MORTALITIES IN SHEEP TRANSPORTED BY SEA

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A Thesis Submitted for the Degree of Doctor of Philosophy

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The live sheep carrier *Al Qurain* ready to load 100,000 sheep at Portland, Victoria bound for the Middle East.
DECLARATION REGARDING LENGTH OF THE THESIS

I hereby declare that this thesis is less than 100,000 words in length, exclusive of tables, footnotes and bibliography.

[Signature]

Andrew Kelly
ABSTRACT

Major animal welfare concerns existed about mortalities which occurred among the two million sheep transported by sea from Victoria, Australia to the Middle East each year during the 1980s. Research was undertaken to better define the extent of the mortalities, to establish the causes of death, and to prioritize and methodically unravel the underlying causes and risk factors involved.

An analysis of five years of existing industry data on 100 sheep shipments from Victoria (1984/85-1988/89) showed that mortality rates ranged mostly between 1% and 4%, with an average of around 2 1/2%. These analyses also showed that sporadic episodes of sudden, high mortality occurred in association with hot and humid conditions in Middle Eastern waters. Heat stress was the presumptive diagnosis. While the occurrences were rare, they accounted for 9% of all deaths.

Observational studies undertaken on 8 research voyages with sheep to the Middle East showed that two other causes of death - an inanition syndrome and salmonellosis - accounted for the majority of all mortalities. Together, these two conditions caused around three quarters of all deaths.

The following risk factors associated with these two major diseases were identified: poor feeding behaviour in the assembly feedlot; physiologic stress at the point of arrival of sheep at the feedlot; and the physical location of sheep on board ships, whereby sheep in the upper tier of pens on every deck of a ship suffered substantially higher mortality rates than those in the lower tier.

Specific studies on the inanition syndrome showed that affected sheep were persistent poor consumers of the pelleted shipboard ration. A problem of severe weight loss was detected in an additional 5% of sheep, which appeared to be associated with inanition. Sheep with the syndrome still had an appetite for familiar
food such as hay. An hypothesis was developed that the syndrome may be caused by the failure of affected sheep to recognise or accept the pelleted ration as food.

The epidemiology of salmonellosis outbreaks in the live sheep trade was elucidated. The outbreaks occurred as rise and fall epidemics starting with a large increase in faecal salmonella excretion from sheep immediately after their arrival in the assembly feedlot near the port of embarkation. Epidemics of mortalities from salmonellosis peaked one to two weeks later, then declined before the voyage was completed. Evidence was obtained that salmonella infections persisted in the feedlot environment between consecutive batches of sheep, initiating new epidemics in subsequent consignments.

The differences in shipboard mortality rates between upper and lower tier pens (the "tier" effect) was investigated with observational studies and a major field trial. An hypothesis that the effect was caused by higher light intensity in upper tier pens was tested and rejected. A remaining hypothesis is that the sheep's fear of elevation in upper tier pens may be the cause.

Overall, the research has advanced knowledge substantially on animal health in the live sheep trade. The findings will influence the debate on animal welfare in the trade, they will be of practical use to the industry, and they have focussed research direction for the future.
ACKNOWLEDGMENTS

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Andrew Kelly
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PUBLICATIONS AND PRESENTATIONS FROM THIS STUDY

SCIENTIFIC PUBLICATIONS:


Kelly AP, Beers PT and Butler KL (1988) - Risk factors: farm, road transport, feedlot and ship (Victoria). In SCA Workshop on Livestock Export Research, Bureau of Rural Resources Proc No 3, Canberra, pp 43-49


Norris RT and Kelly AP(1989) - The export of live sheep from Australia to the Middle East. In Proc No 110 - Refresher course for veterinarians in sheep, Post-graduate committee in veterinary science, University of Sydney, pp 37-46


SCIENTIFIC POSTERS:


SCIENTIFIC PRESENTATIONS:

First Aust Symp on Export of Livestock, Melbourne, February 1986 - The Victorian live-sheep export research project

Aust Vet Assoc, Central Vic Branch, Melbourne, October 1986 - Stress in the live-sheep export trade

Aust Vet Assoc, West Vic Branch, Hamilton, November 1986 - Results from live-sheep export research

Aust Vet Assoc, Launceston, May 1987 - Victorian research into health and welfare in the live-sheep export trade

Standing Committee on Agriculture Workshop on Livestock Export Research, Melbourne, February 1988 - Two papers, 1. Review of published research in health and welfare of sheep transported by sea, 2. Risk factors: farm, road transport, feedlot and ship (Victoria)

Aust Vet Assoc, Vic Division, Mt Buffalo, October 1988 - Animal health and welfare aspects of the live sheep export trade
Aust Vet Assoc, Perth, March 1989 - The spatial distribution of deaths on ships

Aust Meat and Livestock Corp Middle Eastern Seminar Series, Dubai, Kuwait and Riyadh, July 1989 - Animal health research in the live sheep trade

Aust Vet Assoc, Sydney, May 1991 (plenary session) - Health and welfare research in the live sheep export trade
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PREFACE

This thesis study was performed as part of a major multidisciplinary research project investigating health and welfare aspects of the live sheep trade. The project involved up to a dozen scientists in the disciplines of pathology, nutrition, animal behaviour, biometrics, and my own discipline of epidemiology. Within the project, I acted as both the epidemiologic specialist and the overall project coordinator. The work presented here is my own, but it has been performed with assistance from many others in the research team. In particular, Dr Peter Beers supervised all veterinary pathology aspects of the work, and Mr Kym Butler provided support in biometrics, experimental design and general research direction.

An introduction to the unique live sheep trade in which this research was performed is given in Chapter 1. A brief history of the trade is described including the recent debate on animal welfare, and then the literature on mortalities and diseases occurring in this and other animal transportation systems is reviewed.

The general materials and methods used are described in Chapter 2, but details relating to specific studies are given in later Chapters where they may be read along with the results.

Initially existing industry data were analysed to determine the magnitude of the mortality problem and to identify broad risk factor areas (Chapter 3). This was followed by basic observational studies on three shipments to identify the major causes of death and to investigate temporal, spatial and individual animal risk factors (Chapter 4).

The two major causes of death - an inanition syndrome and salmonellosis - were subject to specific investigations. The pathogenesis of the inanition syndrome was clarified (Chapter 5) and the epidemiology of the recurring salmonellosis outbreaks was described (Chapter 6). Finally, the unexpected finding that mortality
rates were affected by where sheep were penned on board ship, was investigated (Chapter 7).

A summary of all the key findings is given in Chapter 8 along with a discussion of the wider implications for the community, the industry, and the directions for future research.