liveexport

LIVE.104A
Influence of pre-delivery management on livestock performance:
Desk Top Study

Report prepared for MLA and Livecorp by:

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EXECUTIVE SUMMARY

The joint Meat and Livestock Australia (MLA)/LiveCorp project LIVE.104, "Desk Top Study" is the first stage of a project that aims to deliver best practice guidelines on the optimal pre-delivery management of livestock for export. This project examines the management of livestock during the pre-embarkation phase and the resulting effect on animal performance during the remainder of the export process. It specifically focuses on the management of stock at the farm of origin and during land transport en-route to the export pre-embarkation site or assembly feedlot.

The desk top study consisted of a review of the scientific literature and industry standards and, a survey of the live export industry to investigate the influence of pre-delivery management on the performance of cattle and sheep during live export. It reviews and identifies key on-farm and transport factors that are associated with deaths and decreased performance during live export. Suggestions for best practice recommendations to manage these factors and recommendations for further research are provided. It is envisaged that the field trials and development of new best practice guidelines would be carried out in the second stage of the project along with the development of a communication strategy to maximise uptake of the guidelines by industry

Stress during the pre-delivery phase of live export will contribute to decreased performance during live export. Stress causes poor performance and all the known causes of stress in livestock production systems are present during the pre-delivery phase of live export. Measuring the effects of this stress accurately and identifying and managing the specific pre-delivery causes of stress that lead to decreased performance during live export is needed for effective pre-delivery management.

Clinical indicators of stress are more sensitive than mortality rates and can be easily measured. Consideration should be given to using a clinical indicator of stress such as liveweight changes, feed intake and level of illness as an industry performance indicator and during research, especially considering that mortality rates are already so low. Demonstrating to the general community the positive steps being taken by the industry to improve animal welfare would be helped by measuring more sensitive indicators and would assist in studying relationships between pre-delivery factors and livestock performance.

Adhering to sound animal husbandry principles and conducting all on-farm and transport operations in a manner that causes minimal stress to livestock will help in improving animal welfare and enhancing live export performance. The Model Code of Practice for the Land Transport of Cattle and the Australian Livestock Export Standards recognise this and provide general guidelines. However, specific pre-delivery causes of poor performance during live export need to be identified and these standards examined to determine if those factors are adequately covered.

Following are the key findings and recommendations of the desk top study. These findings identify key pre-delivery factors associated with deaths and poor performance and analyse the extent to which these are currently being addressed by existing standards and best practices. Suggestions for best practices are provided for those factors that can be validated and are not adequately managed by existing standards. Recommendations for further research to investigate key factors where required are provided in priority order.

KEY FINDINGS FOR PERFORMANCE MONITORING

- ☑ Stressors during live export cause behavioural, nutritional, physical and infectious stress.
- ☑ The most common clinical manifestations of transport stress are liveweight loss, dehydration, reduced feed intake, physical injuries, salmonellosis (sheep) and respiratory disease (cattle).
- ☑ Although mortality rate is an appropriate performance indicator for live export, more sensitive clinical indicators need to be used to demonstrate positive effects of new initiatives.

RECOMMENDATIONS FOR PERFORMANCE MONITORING

Further research

Research recommendation 1

Further research in live export should measure stress and performance with a clinical indicator such as liveweight and feed intake and the industry should consider these as industry performance indicators.

KEY FINDINGS AND SUMMARY FOR SHEEP

Key findings

- ☑ Most sheep deaths occur during the sea voyage.
- ☑ Inanition and salmonellosis (that generally occurs as a result of not feeding) are the main causes of death in sheep at sea.
- ☑ Inappetence that commences during pre-embarkation lot-feeding and persists during shipping is the principal pre-disposing factor for deaths in sheep during shipping.
- ☑ Non-feeding in the pre-embarkation feedlot is the major risk factor for the persistent inappetence syndrome.
- ☑ Modifying and reducing the factors that produce feedlot non-feeders should reduce sheep mortalities during live export.
- ☑ The factors that produce feedlot non-feeders operate on the farm of origin.
- ☑ Key on-farm risk factors for deaths in sheep during live export are:
    - Geographical location of farm:
        - Length of pasture growing season at farm of origin; and
        - Rainfall at farm of origin;
    - Season at time of export; and
    - Animal factors:
        - Fatness of sheep; and
        - Age of sheep.
- ☑ Other possible on-farm factors for deaths in sheep during live export are farm management factors. These are:
    - Previous dietary experience;
    - Handling facilities and procedures;
    - Infectious diseases; and
    - Mixing.

Risk factor summary

RISK FACTOR	STANDARDS		COMMENTS
	ALES[1]	OFQAM[2]	
Geographical location of farm of origin	Not covered	Not covered	• Difficult to manage • Use to identify high risk consignments • Consider treatment option
Time of year of export	Not covered	Not covered	• Difficult to manage • Use to identify high risk consignments • Consider treatment option
Season at time of export	Not covered	Not covered	• Difficult to manage • Use to identify high risk consignments • Consider treatment option
Fatness of sheep	Specific recommendation	Not covered	• Currently addressed • No further research or recommendations required
Age of sheep	Not covered	Not covered	• Difficult to manage • Use to identify high risk consignments • Consider treatment option
Previous dietary experience	Not covered	Not covered	• Consider research into use as a treatment option for high risk consignments
Handling facilities and procedures	General recommendation	Specific recommendation	• Currently addressed • Encourage exporters to source stock from Flockcare farms • No further research required
Infectious diseases	General recommendation	Specific recommendation	• Currently addressed • Encourage exporters to source stock from Flockcare farms • No further research required
Mixing	Not covered	Not covered	• Effect unknown • Further research is a low priority

1. ALES - Australian Livestock Export Standards
2. OFQAM - On-Farm Quality Assurance Manual

RECOMMENDATIONS FOR SHEEP

Best practice suggestion

Best practice suggestion 1

Encourage exporters to select sheep for export from Flockcare accredited properties.

Further research

Research recommendation 1

The industry should not conduct further research into pre-delivery causes of poor performance in sheep during live export at this time.

Research recommendation 2

The industry should investigate the use of treatment options such as, the use of electrolytes during shipping and on-farm pre-conditioning to the shipboard diet to manage high risk consignments.

Research recommendation 3

Contingent on the acceptance of previous recommendations, the industry should develop a performance monitoring system that will:

- identify high risk consignments;
- enable the measurement of more sensitive performance indicators;
- enable continued demonstration of industry improvements; and
- enable the investigation of the effect of farm management factors on live export performance.

KEY FINDINGS AND SUMMARY FOR CATTLE

Key findings

- ☑ There has been very little research into the causes and pre-disposing factors of cattle deaths during live export.
- ☑ Most cattle deaths occur during the sea voyage.
- ☑ Pneumonia and heat stress may be the main causes of cattle mortality during shipping.
- ☑ Results from feedlot and abattoir studies can be extrapolated to live export for best practice recommendations until specific live cattle export research is done.
- ☑ The effect of pre-delivery management on live export performance of cattle has not been definitively determined.
- ☑ Key pre-delivery risk factors (extrapolated from land based studies) for decreased performance in cattle during live export are:
    - Time between yarding and delivery to exporter;
    - Temperament;
    - Sex of animal;
    - Breed of animal;
    - Time of year of export;
    - On-farm handling;
    - Condition score;
    - Horns; and
    - Severe weather.

☑ Other possible on-farm factors associated with death and poor performance of cattle during live export are:
- Mixing;
- On-farm nutrition; and
- Bovine Respiratory Disease.

Risk factor summary

RISK FACTOR	STANDARDS		COMMENTS
	ALES[1]	OFQAM[2]	
Time between yarding and delivery to exporter	Specific recommendation	Not covered	• Currently addressed • No further research or recommendations required.
Temperament	General recommendation	Not covered	• Partly addressed • Encourage exporters to source stock from properties that produce well-domesticated cattle • No further research required
Sex of animal	Specific recommendation	Not covered	• Currently addressed • Adopt Best Practice Study[3] Rec. 3.1.4 (b) • No further research required
Breed of animal	Specific recommendation	Not covered	• Currently addressed • Adopt Best Practice Study[3] Rec. 3.1.1 and 3.1.2 • No further research required
Time of year of export	Specific recommendation	Not covered	• Currently addressed • Adopt Best Practice Study[3] Rec. 3.1.1 • No further research required
On-farm handling	General recommendation	Specific component	• Partly addressed • Encourage exporters to source stock from Cattlecare properties • Minimise the export of non-domesticated ("scrubber") cattle • No further research required
Condition score	Specific recommendation	Not covered	• Currently addressed • Adopt Best Practice Study[3] Rec. 3.1.1 and 3.1.4 • No further research required
Horns	Specific recommendation	Not covered	• Currently addressed • No further research or recommendations required
Severe weather	General recommendation	Not covered	• Cannot be controlled • Adopt Best Practice Study[3] Rec. 3.1.3 • No further research required

RISK FACTOR	STANDARDS		COMMENTS
	ALES[1]	OFQAM[2]	
Mixing	Specific recommendation	Not covered	• Currently addressed • No further research or recommendations required
On-farm nutrition	Not covered	Not covered	• Not addressed • Adopt Best Practice Study[3] Rec. 3.2.1 • Further research required • Investigate as part of performance monitoring system
Bovine Respiratory Disease	Not covered	Not covered	• Effect unknown • Further research required • Investigate as part of performance monitoring system

1. ALES - Australian Livestock Export Standards
2. OFQAM - On-Farm Quality Assurance Manual
3. Ainsworth, R. and McCarthy, M. (2000) *Best practice standards for the preparation and husbandry of cattle for transport from Australia. Part A: Best Practice Recommendations (SBMR.003).* Draft report. Meat and Livestock Australia, Sydney

RECOMMENDATIONS FOR CATTLE

Best practice suggestions

Best practice suggestion 1

Encourage exporters to select stock from properties known to produce well-domesticated cattle.

Best practice suggestion 2

Encourage exporters to select stock from Cattlecare accredited properties.

Best practice suggestion 3

Minimise the export of non-domesticated ("scrubber") cattle.

Best practice suggestion 4

Adopt suggested best practice recommendations of relevance to pre-delivery management made by Ainsworth and McCarthy (SBMR.003, 2000). These are:

- 3.1.1: Source cattle breeds best suited to travel conditions;
- 3.1.2: Source cattle acclimatised to expected weather conditions;
- 3.1.3: Avoid export of cattle not recovered from a stressful incident;
- 3.1.4: Avoid exporting very large and/or very fat animals;
- 3.2.1: Introduce cattle to shipboard ration prior to loading onto vessel;
- 3.2.2: Feed and water curfews prior to loading onto trucks or vessels; and
- 3.2.3: Ensure cattle have adequate rest prior to loading after long road journeys.

Further Research

Research recommendation 1

That the industry continue to support on-ship studies and performance monitoring studies to determine the causes of mortalities and poor performance in cattle during sea transport.

Research recommendation 2

Develop a performance monitoring system for live cattle export that will:

- enable the measurement of more sensitive industry performance indicators;
- enable the industry to better demonstrate performance improvements;
- identify high risk consignments; and
- enable the investigation of the effect of on-farm nutritional and infectious factors on live export performance.

Research recommendation 3

Conduct research to investigate the effects of Bovine Respiratory Disease on live export performance of cattle and examine methods for controlling it.

Research recommendation 4

Conduct field research to investigate the effect of farm management factors such as yard weaning and on-farm nutrition factors such as pre-conditioning to the shipboard diet on live export performance.

KEY FINDINGS FOR ROAD TRANSPORT

Key findings

☑ Key road transport factors associated with decreased performance in livestock during live export are:

- Total transit time;
- Overloading;
- Driving care; and
- Road conditions.

RECOMMENDATIONS FOR ROAD TRANSPORT

Best practice suggestion

Best practice suggestion 1

For both sheep and cattle, adopt the suggested best practice recommendation outlined in Section 6.6 of the draft, revised ALES (August, 2000) that exporters should use transport operators with a relevant livestock transport quality assurance program. This program should specifically address the key risk factors of total transit time, overloading, driving care and road conditions.

1. INTRODUCTION

1.1 BACKGROUND

It is accepted in the live export industry that the management of stock on-farm and during transport to the livestock exporter will affect their subsequent performance during the remainder of the export process. Mortality rate is the principal measurement of livestock performance during live export. It is used to monitor industry performance trends over time and as an indicator of individual shipment performance (Norris and Norman, 2000; Ainsworth, 2000). It is also the focus of the general community, who base their perception of live export performance on individual shipments that have particularly high mortalities.

The community's perception is a significant threat to the industry. It is driving greater community support for the RSPCA, which believes that the trade should be banned (Wirth, 2000). The worth of the live export trade to Australia is well documented. LiveCorp figures value it at $708 million for 1999. It provides valuable support to the cattle and sheep industries as a significant market outlet with approximately 25% of the income for Australia's top 20 beef producers being derived from live export (Alliance, 2000). Scientifically verifiable best practice standards that will minimise stress, morbidity and mortality are required to overcome the threat of closure to the industry (Trivett, 2000).

Long term mortality trends indicate that the livestock export industry is performing well. The numbers of livestock exported live from Australia have increased substantially over the past decade, yet average annual mortality rates have declined (Norris, 2000; Norris and Norman, 2000). Annual sheep mortalities were approximately 4% in the early 1970s, declined to 2% during the 1980s and in recent years are reported as 1.5% (Gardiner and Craig, 1970; Norris, 2000). Mortalities in the live sheep export trade compare favourably with feedlot deaths. In North American sheep feedlots, death rates range from 0.5%-5% with the majority of deaths occurring in the first 4 weeks after entry to the feedlot (Pierson and Jensen, 1975).

Overall shipboard death rates for cattle have also been low, around 0.2% for the previous four years (Norris and Norman, 2000). Mortalities for the Middle East trade were halved in 1999 to 0.35% with twice as many cattle exported that year over the previous year (Norris and Norman, 2000). Cattle live export mortalities compare favourably with death rates seen in feedlots. Average mortalities for cattle in Australian feedlots are 0.7% and most occur in the first 4 weeks (Dunn et al, 1993).

Mortality rates have also been the focus for research. Concerted efforts during the 1980s and 1990s have substantiated the effect of pre-delivery factors on sheep performance and contributed to the decline in mortalities (Norris, 2000). It is this work that is the focus of this review for the sheep trade. Compared to sheep, limited research has been done for cattle probably because the live cattle trade reached significant volumes later than the sheep trade. Studies into the quantification and causes of cattle deaths during live export and performance monitoring from property to destination feedlot have commenced over the last few years. Research into pre-delivery factors that are associated with mortalities and decreased performance during the export process will depend on the findings of these studies and ongoing analysis of industry statistics. Research that uses other performance measurements, such as liveweight, in the context of road transport and feedlots has been done and is reviewed in this report.

1.2 SCOPE OF THE STUDY

The export of live cattle and sheep from Australia by sea involves three phases. The pre-embarkation phase covers the period from the farm of origin to the arrival of livestock at the ship ready for loading. The shipping phase covers the embarkation of the stock and the period that they are at sea en-route to the port of discharge (Trivett, 2000). The final, post-shipping phase of the live export process covers all activities that occur at the destination including disembarkation, re-mixing, feedlotting and processing (Table 1).

Table 1: Phases in the export of live animals by sea

PHASE	ACTIVITY
PRE-EMBARKATION	• Preparation on farm of origin* • Transport to embarkation site* • Assembly at embarkation site
SHIPPING	• Embarkation (loading) • Sea journey
POST-SHIPPING	• Disembarkation (unloading) • Re-mixing • Feedlotting • Processing

* Activities covered by the present study

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The desk top study is a review of the scientific literature and industry standards and practices to investigate the influence of pre-delivery management on the performance of cattle and sheep during live export. It reviews and identifies key on-farm and transport factors that are associated with deaths and decreased performance during live export. It provides suggestions for best practice recommendations to manage these factors and recommendations for further research to investigate those factors where there is insufficient data to suggest a best practice recommendation. It is envisaged that the field trials and development of new best practice guidelines would be carried out in the second stage of the project along with the development of a communication strategy to maximise uptake of the guidelines by industry.

2. METHODOLOGY

The desk top study consisted of:

- a review of the scientific literature and current industry standards and best practices; and
- a survey of the live export industry.

2.1 LITERATURE REVIEW

The literature review examines the causes and indicators of stress and poor performance in cattle and sheep generally and identifies the causes of deaths during live export specifically. It then reviews and identifies key on-farm and transport factors that are associated with deaths and decreased performance in cattle and sheep during live export.

Adams (2000) described the application of epidemiology in developing best practice standards for the preparation and husbandry of cattle for transport. Epidemiology is defined as the study of the distribution and determinants of disease and production in populations and its application to the improvement of the population. Factors contributing to disease occurrence or reduction in production are known as risk factors and they are attributes that increase the probability of occurrence of a specified outcome, such as, in this case, decreased performance and stress (Thrusfield, 1995). Pre-delivery risk factors for decreased performance during live export are the focus of this study.

Current industry standards, codes of practice and quality manuals were then reviewed to determine the extent to which the identified key risk factors are currently being addressed by industry. These included the Australian Livestock Export Standards (1999 and draft 2000 versions) (ALES), the Australian Model Code of Practice for the Welfare of Animals: Land Transport of Cattle (1999) and the On-Farm Quality Assurance Manual (Cattlecare and Flockcare, Version 1) (OFQAM). Older standards and codes of practice such as the standards for the preparation and carriage of cattle and sheep by sea were not reviewed as these have now been superseded by current versions.

Risk factors that are not adequately being covered by existing standards were identified and preliminary best practice suggestions for managing them developed. These factors and suggestions were then subject to further study by way of an industry survey.

2.2 INDUSTRY SURVEY

The survey of the live export industry collected and analysed the opinions of exporters and scientific experts in the field. It was a targeted survey designed to gather views and opinions from experienced exporters and recognised scientific experts in the field rather than as a cross-sectional study of the entire industry. While the sample size was small, the samples selected meant that the survey results do reflect the majority industry view in terms of contribution to industry performance overall.

The survey was the same for both exporters and experts and there were no significant differences in the results from the two groups. This indicated that there was general agreement between exporters and experts on the majority of issues examined by the survey.

2.2.1 Survey of exporters

Survey participants were selected with the assistance of Livecorp and selection was based on the numbers of stock exported annually and experience in the industry. Seventeen exporters received the survey and 8 responded, representing a response rate of 47%. All respondents exported cattle and 3 also exported sheep.

The total number of cattle exported by the survey respondents was 570,000 head per year, which represents 71% of the industry total (Norris and Norman, 2000). The respondents exported 360,000 head to South East Asia and 210,000 to the Middle East and North Africa, which represents 78% and 67% respectively of the industry total. On average, the respondents have been exporting cattle for 10 years (range 5-20). The majority of respondents (75%) exported *Bos indicus*/*Bos indicus* cross cattle that are export feeder and/or slaughter cattle.

The sheep respondents exported around 2.5 million sheep per year, which represents 50% of the industry total (Norris and Norman, 2000). Their primary market was the Middle East. On average, these organisations have been exporting sheep for 21 years.

2.2.2 Survey of experts

Selection of survey participants was based on recognised experience in the live export field. Thirty-eight surveys were sent and 22 replies received, representing a response rate of 58%. The survey respondents represented a significant amount of scientific experience and expertise in the live export industry. On average, the respondents have worked in the industry for 12.5 years (range 3-27) with 59% in the industry for more than 10 years. Nineteen (86%) respondents held at least a Bachelor degree. Fifteen of these were veterinarians and the rest held degrees in agricultural science. Of the respondents with a bachelor degree, 3 also held a masters degree and 2 had a PhD. Thirteen respondents worked with just cattle, while 9 worked with both cattle and sheep.

The survey respondents represented all areas of the live export industry. Ten (46%) of the respondents worked in the industry as either consultants or private practitioners servicing the industry and 12 (54%) worked in government roles providing research, extension and inspection services. Table 2 details the nature of the work undertaken by the respondents.

Table 2: Nature of work undertaken by expert respondents

	No. of respondents	Percent (%)
Type of work undertaken		
Consultant	5	23
Private practice	5	23
Research and extension	8	36
Inspection	4	18
Sector/s of live export chain respondents work in		
All sectors	8	36
Property of origin only	4	18
Assembly and loading only	2	9
Property of origin and assembly and loading	7	32
Destination market only	1	5

3. CAUSES AND INDICATORS OF POOR PERFORMANCE

Livestock performance during live export is viewed in a number of ways but is generally focussed on the shipping phase of the process. The commercial perspective of performance for individual shipments centres on liveweight gains or losses for cattle and the number of animals that meet specification at discharge for sheep. The main performance indicators for monitoring the performance of the industry overall and for research have been mortality rates.

Regardless of its definition, livestock performance is governed by the capacity of animals, through genetics and previous experience, to adapt to changes in the environment and maintain body equilibrium (Dantzer and Mormede, 1983; Young et al, 1989). Stress is the adaptive response to these changes (Dantzer and Mormede, 1983) and has detrimental effects on livestock performance (Kelley, 1980). This can be manifested as liveweight losses and mortalities resulting in commercial penalties on individual consignments, a downward trend in industry performance over the long term and an enhanced negative perception of the industry by the general community.

Stress is a major determinant of sub-optimal performance in all livestock production systems, including live export. Hails (1978) identified disrupted social settings, unusual noise and variations of temperature and humidity as causes of stress. Kelley (1980) supported this, listing the main causes of stress that typically occur in modern livestock production units as: heat, cold, crowding, mixing, weaning, limit-feeding, noise and restraint. All of these factors alter physiological functions in animals and may contribute to sub-optimal performance in animals during live export.

3.1 STRESS FACTORS

Stress occurs when response mechanisms to changes in the environment exceed normal limits (Coffey, 1988; Blood and Radostits, 1989; Stratakis and Chrousos, 1995). It is a general adaptation syndrome resulting from the overburdening of the body's physiological balances due to the cost imposed on it of adapting to stressors (Selye, 1976; McEwen, 1998; Adams, 2000). Stressors are environmental factors that elicit the stress reaction when they act as a result of changes in the environment (Selye, 1976).

The effects of stressors are cumulative when they operate in combination (Dantzer and Mormede, 1983; Adams, 2000). An animal already burdened with one stressor is less able to adapt to another. If a stressor is removed and animals allowed to recover from it, or given the opportunity to adapt to it, the cost of adaptation can be repaid (Adams, 2000). Limiting exposure to stressors during the pre-delivery phase of the live export process will minimise the homeostatic load present in the animals at assembly for live export enabling them to better cope with stressors later in the export process. Also, conditioning animals to live export stressors before they are encountered will minimise the cost of adapting to them when they are eventually met, thus enabling them to better cope with other stressors that may occur.

Adams (2000) classifies stress on cattle during live export as physical, nutritional, behavioural and infectious which is consistent with the general view of transport stress as being mainly physical and psychological (Grandin, 1997; Knowles, 1998). Table 3 indicates the main stressors and effects of these for the different types of stress that are likely during the pre-delivery phase of live export. Behavioural stressors include antagonistic social interactions leading to injury and bruising and psychological stress due to fear. Nutritional

stressors are decreased feed and water intake. Physical stressors include injury and, infectious stressors would be the infective agents for salmonellosis and pneumonia.

Table 3: Stressors in livestock transport

STRESS	STRESSOR	EFFECT
BEHAVIOURAL	Novelty	Fear
	Restraint	
	Noise	
	Mixing	Antagonistic interaction
	Overcrowding	
NUTRITIONAL	Fasting	Dehydration Starvation
PHYSICAL	Mixing	Bruising and injury
	Overcrowding	
	Road conditions	
	Driving technique	
	Horns	
	Weather extremes	Hyper/hypothermia
INFECTIOUS	Dust	Pneumonia
	Fasting	Salmonellosis
	Exposure	Salmonellosis/pneumonia

3.2 INDICATORS OF STRESS

Broom (1996) equates animal welfare to stress referring to it as an animal coping with its environment with death being the end result when it is unsuccessful at this. Mortality statistics are used in the live export trade to collectively measure the impact of stress on animal welfare. Mortality rate is a poor absolute indicator of stress at the individual animal level, since animals are attempting to adapt to their environment well before they die and may have their welfare significantly compromised without dying (Adams, 2000). Nevertheless, it is a good population-based indicator for assessing differences in stress levels among groups of animals associated with a number of factors (Norris and Norman, 2000) and is suitable for evaluating trends and sudden changes in the impact of animal stressors at an industry level.

The steady decline in shipboard mortality rates over time observed for both sheep and cattle can be assumed to indicate improved management with a subsequent improvement in the well being of exported animals during transportation. Although mortality rates are appropriate and practical as the main performance indicator for the live export industry, with mortalities now so low it will be difficult for the industry to continue to demonstrate positive effects of new initiatives using mortality rate as the indicator. Other, more sensitive clinical indicators of stress may need to be considered as industry performance indicators.

To assess the effects of pre-delivery management on animal performance, more sensitive indicators of stress than mortality rate were considered. Most of this work was done in relation to feedlots and meat quality. Stress has been assessed in the live animal by measuring physiological and biochemical parameters (Holmes et al, 1982; Schaefer et al, 1988; Warriss, 1990; Apple et al, 1993; Parrott et al, 1994; Parrott et al, 1998) and behavioural observations (Kenny and Tarrant, 1990; Rushen, 1990). Kenny and Tarrant (1987), Tarrant (1990) and

Tarrant et al (1992) used a combination of physiological and behavioural measurements. Pearson and Kilgour (1980) and Grandin (1997) recommended that this combination be used to accurately assess stress. Ante mortem stress in cattle can also be measured post mortem using biochemical techniques (Warner and Pethick, 1999). Indicators of stress in livestock are summarised in Table 4.

Table 4: Indicators of stress used in livestock

Indicator	Advantages	Disadvantages
Mortality	• Objective • Easily standardised • Simple to measure • Good relative indicator	• Only measures severe stress • Poor absolute indicator
Physiological	• Can assess sub-clinical stress	• Difficult to measure • Expensive
Biochemical	• Can assess sub-clinical stress	• Difficult to measure • Expensive
Behavioural	• Can assess sub-clinical stress	• Subjective • Requires high level of expertise
Clinical	• Simple to measure • Good relative indicator	• Can be subjective • Difficult to standardise • Requires some expertise

3.2.1 Physiological indicators

Physiological changes occur when an animal adapts to its environment (Blood and Radostits, 1989). The body system principally involved in adapting to a stressful situation or change in environment is the endocrine system. The sympathetic-adrenal system responds initially with the secretion of adrenalin from the adrenal medulla. When stress persists, the pituitary-adrenal axis becomes operative releasing corticosteroids from the adrenal cortex (Dantzer and Mormede, 1983; Blood and Radostits, 1989). Hence, the most appropriate physiological measurement of stress is the blood level of cortisol (Blood and Radostits, 1989) and it is the main physiological indicator of stress used in livestock transport studies (Pearson and Kilgour, 1980; Tarrant, 1990; Warriss, 1990; Grandin, 1997; Knowles, 1998; Knowles, 1999).

A variety of physiological changes occur in response to the release of cortisol. These include increases in heart rate, body temperature and blood levels of glucose and free fatty acids, with decreases in serum immunoglobulins and lymphocytes (Leach, 1982; Blood and Radostits, 1989; Warriss, 1990; Tarrant et al, 1992).

There are other physiological responses to stress and the occurrence of these depends on the cause of the stress. Physical stress causing muscle exertion that occurs during transport and handling can cause rises in blood levels of the muscle enzyme, creatine phosphokinase (CPK) (Warriss, 1990; Grandin, 1997). Nutritional stress during transport results mainly in dehydration and this is manifested by haemoconcentration, depression of tissue fluid levels and acidosis (Blood and Radostits, 1989). Heat stress occurs as a result of excessive heat absorption and manifests in high body temperature, increased heart rate and increased respiratory rate and depth. Excessive respiration can result in systemic alkalosis due to a deficit of carbon dioxide in the blood (Blood and Radostits, 1989). Many stressors are encountered during transport and the extent of exposure to each of these will determine the

ultimate physiological response. Schaefer et al (1988) found that transported cattle were alkalotic, suggesting that in this case, other factors were more significant than dehydration.

Stress causes physiological changes in muscle, hence post mortem measurements of these can indicate ante mortem stress. Pre-slaughter stress results in dark cutting or high pH meat (Fabiansson et al, 1988; Warner and Pethick, 1999). High pH meat is caused by a lack of normal acidification during rigor and is a direct result of low muscle glycogen at slaughter (Tarrant, 1988). Starvation, increased levels of circulating adrenalin and excessive muscular activity can trigger glycogen breakdown mechanisms depleting muscle glycogen levels (Tarrant, 1988). Hence, muscle glycogen and pH are useful indicators for measuring the effects of different ante mortem stressors and may be applicable when stock are slaughtered soon after arrival at the destination port.

3.2.2 Behavioural indicators

An animal will exhibit behavioural changes when adapting to changes in its environment. Agitated cattle have higher cortisol levels suggesting behavioural changes are indicative of stress. Measurements of behaviour, together with physiological variables will provide the best overall measure of animal discomfort (Grandin, 1997).

Behavioural indicators of short term stress induced by handling and transport include attempting to escape, vocalisation, kicking and struggling, restlessness and antagonistic interaction (Pearson and Kilgour, 1980; Grandin, 1997). Choice tests and aversion tests are objective behavioural measures of how an animal perceives a handling procedure (Rushen, 1990). Measures of aversion include the time and the amount of force required to induce an animal to undertake a handling procedure, such as moving through a race (Grandin, 1997).

3.2.3 Clinical indicators of transport stress

Transport related stress can be measured by the occurrence of a range of clinical syndromes. These are the clinical manifestations of the physiological and behavioural responses to transport and include loss of liveweight, dehydration, decreased feed intake, traumatic lesions such as bruising and decreased disease resistance. The extent to which these occur depends on a number of other interrelated factors including the environment, transport conditions, animal factors such as nutritional status and presence of infectious agents.

A loss in body weight is a common finding in transported ruminants (Wythes et al, 1980; Hutcheson and Cole, 1986; Knowles, 1998; Knowles, 1999) and most of it occurs in the first few days of the process (Wythes et al, 1981; Holmes et al, 1982). This could be expected, as periods of food and water deprivation will invariably occur during transport. However, the combination of both feed and water deprivation and road transport will compound the weight loss (Knowles, 1999). Most of the liveweight loss is due to loss of body fluids and the loss of gut contents rather than loss of body tissue (Hughes, 1976; Warriss, 1990). Liveweight loss during live export has been demonstrated after road transport to the shipping yards and during shipping by the Toorak Live Export Link Project (1997/98 and 1999).

Dehydration is the principal nutritional stress animals will encounter during transport and is the main cause of liveweight loss during land transport (Wythes et al, 1985a). Animals lose liveweight during transport and the amount of loss increases with travel time (Holmes et al, 1982; Hutcheson and Cole, 1986; Knowles et al, 1995;). Most of the weight loss during transport is water (Wythes et al, 1980; Bond et al, 1981; Phillips et al, 1983) and physiological measurements of transport stress indicate that dehydration is a significant and common finding (Atkinson, 1992; Knowles et al, 1994; Knowles et al, 1995; Warriss et al, 1995). The range of liveweight losses found in the studies reviewed by Warriss (1990) suggests that other factors, such as environment, also have a significant role.

Particularly in relation to feedlots, reduced feed intake following transport has also been found. Aside from being exposed to unfamiliar feeds and feeding systems upon arrival at the feedlot, transport per se is believed to have a negative effect on subsequent feed intake. Reduced appetite or willingness to consume feed has been seen in steers in the first few weeks after arrival at a feedlot (Hutcheson and Cole, 1986) and it is known that sheep may not feed when food is offered subsequent to a fasting period (Franklin and MacGregor, 1944). The factors involved during transit include mixing, crowding and movement as well as, fasting.

Stress suppresses the immune system and therefore increases the likelihood of disease (Kelley, 1980). Increased blood cortisol interferes with immunity and decreased serum immunoglobulins and lymphocytes affect the immune response (Kelley, 1980; Blecha et al, 1984; Blood and Radostits, 1987; Warriss, 1990). Diseases of cattle and sheep that can be triggered by transport and changes of environment from extensive to intensive husbandry conditions include salmonellosis and bovine respiratory disease (BRD). Salmonellosis is common in animals transported to saleyards and abattoirs (Grau et al, 1968; Samuel et al, 1980) and BRD is the most common disease in cattle upon introduction to feedlots (Tarrant, 1990; Dunn et al, 1993).

Physical trauma is a significant and common sequel to transport with bruising and more serious injuries being the main concerns. Injuries can result from antagonistic social interactions from mixing and repenning throughout the transport process (Tarrant, 1990; Grandin, 1997), poor handling and facilities pre- and post-transport (Grandin, 1997a) and struggling for footing and falls during transport (Tarrant, 1990).

3.3 EFFECTS OF PRE-DELIVERY STRESS

Stress during the pre-delivery phase of live export will contribute to decreased performance during live export. Stress causes poor performance and all the known causes of stress in livestock production systems are present during the pre-delivery phase of live export. Measuring the effects of this stress accurately and identifying and managing the specific pre-delivery causes of stress that lead to decreased performance during live export is needed for effective pre-delivery management.

Physiological, biochemical and behavioural changes are very sensitive and indicate stress before it becomes clinical, however measuring these is not practical under commercial conditions. Mortality is easily measured but as it is the end result of stress, it is not a very sensitive indicator. Measuring it alone can under estimate the extent of stress that is present. Clinical indicators of stress are more sensitive than mortality rates and can be easily measured. Consideration should be given to using a clinical indicator of stress such as liveweight changes, feed intake and level of illness as an industry performance indicator and during research, especially considering that mortality rates are already so low. This has already commenced with the Toorak Live Export Link Project (1997/98 and 1999) being conducted by the QLD Department of Primary Industries. Demonstrating to the general community the positive steps being taken by the industry to improve animal welfare would be helped by measuring more sensitive indicators and would assist in studying relationships between pre-delivery factors and livestock performance.

Adhering to sound animal husbandry principles and conducting all on-farm and transport operations in a manner that causes minimal stress to livestock will help in improving animal welfare and enhancing live export performance. The Model Code of Practice for the Land Transport of Cattle and the ALES do recognise this and provide general guidelines. However, specific pre-delivery causes of poor performance during live export need to be identified and these standards examined to determine if those factors are adequately covered.

3.4 KEY FINDINGS FOR PERFORMANCE MONITORING

- ☑ Stressors during live export cause behavioural, nutritional, physical and infectious stress.
- ☑ The most common clinical manifestations of transport stress are liveweight loss, dehydration, reduced feed intake, physical injuries, salmonellosis (sheep) and respiratory disease (cattle).
- ☑ Although mortality rate is an appropriate performance indicator for live export, more sensitive clinical indicators need to be used to demonstrate positive effects of new initiatives.

3.5 RECOMMENDATIONS FOR PERFORMANCE MONITORING

3.5.1 Further research

Research recommendation 1

Further research in live export should measure stress and performance with a clinical indicator such as liveweight and feed intake and the industry should consider these as industry performance indicators.

4. ON-FARM MANAGEMENT AND SHEEP PERFORMANCE

The large amount of research conducted over the years on farm of origin factors and slaughter and feedlot performance together with practical experience in the live export industry strongly suggests that good animal husbandry on-farm is the basis of effective pre-delivery management for sheep. Feedback received from survey respondents strongly supported this view. Conducting all procedures in such a manner that causes minimal stress, using competent stock people and using minimal restraint and appropriate facilities are all keys to good animal husbandry. These guidelines are adequately covered, although non-specifically, in the current (Dec, 1999) and revised, draft (Aug, 2000) ALES.

Although the standards provide general guidelines for minimising stress during export preparation, recommendations for controlling specific factors that could impact on sheep deaths during live export are required for effective pre-delivery management. This review focuses on identifying these factors, examines the existing standards and codes of practice for guidelines to manage the factors and tests preliminary guidelines for managing relevant factors not specifically covered by the current standards.

To examine the effects of pre-delivery factors on sheep mortalities during live export, it is first necessary to determine the causes of these mortalities and where in the export process they occur.

4.1 CAUSES OF DEATHS IN SHEEP EXPORTED BY SEA

The majority of deaths occur aboard ship (77%) with 3.5% of deaths occurring during pre-embarkation lot-feeding. Deaths during trucking to the feedlot are rare (0.5%) while discharge at the destination port accounts for 19% of deaths although these are generally not related to pre-delivery management (Norris et al, 1989a; Norris and Richards, 1989; Norris and Norman, 2000). During shipping the major causes of death are inanition (or malnutrition) (43.4%) and salmonellosis (20.2%). During pre-embarkation lot-feeding, the main cause of death is salmonellosis (42.7%). Relevant mortality data from Richards et al (1989) are summarised in Table 5.

Table 5: Deaths in sheep during live export

CAUSE OF DEATH	ON SHIP (77% OF DEATHS)	PRE-EMBARKATION FEEDLOT (3.5% OF DEATHS)
Inanition	43.4%	10.2%
Salmonellosis	20.2%	42.7%
Miscellaneous diseases	5.8%	23.8%
Trauma	10.6%	12.6%
No diagnosis	19.0%	3.4%
Excessive feed	1.0%	7.3%

Gardiner and Craig (1970) and Jelinek et al (1982) also found that salmonellosis was a significant cause of death in sheep during the shipping phase of live export and McAuliffe et al (1978) also identified salmonellosis as a major cause of deaths in sheep in pre-embarkation feedlots. Salmonellosis is common in animals transported to saleyards and abattoirs as they are subject to significant challenge by the bacteria due to heavy environmental contamination and changes in rumen liquor (Grau et al, 1968; Samuel et al, 1980; Frost et al, 1988).

However, during live export infectious challenge is not a sufficient cause of salmonellosis. The interaction of several factors including failing to eat and transport stress factors such as high stocking densities, mixing and noise together with, challenge with the infective agent leads to the disease (Higgs et al, 1993). This is consistent with current knowledge of salmonellosis that it is a disease of transported ruminants under nutritional stress and that it is a potential cause of death in sheep that are fasting, being mixing or are overcrowded (Grau, et al, 1969; Grau and Smith, 1974; Blood and Radostits, 1989).

Persistent inappetence (absence of appetite) that commences in the pre-embarkation feedlot and continues into the shipping phase is the key factor in deaths of sheep during sea transport (Gardiner and Craig, 1970; Norris et al, 1989; Richards et al, 1989; Norris, 1991). It causes deaths due to inanition and it pre-disposes to death from salmonellosis (Higgs et al, 1993). The spatial and temporal mortality patterns seen on ship are not indicative of an infective cause and inanition precedes the development of pathological lesions of salmonellosis (Richards et al, 1989; Higgs et al, 1993). Therefore, the incidence of salmonellosis aboard ship could be reduced by preventing inanition (Black, 1990; Higgs et al, 1993; Black, 1996).

Inappetence in the pre-embarkation feedlot, as measured by the number of non-feeders, leads to persistent inappetence during shipping. Sheep that eat well in the pre-embarkation feedlot continue to eat regularly and gain weight under simulated shipboard conditions (McDonald et al, 1990) and death rates in feedlot non-feeders are 14 times greater than in feeders (Norris et al, 1990). Feedlot non-feeders have a greater risk of dying from inanition and salmonellosis and 85% of inanition deaths aboard ship are attributable to non-feeding in the feedlot (Higgs et al, 1991). However, withholding feedlot non-feeders from export is not a preferred option for reducing shipboard mortalities, as most non-feeders begin eating aboard ship (Norris, et al, 1990). It is the persistence of inappetence into the shipping phase that is the key factor.

Inappetence in sheep following road transport has been demonstrated but the findings have been contradictory (Arnold and Charlick, 1978; McDonald et al, 1988; McDonald et al, 1990). As suggested by Norris (1991), fasting and transport can cause a temporary appetite depression on arrival at the feedlot, but may not be sufficient to cause persistent inappetence on ship. Modifying the factors that produce non-feeders is the key to reducing shipboard mortality rates.

The miscellaneous diseases that caused deaths in the pre-embarkation feedlot consisted of common diseases of sheep that are encountered in Western Australia and the diseases were pre-existing in the sheep on arrival at the feedlot (Richards et al, 1989). These will be considered in Section 4.2.3.

Losses due to trauma are generally not due to pre-delivery factors. The quality of stockmanship in the feedlot and on ship and the standard of the ship's handling facilities will contribute to trauma death rates (Richards et al, 1989) but are outside the scope of this review.

4.2 ON FARM RISK FACTORS FOR SHEEP DEATHS DURING LIVE EXPORT

Failing to eat pellets in the pre-embarkation feedlot is the principal factor associated with deaths aboard ship and identifying and modifying the factors that produce feedlot non-feeders should reduce mortality rates. Hence, this review focuses on pre-delivery factors associated with feeding behaviour in sheep.

The factors that produce non-feeders in the pre-embarkation feedlot operate on the farm of origin. The greatest variation in feeding behaviour in the pre-embarkation feedlot is between lines of sheep (groups of sheep from the same farm), annual mortality rates are similar for particular farm groups and most deaths occur in sheep from a few farms (Norris et al, 1989a; McDonald et al, 1990; Higgs et al, 1999). Farm of origin factors that are associated with feedlot feeding behaviour are geographical location of the farm, animal factors and farm factors (Higgs et al, 1999) and can be considered as nutritional, behavioural and infectious stressors.

4.2.1 Nutritional

Norris et al, (1990) have described the role of feedlot non-feeders and persistent inappetence in shipboard deaths. Season, animal condition (fatness) and age are the key risk factors and they interact to cause persistent inappetence during live export (Norris and Richards, 1989; Richards et al, 1989; and Higgs et al, 1991).

The geographical location of the farm of origin is a risk factor for deaths in sheep during live export. Farms located in areas with high rainfall and/or an extended pasture growing season turned off sheep with higher mortality rates than farms in low rainfall and/or reduced pasture growing seasons (Higgs et al, 1999). Death rates in sheep from south west Western Australia are higher in the second half of the year, which is the pasture growing season for that area (Higgs et al, 1991; Norris and Norman, 2000). Peak death rates coincided with the season in Western Australia rather than with weather conditions en route or the season at the destination (Higgs et al, 1991). The survey respondents agreed with these findings with 88% of experts and 100% of exporters of the opinion that the time of year of export has a significant impact on sheep performance and most experts (77%) also agreed that the geographical location of the farm of origin is important also. The ALES and the OFQAM do not address this issue at all.

A biological explanation for this phenomenon is found in the fatness of sheep. A significant association has been found between adiposity and shipboard deaths (Higgs et al, 1991). Adiposity is the central factor of the persistent inappetence syndrome, interacting with the effect of season. Higgs et al (1991) suggested that the pathogenesis of the syndrome is linked to interference of the seasonal control of appetite and energy metabolism. They quoted that appetite and basal metabolism follow annual cycles that are regulated by photoperiod (Blaxter and Boyne, 1982; Kay, 1985) and reported that in south-west Western Australia, where they conducted their study, sheep are gaining weight during the second half of the year. Higgs et al (1991) and Richards et al (1991) postulated that the capacity for sheep to adapt to live export depends on, in part, whether they are in a fat loss or fat deposition phase. They suggested that in the second half of the year sheep metabolism in Western Australia is tuned to fat deposition rather than fat mobilisation. As such, inappetent sheep at this time fail to use fat efficiently or for a long time turning to other more costly sources of energy supply such as muscle catabolism. This process is not sustainable and eventually results in death.

The fatness risk factor is specifically addressed in the current and draft, revised ALES with a best practice recommendation for not exporting sheep in body condition score 5 and as such requires no further consideration.

Age of the sheep was also found to be associated with shipboard mortalities. Death rates in hogget wethers were significantly lower than in adult wethers (Higgs et al, 1991; Norris and Norman, 2000). The lower death rates in hoggets have been attributed to the differences in basic appetite patterns of young and adult sheep (Higgs et al, 1991). The nutrient demands of growing sheep ensure that appetite exceeds maintenance requirements irrespective of seasonal changes (Blaxter and Boyne, 1982; Kay, 1985; Higgs et al, 1991). Researchers have consistently observed stronger appetites in young sheep aboard ship (Higgs et al, 1991) and younger animals of all classes had lower mortalities (Norris and Norman, 2000). The trend towards exporting younger sheep over the last few years has contributed to the lowering of mortality rates. The ALES and the OFQAM do not address this issue, however controlling the age risk factor by excluding older sheep from export would not be appropriate. The age of sheep that are exported is market driven and exporters and producers supplying markets that require older animals would be disadvantaged.

Geographical location, time of year of export and age are risk factors for decreased performance that cannot be practically managed. Producers cannot move and the market demands all ages of sheep all year round. However, shipments that are associated with these factors could be identified as high risk consignments and treatment options applied to these shipments in order to reduce the effect of these factors. Consignments in the latter half of the year with a high percentage of older sheep from properties in high rainfall and/or extended pasture growing season zones would be high risk shipments. Risk management strategies that treat or manage the factors that are directly linked to deaths in sheep during shipping would be most effective for these shipments. These could include pre-conditioning sheep to the shipboard diet on-farm prior to export to increase feed intake in the pre-embarkation feedlot and/or providing electrolyte supplements on ship to treat inanition.

4.2.2 Behavioural

The association between sheep mortalities during shipping and the farm of origin appears to extend beyond geographical location and animal factors to farm management factors (Higgs et al, 1999). Behavioural stressors are associated with farm management factors and include prior feeding experience, handling practices and mixing.

Previous dietary experience of a new food may assist sheep to better adapt to new foods. Prior exposure to a new diet has been shown to result in a quicker and higher intake of that food at a later exposure (Chapple and Lynch, 1986; Provenza and Balph, 1987; Provenza and Balph, 1988; Norris, 1991). Memories of these exposures are long term, with lambs exposed to a new food before weaning having a greater intake of that food 3 years later than unsupplemented controls (Green et al, 1984). A simulated live export study supported these findings (McDonald et al, 1988) with previously supplemented sheep eating more than unsupplemented controls in a pre-embarkation feedlot. In this study, sheep supplemented immediately prior to export had a greater intake than sheep supplemented before weaning. However, a study done under actual industry conditions did not show statistically significant differences (Norris et al, 1989).

The majority of survey respondents (77% of experts and 66% of exporters) believed prior experience of trough feeding on-farm would have a moderate to high impact on performance during live export. Most experts (60%) also believed pre-conditioning sheep to the shipboard diet on-farm would have a significant impact. However, there was a consensus that such a management procedure would be impractical under commercial conditions. The ALES, the OFQAM and previous codes of practice do not address this issue.

Despite the practical limitations of feeding pellets to sheep on-farm, pre-conditioning sheep on-farm to the shipboard diet could be considered as a possible treatment option for high risk consignments. Non-feeding in the pre-embarkation feedlot is directly linked with deaths during shipping and land-based studies have shown that prior experience with a feed results in an increased intake of that feed at a later exposure. The limitations imposed on the study done by Norris et al (1989) by conducting it during commercial consignments meant that the study design limited the power of the statistical tests to detect any possible differences. However, before recommending the on-farm supplementation of sheep with the shipboard ration as a treatment option or best practice for high risk consignments, controlled trials under commercial conditions would need to be done to determine the effect and cost-benefit of this procedure.

Handling facilities and procedures on-farm is a risk factor for stress. Animals conditioned to well designed handling facilities using trained stock people are less stressed by handling (Grandin, 1997). The majority of both exporters and experts (100% and 55% respectively) believed that on-farm handling facilities and procedures have a moderate to high impact on performance during live export.

The handling risk factor is addressed generally by Section 6.3.2 of the ALES (Dec, 1999) and the issue is well understood by industry. The current and draft, revised ALES should be sufficient to manage this factor and no further research is required. Element L4 of the OFQAM does provide more specific management procedures for minimising stress due to this factor. Encouraging exporters to preferentially select stock from Flockcare accredited properties should enhance the control of this risk factor and further minimise stress.

The effect of on-farm mixing on the feeding behaviour of sheep in pre-embarkation feedlots is largely unknown. Retained social groupings were thought to have contributed to lower mortalities (Norris and Richards, 1989), however Norris et al (1989) found no significant association between, mixing of lines and feedlot feeding behaviour or shipboard mortality. Most experts (60%) believed avoiding the mixing of unfamiliar lines of sheep on-farm would have little or no impact on performance, while the opinion of exporters was divided. There is no mention of mixing in the ALES or the OFQAM and there is limited information in the literature. This issue could be included into further research into pre-delivery causes of mortalities if undertaken by industry. Given the current low mortality rates and the need to manage factors already identified as having an effect, specific research into mixing is a low priority.

4.2.3 Infectious

Pre-existing disease conditions at the time of mustering are a minor cause of deaths in sheep during live export resulting in approximately 2% of total deaths (Norris et al, 1989a). These include infectious and non-infectious causes such as pneumonia, enteritis, urolithiasis, lupinosis, flystrike and foot abscess (Richards et al, 1989). Most experts (70%) and all

exporters believed that minimising the export of sheep from farms with no disease control programs would have a moderate to high impact on live export performance. Careful selection of stock for export will minimise losses to infectious causes and enhance live export performance. The current (Sections 6.1.1 and 6.1.2) and draft, revised (Sections 7.1.1 and 7.1.2) ALES adequately cover this factor and provide a best practice recommendation for scabby mouth vaccination. Elements L4 and L5 of the OFQAM provide more specific details for the management of this factor. The importance attributed to infectious factors on live export performance by survey respondents supports a best practice recommendation encouraging exporters to preferentially select stock from Flockcare accredited properties.

4.3 KEY FINDINGS AND SUMMARY FOR SHEEP

Key findings

- ☑ Most sheep deaths occur during the sea voyage.
- ☑ Inanition and salmonellosis (that generally occurs as a result of not feeding) are the main causes of death in sheep at sea.
- ☑ Inappetence that commences during pre-embarkation lot-feeding and persists during shipping is the principal pre-disposing factor for deaths in sheep during shipping.
- ☑ Non-feeding in the pre-embarkation feedlot is the major risk factor for the persistent inappetence syndrome.
- ☑ Modifying and reducing the factors that produce feedlot non-feeders should reduce sheep mortalities during live export.
- ☑ The factors that produce feedlot non-feeders operate on the farm of origin.
- ☑ Key on-farm risk factors for deaths in sheep during live export are:
    - Geographical location of farm:
        - Length of pasture growing season at farm of origin; and
        - Rainfall at farm of origin;
    - Season at time of export; and
    - Animal factors:
        - Fatness of sheep; and
        - Age of sheep.
- ☑ Other possible on-farm factors for deaths in sheep during live export are farm management factors. These are:
    - Previous dietary experience;
    - Handling facilities and procedures;
    - Infectious diseases; and
    - Mixing.

Risk factor summary

Table 6 summarises key pre-delivery risk factors associated with deaths in sheep during live export.

Table 6: Sheep risk factor summary

RISK FACTOR	STANDARDS		COMMENTS
	ALES[1]	OFQAM[2]	
Geographical location of farm of origin	Not covered	Not covered	• Difficult to manage • Use to identify high risk consignments • Consider treatment option
Time of year of export	Not covered	Not covered	• Difficult to manage • Use to identify high risk consignments • Consider treatment option
Season at time of export	Not covered	Not covered	• Difficult to manage • Use to identify high risk consignments • Consider treatment option
Fatness of sheep	Specific recommendation	Not covered	• Currently addressed • No further research or recommendations required
Age of sheep	Not covered	Not covered	• Difficult to manage • Use to identify high risk consignments • Consider treatment option
Previous dietary experience	Not covered	Not covered	• Consider research into use as a treatment option for high risk consignments
Handling facilities and procedures	General recommendation	Specific recommendation	• Currently addressed • Encourage exporters to source stock from Flockcare farms • No further research required
Infectious diseases	General recommendation	Specific recommendation	• Currently addressed • Encourage exporters to source stock from Flockcare farms • No further research required
Mixing	Not covered	Not covered	• Effect unknown • Further research is a low priority

1. ALES - Australian Livestock Export Standards
2. OFQAM - On-Farm Quality Assurance Manual

4.4 RECOMMENDATIONS FOR SHEEP

4.4.1 Best practice suggestion

Best practice suggestion 1

Encourage exporters to select sheep for export from Flockcare accredited properties.

4.4.2 Further research

Research recommendation 1

The industry should not conduct further research into pre-delivery causes of poor performance in sheep during live export at this time.

A considerable amount of work has already been done and key on-farm factors have been identified as being associated with sheep mortalities during shipping. As mortality rates are so low and given the current trend of exporting younger animals, possible gains from research in this area would be limited and not justify the costs associated with conducting the work.

Farm management factors appear to be associated with the variation in mortality observed between farms, as there are both high mortality and low mortality farms in the same rainfall zone. If industry wish to conduct further research, it should focus on identifying and clarifying these farm management factors. There are epidemiological methods available for such studies and these can be described if required. However, most possible factors are addressed in the OFQAM, though not specifically in relation to live export. Encouraging exporters to source stock from Flockcare accredited properties should be a cost effective way of applying current scientific knowledge in the form of best practice without resorting to more research that may have a limited cost-benefit. Also, investigating methods of controlling or treating causes that have already been identified as having a significant effect on performance may bring greater benefits.

Research recommendation 2

The industry should investigate the use of treatment options such as the use of electrolytes during shipping and on-farm pre-conditioning to the shipboard diet, to manage high risk consignments.

Trials to determine the effect of a treatment can be high risk especially if the treatment does not specifically treat the causal factor. While prevention is better than cure, given that specific pre-delivery causes of poor performance have been identified and that it is difficult to remove or reduce these, research into strategies for ameliorating the effects of these factors is warranted. Hence, it is recommended that studies be undertaken to determine the cost-benefit of applying treatment strategies to high risk consignments. Strategies that are directly linked with feeding would be most appropriate and these would include:

1. providing electrolytes during shipping to treat the effects of inanition; and
2. pre-conditioning sheep on-farm to the shipboard diet to increase feedlot feed intake.

1. <u>Cost-benefit of shipboard electrolyte supplementation</u>

A suggested approach and trial protocol is provided in the accompanying report LIVE.104: Use of electrolytes to alleviate stress.

2. <u>Cost-benefit of on-farm pre-conditioning of sheep to the shipboard diet</u>

Objective

To investigate the effect and cost-benefit of prior feeding experience on the live export performance of sheep.

Materials and methods

- Conduct under actual industry conditions and include a shipping phase.
- Use animals that are at the highest risk. Select a line of sheep consisting of a high proportion of older animals from a farm in a high rainfall and/or an extended pasture growing season zone and that will be consigned in the latter half of the year. Using the data of Higgs et al (1999), a high mortality farm may be able to be identified. However, these data were collected during the period 1985-1996 and current performance will need to be reviewed to confirm that a high mortality farm identified a few years ago is still having higher than average mortalities.
- Use a cohort study design where the performance of animals that are pre-conditioned to the shipboard diet (treatment group) is compared to the performance of animals from the same line that are not exposed to the shipboard ration (non-treatment group).
- Randomly allocate all sheep in the line (or a large sample if there is a large number of sheep in the line) into treatment and non-treatment groups.
- Apply the treatment. This can be done in 2 ways: supplementing the treatment group with the shipboard ration in the week prior to transport to the pre-embarkation feedlot for a short term study or supplementing the animals prior to weaning for a long term study. An effect is most likely to be seen if the sheep are supplemented immediately prior to export. However, preweaning supplementation may be cheaper and more easily incorporated into farm management.
- Compare feedlot feed intake of the two groups using the technique described by Norris et al (1989).
- Compare liveweight changes, feed intake and mortality rates of the two groups during the sea voyage.
- Compare numbers of animals in each group meeting specification at the completion of the voyage.

Research recommendation 3

Contingent on the acceptance of previous recommendations, the industry should develop a performance monitoring system that will:

- identify high risk consignments;
- enable the measurement of more sensitive performance indicators;
- enable continued demonstration of industry improvements; and
- enable the investigation of the effect of farm management factors on live export performance.

The development of a performance monitoring system may be warranted if:

- treatment options are found to be cost effective and high risk consignments need to be identified on a regular basis;
- the industry elects to measure more sensitive performance indicators; and
- investigation into the effect of farm management factors on live export performance is undertaken.

The performance monitoring system described for cattle, which is based on the Shipboard Management Program could be applied to sheep and is described in more detail in Section 5.4.2.

5. ON-FARM MANAGEMENT AND CATTLE PERFORMANCE

The importance of good animal husbandry on-farm to effective pre-delivery management for live export is well supported by research into slaughter and feedlot performance (Grandin, 1997; Voisinet, 1997; Fabiansson et al, 1988) and by practical experience in the live export industry. Feedback received from survey respondents strongly supported this view. Conducting all procedures in such a manner that causes minimal stress, using competent stock people and using minimal restraint and appropriate facilities are all keys to good animal husbandry. These guidelines are adequately covered, although non-specifically, in the current (Dec, 1999) and revised, draft (Aug, 2000) ALES and the land transport of cattle code of practice.

Although the standards provide general guidelines for minimising stress during export preparation, recommendations for controlling specific factors that could impact on cattle deaths during live export are required for effective pre-delivery management. This review focuses on identifying these factors, examines the existing standards and codes of practice for guidelines to manage the factors and tests preliminary guidelines for managing relevant factors not specifically covered by the current standards.

To examine the effects of pre-delivery factors on mortalities during live export, it is first necessary to determine the causes of these mortalities and where in the export process they occur.

5.1 CAUSES OF DEATHS IN CATTLE EXPORTED BY SEA

Early accounts reported that heat stress was a common cause of mortality in cattle exported by sea (Anonymous, 1988). Controlled investigations that have just begun indicated that pneumonia was the most common cause of death, with heat stress and septicaemia also important (Norris et al, 2000). Most cases of pneumonia were attributed to *Pasteurella multocida* and *Pasteurella haemolytica.* Furthermore, Norris et al (2000) postulated that pasteurellosis was the most likely cause of septicaemia. Most deaths occurred during the shipping phase and specifically during the sea voyage (Norris and Norman, 2000).

The results from Norris et al (2000) were consistent with findings from land based feedlots, although the pre-disposing causes would be different with ventilation possibly having a major role on ship. Bovine respiratory disease (BRD) is the most common clinical problem and the main cause of death in Australian feedlot cattle, with the majority of sickness and deaths occurring in the first 4 weeks after entry to the feedlot (Dunn et al 1993). This is consistent with findings in North America and Canada where BRD (or shipping fever) is also the most important disease in cattle recently introduced to feedlots (Jensen et al, 1976; Church and Radostits, 1981; Blood and Radostits, 1989; Tarrant, 1990). BRD is a clinical entity of bronchopneumonia that has a significant economic impact in feedlot cattle. Its expression is influenced by factors such as stress, nutrition, dust and ammonia levels (Mahony et al, 2000). Transport and nutritional stress results in immunosuppression. The respiratory tract, which is being damaged by dust and ammonia, is therefore more susceptible to various bacterial and viral infectious agents that cause pneumonia (Blood and Radostits, 1989; Tarrant, 1990; Green, 2000). The lesions, clinical signs and deaths are generally attributed to bacterial pneumonia due to *Pasteurella haemolytica, Pasteurella multocida* or *Haemophilus somnus* (Green, 2000).

Other investigations into deaths during sea transport reported mortalities being attributed to various risk factors such as feed and water deprivation, excess stocking densities and inadequate ventilation and temperature control as opposed to specific causes (Knowles, 1999).

Research into cattle mortalities and performance during live export is still in the early stages (Toorak Live Export Link Project, 1997/98 and 1999; Norris, 2000). Hence, the findings of this review are extrapolated from studies into the effects of on farm management and land transport on subsequent performance in feedlots and on carcass and meat quality. The process of livestock handling and road transport is essentially the same irrespective of destination. As such, the factors that are associated with stress during handling and transport to feedlots and abattoirs also apply to cattle being delivered to assembly points for live export by sea. Until industry-specific research can produce more detailed recommendations, the findings from preparation and transport to feedlots and abattoirs can provide an appropriate basis for best practice guidelines.

5.2 ON FARM RISK FACTORS FOR DECREASED PERFORMANCE IN CATTLE

Due to the lack of data available on the specific causes of deaths and poor performance in cattle during live export, it is not possible to examine key factors that may be directly linked to these causes. Hence, this review examines general behavioural, nutritional, physical and infectious risk factors that are known to contribute most to stress in cattle. The effective management of these will minimise the stress load of cattle when delivered to the exporter, enabling them to better withstand the stressors that will be encountered during the remainder of the export process.

The time from yarding on the farm of origin to delivery to the exporter will have a significant effect on live export performance (Knowles et al, 1994; McNally and Warriss, 1997; Warner and Pethick, 1999). Minimising this time will limit the effects of all the behavioural, physical, nutritional and infectious stressors that are encountered during pre-delivery preparation for live export. This risk factor is already adequately covered by the current and draft, revised ALES, which provide a best practice recommendation for minimising time during pre-delivery. As such, no further research is required.

5.2.1 Behavioural

Behavioural stress is mostly attributed to the fear response to an activity or change in environment (Grandin, 1997). Fear is a strong stressor and novelty, or exposure to new experiences, and aversive activities such as restraint and handling are the most significant causes of fear (Dantzer and Mormede, 1982; Grandin, 1997). Most of the stress associated with handling and transport is attributable to fear (Grandin, 1997). The amount of fear felt by an animal will depend on the interaction between previous experience and genetic factors (Dantzer and Mormede, 1982).

Temperament is a genetic factor that plays a significant part in determining the fear response to aversive and novel procedures. Domesticated animals that have been selected for a calm attitude towards people and handling are more stress resistant as temperament is a heritable trait in cattle that will affect how an animal will react to handling (Fordyce et al, 1988; Le Neindre et al, 1995; Grandin, 1997). Cattle with a calm temperament will have less difficulty

adapting to handling procedures, a lower likelihood of injury and exhibit weaker reactions to novelty and handling thus reducing their overall stress loads (Grandin, 1997). Fordyce et al (1985) found that *Bos indicus* cross steers with a more excitable temperament were more likely to bruise. A positive relationship between temperament at weaning and feedlot liveweight gain and lower morbidity was reported by Voisinet et al (1997) and supported by Fell et al (1998). Temperament is also associated with an animal's ability to cope with heat stress. More prominent alarm reactions displayed by flighty cattle will generate more heat, which could be damaging if the heat load is already high (Adams, 2000).

The current and draft, revised ALES (Sections 5.1.2c and 6.1.2c respectively) provide a general standard for not exporting cattle with a temperament that would be a danger to other cattle and/or people. The OFQAM makes no specific mention of temperament. Given the strong association of temperament with stress, a more specific recommendation may be required, such as, encouraging exporters to preferentially select stock from properties known to produce well-domesticated cattle.

Animal sex and breed are other genetic factors that can affect live export performance. It is well recognised that cows are more susceptible to bruising and stress than steers (Wythes et al, 1985). The live export of cows is the subject of a specific study by MLA/Livecorp and the ALES provide specific guidelines on the export of pregnant animals. Hence, these issues do not need to be considered further in this review. An analysis of industry mortality statistics has confirmed anecdotal observations that voyages from northern ports have lower death rates than from southern ports (Norris and Norman, 2000). This is most likely due to the higher *Bos indicus* content of cattle exported from northern Australia and the higher death rates in *Bos taurus* cattle that are mainly exported from southern ports (Norris et al, 2000). *Bos indicus* cattle are bred for heat tolerance and it is this genetic make up that enables them to better adapt to the heat stresses commonly encountered during the sea voyage. Northern cattle are also more likely to be acclimatised to warm weather conditions which will further enhance their capacity to tolerate heat stress (Adams, 2000).

The majority of exporters and experts (100% and 86% respectively) agreed that breed and type of cattle have a major impact on live export performance. Time of year of export was considered to have a moderate to high impact on live export by all exporters and 82% of experts. Type of cattle and time of year risk factors are covered by standards and best practice recommendations in the current and draft, revised ALES. Best practice recommendations 3.1.1 and 3.1.2 made by Ainsworth and McCarthy (2000) will assist the management of these risk factors and as such, no further research is required.

Previous husbandry experience also affects the amount of stress felt by an animal during handling (Grandin, 1997a). The fear response in livestock for export that do not have significant previous experience with humans or handling will contribute substantially to their stress load. The fear response to new and non-painful stimuli can be reduced by gradual exposure (Alam and Dobson, 1986; Grandin, 1997) and Hutson (1985) has shown that stress during handling can be reduced by gradually conditioning the animals to the handling procedures. Cattle that have been handled gently over time will be less agitated, have less bruising and have improved weight gain and less liveweight loss than cattle handled roughly (Grandin, 1997a). Livestock that are conditioned to being handled will be less stressed during live export. It was observed by the destination feedlots in the Toorak Live Export Link Project that these cattle were quieter and settled on to feed better than usual. While management factors of the properties of origin could not be determined, the regular handling

as part of the project in the 6 – 12 months before export appears to have had a positive effect on the performance of the cattle.

Handling facilities also have a major impact on stress, with stress being minimised if facilities have been designed to capitalise on the behavioural traits of cattle. Cattle handled gently in well designed facilities had lower heart rates than cattle handled roughly in poor facilities (Stermer et al, 1981). Yard attributes such as even lighting, solid high walls and curved races are effective in reducing behavioural and physical stress and reducing bruises and carcass damage (Grandin, 1997a).

All exporters and 96% of experts agreed that on-farm handling experience has a major impact on live export performance of cattle and that pre-conditioning cattle to good handling will have a moderate to high impact on performance (83% of exporters and 80% of experts). All exporters and 77% of experts believed that handling facilities on-farm also have a significant impact on performance. The ALES only mentions handling indirectly, while the OFQAM provides very specific guidelines for appropriate handling and handling facilities. These risk factors are well understood and no further research is needed although, specific best practice recommendations are required. Best practice should include exporters sourcing stock from Cattlecare accredited properties and minimising the export of non-domesticated ("scrubber") cattle.

For maximum effect, conditioning of livestock to handling should be done early in their life rather than just prior to export. The effects of proper handling early in life are long lasting and result in animals that are better able to adapt to the psychological stress caused by subsequent handling later in life (Hassall, 1974; Dantzer and Mormede, 1983; Grandin, 1997). Fordyce et al (1985) substantiated this, finding that adult *Bos indicus* cattle handled carefully and intensively at a young age were quieter, less stressed and easier to handle than cattle that were not. Weaning cattle in yards as opposed to weaning in paddocks is an early handling technique. Apart from the general benefits of early exposure to humans, yards and handling, there may also be a specific benefit of direct relevance to the live export industry. Fell et al (1998) found cattle weaned in yards had lower feedlot morbidity to BRD. Stronger social bonds that develop between individual animals during yard weaning and maintenance of these bonds during transport and assembly could protect cattle against the stresses of live export (Schaefer et al, 1988; Fell et al, 1998).

All exporters and 62% of experts believed that yard weaning would have a moderate to high impact on performance of cattle during live export. No mention of yard weaning is made in the ALES, the OFQAM or in any industry-specific research. Further investigation into the role BRD plays in deaths of cattle during shipping and the positive effects of yard weaning should be undertaken.

The effect of on-farm mixing on the performance of cattle during live export is largely unknown. Mixing social groups causes significant behavioural (and physical) stress (Grandin, 1997). Mixing is one of the main stressors that operate in livestock production systems (Kelley, 1980) and it increases the incidence of high pH meat (Tarrant, 1988; Warriss, 1990). Behavioural and physical stress results from antagonistic interactions to determine new social orders as well as the breakdown of existing group bonds. Most experts (66%) believed avoiding the mixing of cattle on-farm would have a significant impact on performance, while the opinion of exporters was divided. However, 75% of exporters believed that avoiding the mixing of cattle on-farm would be highly impractical. The management of this risk factor

would be best done in the assembly feedlot by ensuring that farm groups are retained. Keeping groups together during shipping will maintain social bonds and maximise the benefits of yard weaning This is adequately covered in the current and draft, revised ALES with a best practice recommendation and no specific research is required at this time.

The negative effects of stress adaptation can be recovered if animals are allowed to rest after a stressful episode (Adams, 2000). Most experts (72%) and half the exporters believed that rest between stressful episodes would have a moderate to high impact on performance. It may not be possible to avoid pre-delivery risk factors such as excessive handling, excessive time, poor weather conditions and flighty cattle all the time. In these cases, risk management procedures should be applied in the pre-departure feedlot. Cattle should be allowed to rest and recover from stressful episodes to recover from the effects of stress before being exposed to further stress that will be encountered during loading of the ship. This issue is mentioned in the current and draft, revised ALES (Sections 5.6 and 6.6 respectively) and adoption of Ainsworth and McCarthy's (2000) recommendation numbers 3.1.3 and 3.2.3 will assist the management of this issue. As such, no further research is required.

5.2.2 Nutritional

Pre-transport nutrition and its effects on subsequent performance needs to be considered for both the pre-transport curfew immediately prior to transport and for the week before transport.

Limiting of feed is a major stressor in livestock production systems (Kelley, 1980). There is a conflict between the industry practice of holding cattle off feed and water for 6 hours prior to transport to limit physical stress from injuries due to slipping during transport, and the resultant nutritional stress that occurs (Adams 2000). Although cattle do lose less weight if they are loaded onto road transport straight off pasture (Ridley, 1996), there is conflicting evidence on the effect of fasting before transport on physical stress (Dodt et al, 1979; Bond et al, 1981). Animal factors such as age and sex are a more important source of physical stress than transport and nutritional factors (Wythes et al, 1985). Guidelines addressing the feed and water curfew issue in the current and draft, revised ALES, the code of practice for the land transport of cattle and the OFQAM are considered adequate and hence this issue requires no further consideration.

Depletion of energy reserves is a common outcome in transported cattle (Cole and Hutcheson, 1985). Therefore, appropriate nutrition in the week prior to transport to increase body reserves of energy can enable cattle to better adapt to feed deprivation during transport and improve subsequent performance. Ad libitum feeding and increasing the concentrate percentage of the pre-transport diet results in a greater feed intake subsequent to transport, improving post-transport performance (Hutcheson et al, 1984; Cole and Hutcheson, 1985; Hutcheson and Cole, 1986; Pritchard and Mendez, 1990; Warner and Pethick, 1999). However, most of these studies were conducted on younger feeder calves as opposed to adult cattle and hence the effect of pre-transport feeding management on live export performance is not known.

Feeding cattle grain in troughs prior to transport may have behavioural benefits that can enhance the nutritional effects. It is a common belief in North America that training calves to feed from troughs prior to transport to a feedlot improves weight gains in the feedlot and reduces feedlot morbidity and mortality. This suggests that the on-farm experience of trough

feeding allows cattle to better adapt to feedlot conditions minimising fear stress and improving feed intake. However, these practices have not been substantiated by controlled studies that have reported inconsistent effects of preconditioning on subsequent feedlot performance (Cole, 1985; Pritchard and Mendez, 1990; Drouillard and Kuhl, 1999).

Shy feeders are a significant cause of poor performance during live export and it has been suggested that introducing shipboard rations to cattle on land may decrease the number of shy feeders (Ainsworth and McCarthy, 2000). Most experts (64%) and 80% of exporters believed that previous experience with trough feeding would have a moderate to high impact on the live export performance of cattle. Although, a minority of survey respondents (37% of experts and 48% of exporters) believed that pre-conditioning cattle to the shipboard diet on-farm would have a significant impact on subsequent performance, most respondents (70% of experts and 75% of exporters) felt that this procedure would be impractical under commercial conditions.

Heat stress that is commonly found during shipping may contribute to the shy feeder problem. High environmental and body temperatures will reduce feed intake and absorption of nutrients from the gastrointestinal tract (Guerrini, 1981; Mallonee et al, 1985; Beede and Collier, 1986; Schneider et al, 1986). Current research being undertaken by MAMIC into ventilation efficacy on livestock vessels should reduce heat stress during shipping and may also help reduce shy feeders. The ALES provide no mention of pre-conditioning, however Ainsworth and McCarthy (2000) have recommended a best practice of introducing cattle to the shipboard diet prior to loading onto the vessel. The adoption of this recommendation, to at least the extent of providing the ration in the assembly depot should address the prior feeding experience issue. Should industry require it, on-farm pre-conditioning could be investigated as part of an industry performance monitoring system that is described later in this document.

There have been numerous studies into the supplementation of pre-transport diets to minimise transport stress and enhance subsequent performance. Supplements studied include vitamins, minerals, sugars and electrolytes. Electrolyte studies are reported in greater detail in the accompanying LIVE.104 report on electrolytes.

Results of studies into the pre-transport use of electrolytes are not definitive. Different components of the response to transport stress, from the physiological level to the clinical level have been measured and different electrolyte formulations used. The ambiguity of these studies may be due to the variability of the effect of these components on the overall clinical manifestation of transport stress and other confounding factors that may have been operating in the studies. Apple et al (1993) measured the endocrinal response to stress and determined that electrolytes had no effect. On the other hand, research in Canada and the United States has found otherwise. In a review of the use of electrolyte solutions to reduce transport stress Schaefer et al (1997) examined various studies that showed that pre-transport use of oral electrolytes will reduce the negative effects of transport stress in cattle and decrease liveweight and carcass weight losses.

Research in Australia on the use of electrolytes pre-transport has been limited and the results also inconclusive. There has been no improvement in liveweight loss, carcass weight and muscle pH in cattle supplemented on-farm with electrolytes in southern and northern Australia and it is accepted that electrolytes are not a remedy for poor transport practices (Thompson et al, 1990; Pinch, 1993; Phillips 1997; Warner and Pethick, 1999). The only

finding that could be reported with confidence was an increase in water consumption prior to transport, possibly due to the sugars in the electrolyte solution (Phillips, 1997).
There is no mention of electrolyte supplementation in current standards. Due to the mostly negative findings from research in Australia and the impracticality of supplementing with electrolytes under extensive conditions, specific research into the effects of on-farm electrolyte supplementation on live export performance is probably not warranted at this stage. This issue could be investigated at a later stage as part of the industry performance monitoring system.

Vitamin supplements have also been found to have little or no effect on alleviating transport stress. Vitamins A, D and E do not ameliorate the physiological response to transport stress or prevent weight loss (Bajhau, 1991; Jubb et al, 1993; Mudron et al, 1994; Mudron et al, 1996). However, vitamins and minerals can enhance the immune response (Blecha, 1988; Dubeski et al, 1996) and vitamins A and E boost resistance to respiratory disease (Green, 2000). Studies investigating the effects of on-farm use of vitamins on morbidity and mortality to pneumonia during live export may be warranted if pneumonia is confirmed as a major cause of death at sea.

The condition score of cattle is directly associated with live export performance. Very fat and very thin animals have a decreased capacity to tolerate heat stress (Adams, 2000) and fat cattle are more at risk to ketosis (Lean et al, 1991), a serious metabolic disorder associated with not eating that has been seen during shipping. Differences between breeds exist with *Bos indicus* type cattle less likely to be overconditioned than *Bos taurus* types. This issue is well understood and no further work is required. The issue is adequately covered in the current and draft, revised ALES and adoption of Ainsworth and McCarthy's (2000) best practice recommendations 3.1.1 and 3.1.4 will assist the management of this risk factor.

5.2.3 Physical

The physical attributes of cattle have a greater impact on the amount of physical stress that occurs during transport than transport factors. Horns are a major cause of bruising in transported cattle and cows are more susceptible to bruising than steers (Meischke et al, 1974; Yeh et al, 1978; Wythes et al, 1985). This issue is well understood and no further work is required. The implementation of the dehorning standard (ALES, Section 5.1.3(b)) will address this issue.

Environmental conditions at the time of mustering and transport can be associated with transport stress. Subsequent feedlot performance in cattle can be affected by weather conditions before and during transit (Camp et al, 1981) and weather factors that are most likely to lead to stress in livestock are sudden changes in the weather and weather extremes (Warner and Pethick, 1999). While this factor cannot be controlled, providing an adequate rest period in the assembly depot before loading will allow affected animals to recover. The adoption of Ainsworth and McCarthy's (2000) best practice recommendation 3.1.3 will address this issue.

5.2.4 Infectious

The role of respiratory disease (BRD) in cattle mortality in feedlots and on ship has been described in Section 5.1. Clinical signs of respiratory problems are commonly seen during live export. Viruses most commonly associated with the bovine respiratory disease complex are Pestivirus (Bovine Viral Diarrhoea Virus – BVDV), Infectious Bovine Rhinotracheitis Virus (IBRV – Bovine Herpesvirus 1), Parainfluenza Virus Type 3 (PI3) and Bovine Respiratory Syncitial Virus (BRSV) (Green, 2000; Mahoney, 2000). Apart from Pestivirus, the majority of cattle entering Australian feedlots have not been exposed to these viruses (Dunn et al, 1993) which renders them susceptible to the disease when they enter the contaminated environment of the feedlot.

Fell et al (1998) examined the effect of a pre-feedlot vaccination for BRD on subsequent feedlot morbidity and found a positive effect on weight gain and respiratory health. When yard weaning was combined with vaccination there was a synergistic effect. This issue is not mentioned by any current standards and no research has been done for the live export industry. Further investigations into the effects of clinical and sub-clinical BRD on live export performance and methods for controlling it are warranted if it is determined that respiratory disease is a major cause of cattle mortality and poor performance during shipping.

5.3 KEY FINDINGS AND SUMMARY FOR CATTLE

Key findings

- ☑ There has been very little research into the causes and pre-disposing factors of cattle deaths during live export.
- ☑ Most cattle deaths occur during the sea voyage.
- ☑ Pneumonia and heat stress may be the main causes of cattle mortality during shipping.
- ☑ Results from feedlot and abattoir studies can be extrapolated to live export for best practice recommendations until specific live cattle export research is done.
- ☑ The effect of pre-delivery management on live export performance of cattle has not been definitively determined.
- ☑ Key pre-delivery risk factors (extrapolated from land based studies) for decreased performance in cattle during live export are:
    - Time between yarding and delivery to exporter;
    - Temperament;
    - Sex of animal;
    - Breed of animal;
    - Time of year of export;
    - On-farm handling;
    - Condition score;
    - Horns; and
    - Severe weather.
- ☑ Other possible on-farm factors associated with death and poor performance of cattle during live export are:
    - Mixing;
    - On-farm nutrition; and
    - Bovine Respiratory Disease.

Risk factor summary

Table 7 summarises key pre-delivery risk factors associated with deaths and poor performance in cattle during live export.

Table 7: Cattle risk factor summary

RISK FACTOR	STANDARDS		COMMENTS
	ALES[1]	OFQAM[2]	
Time between yarding and delivery to exporter	Specific recommendation	Not covered	• Currently addressed • No further research or recommendations required.
Temperament	General recommendation	Not covered	• Partly addressed • Encourage exporters to source stock from properties that produce well-domesticated cattle • No further research required
Sex of animal	Specific recommendation	Not covered	• Currently addressed • Adopt Best Practice Study[3] Rec. 3.1.4 (b) • No further research required
Breed of animal	Specific recommendation	Not covered	• Currently addressed • Adopt Best Practice Study[3] Rec. 3.1.1 and 3.1.2 • No further research required
Time of year of export	Specific recommendation	Not covered	• Currently addressed • Adopt Best Practice Study[3] Rec. 3.1.1 • No further research required
On-farm handling	General recommendation	Specific component	• Partly addressed • Encourage exporters to source stock from Cattlecare properties • Minimise the export of non-domesticated ("scrubber") cattle • No further research required
Condition score	Specific recommendation	Not covered	• Currently addressed • Adopt Best Practice Study[3] Rec. 3.1.1 and 3.1.4 • No further research required
Horns	Specific recommendation	Not covered	• Currently addressed • No further research or recommendations required
Severe weather	General recommendation	Not covered	• Cannot be controlled • Adopt Best Practice Study[3] Rec. 3.1.3 • No further research required
Mixing	Specific recommendation	Not covered	• Currently addressed • No further research or recommendations required

RISK FACTOR	STANDARDS		COMMENTS
	ALES[1]	OFQAM[2]	
On-farm nutrition	Not covered	Not covered	• Not addressed • Adopt Best Practice Study[3] Rec. 3.2.1 • Further research required • Investigate as part of performance monitoring system
Bovine Respiratory Disease	Not covered	Not covered	• Effect unknown • Further research required • Investigate as part of performance monitoring system

1. ALES - Australian Livestock Export Standards
2. OFQAM - On-Farm Quality Assurance Manual
3. Ainsworth, R. and McCarthy, M. (2000) *Best practice standards for the preparation and husbandry of cattle for transport from Australia. Part A: Best Practice Recommendations (SBMR.003).* Draft report. Meat and Livestock Australia, Sydney

5.4 RECOMMENDATIONS FOR CATTLE

5.4.1 Best practice suggestions

Best practice suggestion 1

Encourage exporters to select stock from properties known to produce well-domesticated cattle.

Best practice suggestion 2

Encourage exporters to select stock from Cattlecare accredited properties.

Best practice suggestion 3

Minimise the export of non-domesticated ("scrubber") cattle.

Best practice suggestion 4

Adopt suggested best practice recommendations of relevance to pre-delivery management made by Ainsworth and McCarthy (SBMR.003, 2000). These are:

- 3.1.1: Source cattle breeds best suited to travel conditions;
- 3.1.2: Source cattle acclimatised to expected weather conditions;
- 3.1.3: Avoid export of cattle not recovered from a stressful incident;
- 3.1.4: Avoid exporting very large and/or very fat animals;
- 3.2.1: Introduce cattle to shipboard ration prior to loading onto vessel;
- 3.2.2: Feed and water curfews prior to loading onto trucks or vessels; and
- 3.2.3: Ensure cattle have adequate rest prior to loading after long road journeys.

5.4.2 Further Research

Research recommendation 1

That the industry continue to support on-ship studies and performance monitoring studies to determine the causes of mortalities and poor performance in cattle during sea transport.

The industry should continue research into the causes of cattle deaths and poor performance during shipping (eg. Agriculture WA). We recommend that these studies be immediately expanded so that they provide additional data on pre-delivery management issues that can be incorporated into a pilot study for the development of an industry performance monitoring system as described below. Regardless of the feasibility of an industry performance monitoring system, we recommend that these studies should record morbidity data, feed consumption and liveweight changes together with property of origin data to clarify the role of pneumonia, heat stress and shy feeding on poor performance of cattle during shipping.

Other current projects that pre-delivery research could be incorporated into, and which will be influenced by, include the Toorak Live Export Link Project (TLELP) being conducted by the Queensland Beef Industry Institute (QBII), which is monitoring the performance of cattle at all stages of the live export chain and, the stress research project being conducted by James Cook University (JCU).

Research recommendation 2

Develop a performance monitoring system for live cattle export that will:

- enable the measurement of more sensitive industry performance indicators;
- enable the industry to better demonstrate performance improvements;
- identify high risk consignments; and
- enable the investigation of the effect of on-farm nutritional and infectious factors on live export performance.

A performance monitoring system based on the existing Shipboard Management Program (SMP) should be developed that could enable cost effective studies into pre-delivery management under actual commercial conditions to be conducted. The SMP already collects performance data during shipping including feed consumption, clinical syndromes and mortalities. A logical extension to this program would be to link this performance data with property of origin factors, liveweight changes and destination feedlot performance.

Such a system should be designed and tested with a pilot program. The key pre-delivery risk factors identified in this study could form the basis for measuring property of origin factors in a pilot study. The outcomes of the Agriculture WA cattle mortality, the TLEL and the JCU projects would influence the factors measured in a subsequent, fully operational system. Systems for collecting and reporting destination feedlot performance data are already being developed. The TLELP has collected data from two different importers in the Philippines and a private company in Indonesia (Santori) is developing a web-based information system to enable producers to obtain feedback on the feedlot and slaughter performance of their cattle. The National Livestock Identification Scheme (NLIS) will provide the livestock traceability that is integral to a sustainable and effective performance monitoring system.

Some of the elements of an industry performance monitoring system are already in place and the opportunity now exists for the industry to develop a fully integrated program. A well-developed and implemented system that collects data over many voyages will enable specific issues to be investigated retrospectively by interrogation of the database rather than actual on-ship trials. This will enable a range of factors to be examined, not just pre-delivery factors, the measurement and reporting of a range of performance indicators to satisfy wider community concerns and the validation of industry research and best practice. A system such as this will also enable high risk consignments to be identified, which could then be preferentially managed through the application of various treatment methods as suggested below.

We recommend the industry immediately undertake a feasibility and design study for the development of an industry performance monitoring system and test this with a pilot program.

Feasibility/design study for the development and testing of an industry performance monitoring system

Objectives

To determine if an industry performance monitoring system is feasible and if so, design and test this system with a pilot program.

Materials and Methods

- Undertake a consultative program with stakeholders to determine what would be practical and feasible. Initial discussions with Santori's agent in Australia and the QBII indicate that they would be willing to collaborate on this program. The collection of property of origin data could be the responsibility of the Third Party Veterinarian.
- Design a property of origin data collection form around key pre-delivery risk factors.
- Base the collection of on-ship data on the SMP, but expand it to include morbidity data on levels of illness, eg. pneumonia.
- Test and refine the system on the consignments of cattle that will be investigated as part of Agriculture WA/Livecorp's investigation into cattle deaths during shipping. The system could also be developed from and tested with the TLELP. However, consignments done under this project are not totally indicative of commercial shipments as lines of cattle from different properties are backgrounded together on "Toorak" for 6 – 12 months before being exported.
- If implemented, the collection of on-ship data may only occur on long-haul voyages because Accredited Stockmen do not travel on short-haul trips. However, property of origin data and destination feedlot data could still be collected on all voyages.

Research recommendation 3

Conduct research to investigate the effects of BRD on live export performance of cattle and examine methods for controlling it.

Research into cattle deaths and the performance monitoring system needs to quantify the role of pneumonia as a cause of death or illness during shipping. Improvements in ventilation that occur as a result of the MAMIC ventilation study could reduce the incidence of pneumonia during shipping. If pneumonia is confirmed as a significant factor in poor performance despite improved ventilation, then research into cost effective methods for controlling

pneumonia may need to be conducted. Fell et al (1988) found that vaccination against BRD prior to entry into feedlots substantially reduced mortalities due to pneumonia. We recommend that the cost-benefit of BRD vaccination 4 weeks before export be investigated. If proven beneficial, this treatment option could then be applied to high risk consignments as identified by the performance monitoring system.

The effect of vaccination against BRD on the live export performance of cattle

Objectives

To determine the effects of vaccinating for BRD on the live export performance of cattle.

Materials and methods

- Use the methods described by Fell et al (1988)
- Select one line of cattle to constitute the intake of study animals.
- Use a cohort study design where the performance of animals that are vaccinated against BRD is compared to the performance of animals from the same line that are not vaccinated (controls).
- Randomly allocate the line of animals into a treatment and control group.
- Vaccinate the treatment group 4 weeks prior to export.
- Ensure that the study line is penned in the same part of the ship. The performance of animals within the line is being compared. Therefore, all animals in the line need to be penned together so that the treated and control animals are exposed to the same shipboard micro-environment.
- Measure liveweight at embarkation.
- Measure daily feed intake, morbidity and mortality data together with internal and external environmental parameters for the duration of the voyage.
- Measure liveweight at disembarkation.
- Monitor destination feedlot performance.
- Compare performance of the two groups for each line to examine the effect of BRD vaccination.

Research recommendation 4

Conduct field research to investigate the effect of farm management factors such as yard weaning and on-farm nutrition factors such as pre-conditioning to the shipboard diet on live export performance.

The TLELP provides an opportunity for field research into the effect of pre-delivery factors on live export performance to be undertaken. We recommend that the TLELP be utilised immediately to investigate the effect of yard weaning on live export performance. The industry may also wish to consider investigating the effect of on-farm pre-conditioning to the shipboard diet. Contingent on the results of other work, research into on-farm electrolyte and vitamin supplementation may need to be conducted in the medium to long term.

The effect of yard weaning of cattle on live export performance

The effect of yard weaning on live export performance requires further research. It has been proven beneficial for feedlot cattle and is an accepted management practice in the Australian cattle industry, including cattle raised under extensive conditions.

Objectives

To determine the effect of yard weaning on the live export performance of cattle.

Materials and methods

- Use the methods as described by the TLELP and background the study cattle together so that they have common nutrition and handling prior to export.
- Select as many lines of cattle as practical to constitute the intake of study cattle.
- Use a cohort study design where the performance of animals exposed to yard weaning (treatment animals) is compared to that of animals that have not been yard weaned (controls).
- As lines of cattle will most likely all be yard weaned or not, this study will compare the performance of different lines of cattle. Hence, the two lines of cattle that are being compared need to be similar in all other aspects. More than two lines of cattle can be studied in the one intake. Paired lines would be differentiated only by whether they were yard weaned or not.
- During the period of backgrounding, all cattle should be subject to the normal amount of handling that would be expected for a normal consignment.
- Compare liveweight changes, feed intake and morbidity and mortality data during shipping and during the destination feedlot phases between paired lines to examine the effect of yard weaning.

<u>The effect of on-farm pre-conditioning to the shipboard ration on live export performance.</u>

The application of positive findings from this study would not be practical under extensive conditions and during normal commercial consignments. If the results are positive, then pre-conditioning could be applied as a treatment option for high risk consignments.

Objectives

To determine the effect of on-farm pre-conditioning to the shipboard ration on live export performance of cattle.

Materials and methods

- Use the methods as described by the TLELP and background the study cattle together so that they have common nutrition and handling prior to export.
- Select as many lines of cattle as practical to constitute the intake of study cattle.
- Use a cohort study design where the performance of animals that are pre-conditioned to the shipboard diet (treatment group) is compared to the performance of animals from the same line that are not exposed to the shipboard ration (control group).
- Randomly allocate each line into a treatment group and control group.
- Apply the treatment to the treatment group and supplement their diet with the shipboard ration for 7-10 days prior to export.
- Compare liveweight changes, feed intake and morbidity and mortality data during shipping and during the destination feedlot phases between the two groups for each line to examine the effect of pre-conditioning.

6. TRANSPORT MANAGEMENT AND LIVESTOCK PERFORMANCE

As the reaction of cattle and sheep to road transport stress is similar, they are considered together in this section of the review. Sheep are more tolerant of transport than cattle, deaths in sheep during trucking to pre-embarkation feedlots are rare and no statistical association has been found between various transport factors and sheep shipboard mortality (Knowles, 1998; Norris et al, 1989; Norris et al, 1989a). Despite this, minimising stress during road transport is as important for sheep as it is for cattle. Road transport makes a significant contribution to the stress load of the animal when delivered to the exporter and this load is a factor in deaths of cattle and sheep during the shipping phase of live export (Richards et al, 1989; Norris et al, 2000).

6.1 TRANSPORT RISK FACTORS FOR DECREASED PERFORMANCE

Behavioural, nutritional and physical stress during road transport is unavoidable, as most of the main stressors operate during this process. The fear response causes transport stress at loading and during the early part of the journey although animals adapt to it as the journey proceeds while, physical and nutritional stressors exert greater effects the longer the journey (Wythes et al, 1981; Kenny and Tarrant, 1987; Knowles et al, 1995; Warriss et al, 1995; Broom, 1996; Parrott et al, 1998; Hall et al, 1999). Given the variability of the number and types of stressors that can operate during transport, minimising the time between loading at the farm and unloading at the assembly yard is essential for decreasing stress, minimising the suppression of disease resistance and minimising nutritional stress due to water deprivation (Grandin, 1997; Green, 2000). Total transport time is the most significant factor in transport stress (Wythes et al, 1981; Holmes et al, 1982; Warriss, 1990).

The survey respondents agreed with this sentiment. All exporters and 90% of experts believed that minimising total transport time will have a moderate to high impact on performance of stock during live export. This issue is covered in the current ALES with a best practice recommendation for minimising transport time. The code of practice for the land transport of cattle also specifically addresses this. The draft, revised ALES recommends replacing the transportation time best practice recommendation with a broader recommendation for using transport operators with a relevant livestock transport quality assurance program and compliance with the model code of practice.

Most experts (90%) and 71% of exporters believed that using transport operators with an appropriate quality assurance system would have a moderate to high impact on performance of stock during live export. Adoption of this recommended best practice should effectively minimise the stress associated with road transport to the exporter. No further research or recommendations are required. However, it needs to be ensured that the livestock transport quality assurance system that is used effectively manages the key risk factors outlined in this review. Truckcare is one such scheme that could be appropriate.

6.1.1 Key risk factors for transport stress

Physical stressors are the main stressors associated with road transport and are inevitable, but they can be managed. The major hazard for physical injury during transport is irretrievable

loss of balance. Hence, overloading, driving care and road conditions are the major risk factors for injury during road transport (Tarrant, 1990).

Overloading is a significant physical and behavioural stressor and is recognised as a major transport hazard (Tarrant, 1990). The probability of loss of balance and trapping on the floor is greatly increased at high stocking densities (Kenny and Tarrant, 1990). This association was supported by Tarrant et al, (1992) who demonstrated increases in bruising and muscle enzyme (CPK) levels with increased stocking density. Close confinement during transport is also a behavioural stressor (Warriss, 1990; Eldridge et al, 1984) exacerbated by overloading. All exporters and 90% of experts for cattle together with 66% of exporters and 88% of experts for sheep believed that stocking density on the truck has a significant impact on live export performance.

Driving care and road conditions are the other main causes of physical stress. Major factors causing loss of balance are excessive braking and poor cornering (Kenny and Tarrant, 1990; Tarrant, 1990). These factors are under the control of the driver and using smooth, open roads and a considerate driving technique will decrease the amount of physical stress sustained by transported animals. Tarrant (1990) demonstrated lower heart rates in cattle travelling on smooth highways as opposed to rougher country roads and suburban roads with frequent stops. Using dry, dusty country roads can also lead to infectious stress, as excessive dust is a pre-disposing factor for BRD (Green, 2000). Most respondents also agreed that driving care (83% of exporters and 77% of experts) and road conditions (83% of exporters and 86% of experts) could have a significant effect on live export performance, particularly for cattle.

Mixing is a cause of road transport stress and its effects can be manifested in physical and infectious stress as well as behavioural stress. However, it may not be a significant factor under Australian conditions, as the majority of survey respondents did not believe that mixing on truck has a significant impact on performance. Antagonistic social interactions do still occur, especially when the truck is stationary, although they are decreased at higher stocking densities on trucks (Warriss, 1990). Mixing of cattle from different sources on the same truck can also be associated with infectious stress as reported by Ribble et al, (1995) who correlated it with a higher incidence of post-transport pneumonia.

6.2 KEY FINDINGS FOR ROAD TRANSPORT

Key findings

☑ Key road transport factors associated with decreased performance in livestock during live export are:
- Total transit time;
- Overloading;
- Driving care; and
- Road conditions.

6.3 RECOMMENDATIONS FOR ROAD TRANSPORT

6.3.1 Best practice suggestion

Best practice suggestion 1

For both sheep and cattle, adopt the suggested best practice recommendation outlined in Section 6.6 of the draft, revised ALES (August, 2000) that exporters should use transport operators with a relevant livestock transport quality assurance program. This program should specifically address the key risk factors of total transit time, overloading, driving care and road conditions.

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