensional limits of crate design. This meeting highlighted the many regulatory differences between states and the difficulties encountered by livestock transporters working within and between a number of states. This was an early attempt (if not the first) to get some uniformity of regulations nationally for the livestock transport industry.	Highlighted the Animal welfare benefits of uniformity of national standards
1984	Progressive uptake within industry of fixed 3 deck sheep crates.	
1984 (ongoing)	QDPI develops relationships with various other Government Departments to assist national adoption of volume loading and the drafting of other legislation to ensure it was compatible with and embraced animal welfare issues. These relationships led to better understanding by all parties of the issues involved and the impositional and flow on effects of new regulations. This co-operational rather than confrontational attitude allowed for better planning of future infrastructure needs which resulted in reduced infrastructure costs and overall improvement in logistics.	Reduced time in transit Better roads – less stress, bruising and injury

1985	Discussions at a Ministerial level were held with the WA Government to explain the benefits of Volume loading (livestock loading) and how it was achieved in Queensland.	Animal welfare benefits highlighted as the necessity or benefit from adoption
1985	WA – Interstate rail transport of sheep ceased.	
1985	The increased use of fixed 4 deck sheep crates nationally began.	Easier loading/unloading Move bigger mobs quicker
1985	Technical bulletins published by Qld DPI specifying loading densities, stockcrate designs for body trucks, loading ramps (single & double). This extension material was distributed at field days, truck shows, agricultural and machinery shows and on ABC rural radio programs. It was also made available to all other State and Territory Departments and sent overseas on request. It is believed that this material helped heighten the awareness of the benefits of good animal welfare planning and handling facilities.	Improvements in overall animal welfare for animals in transit for small and large operators
1985	Through loading introduced to WA in the mid to late 1980s.	See previous notes on 1979-1980
1985	Low profile trailers were first introduced. These trailers were almost 300mm lower than previous trailers and those in common use by general freight carriers. The lower centre of gravity of these trailers gave animals a better ride and resulted in fewer rollovers.	Better ride Reduced incidence of rollovers Less losses from death or injury
1985	S.A. – Lighting installed at all major selling centre and processing plants. This allowed for the safer movement of animals at night time.	Easier loading/unloading Reduced stress
1986	Development work commenced in Qld in order to reduce trailer and stockcrate tare weight and improve interior design in the interests of animal welfare. This work built on the 1983 minimum design standards to build animal friendly stockcrates. The reduction in tare weight would help to reduce road damage believed to be caused by over weight stockcrates and trailers.	Better ride Reduced level or injury and stress Less bruising

1986	WA –Sheep crates with four (4) fixed decks first manufactured around this time.	Shift bigger mobs quicker
1986	The first 20' x 40' B double was built in Tamworth NSW. This enabled carriers to better mix and match loads, especially where producers would only present small numbers of animals for transport. Figure 4.	Reduced stress Easier loading/unloading
1986/90	An extension program was designed by QDPI to promote the adoption of improved stockcrate design aimed at meat processors, producers, stockcrate manufacturers and livestock transporters. The displays were presented at local agricultural shows, meat processing plants, truck shows and LTA conferences. The adoption of these improved designs is still evident today.	Overall increase in the awareness of benefits of good animal welfare
1987	Design blueprint developed for improved double deck stockcrate. These blueprints were used by both stockcrate manufacturers, transporters and producers to ensure that as many animal welfare features as possible were included in the building of a new stockcrate.	All sectors could justify design modification in the interests of animal welfare.
1987	Loading density for various classes of livestock proposed and put in DPI farm note. This now corresponds to the current Cattle transport Code. These densities were to be used as a guide for both producers and drivers to get an idea of the number of various classes of stock to be loaded in the various pens. Drivers often use it as a reference if producers try to overload stock in the various pens.	Reduced stress and risk of injury Reduced levels of overloading
1987	W.A. – The first B double were manufactured for sheep.	
1987	First fixed 4 deck sheep crate was manufactured in NSW.	
1988	4.6m livestock trailer height became legal in NSW.	Improved air flow in stockcrate Reduced stress

1989	The first airbag suspension was used on livestock transport (convertibles). It was reputed to give animals a better ride, was less damaging to road surfaces and the trailer deck height could be adjustable to fit a variation of ramp heights.	Better ride Less stress
1990 approximate	NT developed through-loading of double deck livestock rail wagons. This was an innovative change to rail transport of livestock that had the potential to save a significant amount of time loading/unloading. It follows therefore that injury and other stresses could also be significantly reduced as would the cost incurred during loading/unloading.	Easier quicker loading/unloading Reduced levels of stress and bruising
1990	The use of feedback from abattoirs feedlot and producers on the condition of cattle on arrival at their destination. This has resulted in reduced levels of injury and stress. Drivers now have more understanding of the effects of transport on animals and take more care of animals and have a greater level of interest in what they do.	Reduced bruising and injury Reduced stress More care when handling, loading/unloading and density in transit
1990	WA - the first B doubles for cattle were manufactured. The B double configured stock crate allowed an extra deck of animals to be carried within the legal road regulations at no extra cost to the producer. Through loading on each deck meant that the stress of loading/unloading was reduced, more animals could be moved in one trip, and the chances of a few animals being left behind or too many animals being loaded for a journey were reduced.	
1990	The use of B doubles commenced in WA. There is now about a 90% use of this technology in the cattle carrying business, particularly in the semi extensive and intensive areas.	
1990	SA begins replacing wooden floors with steel sheets (less weight, less cost, easier to clean).	Reduced stress
1990	First fixed 4 deck sheep crate used in SA.	
1990	4.6m livestock trailer height became legal	Improved airflow in stockcrates

	in SA.	
1990 onwards (various)	TAFE colleges at Toowoomba, Armidale, Orange and Katherine scope the development of driver training courses for livestock transport. Unfortunately in these cases the intentions were good but little came of the intent. Armidale TAFE produced a video on handling practices and good and bad features/maintenance for stockcrate design. Katherine produced a booklet and to date has run two courses.	The intent was to improve animal welfare through increased awareness of benefits of good animal welfare
1990	The reduced use of electric gates to assist loading. Some companies now actively discourage their use as a normal part of loading practice.	
1990	First fixed 4 deck sheep crate was used in S.A. This was a step deck type.	
1991	Industry-funded MLA project on reducing stressors for cattle during transport. In some of the more extensive cattle areas it was thought that dust caused respiratory problems for animals transported in the rear trailers of type 2 roadtrains. This study found a number of ways to minimise the entry of dust into stockcrates. See Section 4.7.2.	
1992	Loading density reduced in QDPI recommendations to ensure that trucks would not be overloaded. The original maximum loading densities were too high. A review of this recommendation suggested that densities should be made more exact. This would avoid overloading and be closer aligned with good industry practice. New densities determined in consultation with industry and based on industry good practice.	
1993	Major Australian transport operator puts all operational staff through a drive-training program. This course was initiated and facilitated by DPI (John Lapworth) and would have put through about 100 people. This was not repeated on a formal basis but had word of mouth spin offs to new staff in this company, other transport	

	companies and producers as to the need/benefits or improved methods of handling in yards and transport and the use of normal animal behaviours. This program looked at all animal welfare aspects related to handling when loading and unloading and driving techniques. Staff were shown the benefits of using normal animal behaviours to make loading and other handling practices less stressful on animals. They were also shown the benefits of improved driving techniques and stockcrate maintenance. In this two day course producers and meat processors also explained the benefits of good animal welfare practices from their perspective and the effect their actions had on the animals they were handling.	
1993	Design and build a modular stockcrate for body trucks (1/25 scale) for use in SE Asia – This was demonstrated in Philippines and Indonesia. One of these models was left with the Philippines Feedlot Association. The aim of this project was to get the SE Asian cattle importers to improve their transport methods. It was designed in a modular form so that it was easily erected as required and when not in use could be dismantled, stocked against a wall and not take up much space. Most trucks in SE Asia are multi use vehicles. Very few are purpose built for carrying livestock.	Reduced stress, injury and losses in the whole export process particularly in the countries of destination
1993	Hydraulic ramps used in cattle crates in the Aramac area. This modification helped to reduce the time taken to load/unload animals. Easier loading helps to reduce the level of injury, bruising and stress.	Reduced levels of stress, bruising and injury
1993	Volume loading (livestock loading) officially approved for S.A livestock transporters.	Reduced stress, improved loading densities Reduced time in transit
1994	SA – Changes to the floor profile from a cross drainage system to longitudinal drainage. This design change also included other design features that reduced the chances of hoof damage.	Travel better Less foot injuries Not as tired when they reach the destination
1994	First B double built in NSW, mainly for sheep initially. From 1995 nearly all stock	

	crates built (sheep and cattle) are the B double type.	
1994	Rail ceased operation in the NT.	
1995	WA – Interstate rail transport of cattle ceased. All states except Queensland no longer transport livestock by rail. Logistics, cost and perceived animal welfare requirements have seen the demise of livestock transport by rail in all other states. Queensland Rail (QR) still continues to carry cattle but only in larger consignments on dedicated livestock trains.	
1995	Through loading commenced in south of NT.	Quicker loading/unloading Less stress
1995	DDLR installed at Alice Springs rail and trucking centre.	Quicker load/unloading Less stress and injury
1995	Began putting sheeting on the inside of stock crates, while at the same time installing full width internal stock crate loading ramps.	Reduced levels of bruising, injury and stress
1995	From mid 1990's onwards truck wash systems had gained widespread adoption. Many larger saleyards had already installed washing systems in the late 1980's.	Cleaner stock crates Floors less slippery
1996	Industry-funded MLA project – Monocoque design of all-steel lightweight double-deck trailer. This project designed an all steel stockcrate using computer aided technology. It helped to pave the way for the now more common "space frame" constructed stockcrates. Bohle (Townsville) live export quarantine yards open. This yard had access to all the handling facilities of the Bohle Saleyards.	Easier travel Maintains good airflow
1996	"Truck care" an auditing system of livestock transport management began in SA. Some individual companies had their own schemes prior to this date, but this was the beginning of the national QA scheme for livestock transport.	Overall improvement in standards of animal welfare Community awareness of efforts of transporters in adoption of animal welfare practices

	TruckCare has made transport operators more aware of animal welfare needs.	
1996/97	Qld Rail designs new and improved rail livestock wagon. This new wagon incorporated new flooring that would make long distance travel easier on the animals. They had wider exit doors (with rubber flaps) to reduce the damage when animals exited the wagon. They were easier to maintain, which greatly improved the availability of wagons and had an improved braking system.	Animals travel better Less stress, bruising and injury
1997	WA – began changing from all wooden sides to steel sides on stock crates. Animal welfare benefits from this change were small.	Reduced levels of bruising
1997 onwards	Qld Rail begins QA program for all staff involved in livestock transport- "Stockcare". All QR staff involved in their livestock transport business have to be accredited and the accreditation process is updated on an annual basis. The QA program looks at all aspects of animal welfare, and in particular yarding and handling during loading and unloading.	Reduced animal stress and injury Reduced level of prodding during loading especially the use of electric prodders
1998	New private export yards built about 45 km from wharf at Darwin to hold 2000 head. This yard was further extended in 2000 and again in 2003 and now has an 11,000 head capacity. Animals can be inducted into this facility to undergo required health protocols prior to loading for export.	Improved spelling and feeding prior to loading on ship Easier loading/unloading Reduced stress
1998	Northern NT operator begins leaving long distance cattle on water and hay right up until loading.	Travel better, arrive less tired
1998 (ongoing)	Consult to exporters and importers on issues relating to transport and animal welfare on ships and in SE Asia countries. This included investigating handling of animals during the health protocol period prior to departure and the loading of ships at departure by both road and rail. Other issues were the background feeding prior to loading and on ship to ensure all	Reduction in levels of stress, injury and losses Begin feeding on ship earlier

	animals would eat enroute and improving the discharge and transport procedures at the port of destination.	
1999	Rail – The end of the onboard train drovers. QR ceased employing onboard train drovers. These people would travel on the train looking after the welfare of the animals enroute. Competent and reliable staff were becoming increasingly difficult to find and QR modified their QA program to include trackside checks and management enroute to ensure animal welfare.	Improved commitment to animal welfare
1999	Qld – Animal welfare strategies included in the Livestock Drive fatigue management plan. This inclusion was a co-operative effort between the Transport Department, DPI and Livestock Transporters Association Queensland to ensure that the welfare of animals was considered in the process to achieve positive outcomes.	Reduced time in transit
1999	Electrolytes added to the water at most major rail trucking complexes. Initially electrolytes were administered to all cattle travelling in large consignment by rail. Electrolytes are now only given to cattle at the owner's request as it was proving costly and the benefits of electrolytes in this situation are not proven.	Perceived improvement in hydration of animals
1999	WA transporter introduces pre-transport management plan for stock transported across the Nullabor to SA feeders and processors. All animals have access to feed and water up to time of loading.	Animals travelled better and arrived at destination less stressed and tired
Late 1990s onwards	Gradual increased adoption of air suspension on commercial livestock transport vehicles. It is currently estimated to be installed on about 60% of trucks in Australia. This system is not popular in the harder and more extensive regions. This has generally only been adopted in areas where the road conditions are good. Operators in the more extensive areas where conditions are more severe have continued using spring suspension as they are less prone to breakdown.	Perceived better ride for animals Less stress from excess rocking of stock crate in transit

	They also believe that animals have an easier ride under rough conditions on steel springs.	
Early 2000s onwards	Gradual increased adoption of TruckCare QA program among LTA members. See Section 4.9. The continuous upgrading of this program to make it more relevant and user friendly has resulted in an improved adoption of this auditing process. There have been increasing requests by all sectors of the industry that transporters need to have an auditable QA system to ensure they will get repeat business. All sectors of industry can see the flow on benefits to animal welfare by the uptake of "Truck Care" or similar auditable QA packages.	
2000	WA – all sheeting of stockcrates now on the inside of the stockcrate frame. This gives a smooth internal surface and helps to reduce bruising.	Reduced levels of bruising and other minor injuries
2000	Cattle weight at Darwin export depots accepted as sale weight. This charge eliminated animal stress caused by weighing at the wharf and also an environmental requirement to clean animal waste from the wharf.	Reduced stress and injury
2000	A modulated stockcrate designed for SE Asia was showcased at Beef Expo 2000 in Rockhampton. International delegations from most countries in SE Asia and also China were invited to attend this expo. The modulated stockcrate was on display in the International lounge and regular demonstrations were given to point out the benefits of using such a stockcrate as it was relatively easy and cheap to construct, easy to install and remove from a truck and could be stored without taking up too much space.	Improved adoption of animal welfare in receiving countries particularly related to transport and handling Reduced stress, injury and losses
2000	New pressed metal flooring designed that would be easier on the feet of cattle. This helped to reduce injury and stress,	Reduced foot and leg injuries Travel better
2000	The use of hydraulics to operate the lifting of internal stockcrate ramps. These have now been replaced by use of	Easier loading/unloading Reduced stress during this process

	electric winches as it is felt they are more reliable.	
2000	Animal welfare components included in the NVD (National Vendor Declaration) that is carried by all interstate and long distance transport movements. This has coincided with an increased demand for transport companies to be accredited and have animal welfare built into an auditable accreditation process.	Increased awareness of needs and benefits of good animal welfare practices
2000	Loading times begin to change from loading at night and travelling in the dark to loading early in the morning and travelling by day. Benefits of this change are that animals can rest during the night as can the drivers. Those using this system say that both animals and drivers travel better and it incorporates normal animal and human sleep patterns resulting in a safer journey. Vehicle stationary periods thus occur more during the night which minimises heat build-up when the vehicle is not moving.	Animals travel better and appear to arrive less stressed
2000	WA Stockcrate manufacturer raised the height of the kickboard on the bottom deck (100mm to 150mm) to reduce the incidence of sheep getting legs protruding outside the crate. This modification has been reasonably successful.	Reduced level of injury to sheep between depots and wharf
2000	Cattle stations in the southern NT begin installing DDLR.	Easier quicker loading Less stress and injury
2000	Muzzling of dogs for use in stockyards and loading of trucks becomes compulsory. This started in southern states but now has been adopted nationally.	
2000	The changes to longitudinal lower profile pressing on crate floors to allow for quicker easier cleaning. At the same time the ridges were lowered from 10mm to about 5mm.	Reduced levels of foot and leg injuries Travel better
2000/2001	NSW & SA – 4 x 2 convertible stockcrates (sheep x cattle) became more acceptable due to design changes that made the conversion much easier. These design changes also significantly reduced the bruising of cattle carried in	Reduced levels of bruising and other minor damage in cattle

	stockcrates incorporating these new design features.	
2001	Cover in the skid pan area to reduce the risk of feet and leg injuries. This was adopted in SA in 2003. There was a 50mm loss in deck clearance in this area on the lower deck and a reduction of 1-2 sheep loaded in that pen on sheep trailers. The skid pan area is located at the front of each trailer and is where the trailer and truck are coupled together. This area has to be particularly strong as it is the pivot point between the two vehicles. Covering this area with steel plate also adds a lot of strength, but the down side is that deck clearance can be lost.	Prevents rubbing of taller cattle on overhead structure
2002	NSS Stevedores in Townsville began using a double deck unloading ramp to discharge export cattle from trucks direct onto ships This ramp reduces stress by reducing the time taken to unload trucks and making the unloading process much easier on the animals.	Easier quicker loading Reduced stress
2002	NT operators begin changing to daylight loading in the interests of animal welfare and driver fatigue management. They do not believe change is being adopted quickly enough.	Animals travel better and appear to arrive less stressed
2003	One transport company takes drivers to visit a meat processor. The drivers were shown carcasses with bruising and dark cutting and had discussion on how method of loading and driving techniques could be improved to reduce this problem. This probably involved about 30 people and is not a regular operational management procedure but is continuing to have word of mouth spin offs.	Overall improvement in animal welfare and driver techniques
2004	Safety systems (harnesses of various types) fitted to trailers to prevent injuries from falling when working on the outside of stock crates to get animals to exit or enter the pens onboard.	
2004	Transport operators in extensive areas increasingly going back to steel spring suspension. To some extent (in some areas) this is governed by legal load	

	regulations.	
2005	Industry groups formed (led by Vic DPI) including representatives from LTA (and other industry and animal welfare organisations) to develop industry-based animal welfare standards for livestock transport.	
2005	First B double introduced to Alice Springs. This area has smaller sized properties than further north which meant the B double size fitted more readily into total cattle movement from each property.	
2006	SA – All long distance transport (>400km) now done using B double through loading configuration. This resulted in easier loading more animals per load, and reduced time in transit.	Easier loading/unloading Reduced stress Reduced time in transit
2006	Current airbag use is about 50% in the livestock transport industry in WA. Would probably be higher if this system was easier and cheaper to install and maintain.	
2006	Publication of "Is it fit to load? guidebook for livestock producers, agents, transporters and others in the supply chain to assist them with determining whether animals are in a fit state to travel.	Helps ensure that only animals suitable for transport are transported.

4.8.1 Summary of current practices

The key feature of the Australian livestock transport sector which has emerged from these investigations is its diversity. The level of diversity is such that it makes the industry difficult to simply characterise in terms of how it operates. There is a wide range of size of operations, from owner operators driving locally, to medium size businesses with a number of vehicles, through to large operations with a fleet of 20-50 large transport vehicles. Vehicle combinations used similarly range at the lower end from small- to medium-sized fixed body trucks typically operating over smaller distances, such as to and from local saleyards. Such vehicles may have wooden floors overlaid with a metal grid, and metal crates divided into two to three internal pens. Bedding is essentially not used. Convertible crates have the provision for fold-down decks to carry two levels of sheep. Larger vehicle combinations include semitrailers with steel and alloy crates incorporating four pens, with two deck cattle crates, or four decks for sheep. The most common vehicle type for longer haulage of significant numbers of sheep or cattle is the B double (see Figure 4 below), which may be convertible between two decks of cattle and four decks of sheep. A typical stockcrate manufacturer will offer a range of trailers, such as for crates - single deck, 2 pens x 1 deck, 3 x 1, 3 x 2, 4 x 2 convertible, and straight 3- and 4- deckers. These can be in standard 12.5 m, 19 and 25 m B double and road train specifications. On smaller vehicles, spring suspension is more common, whereas air suspension is becoming more popular on larger livestock haulage vehicles because it is viewed as providing a smoother ride. However, air suspension is not so common on road trains or where vehicles are travelling on rough roads, because under these conditions spring suspension is viewed as preferable for providing a better ride for the animals.

The key features of the main livestock vehicles now used in Australia is that the crates incorporate non-slip grid, mesh or pressed metal flooring, wide internal doorways and no protrusions to minimise bruising, and all utilise natural flow-through ventilation. This last aspect is very different to many of the longer-haul livestock transport vehicles in Europe which may use mechanically adjustable and even forced ventilation (see Figure 6). Under Australian conditions, natural ventilation is viewed by the industry as working well, with sufficient airflow to maintain suitable temperatures and less to go wrong mechanically. Some variations to crate design are present in Western Australia, including a move to modify the sides of sheep transport vehicles to further reduce the risk of animals having their legs protruding through the sides of the vehicle. This is partly prompted by the high visibility and welfare controversies associated with sheep transport vehicles driving through built-up areas en route to the port of Fremantle for the live sheep export trade. Given that vehicles in Western Australia may typically have 8 pens per deck level (compared with 4 pens in the Eastern States), some operators have suggested that reduced effective space onboard WA vehicles may also be a contributing factor.

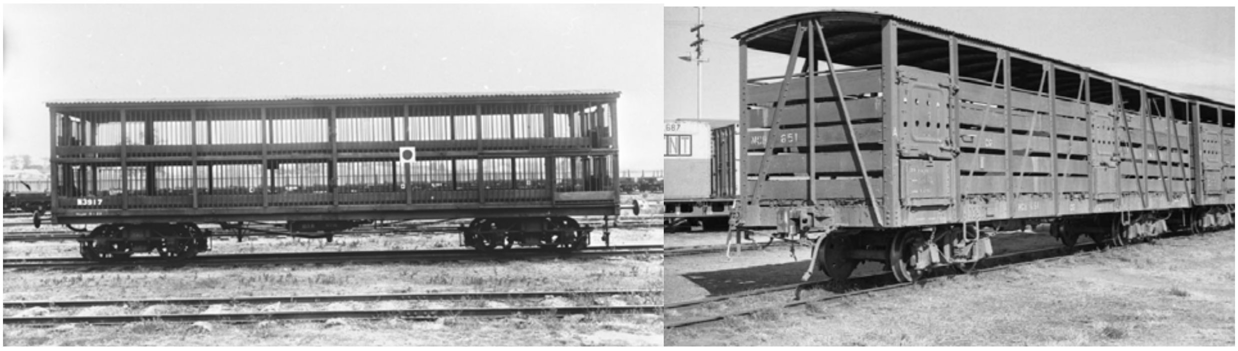


Figure 2. Photographs of livestock rail wagons used during the mid-20th century. Left: Double-deck sheep wagon. Right: Cattle wagon (photograph taken by Murray Billett at Alice Springs in the mid 1970s)

Figure 3. Left: Photograph of a semitrailer unit for livestock transport, convertible between one deck for cattle and two decks for sheep, with four internal pens. Right: Fixed body tray truck fitted with a 3 pen x 1 deck crate for cattle, convertible to 3 x 2 for sheep

Figure 4. Two views of a typical well-used B-double livestock transport crate. This one includes walk-through loading, airbag suspension and steel and alloy construction incorporating extruded aluminium sideboards. Loading may be either side or rear, with side loading making for easier vehicle positioning before loading/unloading

Figure 5. 4 x 2 convertible B-Triple unit with walk-through rear loading, hydraulic internal ramp winch and spring suspension

Figure 6. Photograph of a long-haul European transport vehicle. Note the adjustable ventilation flaps, some of which are covering electric fans for forced ventilation. Another aspect to note is the drop-down loading ramp at the rear, which loads animals from ground level. The vehicle is convertible between one and three decks, with decks being raised by hydraulic rams once loaded. There are three internal pens, and an on-board water supply and water drinkers.

Figure 7. Photographs of double deck loading ramps. The animals are either directed into the right-hand race (which curves inwards to become the lower ramp), or straight ahead to the upper loading ramp. The structure running up the left-hand side of the ramp on the right is a catwalk for stockpersons to assist with loading. These ramps are made by Towers Engineering of Charters Towers in Queensland.

There is also considerable variation in the standard of loading facilities, and this represents one of the welfare concerns of the industry (see Section 4.8.2). Generally, loading facilities are better on properties or enterprises which are larger or produce higher numbers of livestock. Larger cattle enterprises, particularly in central or northern latitudes within Australia are more likely to have well-designed (and often double deck) loading ramps. Generally, facilities at unloading are reported as being reasonable to good in standard, largely due to them being located at central collection or processing points, such as saleyards, abattoirs and feedlots. Good loading facilities are well maintained, have non-slip flooring, are designed with flow-through systems to minimise animal turning and baulking, and have no protrusions or other elements likely to cause bruising or injury. The LTA (Victoria) are reported to have produced a design template for good loading facilities that is available to producers and other interested parties.

Loading of livestock is typically undertaken by drivers, including the not infrequent use of hand-held electric prods when loading cattle, particularly animals that baulk or refuse to load. Thus, there is an interaction between the standard of loading facilities and the level of electric prod use. Clearly, animal temperament and handler skill are also potential factors. The use of the electric prod is viewed as having decreased in recent years, with its use more targeted at recalcitrant animals. Drivers may also use a prodder if an animal goes down in the vehicle to encourage them to get to their feet and prevent possible injury from trampling. Loading of sheep is more commonly facilitated through the use of dogs, although it is not unknown for prodders to be used in some instances. Loading is carried out to conform to the standard recommendations for loading density, with some downward adjustments made for particular conditions, such as very hot weather, longer haulage, horned or full-wool animals. Drivers check to ensure that the stock are upright and secure within the vehicle before commencing the journey, and will check at intervals thereafter, particularly for animals that have gone down in the vehicle and are thus at risk.

There is considerable variation and debate around the practice of curfews. Some of this variation is a result of producers not curfewing their animals in line with the wishes of the transport operators or purchaser (e.g. abattoir). Curfews are often 6 – 12 hours in duration and may vary depending on species and pre-existing diet. For example, some view it as acceptable to have cattle with access to water and hay right up to loading, but there is a strong and generalised argument that sheep on pasture should be curfewed before loading. Journey duration is another factor- for very short journeys there may be no curfew. The practice of curfewing reduces the total amount of excreta in trucks (and spilling from trucks), and the level of faecal soiling on animals. The reports from livestock transporters are that cattle and sheep tend to travel better following pre-transport curfews. One of the main benefits claimed is a reduction in the number of animals that go down or slip on the truck during the journey.

Transport durations also vary widely. It does not appear to be common for cattle to be transported at the 48 hour limit, and no-one claimed to be exceeding the code maxima. Indeed, one pastoral company indicated that they prefer to spell their cattle half-way on a journey that would otherwise take close to 2 days. Typical longer journeys for cattle include those from western Queensland or Northern Territory properties of origin to central or southern Queensland backgrounding properties and feedlots. For sheep, transport from outlying regions to the pre-embarkation feedlots of Portland and Fremantle would constitute some of the longer journeys, and take in the order of 15 to 30 hours. Short-term environmental and economic factors can also have an impact on transport practices in regard to journey duration (i.e. with animals being moved from areas of drought). As an example, during 2006, there has been an increase in the numbers of sheep trucked from Western Australia to the eastern states.

Rather than the duration of a transport event itself being an issue, one of the areas highlighted by industry representatives was the occurrence of animals being transported to a point of sale, sold, and then transported again, without it necessarily being known for how long they were transported beforehand, or when the stock last had access to feed or water. It is not known how frequently this occurs in a way which approaches or exceeds the limits of the codes of practice. For example, in Queensland, saleyard pens where animals are held overnight have water available, but holding pens in which animals are unloaded into in the morning and transported from at the end of the day following sale typically do not have water. The Australian Welfare Code for Saleyards indicates that water should be provided in receival yards and in yards where animals are held for more than 24 hours. The Code also states that animals that have been travelling for more than 24 hours or deprived of water for more than 24 hours, or held in saleyards for more than 24 hours, should be provided with water. However, these provisions are not necessarily able to address the question of repeated transport punctuated by shorter spells in saleyards.

Rail transport of livestock, which now only occurs in Queensland, has practices which are covered by the QR Stockcare scheme (see Section 4.9).

4.8.2 Industry identified knowledge gaps and problems with current practices

In the area of pre-transport preparation, many of the comments related to curfews. Specifically, it was felt that there was a lack of hard knowledge on the effects of time off water/feed on the animals' ability to stand, cleanliness, bruising, and meat quality and safety. It was also commented that the washing out of stock crates, particularly multi deck sheep crates costs time and money and uses a lot of water, which in turn becomes an environmental issue. This is particularly seen as a problem with animals fed on lush pasture or crops. It was argued by transport operators that producers need to find ways to reduce or minimise this problem by better pre-transport preparation. There was a complaint that producers often do not conform to the transport operators wishes in preparing livestock for transport, such as when animals only travel for a short distance prior to weighing for sale on a weight basis, the producer was seen as tending to overfill (water) the animals, resulting in the trailer decks becoming wet and slippery and resulting in increased soiling of the animals. It was also suggested that livestock transport would benefit by facilities being available for operators to dump on-board animal waste.

Other comments on pre-transport preparation included suggestions from Queensland to keep sheep and cattle on hay but off water prior to loading in the early morning when the season is good, with no need to fast at all in a poor season or in drought. Under these conditions, it was suggested that it is better to feed hay for a couple of days prior to transporting, particularly for poor sheep. It was also suggested that poor off-shears sheep do not travel well as they have depleted energy reserves and it may be advantageous to feed for a few days prior to transport to increase energy reserves.

There were numerous comments on a perceived need for producers to improve their loading facilities, specifically the handling yards and ramps. Other comments related to problems in achieving the correct loading density under some circumstances, with producers and station managers sometimes insisting on loading extra animals (increasing the density) against the drivers' wishes. It was also commented that the opposite situation could sometimes arise, with potential adverse consequences during long distance transport if the stocking density is too light.

The topic of saleyards also received a significant number of comments. It was suggested that many saleyards did not have sufficient watering facilities for stock, compounding the uncertainty about the duration of water deprivation for animals. It was commented that with newer guidelines (such as those conforming with the live export standards), drivers/operators will need information on time off feed and water to match against a transit plan, and thus need to have a major say on these issues. In general, it was commented that there were difficulties in transporting animals from saleyards, such as when there has been a change of ownership of groups of animals and the transporter takes delivery of animals from the pen and is left to sort the density according to class, horn status, and number. In some cases, the transport operator finds that there are a few too many animals and all agents and saleyard staff have gone.

There was little comment on knowledge gaps concerning stock crate design, perhaps suggesting that years of industry experience have resulted in vehicles that meet the operators' needs. There was one suggestion that it may be worth examining the differences in effective ventilation between 3- and 4-deck sheep crates to ascertain if there are any animal welfare benefits between these two stock crate types. Also for sheep, it was suggested that improved means of avoiding leg protrusions on multi-deck sheep crates could be examined. Again, the 8 pens per deck configuration in Western Australia (compared with 4 pens in the east) may be an influencing factor.

The question of the effective management of transport duration attracted a number of comments and suggestions. Some comments related to a perceived knowledge gap about the management of transit stops for spelling animals during very long journeys. It was suggested that it was not known how much animals drink when spelled at transit centres for 12 and 24 hours, and whether palatable hay should be offered early or late in the spelling period or at all times. Another operator commented that despite the belief that pre-transport curfews were beneficial, it was felt that animals spelled in transit can be left on feed and water without detrimental effect. It was also suggested that there was a general need to look at positioning spelling facilities at strategic locations for long distance transport if they do not already exist (e.g. across the Nullabor Plain, in NT and possibly at or near some border crossings). The problem identified was that it was not obvious who will build, maintain and ensure an adequate supply of suitable feed and water at such facilities, which were seen as improving fatigue issues for cattle, sheep and drivers. One aspect of improved transport duration management was suggested as facilitating the ability of transport operators to organise their departure times to fit in with arrivals particularly at feedlots and export depots or any point of destination that is not manned on a 24-hour basis. As an example it was highlighted that such a facility may be open between 7.00AM and 6.00PM, and when the driver arrives at 7.00PM they and the animals then have to wait until 7.00AM to unload after long journey. Finally, the increasing consolidation and integration of the cattle industry was seen as increasing the amount of longer distance cattle transport. It was commented that with large Queensland family cattle businesses as well as some of the larger pastoral companies purchasing more cattle properties in NT, it will result in increased long distance movement of cattle in both directions depending on prevailing seasonal conditions, cattle prices and the value of the Australian dollar.

4.9 Current Transport Codes and Standards

In addition to increases in scientific knowledge and technical advances in livestock transport practices, the standards for the land transport of livestock in Australia have become increasingly codified during the past 30 years.

One of the first steps was the formulation of the Model Code of Practice: Road Transport of Livestock in 1983. This welfare code, developed under the auspices of the Australian Agricultural Council (now the Primary Industries Ministerial Council), provided recommendations for ensuring the welfare of cattle, sheep, pigs, goats, deer, horses and poultry during road transport. Key initiatives included the requirement for in transit inspection of animals within 30 minutes of journey commencement and at least every 2 hours thereafter. Maximum journey durations for mature ruminants were 36 hours, or 48 hours if a 24-hour rest period was subsequently provided. An accompanying code for rail transport, the Model Code of Practice: Rail Transport of Livestock was also published in 1983. Many of the provisions of this code were the same as those of the road transport code, such as the specification of maximum journey lengths. The rail transport code further recommended that where livestock were fed and watered in transit, they should be unloaded from the rail vehicle every 36 hours if there was insufficient room within the vehicle for them to lie down. The code also recommended that train drovers should be on the train for all journeys greater than 12 hours.

Since the development of these original national codes, there has been a move towards species-specific codes. In 1999, the Australian Model Code of Practice for the Welfare of Animals: Land Transport of Cattle was published by the Standing Committee on Agriculture and Resource Management under the auspices of the Agriculture and Resource Management Council (now the Primary Industries Ministerial Council). This new code provided a far greater level of detail than the original codes, and incorporated both road and rail travel. Furthermore, the Land Transport of Cattle Code was designed and written in such a way to facilitate the adoption of its content at a State and Territory level. The code defines the responsibilities for animal welfare at each stage of the transport process, provides information on the requirements for transport vehicle design, and contains detailed tables on stocking densities for different classes of cattle. The requirements for the inspection process were adjusted slightly to require inspection within 30 to 60 minutes of journey commencement and at least every 2 to 3 hours thereafter. The maximum permissible journey time was linked to a maximum water deprivation time, which remained at 36 to 48 hours for healthy mature stock, but with more detail on lesser maximum durations for other classes of cattle.

Currently, at a national level, sheep and goat transport requirements are still codified within the 1983 codes, although in some cases State regulations and codes have effectively superseded the older documents. There is a new Model Code of Practice for the Land Transport of Sheep that is drafted and awaiting presentation to the Primary Industries Standing Committee for recommendation for adoption by the Primary Industries Ministerial Council. This draft code has been developed under the auspices of the Animal Welfare Working Group, which by virtue of its membership comprising senior animal welfare regulatory officials from each Australian jurisdiction, is aimed at producing codes that can be efficiently adopted at a State and Territory level. The draft land transport of sheep code is again substantially more detailed than the 1983 code, with specific minimum standards defined (i.e. “musts”), and accompanying text containing recommendations for best practice (i.e. “shoulds”). The draft minimum standards require that feed and water must be provided to sheep between mustering and loading if the anticipated journey duration is 24 hours or more. The maximum water deprivation times are reduced to 32 to 38 hours for mature sheep, 20 hours for sheep less than 6 months of age, and 12 hours for drought-affected sheep and ewes that are more than 4 months pregnant or with lambs at foot.

Specific standards apply to animals that are being transported on land to a point of embarkation for live export. These standards are defined in the Australian Standards for the Export of Livestock, and unlike other animal welfare regulations, they are enforced at a federal level. There are specific requirements for stock selection, pre-transport preparation and the formulation of a journey plan. Journey times (maximum water deprivation times) are in alignment with the existing cattle and draft sheep codes.

As noted, the regulation and enforcement of animal welfare standards for livestock come under the jurisdiction of the States and Territories, unless the animals are being exported from Australia. Accordingly, each State has acts that legislate for animal welfare (or against animal cruelty), and regulations that underpin these acts. Some States also have their own animal welfare codes that generally follow the national codes. For example, in regard to sheep, the 2002 Victorian Code of Practice for the Welfare of Farm Animal during Transportation follows the national code almost word for word. The legal status of the state and national codes also vary.

Currently, the national model codes of practice are advisory only, apart from States where sections are incorporated into state regulations (with wording changes to alter the “shoulds” to “musts”), such as Queensland. The new format for codes, which will contain minimum standards and accompanying recommendations, is designed to facilitate the adoption of the standards into state regulations.

Currently, some states provide for adherence to the codes as a defence against a prosecution under their relevant animal welfare legislation, but this does not make the codes themselves legally enforceable. Queensland has developed a system of “Adopted Codes” and “Compulsory Codes”. Compliance with Adopted Codes is not compulsory under the Queensland Animal Care and Protection Act 2001; however these codes should be used by people in charge of animals as a reference to assist them to meet their duty of care obligations contained in the Act. The Australian MCOP for land transport of cattle has adopted code status in Queensland.

In addition to the codes of practice, there are industry quality assurance schemes that apply to livestock transport. TruckCare is an audited voluntary quality assurance program developed for livestock transporters by the Australian Livestock Transporters Association. The scheme is designed to represent best practice in optimising animal welfare, meat quality and meat safety. The elements of TruckCare pertaining to animal welfare are: 1) preparation of livestock prior to pickup; 2) loading facilities that promote quiet movement; 3) truck crate is well maintained with no holes or protrusions; 4) electric prodders are used sparingly; 5) drivers are trained in stock handling and manoeuvre the truck as smoothly as possible; 6) stock are checked during transit and are kept on the truck for the minimum period of time. By 2005, there were 66 livestock transport companies operating under the TruckCare scheme out of an estimated total of hundreds of large and small transport companies and operators.

In detail, TruckCare is a comprehensive set of guidelines and templates designed to provide the basis for livestock transporters to improve the way they do business, especially in regards to food safety and animal welfare. It involves the design and implementation of a number of policies and procedures all aimed at providing the best in quality service to their customers. Emphasis is placed on correct documentation and record keeping at all times.

To become accredited, transporters need to have in place a system which provides documentary evidence of compliance with the standards and to remain accredited, regular external audits need to be conducted to verify this compliance.

The eleven standards applicable to TruckCare are as follows;

1/ The authorities, responsibilities and duties of all positions involved in the management, operation, administration, participation and verification of the TruckCare system are current, clearly defined and documented.

2/ The operator shall establish and maintain documented procedures for customer management and for the co-ordination of these activities.

3/ The operator shall establish and maintain documented procedures to demonstrate the effective operation of the TruckCare system.

4/ The operator shall establish and maintain documented procedures to ensure that subcontractors and suppliers conform to specified requirements.

5/ The operator shall establish and maintain documented procedures to demonstrate an effective maintenance management system is utilised for all vehicles carrying livestock controlled by the TruckCare system.

6/ The operator shall establish and maintain documented procedures for the verification, control and management of customer supplied livestock. All incidents of non-conformance shall be recorded and reported.

7/ The operator shall establish and maintain documented procedures for identifying the livestock by a suitable means during all stages from receiving and carriage to delivery.

8/ The operator shall establish and maintain documented procedures for inspection and status in order to verify the specified requirement for each load is defined.

9/ The operator shall establish and maintain documented procedures to ensure livestock that does not conform to specified requirements is identified. This control shall provide for identification, documentation, evaluation, segregation (when practical) and disposition of nonconforming livestock, and for notification to the individuals concerned.

10/ The TruckCare system must be subject to annual internal reviews to verify that all results and activities comply with the systems policies, procedures and instructions.

11/ The persons who hold a position of responsibility under the TruckCare system are trained in and are familiar with the specific policy, procedure and instruction they are to carry out.

With reference to Standard 6, procedures must be in place to document each step of loading, unloading and handling of livestock. Drivers must understand their responsibilities and the business policy for any situation which may arise including animal welfare issues.

As described above, TruckCare is not so much focussed on describing exactly how animals should be loaded and transported, as much as ensuring that there are documented and auditable procedures in place for recording how, when and where animals are managed for good welfare. In regard to livestock handling, loading and unloading, the following specifications are made:

A driver must be trained in the steps of loading, transporting and unloading livestock.

Handling procedures and work instructions must be developed covering all aspects of safe and secure handling of livestock.

Delivery procedures should address the delivery of livestock from point of collection to point of delivery to prevent injury or damage.

The animal welfare standards incorporated in TruckCare are currently being revised (Michelle Edge, personal communication), with the expectation that the revised standards will incorporate significantly more detail on required animal welfare practices.

Rail movement of cattle is a component of the livestock transport industry in Queensland. Queensland Rail has introduced a livestock quality assurance program called Stockcare. Stockcare is intended to reflect the requirements of the Queensland legislation and codes, and provides for monitoring and handling of livestock by trained Stockcare attendants at strategic points during livestock journeys on the rail network. The program includes a system for reporting on the welfare of livestock for journeys. In 2003 (the most recent year for which data is available), 423,280 cattle were transported by rail in Queensland with a total of just 48 deaths (0.011%). In consultation with the Queensland Animal Welfare Unit, Queensland Rail have recently updated their Stockcare Attendant training, introduced a new owner declaration affirming that stock are fit to travel, and updated their Stockcare Attendant Checklist, specifically detailing potential animal welfare problems to be monitored.

Responsibilities for the attendants include assessing whether animals are in a fit state to continue travel whilst enroute. If there are injured or dead stock then the attendant must arrange unloading of the affected animal/s and if injured, see to their feed/ water and treatment or if necessary, humane euthanasia and disposal.

It is the responsibility of the owner or agent in charge of the cattle to load and unload the animals onto the wagons in the correct manner and density. The loading density matrix provided in Queensland Rail's Stock Handling Guidelines conforms to The Code of Practice for the Land Transport of Cattle (MCOP 1999).

Close attention must be made by the Stockcare attendant to time off water and this includes time deprived prior to loading, the time taken to load the stock and any delays in travel either scheduled or unscheduled as well as the actual travel time. The maximum allowable time is 36 hours for mature cattle extendable to 48 hours if upon inspection the animals are deemed to be in good condition and travelling well. This extension can only be applied if the journey can be completed within the 48 hours and there are no adverse weather conditions either prevailing or pending. The stock must then be rested with feed and water for a minimum of 18 hours immediately on arrival. Other classes of stock eg. calves less than 6 months old, pregnant cows > 8 months gestation are not allowed any extensions from the listed maximum time off water. If these times cannot be met, then spelling of the stock with feed and water in holding yards must be arranged.

The recently launched Livestock Production Assurance program by MLA (LPA, 2006) includes requirements on loading facilities, handling practices and suitability of vehicles for transport. At this stage, the level of uptake of the program remains to be determined.

The Livestock Production Assurance program includes requirements to:

1/ Muster, assemble and transport livestock so that there is minimal contamination and stress on the animal.

2/ Only select animals that are in a condition fit for travel. No sick or injured animals should be consigned.

3/ When transporting, inspect the vehicle for cleanliness and ensure the construction of multi-level trucks minimises soiling of livestock on lower decks (i.e. waste from the top level is drained away from animals on the lower levels).

4/ Meet curfew requirements, unless a customer specifies otherwise: i) cattle destined for slaughter have at least six hours curfew before departure; ii) sheep/goats destined for slaughter have at least 12 hours dry curfew.

5/ Record details of livestock yardings and transport times.

6/ Demonstrate that sheep and lambs being prepared for transportation are not lifted or pulled by their wool.

7/ Inspect livestock transports prior to loading to ensure that: i) decks on the stockcrate are free of sharp edges or projections capable of injuring animals; ii) side rails are designed to prevent animals placing their legs and heads between them; iii) stockcrate floors shall be of non-slip material without holes large enough to injure hooves or legs; iv) hinges and latches of stockcrate gates/gateways shall not project onto the path of animals; v) deck-height design of multi-deck stockcrates is sufficient to allow animals to stand upright without contacting overhead structures; vi) safety devices are in place to restrain livestock once loading gate is opened.

8/ Ensure the stock crate is as clean as possible prior to loading and is designed to prevent soiling of livestock on lower decks.

9/ Where possible utilise a quality assured transporter (eg Truckcare accredited or equivalent).

10/ Ensure the livestock loaded onto transport are segregated in accordance with animal type (i.e. horned verses polled/dehorned, bulls verses cows/heifers and/or in accordance with customer requirements).

11/ Ensure loading density of livestock takes into consideration distance to be travelled, livestock class and prevailing weather conditions.

12/ Ensure food and water allowances and rest stops (including visual inspections) are appropriate for type of animal being transported, seasonal conditions and distance to be travelled.

The Tables and Figures below summarise the Australian model codes of practice for transport.

Table 6. Summary of livestock transport codes- maximum duration of transport.

Maximum transport times for cattle

	Normal time	**Extended time**
Mature stock	36 hours	48 hours
Lactating dairy cows	24 hours	No extension
Cows more than 8 months pregnant	8 hours	No extension
Calves less than 1 month old travelling without mothers	10 hours	No extension
Calves less than 1 month old travelling with mothers	24 hours	No extension
Calves 1-6 months old	24 hours	No extension

From Australian Model Code of Practice for the Land Transport of Cattle (1999).

Maximum transport times for sheep

	Existing Code (Land Transport of Livestock 1983)		Draft Australian Model Code of Practice for the Land Transport of Sheep	
	Normal time	Extended time	Normal time	Extended time
Mature stock	36 hours	48 hours	32 hours	38 hours
Young stock*	24 hours	36 hours	20 hours	28 hours

*Categorised as less than 3 months old for 1983 Code and less than 6 months old for new draft Code.

Maximum water deprivation times for goats

	Normal time	**Extended time**
Mature goats	32 hours	38 hours
Young goats (less than 12 months old)	20 hours	28 hours

From Australian Standards for the Export of Livestock: Standard 2 – Land transport of livestock.

Table 7. Space allowances for transported cattle from the original 1983 Code (MCOP, 1983), and the current code (MCOP, 1999), in comparison with allometric calculations of the floor area occupied by standing cattle. The data indicate that space overlapping would occur at the original code densities.

Average weight (kg)	MCOP (1983)	Allometric calculation*	MCOP (1999)	
	m^2 per head	m^2 per head	m^2 per head	Volume loading No. head per 12.2 m deck
250	0.70	0.73	0.77	38
300	0.74	0.82	0.86	34
350	0.78	0.91	0.98	30
400	0.87	0.99	1.05	28
450	0.99	1.07	1.13	26
500	1.06	1.15	1.23	24
550	1.14	1.22	1.34	22
600	1.23	1.30	1.47	20
650	1.35	1.37	1.63	18

*Allometric calculation of floor space occupied by standing cattle
Petherick (1983); Randall (1993)

Table 8. Space allowances for transported sheep from the original 1983 Code (MCOP, 1983), and the Revised draft Code in comparison with allometric calculations of the floor area occupied by standing sheep. The data indicate close agreement between the standards and the theoretical allowances.

Average weight (kg)	MCOP (1983)	Allometric calculation*	Revised draft sheep transport Code
	m^2 per head	m^2 per head	m^2 per head
20	0.17	0.14	0.17
30	0.19	0.18	0.19
40	0.22	0.22	0.22
50	0.27	0.25	0.25
60	0.29	0.28	0.29

*Allometric calculation of floor space occupied by standing sheep
Petherick (1983); Randall (1993)

Figure 8 Summary of current cattle transport code (MCOP, 1999)

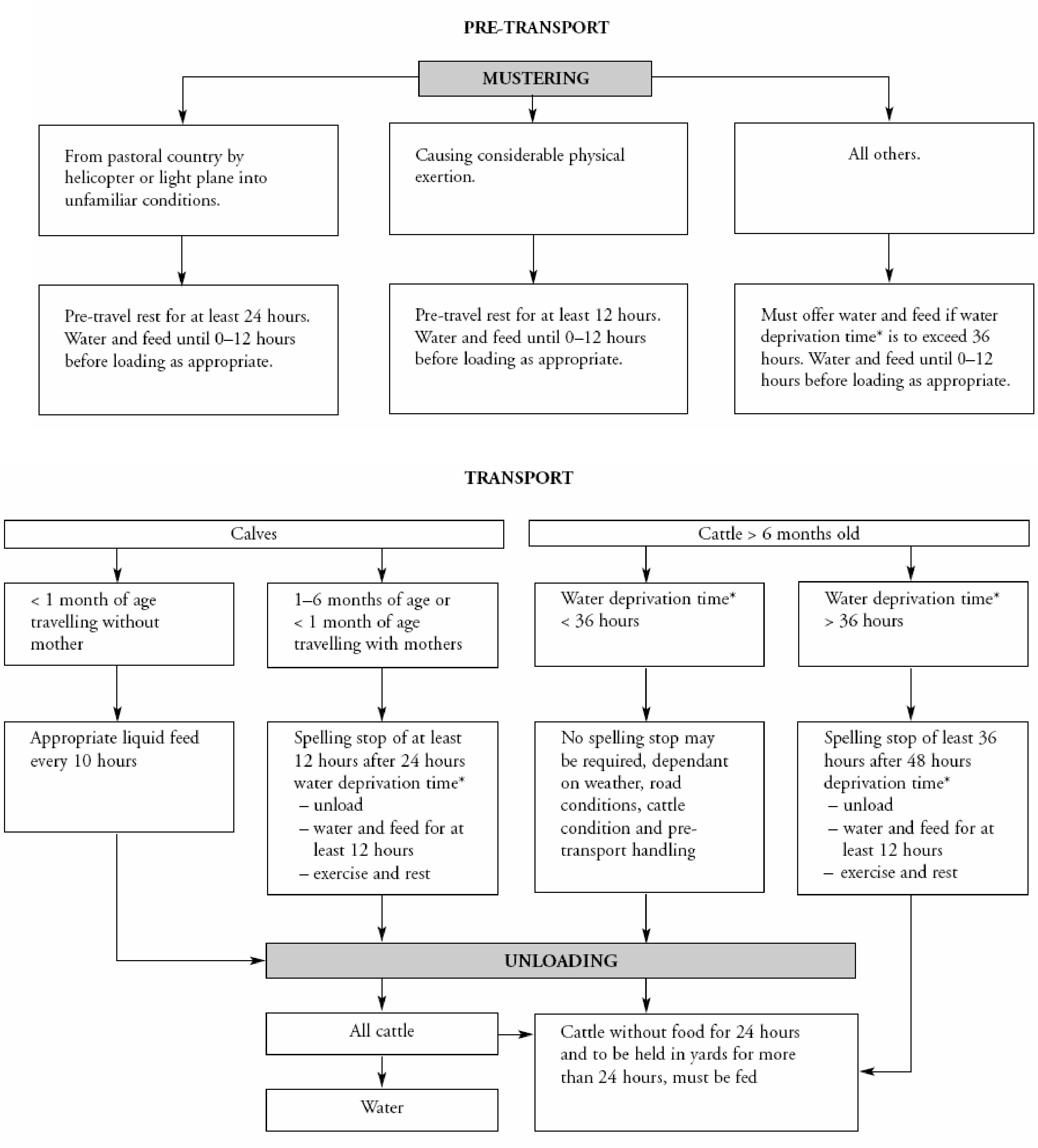
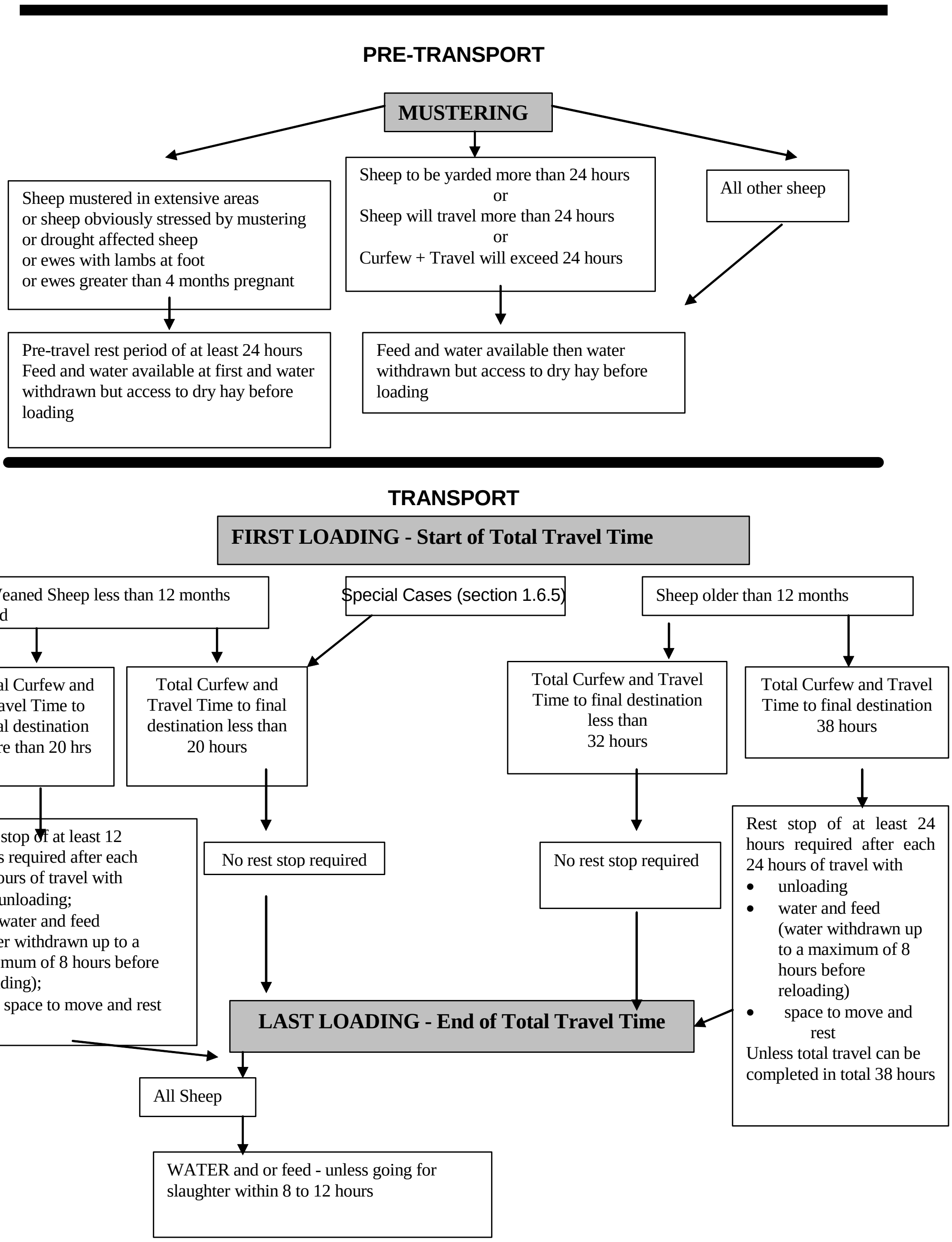


Figure 9 Summary of sheep transport code (Draft Australian Model Code of Practice for the Land Transport of Sheep: PIMC, 2006)



5 Success in Achieving Objectives

5.1 Comparison of science, practices and codes

It has become apparent during the preparation of this review that the development of how the livestock transport industry operates (practices), and the standards to which it is deemed to operate (codes and QA) have not occurred as a simple linear process following scientific research and discovery. In most cases, the practices have arisen through experience, and the codes and the science have either followed in time, or provided support to what is done. In some areas there is little or no scientific data to support or contradict a practice. Nevertheless, in many areas there is good alignment between the state of scientific knowledge and the ways in which land transport of livestock is undertaken in Australia. Furthermore, areas in which previous practices and codes have fallen short of the available science have been corrected, such as the original stocking densities for cattle in the 1983 Code. It is not possible to state categorically that this was in response to scientific knowledge, or practical experience, or a combination of both, but it is nonetheless worthwhile to point out that it has occurred. The following sections provide a summary of the alignment between the state of scientific knowledge, and current practices in the Australian livestock transport sector.

5.1.1 Fitness to travel

As highlighted earlier, there has not been extensive scientific research on what constitutes fitness to travel in livestock. Appropriately, the knowledge in this area is based more on clinical know-how, years of practical experience and common sense. The Australian model codes contain appropriate guidelines on animals that are not fit to be transported, but the most important development has been in the production and widespread distribution of the “Fit to Load” booklet. This will help practices become more aligned with industry knowledge and the Model Codes of Practice, by enabling producers to select suitable animals for transport and by helping transport operators decline to transport animals that are not suitable for transport. Positive comments about the “Fit to Load” booklet were made by transport industry representatives. There is a gap in our scientific knowledge in terms of the animal welfare outcomes of transporting livestock in varying degrees of weakness for varying durations and conditions. However, research to completely address such a knowledge gap would be extremely involved and costly in terms of the many different classes and conditions of animals and transport events that would need to be included. Furthermore, Australia is in a similar position to other countries where there has been a reliance on extensive practical experience and knowledge in dealing with the issue of fitness to travel.

5.1.2 Pre-transport therapies

Specifically, this category refers to the treatment or provision of animals with electrolytes and energy supplements before transport. There is alignment between the science and Australian practice on this issue, because there is no conclusive data supporting the welfare benefits of pre-transport electrolyte therapy, and in general, such supplements are not widely used here.

5.1.3 Curfew

This area represents one of the key knowledge gaps within Australian livestock transport. As described earlier, there is a lack of scientific data to support the views from livestock transporters that pre-transport curfews facilitate improvements in the capacity of cattle and sheep to cope with transport. The application of pre-transport curfews will result in less excreta in trucks, but it is not clear whether this reduces the amount of slippage and losses in balance during the journey.

There is insufficient scientific evidence to conclude that pre-transport curfew improves the capacity of ruminants to cope with transport. Clearly, this association requires research attention, as the results are central to any informed judgment of the impact of curfews on animal welfare during transport. A start has been made in addressing this issue through an MLA-funded literature review (LIVE.122A).

5.1.4 Loading and Unloading

There is alignment between the science and industry knowledge in this area, in that the scientific results demonstrate the relative stressfulness of these components of the transport process, emphasising the importance of good loading facilities and handling. Similarly, this is backed by industry awareness of the importance of good loading facilities, but in practice these facilities are not always present. The basic design components of good loading facilities and practices are known by industry, but are not always deployed in practice. Training and QA auditing may help with this issue.

5.1.5 Stocking density

In general, stated industry practice follows the welfare code guidelines for stocking density, unless there are circumstances for reducing density slightly. The main question therefore pertains to how well do the stated stocking densities in the codes align with scientific results. As detailed earlier, the stocking densities in the Cattle Transport Code are in relatively good alignment with the results of research (conducted in Australia) on the issue, as well as allometric equations for standing cattle. In contrast, there has been little direct research under Australian conditions on stocking densities for sheep. The values in the Australian codes represent space allowances for sheep at the lower end or just below the conclusions on appropriate space allowance from European studies. However, this does not necessarily mean that Australian transported sheep are too tightly packed or that there is an urgent need for research on sheep stocking density under Australian conditions. Rather, it should be noted that the European scientific conclusions were based on a perceived need for sheep to have enough room to lie down during longer journeys. In contrast, under Australian conditions, sheep are discouraged under industry practice from lying down. The issue of space allowance for sheep under Australian conditions therefore interacts with that of journey duration, in that the key question relates to the welfare (particularly fatigue) of sheep transported for code-permitted durations at recommended stocking densities. If it is shown that sheep are so fatigued that their welfare is compromised when they are transported beyond a certain time at current stocking densities, then either the stocking density or the maximum duration would need to be reduced,.

5.1.6 Transport duration

As detailed earlier, there is little scientific data on the welfare of cattle when they are transported at durations close to the current code maximum of 48 hours under Australian conditions. Accordingly, it is not possible to compare the science, codes and industry practice until further research has been undertaken. Two key MLA projects that will inform this issue are currently underway: AHW.055 “Animal Welfare Outcomes of Livestock Road Transport Practices”, which will measure the welfare of cattle transported for set durations up to the code maximum, and AHW.125 “Assessing long distance livestock land transport practices in Australia to benchmark animal health and welfare outcomes”, which may provide some information on the relative duration of transport events in commercial practice, depending on the outcomes of an initial pilot study. There is also no direct comparative data for Bos indicus and Bos taurus breeds in terms of their ability to cope with transport duration. Although it could be presumed that tropically-adapted breeds would be more resistant to transport-associated periods of water deprivation and heat, specific recommendations are hampered by a relative lack of data and by the experience of other areas of research in which within-breed variation in individual response can rival between-breed differences.

For sheep, there is similarly little scientific data on the welfare of animals transported at durations around 38 hours (revised draft code) or 48 hours (current proclaimed code). Again, the results of the two research projects AHW.055 and AHW.125 will inform this issue.

5.1.7 Vehicle design

The design of Australian livestock transport vehicles has been largely driven by industry practical experience, with science essentially confirming the usefulness of some key features, such as wide internal doorways, lack of bruise points and similar. It would appear that the design of vehicles used is now well-suited to Australian conditions and practices. One aspect that is worth noting is that the reliance on natural ventilation works well when the vehicle is moving, but can create ventilation problems, particularly for multideck sheep vehicles, when the vehicle is stationary. However, within the literature, and in discussion with industry, there were no major design issues identified as causing animal welfare problems in the current environment.

6 Impact on Meat and Livestock Industry – now & in five years time

The results of this review should provide security to the meat and livestock Industry in the knowledge that there are no substantive contradictions between the current scientific knowledge concerning livestock land transport, and the way in which such transport is undertaken in Australia. The review should also help the Industry to highlight knowledge gaps (such as on animal curfew), and undertake steps to address these. The main impact should occur in five years' time, when these knowledge gaps have been addressed, and the industry is in an enhanced position to stand by its practices on animal welfare grounds.

7 Conclusions and Recommendations

The conclusions of this review are that there are no substantive contradictions between the science of land transport of livestock under Australian conditions, and the ways in which such transport is undertaken. This is despite the development of practices and the advances in scientific understanding occurring in separate, parallel processes in many areas.

There are however areas where the science is not complete, areas where the knowledge of what occurs in Australia is incomplete, and areas where there are gaps between what is known and recommended as good practice and what may occur in practice, as reported during our industry discussions. The main priorities relate to knowledge gaps of animal welfare outcomes in relation to transport duration and curfews, and limited knowledge regarding current welfare outcomes for the transport of livestock in Australia.

For transport duration, there are knowledge gaps concerning the animal welfare outcomes of the maximum durations permitted under Australian codes and practices. However, this is currently being addressed by MLA-funded research (AHW.055 ~ Animal Welfare Outcomes of Livestock Road Transport Practices). There is also a knowledge gap in terms of identifying best practice for transporting animals in Australia for durations of 36 to 48 hours compared with providing a rest stop off the vehicle. It should be noted that the legislative requirements in the European Union, which has much lower permitted transport durations for livestock than Australia, do not appear to be absolutely necessary, when compared with the scientific literature.

Quantifying the benefits of pre-transport curfews is recognized as a significant knowledge gap. The fundamental questions of whether they are necessary in the context of enabling animals to better adapt to transport and if so, how long should cattle and sheep be deprived of feed and/or water prior to transport after taking into consideration their condition and nutritional background, requires immediate attention. The critical issue of pre-transport curfews was recently reviewed by MLA (LIVE 122A ~ Investigating feed and water curfews for the transport of livestock within Australia - a literature review) and the recommendations identified in that review will be influential in any future research of the effects of pre-transport curfews in livestock. Furthermore, the results of current research (MLA Project AHW.055 ~ Animal Welfare Outcomes of Livestock Road Transport Practices) will, in part, address this knowledge gap. However, it is recommended that additional research into the development of pre-transport curfew best practice needs to be considered.

An additional knowledge gap is that we do not have a good understanding of what actually happens in practice for the transport of livestock in Australia. This limited knowledge includes key issues such as the numbers and classes of animals that are trucked for differing durations, in some cases mortality and morbidity rates resulting from transport and livestock performance during and post transport. This knowledge gap is also currently being addressed (MLA Project AHW.125 ~ Assessing long distance livestock land transport practices in Australia to benchmark animal health and welfare outcomes).

There was clear convergence between the scientific knowledge and industry support for the need for well designed loading facilities, particularly on properties of origin. On-farm loading facilities were reported as being highly variable, with substandard facilities raising concerns about poorer or more difficult handling, and risks to animal welfare. Consideration should be given to methods of improving this issue by removing or replacing problem yards and loading facilities. This also has obvious implications for animal welfare on-farm, and could be encouraged through incorporation of suitable standards into on-farm quality assurance systems and minimum competencies in stock handling.

A similar gap concerns the current inability under some circumstances to be certain that livestock are not exceeding the maximum water deprivation period during transport events. Although there are moves through NVD and journey plan provisions to capture data on when animals were loaded and/or last received access to water, the failure to follow this through repeated transport events could present a problem, such as when animals are transported to a saleyard, sold and then transported out that evening.

Australia has a good record of continuous improvement in livestock transport vehicles and methods, and although there has not been a strong level of alignment in the past between the conduct of research and improvements in practices, this is now being addressed in several areas, including current research commissioned by MLA, and overarching developments in Australian welfare codes and standards, as part of the Australian Animal Welfare Strategy.

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9 Appendices

9.1 Appendix 1- Index

9.2 Appendix 2- Industry contacts

Industry contacts utilised in the preparation of this report. These tables are grouped into different sectors representing ALTA representatives, government, transport operators, stockcrate manufacturers and others with industry knowledge.

STATE LTA AND ALTA REFERENCE GROUP

Name	Town	State	Title	Email	Phone	Mobile	Fax	Address
Luke Fraser	Canberra	ACT	Australian Livestock Transport Association Executive Director	'luke@alta.org.au'	02 6247 5434			ALTA GPO Box 2078 Canberra ACT 2610
Ross Fraser	Warwick	QLD	Past President LTAQ Past president ALTA	'ross@fraserstransport.com.au'	07 4661 2922	0408718619	07 4661 8589	PO Box 1073 Warwick Q 4370
Mick O'Hara		SA	State Rep. LTASA Past president LTASA Past President LTASA	'ohatrans@lm.net.au'		0428 751 028		
Peter Berwick		TAS	Owner/Manager PB Livestock Transport Past President LTA Tas State Rep on ALTA			0428 131 594	03 6353 2303	
Gavin O'Sullivan	Elsmore	VIC	Managing Director Elmore Haulage Pty Ltd	'osulltpt@bigpond.com'		0418 509 260		
Mark Flemming	Katanning	WA	ALTA President Managing Director Stockhaul WA	stockhaul@westnet.com.au		0408599041		
Jim Savage	Tamworth	NSW	Managing Director Stockmaster Pty Limited	JTS@stockmaster.net.au	02 6760 7388	0427936293		

GOVERNMENT REFERENCE GROUP

Name	Town	State	Title	Email	Phone	Mobile	Fax
Ian Dodderil		NT	Senior Stock Inspector NT Department of Primary Industries & Fisheries	Ian.dodderil@nt.gov.au	08 8999 2030		
Kel Small	Darwin	NT	Principal Veterinary Officer DPI & F				
Bill Giles	Adelaide	SA	Former Beef Program Manager SA Dept of Agriculture		08 8207 7842	0401121896	
Brian McIntyre	Perth	WA	Senior Research Officer Animal Research and Development Services Department of Agriculture WA	bmcintyre@agric.wa.gov.au	08 9368 3736	0418908829	
Michael Paton	Perth	WA	Senior Veterinary Officer Department of Agriculture WA	mpaton@agric.wa.gov.au	08 9368 3627		
Richard Norris	Perth	WA	Manager Veterinary Services Department of Agriculture WA	Norris@agric.wa.gov.au	08 9368 3637		
Brian Bartsch	Glenside	SA	Manager Industry Development Livestock Industries Primary Industries and Resources SA	brian.bartsch@state.sa.gov.au	08 8207 9955 08 8388 8344 (AH)	0418811853	08 82077852
David Rathbone	Toowoomba	QLD	Accounts Executive Livestock QR National	rathbone@qr.com.au		0427729952	
John Galligan	Brisbane	QLD	Manager Agriculture Products QR National	John.galligan@qr.com.au			

LIVESTOCK TRANSPORTERS REFERENCE GROUP

Name	Town	State	Title	Email	Phone	Mobile	Fax
Pete Walsh		WA	Product Test Engineer John Deere Ltd	walshpeter@johndeere.com		0428745850	
John Mitchell	Waroona	WA	Managing Director Mitchell's Livestock Transport	johnm@mitchellstransport.com.au	08 9733 1246	0418420880	08 9733 2314
Mark Johnston		QLD	Sales & marketing Manager Haulmark Trailers (Australia)	markj@haulmark.com.au	07 3277 3666	0417782833	
Barney Hayes	Orange	NSW	Manager Cec Hayes Livestock Transport	'bhayes@nolly.com.au'	02 6362 3904 02 6362 3600	0417 444 411	02 6361 7371
Jim Savage and Jim Marshall	Tamworth	NSW	Managing Director Stockmaster Pty Limited	JTS@stockmaster.net.au	02 6760 7388	0427936293	
Bob Richardson	Scone	NSW	Martins' Stock Haulage Scone	'brichardson@martinshaulage.com.au'	02 6545 3222	0428 681 488	02 6545 3222
Ron Shanks	Dubbo	NSW	Shanks Trailers	shankstrailers@crt.net.au	02 68885149	0402455011	02 68885204
Wayne Dickenson	Dubbo	NSW	Managing Director Bruce Dickenson Transport	wgdd@ozemail.com.au		0429635989	
Allan Rogers	Alice Springs	NT	Tanami Transport (NT) Pty Ltd	'tanami@dodo.com.au'	08 8952 1166	0418 897 214	08 8952 9457
Brooke Hartley	Darwin	NT	Manager – NT Hampton Transport Services	'noelenehts@bigpond.com'	08 8988 4800	0407 123 117 Sat 0147165131	08 899884855
Jim Cooper	Darwin	NT	Manager Gulf Transport	'jim.cooper@gulfrta.com'	08 8947 5104	0417 836 921	
Kel Small	NT DPI	NT	Principal Veterinary Officer	Kel.small@nt.gov.au	08 8999 2030		
Ross Fraser	Warwick	QLD	Managing Director Frasers Livestock Transport	'ross@fraserstransport.com.au'	07 4661 2922	0408 718 619	07 4661 8589
Stephen Curley	Cloncurry	QLD	Manager Curley Cattle Transport	'curleyct@bigpond.com'	07 4742 1220	0417 787 314	07 4742 1690
Mike Bailey	Mt Isa	QLD	Operations Manager (Qld) Road Trains of Australia	'rtaisa@austarnet.com.au'	07 4743 2500	0428 989 434	07 4743 2982
David Bielenberg	Longreach	QLD	Manager Longreach Transport Co P/L	'longtpt@bigpond.net.au'	07 4658 3300	0145 113 895	
Stewart McIver	Charters Towers	QLD	Formerly Manager McIver Bros	kalhire@hotmail.com		0419642068	

STOCKCRATE MANUFACTURERS REFERENCE GROUP

Name	Town	State	Title	Email	Phone	Mobile
Doug McDonald	Perth	WA	Managing Director SFM Engineering	doug@sfmeng.com	08 9274 5566	0418 916 469
Mark Johnston	Brisbane	QLD	Haulmark Trailers (Australia) Sales and Marketing Manager	markj@haulmark.com.au	07 3277 3666	0417782833
Ron Shanks	Dubbo	NSW	Managing Director Shanks Trailers	shankstrailers@crt.net.au	02 6888 5149	0420 455 011
Wayne Dickenson	Dubbo	NSW	Managing Director Bruce Dickenson Transport	wgdd@bigpond.com	0429635989	

OTHERS CONSULTED FOR THEIR INDUSTRY KNOWLEDGE

Name	Town	State	Title/company	Email	Phone	Mobile
Stewart McIver	Charters Towers	QLD	Formerly Manager McIver Bros	kalhire@hotmail.com		0419642068
Pete Walsh	Perth	WA	Product Test Engineer John Deere Ltd	walshpeter@johndeere.com		0428745850
Dave Napier	Darwin	NT	Formerly Chief Inspector of Stock Northern Territory		08 8985 1573	
Rodney Wolski	Oakey	QLD	Former General Manager McIvor Brothers	rwolski@abgrains.com.au	07 4691 1211	0418785113
Charlie Hudson	Townsville	QLD	Former Managing Director Hudson Livestock Transport, Cloncurry			
Phil Smith	Cloncurry	QLD	Owner/Manager PG & LJ Smith Livestock Transport	pg&ljsmith@bigpond.com.au	07 47421316	
Tim Clifford	Brisbane	QLD	Client Liaison officer Frasers Transport Formerly Manager(Toowoomba) Byrne Trailers, Depots Manager McIvor Brothers		07 4633 3663	0428692746

9.3 Appendix 3- DEFRA research projects on livestock transport

A list of DEFRA projects on transport of livestock with links. Some of these projects are of direct relevance to this review, and others are listed because they are of general relevance to the transport of farm animals.

DEFRA Projects on Transport of Livestock

AW0505 : Further development of non-invasive sensor systems for pigs
More Project Details
From **2003** To **2005** , Cost: **£168,037**
Contractors/Funded Organisations : Central Science Laboratory
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0507 : The potential use of idENTICHIP with bio-thermo for monitoring deep body temperature in livestock (pigs).
More Project Details
From **2005** To **2005** , Cost: **£25,173**
Contractors/Funded Organisations : Roslin Institute, Edinburgh (BBSRC)
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0808 : Long distance road transport of farm animals
More Project Details
From **1997** To **2002** , Cost: **£810,545**
Contractors/Funded Organisations : Silsoe Research Institute (BBSRC)
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0809 : To understand and alleviate physiological stress during transportation of livestock
More Project Details
From **1997** To **2002** , Cost: **£910,406**
Contractors/Funded Organisations : Roslin Institute, Edinburgh (BBSRC)
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0810 : Development of telemetry systems for the remote monitoring of physiological signals in livestock.
More Project Details
From **1999** To **2002** , Cost: **£292,358**
Contractors/Funded Organisations : Roslin Institute, Edinburgh (BBSRC)
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0812 : Effect of stocking density and pen size on livestock welfare
More Project Details
From **2000** To **2002** , Cost: **£24,172**
Contractors/Funded Organisations : Silsoe Research Institute (BBSRC)
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0815 : Road Transport of Farm Animals in Hot Climates
More Project Details
From **2003** To **2005** , Cost: **£470,372**
Contractors/Funded Organisations : Silsoe Research Institute (BBSRC)
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0816 : Study to investigate the space above the head and shoulders of pigs and cattle when standing during transport

More Project Details
From **2003** To **2003** , Cost: **£28,609**
Contractors/Funded Organisations : University - Oxford
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0817 : Development of a proximity sensor to measure automatically spatial associations between animals and resources
More Project Details
From **2004** To **2004** , Cost: **£10,247**
Contractors/Funded Organisations : Central Science Laboratory
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0819 : Welfare assessment of animals moving through markets
More Project Details
From **2005** To **2007** , Cost: **£134,896**
Contractors/Funded Organisations : Royal Veterinary College
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0820 : Transcontinental road transport of breeder pigs - effects of hot climates
More Project Details
From **2006** To **2009** , Cost: **£1,160,814**
Contractors/Funded Organisations : ADAS Consulting Ltd, SAC Commercial Ltd
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0907 : A literature review of transport and stocking densities of slaughter sheep
More Project Details
From **1997** To **1997** , Cost: **£14,899**
Contractors/Funded Organisations : University - Bristol
Policy Area : Animal Welfare

AW0908 : `Literature reviews of cattle, deer and ostrich transport`
More Project Details
From **1998** To **1998** , Cost: **£14,700**
Contractors/Funded Organisations : University - Bristol
Policy Area : Animal Welfare

AW0917 : The effect of transporting cattle by road for 30 hours
More Project Details
From **1997** To **1998** , Cost: **£302,128**
Contractors/Funded Organisations : University - Bristol
Policy Area : Animal Welfare

AW0918 : Study to investigate the standardisation of the visual assessment of sheep stocking density during transport
More Project Details
From **1998** To **1998** , Cost: **£2,000**
Contractors/Funded Organisations : Cambac JMA Research Limited
Policy Area : Animal Welfare

AW0919 : Study to investigate the space above the head and shoulders of sheep when standing during transport
More Project Details
From **1998** To **1998** , Cost: **£14,350**
Contractors/Funded Organisations : Cambac JMA Research Limited
Policy Area : Animal Welfare

AW0922 : Understand and alleviate physiological stress during the transport of pigs Limited Tender
More Project Details
From **2000** To **2004** , Cost: **£437,646**
Contractors/Funded Organisations : Silsoe Research Institute (BBSRC)
Keywords: Plants and Animals - Animal Welfare - Pigs
Policy Area : Animal Welfare

AW0928 : A method of assessing the stocking density of sheep during commercial transport.
More Project Details
From **2000** To **2001** , Cost: **£15,763**
Contractors/Funded Organisations : University - Bristol
Policy Area : Animal Welfare

AW0931 : Driver stressors in the livestock (red meat) sector.
More Project Details
From **2002** To **2002** , Cost: **£90,259**
Contractors/Funded Organisations : Silsoe Research Institute (BBSRC)
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0932 : Human factors affecting the welfare of animals during transport
More Project Details
From **2002** To **2005** , Cost: **£275,952**
Contractors/Funded Organisations : Central Science Laboratory
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0933 : Animal welfare in livestock trailers and optimisation of ventilation
More Project Details
From **2004** To **2007** , Cost: **£281,827**
Contractors/Funded Organisations : Central Science Laboratory
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0934 : A study to assess the effect of handling & transport on
More Project Details
From **2005** To **2008** , Cost: **£244,329**
Contractors/Funded Organisations : ADAS Consulting Ltd, University - Edinburgh
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare

AW0935 : Study to assess the best spacing strategy for the welfare of sheep during transport
More Project Details
From **2005** To **2007** , Cost: **£129,902**
Contractors/Funded Organisations : University - Oxford
Keywords: Plants and Animals - Animal Welfare - Sheep
Policy Area : Animal Welfare

AW0936 : Effect of driver behaviour on the behaviour of cattle & pigs in transit
More Project Details
From **2005** To **2007** , Cost: **£140,742**
Contractors/Funded Organisations : University - Edinburgh
Keywords: Plants and Animals - Animal Welfare - Livestock - Transport
Policy Area : Animal Welfare