liveexport

National livestock exports mortality summary 2005

Project code: **LIVE.235**

Prepared by: **RT Norris and GJ Norman**

Department of Agriculture and Food, Western Australia

Date published: **July 2006**

ISBN: **1740367537**

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

Department of Agriculture and Food
Government of Western Australia

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Abstract

Mortality levels were summarised for sheep, cattle and goats exported by sea from Australia in 2005, and a report was distributed to industry stakeholders, government, animal welfare groups and other parties interested in monitoring mortalities in the live animal export trade.

The overall death rate for sheep during sea transport from Australia to all destination regions during 2005 was 0.95% out of approximately 4 million sheep exported, a rise from the 0.75% observed in 2004 ($P < 0.05$). The main port of loading was Fremantle (3.5 million sheep exported and death rate of 0.97%), followed by Portland (311,000 sheep exported and death rate of 0.83%) and Adelaide (301,000 sheep exported and death rate of 1.00%).

The overall death rate among the 0.56 million cattle exported from Australia in 2005 was 0.14%, a rise from the 0.10% observed in 2004 ($P < 0.05$). The highest overall death rate on a regional basis was to the Middle East/North Africa followed by Mexico.

The overall death rate was 0.77% among the 14,706 goats exported from Australia in 2005, a decline from the 0.88% observed in 2004 ($P > 0.05$).

Industry stakeholders, government, animal welfare groups and the general public have a keen interest in monitoring mortalities in different sectors of the live export trade. The summary report provides a breakdown of industry performance in each of the major sectors.

Executive summary

The objectives of the project were to summarise the mortality levels of sheep, cattle and goats exported by sea from Australia in 2005. A second objective was to distribute a summary report to industry stakeholders, government, animal welfare groups and other parties interested in monitoring mortalities the live animal export trade.

The overall death rate for sheep during sea transport to all destinations during 2005 was 0.95% out of approximately 4 million sheep exported. This was greater than the 0.75% death rate observed in 2004 ($P < 0.05$). The likely explanation for the increased annual death rate in sheep exported in 2005 compared to 2004 is that there were almost one million more sheep exported during the second half of 2005 than in 2004. Consequently, exports in the second half of the year comprised 64% of all sheep exported in 2005 compared to 51% in the same period in 2004. Exports to Saudi Arabia recommenced in July 2005. The risk of death is known to be higher in the second half of the year in sheep sourced from southern Western Australia associated with the natural metabolic state of sheep associated with the pasture and nutritional conditions at that time of the year (Refer to Appendix 1). The main port of loading was Fremantle (3.5 million sheep exported and death rate of 0.97%), followed by Portland (311,000 sheep exported and death rate of 0.83%) and Adelaide (301,000 sheep exported and death rate of 1.00%). Death rates of sheep exported from Portland remained low during winter months, repeating the pattern seen in recent years.

The overall death rate among the 0.56 million cattle exported from Australia in 2005 was 0.14%, a rise from the 0.10% observed in 2004 ($P < 0.05$). The increase in death rates of cattle in 2005 compared to 2004 was mainly due to increased death rates on voyages to South East Asia associated with changes in the fleet carrying the cattle and journey times. The highest overall death rate on a regional basis was to the Middle East/North Africa followed by Mexico. Death rates on voyages to the Middle East/North Africa fell slightly in 2005 despite an almost 50% increase in the number of cattle exported compared to the previous year.

The overall death rate was 0.77% among the 14,706 goats exported from Australia in 2005, a decline from the 0.88% observed in 2004 ($P > 0.05$). There are only 12 goats exported to the Middle East in 2005, a sharp reduction from the 70,000 exported in 2002.

Industry stakeholders, government, animal welfare groups and the general public have a keen interest in monitoring mortalities in different sectors of the live export trade. The summary report provides a breakdown of industry performance in each of the major sectors.

Contents

1 Background

The live export of sheep and cattle makes a significant contribution to the Australian economy and provides employment in services that support this industry. The live export trade provides important support for the sheep and cattle industries of Australia and is the only market outlet for producers in some areas of the country.

This report summarises information about mortalities in sheep, cattle and goats during sea transport from Australia. It allows industry, government and others to monitor mortality trends in these sectors. The report also lists relevant published studies.

2 Project objectives

Produce a report which summarises the mortality levels of sheep, cattle and goats for the 2005 calendar year and provides an informed analysis of mortality trends in the livestock export industry.

Distribute a summary report to industry, government, animal welfare groups and other parties interested in the live animal export trade.

3 Methodology

The information in this report was obtained from ship Masters' reports which record livestock deaths and other information about each voyage, and also from "Yellow Books" which record more detailed information about numbers of livestock deaths than is available from the Masters' report. The 2005 report is based on analysis of ship Masters' reports and "Yellow Books" which were to hand on 17th March 2006.

Readers should be aware that mortality information for a particular year may be received after publication of that year's summary report. These records are added to the database and used in subsequent analyses. Therefore, statistics for a particular year may vary slightly in subsequent reports from the results as originally published.

Codes are used where appropriate in order to maintain confidentiality.

Summary information was produced using Statistix 7.0

4 Results and discussion

4.1 Sheep

4.1.1 Overview

Most sheep exported live by sea from Australia are sent to the Middle East and are mainly loaded at Fremantle, Adelaide and Portland. Some sheep are exported to other regions, mainly South-East Asia. An overview of the findings of research into the causes of sheep deaths during export to the Middle East is given in Appendix 1.

4.1.2 Port of loading

The number of sheep exported by sea from Fremantle, Adelaide and Portland during 2005 is shown in Table 1. Most sheep exported by sea from Australia during 2005 were loaded at Fremantle (82.1% of all sheep, Figure 1) with smaller numbers loaded at Portland (9.2%) and Adelaide (7.2%), other (1.5%). There was an increase of 24.5% in overall numbers exported in 2005 compared to 2004. The classes most affected were adult and hogget wethers and ewe lambs from Fremantle, and adult wethers from Portland.

Table 1 The number of sheep exported by sea from Fremantle, Adelaide and Portland during 2005

Livestock		Fremantle / other WA ports		Adelaide	Portland	
		Middle East	S.E. Asia	Middle East	Middle East	Total
Wethers	adults	1,720,395	3,901	265,764	361,331	2,351,391
	hoggets	429,895	1,655	19,439	9,066	460,055
	lambs	439,869	11,007	0	1,204	452,080
Rams	adults	77,829	8,250	8,578	3,927	98,584
	hoggets	81,777	229	2,435	0	84,441
	lambs	387,556	7,443	1,258	4,284	400,541
Ewes	adults	82,440	30	0	0	82,470
	hoggets	0	0	0	0	0
	lambs	171,271	0	261	0	171,532
Total	sheep	3,391,032	32,515	297,735	379,812	4,101,094

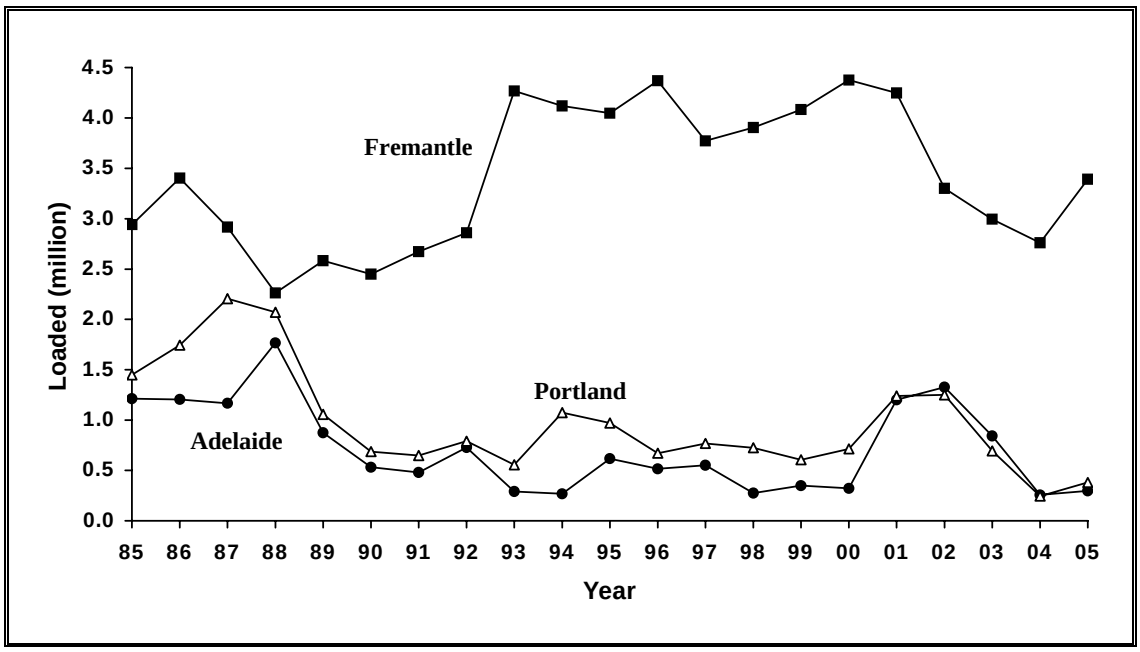

Figure 1 *Numbers of sheep exported by sea from Fremantle* (*Western Australia*)*, Portland* (*Victoria*) *and Adelaide* (*South Australia*) *since 1985*

4.1.3 Destination

The main importing countries for Australian sheep in 2005 are shown in Table 2. Saudi Arabia was the main market (26% of all sheep) followed by Jordan (22%) and Kuwait (21%).

Table 2 Destination country for sheep exported from Fremantle/WA, Adelaide and Portland during 2005

Country	Fremantle/WA	Adelaide	Portland	Total
Bahrain	278,585	79,560	111,350	469,495
Israel	5,000			5,000
Jordan	840,431	44,455		884,886
Kuwait	697,095	69,770	81,680	848,545
Oman	276,022	26,500	46,450	348,972
Qatar	100,535	41,850	37,500	179,885
Saudi	1,056,178	15,911		1,072,089
UAE	161,665	20,000	34,051	215,716
S.E. Asia	35,433	3,602		39,035
Total	3,450,944	301,648	311,031	4,063,623

SOURCE – Australian Bureau of Statistics, 5th April 2006

4.1.4 Death rates

There were 11 voyages to the Middle East for which sheep were loaded at more than one port in Australia (split-load voyages) in 2005. Mortalities for split-load voyages were attributed to the port of loading wherever possible. Where analysis involving split-load voyages has been performed, the consignments of sheep from each load port have been considered as separate "voyages".

The shipboard part of the export process is divided into three phases: loading; voyage to the first port of unloading; and discharge. The discharge phase includes all deaths after arrival at the first port. Consequently if a ship called at more than one discharge port, all the deaths after arrival at the first port were included in the discharge phase.

The total death rate for all sheep exported to all destination regions during 2005 was 0.95% (Table 3), a rise from the 0.75% observed in 2004 ($P < 0.05$).

There were 16 shipments to South-East Asia, and the death rate was 0.42% out of 32,515 sheep loaded. For shipments to the Middle East, there were more deaths during the voyage phase from Fremantle compared to previous years (Table 3 and Figure 2), thus interrupting the downward trend in mortality over the previous 6 years. There was a moderate rise in the mortalities during the discharge phase for shipments from Adelaide in 2005 but this was offset by a fall in mortalities during the voyage phase. Death rates out of Portland continued at low levels.

Table 3 Annual shipboard death rates for sheep exported from Fremantle, Adelaide and Portland to the Middle East, and Total death rate for all sheep exported to all destinations

		Death rate (%)			
	Year	Load	Voyage	Discharge	Total
Fremantle*	2002	0.01	0.61	0.26	0.87
	2003	0.01	0.56	0.20†	0.76†
	2004	0.00	0.46	0.25	0.71
	2005	0.02	0.73	0.22	0.97
Adelaide*	2002	0.01	0.99	0.29	1.29
	2003	0.01	0.91	0.26	1.18
	2004	0.00	0.89	0.25	1.15
	2005	0.00	0.54	0.46	1.00
Portland*	2002	0.01	1.27	0.82	2.10
	2003	0.00	0.72	0.29	1.01
	2004	0.00	0.49	0.29	0.78
	2005	0.00	0.51	0.32	0.83
Total**	2002	0.01	0.84	0.39	1.24
	2003	0.01	0.65	0.23†	0.88†
	2004	0.00	0.49	0.25	0.75
	2005	0.01	0.69	0.25	0.95

* Middle East only

** Total includes all sheep exported by sea from Australia to all destinations

† Excludes deaths on the MV Cormo Express after it was rejected at Saudi Arabia

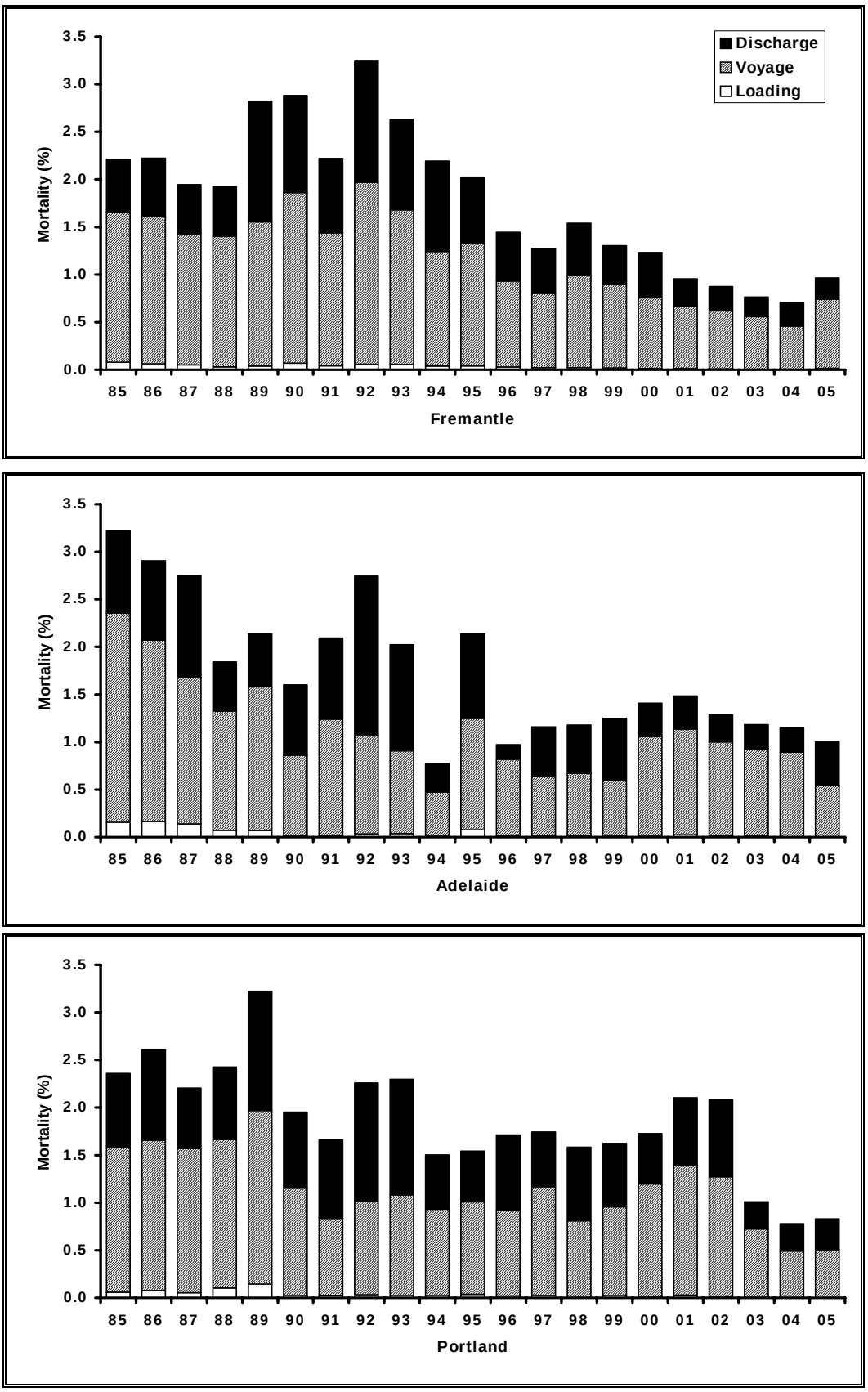

Figure 2 *Annual mortality for sheep exported from Fremantle, Adelaide and Portland to the Middle East since 1985 – figure for Fremantle excludes deaths on the MV Cormo Express after it was rejected at Saudi Arabia in 2003*

4.1.5 Class of sheep

The death rates of various classes of sheep exported from Australia to the Middle East are shown in Table 4 and Figure 3. The highest death rates were in adult rams, followed by ram hoggets and ram lambs.

Table 4 Overall mortality (%) for classes of sheep exported from Fremantle, Adelaide and Portland to the Middle East in 2005

Class of sheep		Fremantle	Adelaide	Portland	Total
Wethers	adult	1.0	1.0	0.8	1.0
	hogget	0.6	0.5	0.8	0.6
	lamb	0.8	n/a	0.3	0.8
Rams	adult	1.2	1.4	1.2	1.2
	hogget	1.3	0.5	n/a	1.2
	lamb	1.2	0.4	1.1	1.2
Ewes	adult	1.1	n/a	n/a	1.1
	hogget	n/a	n/a	n/a	n/a
	lamb	0.9	0.0	n/a	0.9

n/a not applicable (no sheep of this class were loaded)

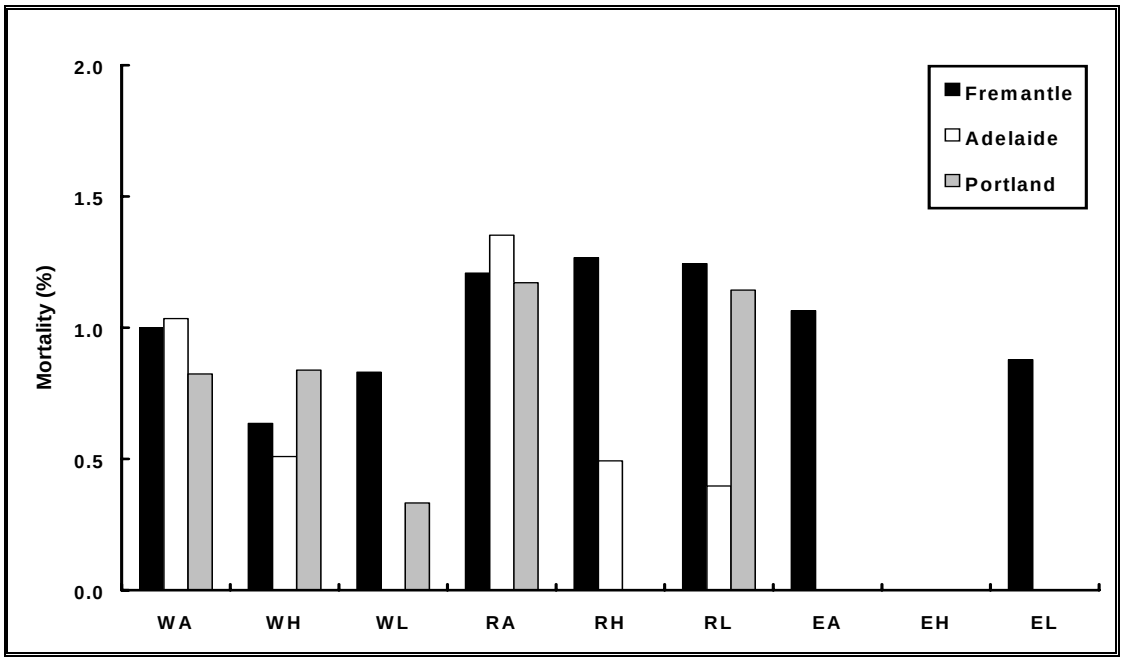

Figure 3 *Overall mortality (%) for classes of sheep exported from Fremantle, Adelaide and Portland to the Middle East in 2005*

WA = wether adults *WH = wether hoggets* *WL = wether lambs*
RA = ram adults *RH = ram hoggets* *RL = ram lambs*
EA = ewe adults *EH = ewe hoggets* *EL = ewe lambs*

4.1.6 Time of year

Death rates were higher ($P < 0.01$) in the second half of 2005 compared with the first half in sheep exported from Fremantle, Adelaide and Portland (Figure 4). On a monthly basis, death rates were higher on voyages from Fremantle between August and October and during December in 2005 compared to previous years (Table 5). Monthly death rates between May and October 2005 on shipments out of Portland continued at the low levels observed in 2004.

Table 5 Monthly mortality for all sheep exported from Fremantle, Adelaide and Portland to the Middle East from 2000 to 2005.

		Year					
Port	Month	00	01	02	03	04	05
Fremantle	J	0.8	0.7	0.9	0.5	0.8	0.7
	F	0.8	0.5	0.7	0.5	0.5	0.6
	M	1.0	0.5	0.5	0.4	0.5	0.5
	A	1.0	0.6	0.7	0.6	0.4	0.7
	M	1.1	0.7	0.7	0.6	0.5	0.5
	J	2.2	1.3	0.9	0.8	0.9	0.9
	J	2.4	1.4	1.4	0.9	0.6	0.5
	A	1.3	1.6	1.1	1.0	0.9	1.4
	S	1.8	1.7	0.9	1.0	1.0	1.3
	O	1.1	1.1	1.1	1.1	0.8	1.4
	N	1.0	1.1	0.9	1.2	0.7	0.7
	D	0.9	0.8	0.6	0.7	0.6	1.0
	M – O*	1.6	1.3	1.0	0.9	0.8	1.2
	Total	1.2	1.0	0.9	0.8	0.7	1.0
Adelaide	J	0.2		1.7	0.9	1.2	
	F		1.5	0.8	1.0	1.3	
	M		1.3	0.8	0.9		
	A	0.6		1.2	0.6		0.5
	M	0.5	1.1	0.7	1.2	0.5	0.9
	J	2.4		1.8	2.3	1.1	
	J	1.3	1.5	1.7	1.2	0.7	1.4
	A		2.4	0.9	1.0	1.3	1.0
	S	0.5	1.7	1.5	1.7	1.3	
	O	0.7	1.0	1.9	1.1		
	N		1.8	1.1			1.1
	D	2.3	1.4	1.4	1.8		
	M – O*	1.3	1.5	1.5	1.4	1.1	1.1
	Total	1.4	1.5	1.3	1.2	1.1	1.0
Portland	J	1.3	1.9	1.3	0.6		1.0
	F		2.4	1.0		0.8	0.4
	M	0.9	0.7	0.7	0.6	1.0	
	A	0.7	1.0	1.1	0.6	0.8	
	M		1.8	1.0	0.7	0.5	
	J		4.0	1.7	1.0	1.0	0.5
	J		1.6	5.5	1.7	0.7	1.1
	A		2.2	7.5	1.4		
	S	2.8	2.1	2.1	1.8		0.7
	O	2.2	3.2		1.4		1.5
	N	1.6	2.4			0.9	1.0
	D	5.3	2.1	1.3	0.7		0.6
	M – O*	2.5	2.7	3.0	1.3	0.6	0.9
	Total	1.7	2.2	2.1	1.0	0.8	0.8

* May to October

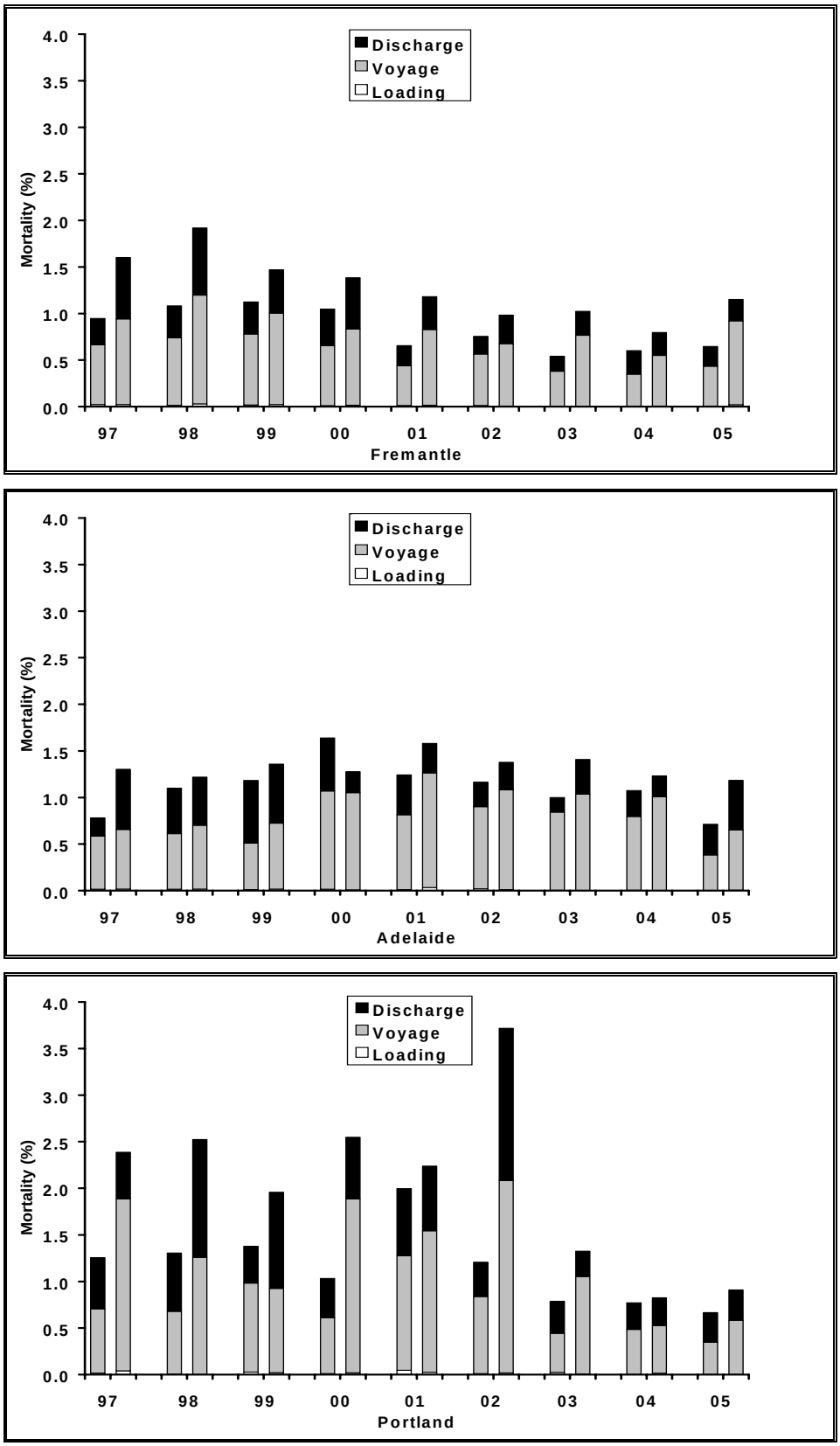

Figure 4 *Mortality (%) for sheep exported by sea from Fremantle, Adelaide and Portland to the Middle East for the first and second half of each year from 1997 to 2005*

The likely explanation for the increased annual death rate in sheep exported in 2005 compared to 2004 is that there were almost one million more sheep exported during the second half of 2005 than in 2004 (Table 7). Consequently, exports in the second half of the year comprised 64% of all sheep exported in 2005 compared to 51% in the same period in 2004. Exports to Saudi Arabia recommenced in July 2005. The risk of death is known to be higher in the second half of the year in sheep sourced from southern Western Australia associated with the natural metabolic state of sheep associated with the pasture and nutritional conditions at that time of the year (Refer to Appendix 1).

Table 6 Number and death rate of adult wethers exported from Western Australia to the Middle East during each half of 2004 and 2005, and relative risk of death in the second half of the year compared to the first half

	Jan to June		July to Dec		
Year	Sheep (No)	Dead (%)	Sheep (No)	Dead (%)	Relative risk (95% CI)
2004	568,478	0.67	838,790	0.82	1.2 (1.2-1.3)
2005	539,694	0.61	1,180,701	1.18	1.9 (1.8-2.0)

Table 7 Numbers and percentage of sheep exported from Australia to the Middle East during each half of years 2002 to 2005

	Numbers Exported			Percentage	
Year	Jan - Jun	Jul - Dec	Total	Jan - Jun	July - Dec
2002	2,656,638	3,208,201	5,864,839	45.30	54.70
2003	2,448,986	1,999,405	4,448,391	55.05	44.95
2004	1,574,919	1,649,146	3,224,065	48.85	51.15
2005	1,478,844	2,589,735	4,068,579	36.35	63.65

4.1.7 Ship

The voyages of each ship were classified into low, medium and high mortality categories for sheep exported to the Middle East from Fremantle (Table 8a), Adelaide (Table 8b) and Portland (Table 8c).

During 2005 there were two voyages from Fremantle classified as “high mortality” both involving ship 32, and none from Portland and Adelaide. Approximately 60% of voyages from Fremantle, 56% of voyages from Portland and 50% of voyages from Adelaide were in the “low” category.

Table 8a Number of voyages in low, medium and high mortality categories for ships loaded at Fremantle in 2005

	Mortality rate			
Ship (code)	Low <1.0%	Medium 1.0–2.0%	High >2.0%	Total
2	1	3	0	4
31	0	1	0	1
32	2	1	2	5
33	1	4	0	5
34	4	2	0	6
35	4	3	0	7
36	4	2	0	6
37	8	1	0	9
38	4	0	0	4
39	1	0	0	1
Total	29	17	2	48

Table 8b Number of voyages in low, medium and high mortality categories for ships loaded at Adelaide in 2005

	Mortality rate			
Ship (code)	Low <1.0%	Medium 1.0–2.0%	High >2.0%	Total
32	1	1	0	2
33	1	0	0	1
34	0	2	0	2
39	1	0	0	1
Total	3	3	0	6

Table 8c Number of voyages in low, medium and high mortality categories for ships loaded at Portland in 2005

	Mortality rate			
Ship (code)	Low <1.0%	Medium 1.0–2.0%	High >2.0%	Total
2	1	0	0	1
32	1	1	0	2
34	2	0	0	2
38	1	3	0	4
Total	5	4	0	9

4.2 Cattle

4.2.1 Overview

The live cattle trade from Australia is characterised by the large number of ports of loading in Australia, the number of ships involved and the regions to which the animals are shipped. This is in contrast to the live sheep trade where there are only three main ports of loading, and virtually all sheep are shipped to the Middle East.

There were 20 voyages in 2005 for which cattle were loaded at more than one port in Australia. Mortalities for split-load voyages were attributed to the port of loading where possible. Where analysis involving split-load voyages has been performed, the consignments of cattle from each load port have been considered as separate “voyages”.

The overall death rate among the 0.56 million cattle exported from Australia in 2005 was 0.14% (Table 9), a rise from the 0.10% observed in 2004 ($P < 0.05$). The highest overall death rate on a regional basis was to the Middle East/North Africa followed by Mexico.

Exports to South-East Asia were characterised by small consignments on short voyages with very low death rates. Exports to North-East Asia were mainly dairy cattle exported to China.

The number of cattle exported to North-East Asia in 2005 was lower than in 2004 while the number of cattle exported to the Middle East was higher. Exports to South-East Asia fell slightly in 2005, and those to Mexico were more than triple those of 2004.

Table 9 Death rates, number of voyages and number of cattle exported for voyages to major destination regions during 2005

Parameter	ME/N Africa	SE Asia	NE Asia	Mexico	Total
Voyages (No.)	38	168	36	9	251
Cattle (No.)	90,808	402,210	52,565	17,464	563,047
Death rate overall (%)	0.34	0.09	0.09	0.26	0.14
Death rate range (%)	0.0 – 1.0	0.0 – 0.8	0.0 – 0.4	0.0 – 0.8	0.0 – 1.0
Voyages with nil deaths (No.)	12	73	14	1	100

4.2.2 Middle East

The live cattle trade to the Middle East has contracted substantially over the last three years (Table 10). Overall death rates have remained below 0.5% since 1999 except for 2002. In 2005 mortalities fell by 21% compared to 2004.

Table 10 Death rates, number of voyages and number of cattle exported to the Middle East from 1995 to 2005

Year	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Death rate range (%)	Voyages with nil deaths (No.)
1995	11	14,557	0.67	0.0 – 2.1	2
1996	36	65,066	0.65	0.0 – 5.0	14
1997	62	137,869	0.67	0.0 – 4.2	15
1998	122	266,286	0.69	0.0 – 41.5*	23
1999	112	314,981	0.35	0.0 – 3.3	25
2000	96	274,159	0.42	0.0 – 8.0	22
2001	101	287,447	0.32	0.0 – 5.0	27
2002	102	265,005	0.61	0.0 – 35.0*	33
2003	52	106,080	0.45	0.0 – 2.0	18
2004	31	61,679	0.43	0.0 - 1.2	9
2005	38	90,808	0.34	0.0 – 1.0	12

* exceptional voyages involving presumed heat stroke in 1998 and heat stroke in 2002

4.2.2.1 Port of loading

There were 5 ports of loading for voyages to the Middle East in 2005, and most cattle were exported from Fremantle, followed by Broome and Portland (Table 11). Death rates in 2005 were highest from Fremantle, followed by Broome and Portland.

The voyages from each port were classified into various mortality categories as shown in Table 12. Only one voyage was in the high category, and this involved a consignment from Fremantle.

Table 11 Death rates, number of voyages and number of cattle exported from various ports to the Middle East for 2005

Port	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Death rate range (%)
Fremantle	28	66,098	0.39	0.0 – 1.0
Adelaide	1	1,171	0.08	n/a
Portland	6	11,310	0.14	0.0 – 0.3
Devonport	1	51	0.00	n/a
Broome	2	12,178	0.28	0.1 – 0.3

Table 12 Number of voyages in nil, low, medium and high mortality categories for shipments from various ports to the Middle East for 2005

Port	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
Fremantle	9	16	2	1	28
Adelaide	0	1	0	0	1
Portland	2	4	0	0	6
Devonport	1	0	0	0	1
Broome	0	2	0	0	2
Total	12	23	2	1	38

4.2.2.2 Time of year

Monthly death rates from southern ports were below 0.5% throughout the year except for two months (Figure 5). There were only two voyages to the Middle East from a northern port in 2005 (see Table 11), which resulted in a combined mortality rate of 0.28%. These voyages are not included in Figure 5.

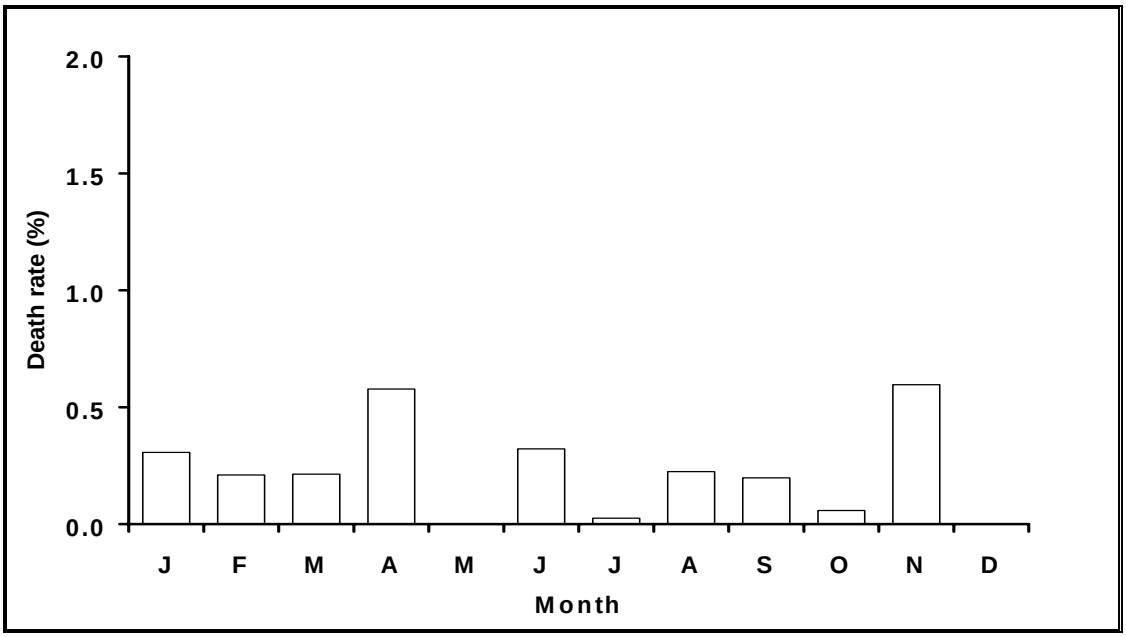

Figure 5 *Monthly death rate of cattle on voyages from southern ports to the Middle East for 2005*

4.2.2.3 Voyages from southern ports 1999 to 2005

Additional analysis was conducted for the ports of Fremantle, Adelaide and Portland because of the higher death rates on voyages from these ports compared to northern ports in previous years.

The death rate of cattle exported from Portland fell markedly in 2005 compared to the previous year, despite a substantial increase the number of cattle loaded (Table 13).

Table 13 Death rates for cattle loaded at Fremantle, Adelaide or Portland from 1999 to 2005

Year	Fremantle			Adelaide			Portland		
	Voys (No.)	Cattle (No.)	Dead (%)	Voys (No.)	Cattle (No.)	Dead (%)	Voys (No.)	Cattle (No.)	Dead (%)
1999	43	103,290	0.33	10	30,139	0.51	14	45,087	0.83
2000	45	94,787	0.43	7	19,158	0.66	13	40,748	1.01
2001	48	104,404	0.34	11	22,274	0.53	16	35,797	0.82
2002	57	103,914	0.36	17	25,035	0.47	15	46,624	2.03*
2003	50	68,167	0.45	9	16,083	0.70	9	11,146	0.35
2004	22	54,585	0.42	5	4,743	0.63	4	2,351	0.30
2005	28	66,098	0.39	1	1,171	0.08	6	11,310	0.14

* 0.74% if one high mortality voyage is excluded

4.2.2.4 Class of cattle

Recording of death rates for each class of cattle loaded began in July 2002. In 2005 the highest death rates occurred in bull calves followed by adult bulls and dairy cows (Table 14).

Table 14 Death rates, number of voyages and number of cattle in various classes exported to the Middle East in 2005

Class	Voyages (No.)	Cattle (No.)	Death rate (%)	Death rate range (%)
Steer adult	24	21,1126	0.27	0.0 - 1.4
Steer calf	1	807	0.00	n/a
Bull adult	23	44,039	0.36	0.0 - 1.0
Bull calf	8	12,922	0.53	0.0 - 1.7
Cow dairy	7	2,761	0.36	0.0 – 2.2
Heifer beef	1	168	0.00	n/a
Heifer dairy	6	8,985	0.11	0.0 - 0.7

Note: one voyage excluded because mortalities could not be determined by class

4.2.2.5 Ship

The voyages of each ship from Australia to the Middle East were classified into the following mortality categories: nil (no deaths reported); low (death rate up to 0.5%); medium (death rate from 0.5 to 1.0%); and high (death rate greater than 1.0%). Note that for this comparison, "voyage" equates to consignment from a port. Consequently, if a ship loaded at two ports, then two "voyages" are shown for that ship, one for each port.

Table 15 shows the number of voyages in the various mortality categories for each ship. There were only three voyages in the medium or high categories.

Table 15 Number of voyages in nil, low, medium and high mortality categories for shipments to the Middle East for 2005

	Mortality rate				
Ship (code)	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	Total
32	1	2	0	0	3
33	0	3	2	0	5
34	6	2	0	0	8
35	2	5	0	0	7
36	0	4	0	0	4
37	2	0	0	0	2
38	0	2	0	1	3
39	0	1	0	0	1
59	1	0	0	0	1
95	0	1	0	0	1
103	0	3	0	0	3
Total	12	23	2	1	38

4.2.3 South-East Asia

Approximately 0.40 million cattle were exported to South-East Asia in 2005 (Table 16) and the death rate was higher than in 2004. No deaths were reported on 43% of the voyages to the region. The death rate has remained below 0.1% since 2001.

Table 16 Death rates, number of voyages and number of cattle exported to South-East Asia from 1995 to 2005

Year	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Death rate range (%)	Voyages with nil deaths (No.)
1995	365	430,653	0.11	0.0 – 8.5	206
1996	415	505,777	0.05	0.0 – 1.2	280
1997	507	678,585	0.09	0.0 – 1.7	277
1998	229	296,823	0.17	0.0 – 8.8	127
1999	326	462,540	0.34	0.0 – 74.7*	162
2000	385	587,049	0.11	0.0 – 5.3	168
2001	312	472,363	0.08	0.0 – 5.0	139
2002	365	656,767	0.07	0.0 – 8.5	191
2003	306	587,716	0.05	0.0 – 2.2	190
2004	215	460,131	0.05	0.0 – 1.8	116
2005	168	402,210	0.09	0.0 – 0.8	73

* exceptional voyage involving heat stroke caused by ventilation failure due to contaminated fuel

4.2.3.1 Port of loading

Most cattle exported to South-East Asia in 2005 were loaded at Darwin followed by Wyndham and Broome (Table 17). The death rate was highest for cattle exported from Wyndham followed by Fremantle.

The voyages from each port were classified into various mortality categories as shown in Table 18. There were no voyages in the high category, and all except two voyages were in the nil or low categories.

Table 17 Death rates, number of voyages and number of cattle exported from various ports to South-East Asia in 2005

Port	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Death rate range (%)
Mourilyan	1	977	0.00	n/a
Karumba	5	7,909	0.00	n/a
Darwin	87*	198,716	0.06	0.0 – 0.8
Wyndham	13*	67,766	0.18	0.0 – 0.5
Broome	32*	56,548	0.11	0.0 – 0.5
Port Hedland	4	7,141	0.07	0.0 – 0.1
Geraldton	15	30,212	0.09	0.0 – 0.3
Fremantle	10	14,222	0.14	0.0 – 0.4

* One split-load voyage excluded: mortalities could not be determined by consignment (port of loading). Total mortality for this voyage was 0.12%

Table 18 Number of voyages in nil, low, medium and high mortality categories for shipments from various ports to South-East Asia for 2005

Port	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
Mourilyan	1	0	0	0	1
Karumba	5	0	0	0	5
Darwin	50	36	1	0	87
Wyndham	4	8	1	0	13
Broome	8	24	0	0	32
Port Hedland	0	4	0	0	4
Geraldton	3	12	0	0	15
Fremantle	2	8	0	0	10
Total	73	93	2	0	168*

* One low mortality split-load voyage excluded: mortalities could not be determined by consignment (port of loading).

4.2.3.2 Ship

The voyages of each ship from Australia to South-East Asia were classified into various mortality categories as shown in Table 19. Most voyages of most ships were in the nil or low mortality categories, with no voyage in the high category.

Table 19 Number of voyages in nil, low, medium and high mortality categories for shipments to South-East Asia for 2005

	Mortality rate				
Ship (code)	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	Total
5	3	3	0	0	6
37	1	10	1	0	12
59	5	4	0	0	9
75	0	2	0	0	2
88	13	6	0	0	19
90	12	8	0	0	20
100	6	7	0	0	13
102	4	1	0	0	5
109	7	5	0	0	12
111	0	14	0	0	14
112	4	6	0	0	10
113	3	4	0	0	7
114	3	3	1	0	7
117	9	13	0	0	22
119	3	7	0	0	10
Total	73	93	2	0	168*

* One low mortality split-load voyage excluded: mortalities could not be determined by consignment (port of loading).

4.2.4 North-East Asia

The number of cattle exported to North-East Asia in 2005 decreased by 44% compared to 2004 (Table 20). The death rate has remained relatively constant at about 0.1% since 2001.

Table 20 Death rates, number of voyages and number of cattle exported to North-East Asia from 1995 to 2005

Year	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Death rate range (%)	Voyages with nil deaths (No.)
1995	7	7,311	0.29	0.1 - 0.5	0
1996	9	12,587	0.40	0.1 - 1.2	0
1997	11	15,960	0.29	0.0 - 2.6	4
1998	10	14,734	0.17	0.0 - 0.4	2
1999	8	10,772	0.22	0.0 - 0.4	1
2000	10	13,830	0.14	0.0 - 0.4	4
2001	14	18,190	0.11	0.0 - 0.9	5
2002	17	22,483	0.12	0.0 - 0.7	7
2003	36	66,861	0.12	0.0 - 1.1	10
2004	49	93,303	0.10	0.0 - 0.8	12
2005	36	52,565	0.09	0.0 – 0.4	14

4.2.4.1 Port of loading

Cattle were exported to North-East Asia mainly from Brisbane followed by Portland (Table 21). The cattle loaded at Brisbane were exported to Japan while those loaded at other ports were exported to China and South Korea.

Table 21 Death rates, number of voyages and number of cattle exported from various ports to North-East Asia for 2005

Port	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Death rate range (%)
Geraldton	1	851	0.12	n/a
Fremantle	7*	3,484	0.11	0.0 - 0.4
Portland	9*	21,211	0.11	0.0 - 0.3
Brisbane	18	24,372	0.06	0.0 - 0.3

* One split-loaded voyage excluded: mortalities could not be determined by consignment (port of loading). Total mortality for this voyage was 0.19%.

4.2.4.2 Ship

The voyages of each ship from Australia to North-East Asia were classified into various mortality categories as shown in Table 22. All voyages were in the nil or low mortality categories.

Table 22 Number of voyages in nil, low, medium and high mortality categories for shipments to North-East Asia for 2005

	Mortality rate				
Ship (code)	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	Total
5	0	1	0	0	1
59	2	4	0	0	6
75	0	2	0	0	2
87	6	5	0	0	11
95	0	1	0	0	1
100	1	5	0	0	6
109	0	1	0	0	1
112	0	2	0	0	2
119	5	1	0	0	6
Total	14	22	0	0	36

4.2.5 China

Although considered part of North East Asia for the purposes of this report, exports to China were previously reported separately because of the rapid growth in exports of dairy cattle to this country (Table 23). The number of cattle fell substantially in 2005, while the mortality rate was the same as the 2003 level.

Table 23 Death rates, number of voyages and number of cattle exported to China from 1995 to 2005

Year	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Death rate range (%)	Voyages with nil deaths (No.)
1995	0				
1996	0				
1997	1	1,290	2.56	n/a	n/a
1998	0				
1999	0				
2000	0				
2001	1	1,363	0.07	n/a	n/a
2002	6	8,407	0.25	0.0 - 0.7	0
2003	18	43,152	0.13	0.0 - 0.8	3
2004	36	75,460	0.09	0.0 - 0.5	7
2005	16	26,491	0.12	0.0 - 0.4	3

4.2.5.1 Port of loading

Nearly all of the cattle exported to China in 2005 were loaded at Portland (Table 24).

Table 24 Death rates, number of voyages and number of cattle exported from various ports to China for 2005

Port	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Death rate range (%)
Portland	9*	21,211	0.11	0.0 - 0.3
Fremantle	6*	2,633	0.15	0.0 - 0.4

* One split-loaded voyage excluded: mortalities could not be determined by consignment (port of loading). Total mortality for this voyage was 0.19%.

4.2.5.2 Class of cattle

Recording of death rates for each class of cattle exported to China was introduced in July 2003. The results for 2005 are presented in Table 25.

Table 25 Death rate, number of voyages and number of cattle in the classes exported to China in 2005

Class	Voyages (No.)	Cattle (No.)	Death rate (%)	Death rate range (%)
Bull adult	3	55	0.00	n/a
Heifer dairy	15	23,789	0.12	0.0 - 0.4

Note: One voyage excluded; cattle could not be determined by class.

4.2.6 Mexico

There was a threefold rise in the number of cattle exported to Mexico in 2005 compared with 2004 (Table 26). Despite this increase, the death rate remained below the level for 2004.

Table 26 Death rates, number of voyages and number of cattle exported to Mexico from 1995 to 2005

Year	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Death rate range (%)	Voyages with nil deaths (No.)
1995	0	n/a	n/a	n/a	n/a
1996	2	4,359	0.66	0.6 – 1.0	0
1997	3	6,960	0.80	0.6 – 1.0	0
1998	2	21,163	0.83	0.4 – 1.1	0
1999	4	7,701	0.60	0.0 – 0.7	1
2000	5	9,556	1.38	0.0 – 4.8	1
2001	10	21,478	0.47	0.0 – 1.2	2
2002	6	17,434	0.74	0.0 – 3.0	1
2003	1	2,558	0.08	n/a	n/a
2004	3	5,633	0.37	0.0 – 0.7	1
2005	9	17,464	0.26	0.0 – 0.8	1

4.2.6.1 Port of loading

All cattle exported to Mexico in 2005 were loaded at Portland and Fremantle (Table 27).

Table 27 Death rates, number of voyages and number of cattle exported from various ports to Mexico in 2005

Port	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Death rate range (%)
Portland	6	15,756	0.22	0.0 - 0.5
Fremantle	3	1,708	0.58	0.0 - 0.8

4.2.6.2 Ship

The voyages of each ship from Australia to Mexico were classified into various mortality categories as shown in Table 28. Most voyages were in the low mortality category.

Table 28 Number of voyages in nil, low, medium and high mortality categories for shipments to Mexico for 2005

	Mortality rate				
Ship (code)	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	Total
56	0	1	0	0	1
75	1	1	0	0	2
103	0	4	2	0	6
Total	1	6	2	0	9

4.2.6.3 Class of cattle

Recording of death rates for each class of cattle loaded began in July 2002. The results for cattle exported to Mexico in 2005 are shown in Table 29.

Table 29 Death rates, number of voyages and number of cattle in various classes exported to Mexico in 2005

Class	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Death rate range (%)
Bull adult	2	58	0.00	n/a
Cow dairy	1	118	0.85	n/a
Heifer dairy	9	17,288	0.25	0.0 – 0.8

4.3 Goats

4.3.1 Overview

Most goats exported by sea from Australia are sent to South-East Asia with smaller numbers exported to the Middle East. The overall death rate was 0.77% among the 14,706 goats exported from Australia in 2005 (Table 30). This was not significantly different to the death rate of 0.88% in 2004 (P > 0.05). There were only 12 goats exported by sea to the Middle East in 2005 with no mortalities.

Table 30 Death rates, number of voyages and number of goats exported by sea for voyages to major destination regions during 2005

Parameter	ME/N Africa	SE Asia	Total
Voyages (No.)	1	25	26
Goats (No.)	12	14,694	14,706
Death rate overall (%)	0.00	0.78	0.77
Death rate range (%)	n/a	0.0 – 2.0	0.0 – 2.0

The number of goats exported annually to all destinations from Fremantle, Adelaide and Portland since 1993 is shown in Figure 6.

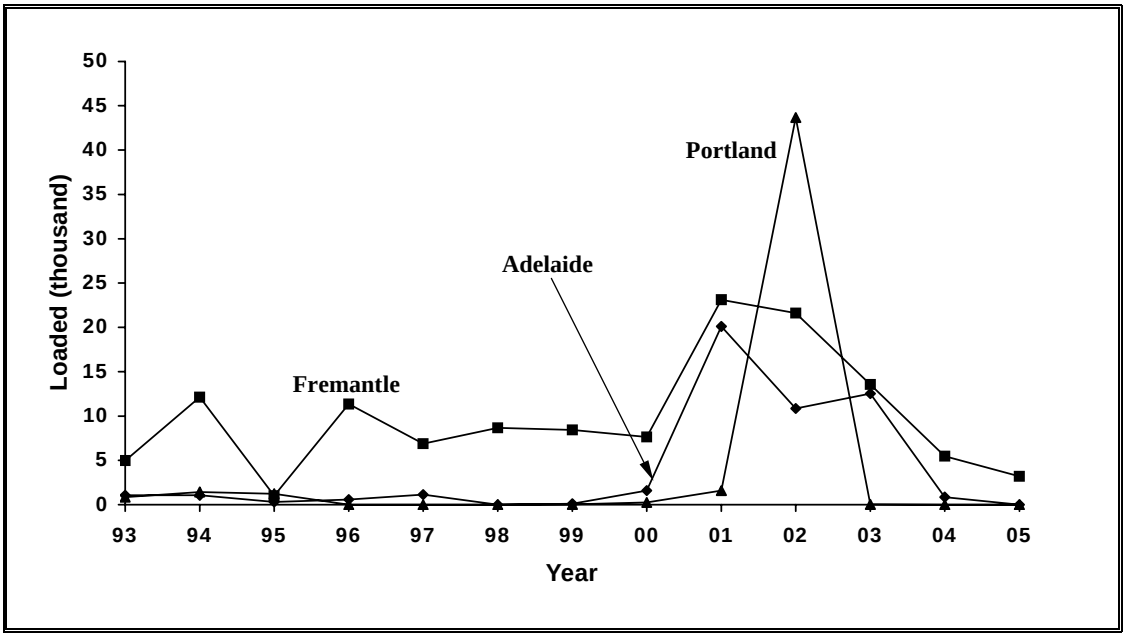

Figure 6 *Number of goats (x1000) exported by sea from Fremantle (Western Australia), Adelaide (South Australia) and Portland (Victoria) since 1993*

The annual death rate of goats exported from Australia in 2005 showed a small decrease compared to 2004 (Figure 7).

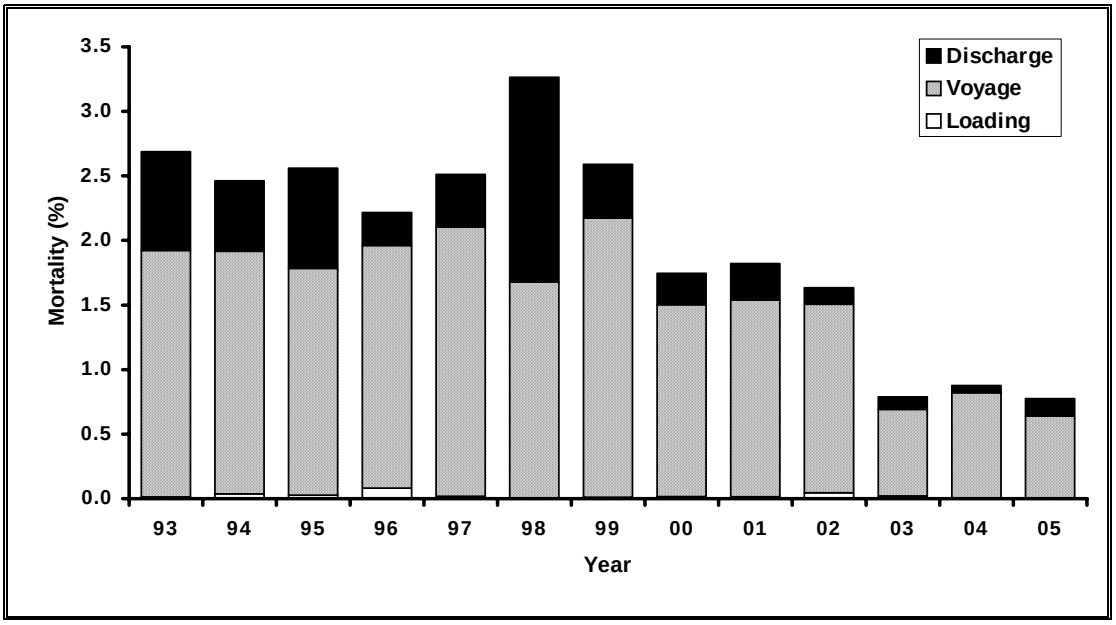

Figure 7 *Annual mortality of goats exported by sea from all ports in Australia to all destinations since 1993*

4.3.2 Middle East

Large numbers of goats were exported by sea to the Middle East in 2001 and 2002 (Table 31) but have since fallen to virtually nil. The death rate has fallen to 0.1% in 2004, then to nil in 2005. No further description of the Middle East trade is given in this report.

Table 31 Death rates, number of voyages and number of goats exported by sea to the Middle East from 1993 to 2005

Year	Voyages (No.)	Goats (No.)	Death rate overall (%)	Death rate range (%)
1993	15	6,681	3.85	0.0 - 7.2
1994	16	13,948	2.78	0.0 - 8.8
1995	4	2,526	3.17	0.0 - 6.5
1996	9	9,760	2.17	0.0 - 4.1
1997	10	6,259	2.48	0.0 - 4.6
1998	13	8,650	1.68	0.0 - 5.0
1999	8	6,193	2.80	0.0 - 7.6
2000	12	6,310	2.08	0.0 - 8.0
2001	35	42,878	2.25	0.0 - 9.0
2002	23	69,419	2.03	0.0 - 3.4
2003	16	16,552	0.88	0.0 - 1.7
2004	4	1,021	0.10	0.0 - 0.3
2005	1	12	0.00	n/a

4.3.3 South-East Asia

The number of goats exported by sea to South-East Asia increased substantially in 2001 and 2002 compared to previous years, but has fallen steadily since then (Table 32). The death rate in 2005 was similar to the 2003 level.

Table 32 Death rates, number of voyages and number of goats exported by sea to South-East Asia from 1993 to 2005

Year	Voyages (No.)	Goats (No.)	Death rate overall (%)	Death rate range (%)
1993	17	7,497	1.63	0.0 - 4.7
1994	19	7,867	1.89	0.0 - 5.5
1995	11	4,818	2.24	0.0 - 7.8
1996	12	5,208	1.73	0.0 - 4.1
1997	26	14,363	2.53	0.0 - 7.0
1998	14	10,698	4.55	0.0 – 28.8*
1999	19	10,143	2.44	0.0 - 5.0
2000	28	14,728	1.65	0.0 - 8.7
2001	45	31,150	1.37	0.0 - 6.9
2002	49	42,032	1.05	0.0 - 9.9
2003	41	36,048	0.76	0.0 - 3.1
2004	29	20,801	0.93	0.0 - 2.6
2005	25	14,694	0.78	0.0 – 2.0

* One voyage delayed at discharge, resulting in excessive discharge mortality

4.3.3.1 Port of loading

For voyages to South-East Asia in 2005, most goats were exported from Darwin, followed by Geraldton and Fremantle (Table 33). Death rates were highest from Fremantle and Geraldton.

The voyages from each port were classified into various mortality categories as shown in Table 34. One voyage out of 25 was in the high category, involving the port of Fremantle.

Table 33 Death rates, number of voyages and number of goats exported from various ports to South-East Asia for 2005

Port	Voyages (No.)	Goats (No.)	Death rate overall (%)	Death rate range (%)
Darwin	8	4,445	0.47	0.0 – 0.7
Broome	8	2,222	0.58	0.0 – 0.9
Port Hedland	1	1,052	0.09	n/a
Geraldton	5	3,797	0.95	0.0 – 1.7
Fremantle	3	3,178	1.35	0.8 – 2.0

Table 34 Number of voyages in low, medium and high mortality categories for shipments from various ports to South-East Asia for 2005

Port	Mortality rate			Total
	Low <1.0%	Medium 1.0–2.0%	High >2.0%	
Darwin	8	0	0	8
Broome	8	0	0	8
Port Hedland	1	0	0	1
Geraldton	3	2	0	5
Fremantle	2	0	1	3
Total	22	2	1	25

4.3.3.2 Ship

The voyages of each ship from Australia to South-East Asia were classified into the low, medium and high mortality categories. Note that for this comparison, "voyage" equates to consignment from a port. Consequently, if a ship loaded at two ports, then two "voyages" are shown for that ship, one for each port.

Table 35 shows the number of voyages in the various mortality categories for each ship. Most voyages of most ships were in the nil or low mortality categories. There was one voyage in the high category; involving ship 113.

Table 35 Number of voyages in low, medium and high mortality categories for shipments to South-East Asia for 2005

Ship (code)	Mortality rate			Total
	Low <1.0%	Medium 1.0–2.0%	High >2.0%	
5	1	0	0	1
37	0	1	0	1
59	3	0	0	3
75	1	0	0	1
88	5	0	0	5
90	1	0	0	1
100	2	0	0	2
112	1	0	0	1
113	1	0	1	2
114	1	1	0	2
117	1	0	0	1
119	5	0	0	5
Total	22	2	1	25

4.3.3.3 Time of year

The monthly death rate during 2005 and the moving 5-year "average" (proportion of all deaths divided by number loaded) in all goats exported to the South-East Asia are shown in Figure 8. There were no goats exported during April 2005. The 2005 rate approximated the 5-year pattern, but was well below the 5-year rate from May to October.

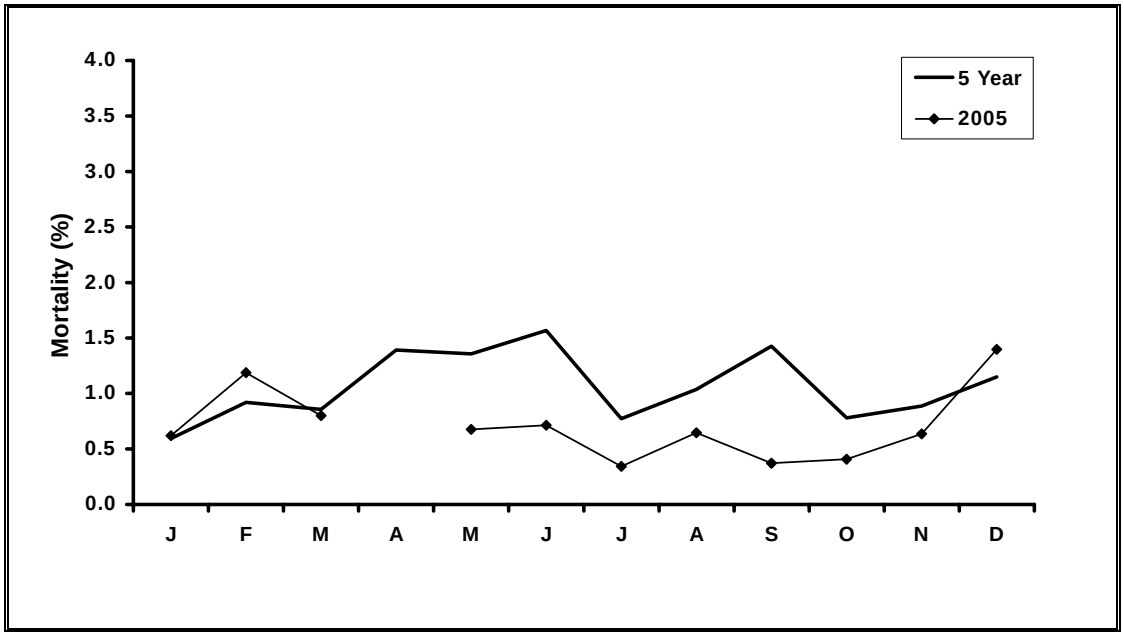

Figure 8 *Monthly mortality during 2005 and moving 5-year average in goats exported to South-East Asia*

5 Success in achieving objectives

The objectives of the project were achieved. The mortality levels of sheep, cattle and goats during sea transport from Australia in the 2005 calendar year were summarised in the current report. The report also includes analysis of mortality trends in the livestock export industry.

The summary report was distributed to industry, government, animal welfare groups and other parties interested in the live animal export trade.

6 Impact on meat and livestock industry

The welfare of animals during sea transport from Australia is of increasing interest to the public and animal welfare activists, here in Australia and overseas. The current report enables industry, government, animal welfare groups and others to monitor mortalities in different sectors of the live export trade. Continuation of the trade depends in part on mortalities remaining at acceptable levels.

7 Conclusions and recommendations

Industry stakeholders, government, animal welfare groups and the general public have a keen interest in monitoring mortalities in different sectors of the live export trade. The summary report provides a breakdown of industry performance in each of the major sectors.

8 Bibliography

Nil

9 Appendices

9.1 Appendix 1 - Sheep and cattle deaths: research summary

To assist with interpretation of the results for sheep, the main findings from research conducted into the causes of death and the risk factors for sheep exported from Western Australia to the Middle East are summarized here. It should be noted that these findings are based on information published in the refereed scientific journal articles listed in Appendix 2.

The research involved analysis of industry mortality records, land-based studies and investigations on ships travelling from Western Australia to the Middle East. The aims were to define the level of sheep mortality during the export process, and to identify the causes of death and the risk factors.

A typical research voyage involved selecting and identifying about 10,000 sheep on arrival at a pre-embarkation feedlot, tracing them back to the farm and interviewing the farmer/manager to gather information about the previous management of the sheep, undertaking observations and treatments in the pre-embarkation feedlot, loading onto the ship, and conducting post mortem examinations and other observations during the voyage. Many research voyages and more than 1,000 detailed post mortem examinations were undertaken.

The main causes of sheep deaths during sea transport were inanition and salmonellosis (Richards *et al* 1989). These two causes accounted for about 75% of all deaths aboard ship. The most important risk factors for sheep deaths were failure to eat the pelleted feed, farm-group of sheep, age, time of the year, fatness, duration between leaving the farm and unloading in the Middle East, and occasionally, excessive temperature and relative humidity (Norris *et al* 1989b, Norris *et al* 1989a, Higgs *et al* 1991, Norris and Richards 1989, Higgs *et al* 1999).

Death rates during the shipping phase varied widely between farm groups of sheep, with high death rates concentrated in only a few farm groups (Norris *et al* 1989a, Higgs *et al* 1999). A study of 479 farm groups of sheep from 405 farms in Western Australia showed that death rates ranged from nil to 28% with half of all deaths in only 14% of the farm groups. There were more deaths in sheep from the zones of higher rainfall and longer pasture-growing season (Higgs *et al* 1999).

Bars wrapped in dye-soaked sponge were attached to feed troughs to identify sheep which ate the pelleted feed (Norris *et al* 1989a). Although most sheep began eating the pelleted feed in the pre-embarkation feedlot or aboard ship, a few became persistent non-feeders, and it is these animals that were most likely to die. Giving them abundant quantities of feed or increased access to the feed troughs did not reduce the number of persistent non-feeders (Norris *et al* 1990).

Age, fatness and time of year predisposed to mortality (Higgs *et al* 1991). Death rates during sea transport were higher in adult wethers (castrated male) than in younger wethers, and were higher in adult wethers in fat condition than in lean condition, and there were more deaths during the second half of the calendar year than in the first half.

The explanation (Richards *et al* 1991, Higgs *et al* 1991) is that sheep coming from dry pasture in the first half of the year are in negative energy balance and are metabolically adjusted to using body fat reserves for energy – southern Western Australia experiences a Mediterranean climate and pastures decline in quality and quantity during the first half of the calendar year, and supplementary feeding usually with cereal grains or lupins is required for animals to maintain

bodyweight. Any sheep which is not eating during the export process therefore has a better chance of survival because it is able to mobilise body fat reserves to produce energy.

In contrast, sheep coming from green pasture in the second half of the year are metabolically adjusted to laying down body fat and those which do not eat during the export process are not able to use body fat reserves for energy and are therefore at increased risk of death.

Immature sheep have a strong growth requirement and their powerful appetite drive overrides the seasonal cycles that are prominent in adult sheep. Consequently, there were fewer non-feeders and deaths among immature sheep.

Factors for which no association (or no consistent association) with mortality was shown include (Norris *et al* 1989b): distance trucked from farm to pre-embarkation feedlot, time on the truck, time off feed from yarding on farm to unloading at the feedlot, purchase history on the farm, social interaction on the farm, experience of supplementary feeding and type of feed as unweaned lambs, experience of supplementary feeding and type of feed in the last 9 months before export and time of shearing on the farm.

An important finding was that most sheep began eating the pelleted feed within the first few days after loading onto the ship, even if they had not eaten this feed in the pre-embarkation feedlot. This was a consistent finding in research studies during actual commercial voyages and during simulated voyages (Norris *et al* 1990, Norris *et al* 1992). In one such study, 85% to 93% of non feeders in the pre-embarkation feedlot ate pelleted feed within the first three days of simulated shipping (Norris *et al* 1990).

In contrast to exports of sheep, live cattle are exported from many ports around Australia to destinations in south east Asia, north Asia and the Middle East. Investigations on voyages to the Middle East showed that the main causes of cattle deaths were heat stroke, trauma and respiratory disease (Norris *et al* 2003). All of the deaths from heat stroke were in *Bos taurus* breeds and occurred in the latter half of the voyage.

The research also showed that the risk of death on voyages to the Middle East was three times greater among cattle exported from southern ports in Australia compared to northern ports. The likely reason is the higher content of tropically-adapted *Bos indicus* cattle in northern Australia and their ability to handle the heat and humidity encountered during the voyage, in contrast to the *Bos taurus* breeds from southern Australia.

9.2 Appendix 2 - Published studies

A list of scientific and extension publications, relevant to the live sheep trade, is shown below.

Norris, RT and Richards, RB (1989) Deaths in sheep exported by sea from Western Australia – analysis of ship Master's reports Aust Vet J **66:** 97-102

Norris, RT, Richards, RB and Dunlop, RH (1989a) An epidemiological study of sheep deaths before and during export by sea from Western Australia Aust Vet J **66:** 276-279

Norris, RT, Richards, RB and Dunlop, RH (1989b) Pre-embarkation risk factors for sheep deaths during export by sea from Western Australia Aust Vet J **66:** 309-314

Richards, RB, Norris, RT, Dunlop, RH and McQuade, NC (1989) Causes of death in sheep exported live by sea Aust Vet J **66:** 33-38

McDonald, CL, Norris, RT, Ridings, H and Speijers, EJ (1990) Feeding behaviour of Merino wethers under conditions similar to lot-feeding before live export Aust J Exp Agric **30:** 343-348

Norris, RT, McDonald, CL, Richards, RB, Hyder, MW, Gittins, SP and Norman, GJ (1990) Management of inappetant sheep during export by sea Aust Vet J **67:** 244-247

Thomas, KW, Kelly, AP, Beers, PT and Brennan, RG (1990) Thiamine deficiency in sheep exported live by sea Aust Vet J **76:** 215-218

Higgs, ARB, Norris, RT and Richards, RB (1991) Season, age and adiposity influence death rates in sheep exported by sea Aust J Agric Res **42:** 205-214

Norris, RT (1991) Studies of factors affecting sheep deaths during lot-feeding and sea transport PhD Thesis, Murdoch University, Perth

Richards, RB, Hyder, MW, Fry, JM, Costa, ND, Norris, RT and Higgs, ARB (1991) Seasonal factors may be responsible for deaths in sheep exported by sea Aust J Agric Res **42:** 215-226

Norris RT, Richards RB and Norman, GJ (1992) The duration of lot-feeding of sheep before sea transport Aust Vet J **69**: 8-10

Scharp, DW (1992) Performance of Australian wethers in Arabian Gulf feedlots after transport by sea Aust Vet J **69:** 42-43

Higgs, ARB, Norris, RT and Richards, RB (1993) Epidemiology of salmonellosis in the live sheep export industry Aust Vet J **70:** 330-335

Richards, RB, Norris, RT and Higgs, ARB (1993) Distribution of lesions in ovine salmonellosis Aust Vet J **70:** 326-330

McDonald, CL, Rowe, JB and Gittins, SP (1994) Feeds and feeding methods for assembly of sheep before export Aust J Exp Agric **34:** 589-94

Higgs, ARB, Norris, RT, Baldock, FC, Campbell, NJ, Koh, S and Richards, RB (1996) Contagious ecthyma in the live sheep export industry Aust Vet J **74:** 215-220

Higgs, ARB, Norris, RT, Love, RA and Norman, GJ (1999) Mortality of sheep exported by sea: evidence of similarity by farm group and of regional differences Aust Vet J **77:** 729-733

Norris, RT, Richards, RB, Creeper, JH, Jubb, TF, Madin, B and Kerr JW (2003) Cattle deaths during sea transport from Australia Aust Vet J **81:** 156-161

9.3 Appendix 3 - Acknowledgements

The cooperation of ships' officers in recording details of daily mortalities is gratefully acknowledged. This work was funded by Meat and Livestock Australia, LiveCorp and the Department of Agriculture and Food, Western Australia.