National Livestock Export Industry Shipboard Performance Report 2008

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Executive summary

The objective of this project was to summarise the performance of the livestock export industry in terms of mortality levels of sheep, cattle and goats exported by sea from Australia during 2008.

Industry stakeholders, government, animal welfare groups and the general public have a keen interest in monitoring performance in different sectors of the livestock export trade. The summary report provides a breakdown by species and major destinations.

The overall mortality rate for sheep during sea transport to all destinations during 2008 was 0.84% out of approximately 4.2 million sheep exported. This was less than the 0.97% mortality rate observed in 2007. The main port of loading was Fremantle (3.1 million sheep exported with mortality rate of 0.86%), followed by Portland (0.6 million sheep exported with mortality rate of 0.63%) and Adelaide (0.4 million sheep exported with mortality rate of 0.97%). A seasonal difference in mortality between the first and second half of the year was observed for the first time in hoggets and lambs.

The overall mortality rate among the 0.86 million cattle exported from Australia in 2008 was 0.12%. This was higher than the 0.10% mortality rate observed in 2007. The overall mortality rate on voyages to the Middle East/North Africa was 0.29% in 2008, a rise from 0.19% in 2007. The overall mortality rate on voyages to South-East Asia was 0.09%, similar to 2007. The highest overall mortality rate on a regional basis was 0.29% for exports to the Middle East/North Africa, while the lowest overall mortality rate was 0.06% for exports to North-East Asia.

The overall mortality rate among the 3,118 goats exported by sea from Australia in 2008 was 0.51%, which was less than the 0.69% observed in 2007. All goats exported by sea during 2008 went to South-East Asia.

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 livestock 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.

The Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) also presents mortality data, though in a different format, at their website: www.daff.gov.au/animal-plant-health/welfare/export-trade/mortalities. The DAFF data refers to reports received during the calendar year, in contrast to the current report which refers to voyages which departed during the calendar year.

2 Project objectives

1. Produce a report which summarises the mortality of cattle, sheep and goats for the 2008 calendar year and provides an informed analysis of mortality trends in the livestock export industry.

2. Maintain data and expertise to provide analysis and informed comment.

3 Methodology

The information in this report was obtained from ship Master's reports which record livestock mortalities and other information about each voyage, and also from "Yellow Books". "Yellow Books" record more detailed information about numbers of livestock mortalities (by age-sex category and port of loading) than is available from the Masters' report. The 2008 report is for voyages which departed Australia during 2008 and which were to hand on 27 March 2009. The Australian Bureau of Statistics provided information on the number of sheep exported to various destination countries from ports in Australia.

Readers should be aware that additional mortality information (Masters' reports or "Yellow Books") 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 Performance trend

Figures 1 and 2 show the number of sheep exported and the number of mortalities during sea transport from all ports in Australia to all destinations since 1985 as well as the trendline (linear regression) across the years. The number of sheep exported annually has varied between 3.5 and 6.5 million, and the annual mortality has varied between 0.75 and 3.0%. The trend for numbers of sheep exported and annual mortality has been downward, with a greater decline for annual mortality.

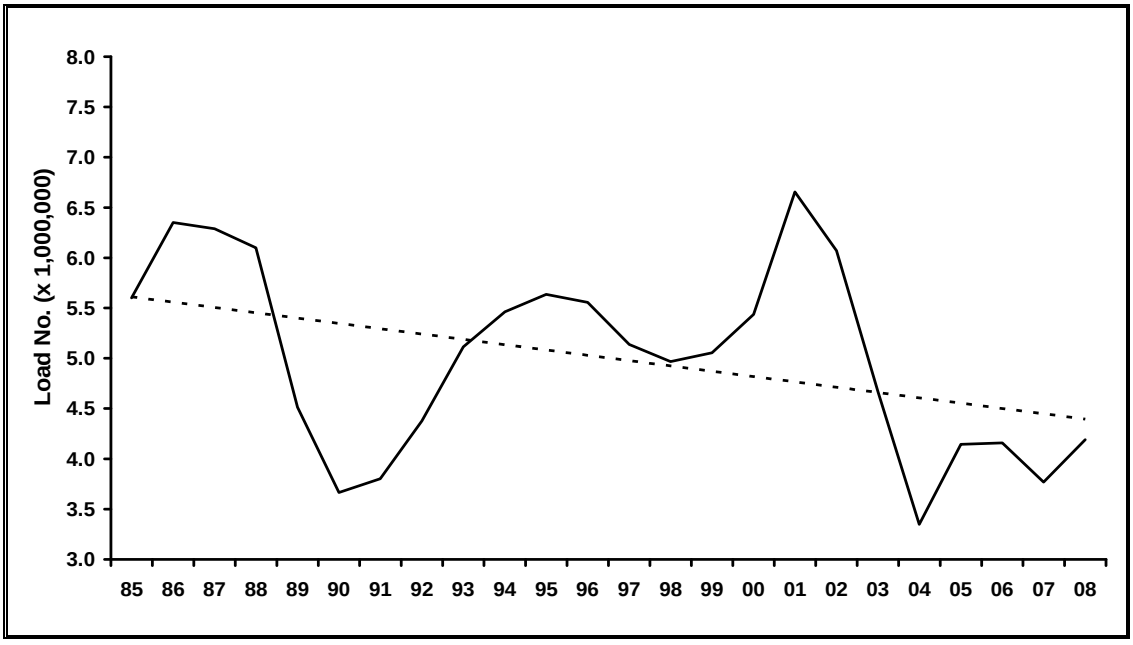

Figure 1 *Number of sheep exported by sea from Australia to all destinations since 1985*

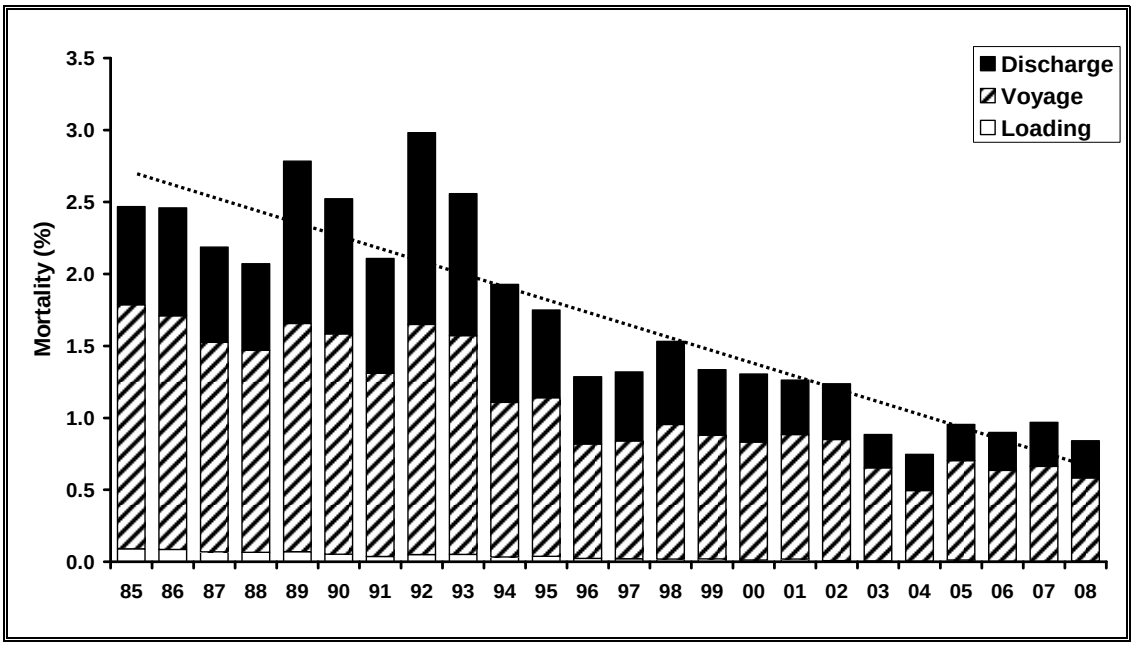

Figure 2 *Annual mortality of sheep exported by sea from Australia to all destinations since 1985*

Overview

Most sheep exported live by sea from Australia in 2008 were sent to the Middle East and were mainly loaded at Fremantle, Adelaide and Portland. Some sheep were exported to other regions including South-East Asia and Mauritius. Except where indicated, the comments below refer to voyages of sheep to the Middle East. An overview of the findings of research into the causes of sheep mortalities during export to the Middle East is given in Appendix 1.

4.1.2 Port of loading

The number and classes of sheep exported by sea to the Middle East from Fremantle, Adelaide and Portland during 2008 are shown in Table 1. Overall numbers exported in 2008 rose by over 11% compared to 2007. The main changes in 2008 compared to 2007 were an increase in exports of adult wethers from Fremantle and Portland (31% and 23% respectively), an increase in adult ewes from Fremantle (72%) and a decrease in ram lambs from Fremantle (43%).

Table 1 The numbers and classes of sheep exported by sea to the Middle East from Fremantle, Adelaide and Portland during 2008

Livestock		Fremantle	Adelaide	Portland	Total
Wethers	adults	1,558,738	411,389	580,187	2,550,304
	hoggets	241,673	17,914	4,406	263,993
	lambs	478,633			478,633
Rams	adults	101,306	4,592	14,382	120,280
	hoggets	77,332			77,332
	lambs	310,259		194	310,453
Ewes	adults	269,704			269,704
	hoggets	1,398			1,398
	lambs	91,515			91,515
Total	sheep	3,130,558	433,885	599,169	4,163,612

Most sheep exported by sea from Australia to the Middle East during 2008 were loaded at Fremantle (75.2% of all sheep, Figure 3) with smaller numbers loaded at Portland (14.4%) and Adelaide (10.4%).

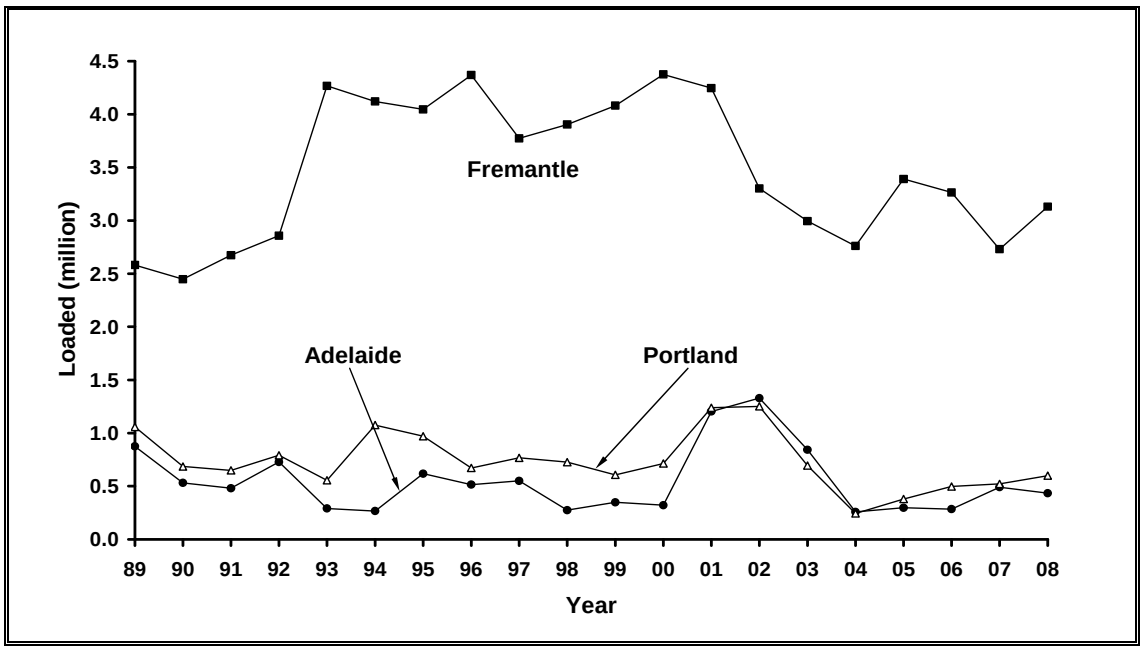

Figure 3 *Number of sheep exported by sea to the Middle East from Fremantle* (*Western Australia*)*, Portland* (*Victoria*) *and Adelaide* (*South Australia*) *since 1989*

4.1.3 Destination

The main importing countries for Australian sheep in 2008 are shown in Table 2. Kuwait was the main market (23% of all sheep) followed by Saudi Arabia (21%), Oman (18%) and Bahrain (17%).

Table 2 Destination country for sheep exported from Australia during 2008

Country	Fremantle	Adelaide	Portland	Other	Total
Bahrain	286,528	200,000	229,512		716,040
Israel	36,834				36,834
Jordan	362,572		21371		383,943
Kuwait	574,401	163,640	218,235		956,276
Mexico	25076				25,076
Oman	599,450	67,656	74,000		741,106
Qatar	263,251	5,865			269,116
Saudi Arabia	873,937				873,937
UAE	109,506	10,000	56,023	100	175,629
S.E. Asia	19,080			15,408	34,488
N.E. Asia				276	276
Other	250			2018	2,268
Total	3,150,885	447,161	599,141	17,802	4,214,989

SOURCE – Australian Bureau of Statistics, March 2008

Note: - ABS figures also include exports by air

4.1.4 Mortality rates

There were 19 voyages to the Middle East in 2008 for which sheep were loaded at more than one port in Australia (split-load voyages). 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 mortalities after arrival at the first port. Consequently if a ship called at more than one discharge port, all the mortalities after arrival at the first port were included in the discharge phase.

The total mortality rate for all sheep exported to all destination regions during 2008 was 0.84% (Table 3), a fall from the 0.97% observed in 2007.

There were 8 shipments to South-East Asia, and the mortality rate was 0.40% out of 26,150 sheep loaded.

There were 2 shipments to Mexico and the mortality rate was 0.31% out of 319 sheep loaded.

For shipments to the Middle East, the main changes compared to 2007 were substantially decreased voyage and discharge mortality rate for shipments from Portland, and decreased voyage mortality rates for shipments from Fremantle and Adelaide (Table 3 and Figure 4).

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

		Mortality rate (%)			
	Year	Load	Voyage	Discharge	Total
Fremantle*	2004	0.00	0.46	0.25	0.71
	2005	0.02	0.73	0.22	0.97
	2006	0.00	0.63	0.23	0.86
	2007	0.00	0.66	0.29	0.96
	2008	0.01	0.61	0.25	0.87
Adelaide*	2004	0.00	0.89	0.25	1.15
	2005	0.00	0.54	0.46	1.00
	2006	0.01	0.67	0.30	0.98
	2007	0.00	0.74	0.28	1.03
	2008	0.00	0.67	0.30	0.97
Portland*	2004	0.00	0.49	0.29	0.78
	2005	0.00	0.51	0.32	0.83
	2006	0.00	0.57	0.35	0.92
	2007	0.00	0.60	0.40	0.99
	2008	0.00	0.36	0.27	0.64
Total**	2004	0.00	0.49	0.25	0.75
	2005	0.01	0.69	0.25	0.95
	2006	0.00	0.63	0.26	0.90
	2007	0.00	0.66	0.31	0.97
	2008	0.00	0.58	0.26	0.84

* Middle East only

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

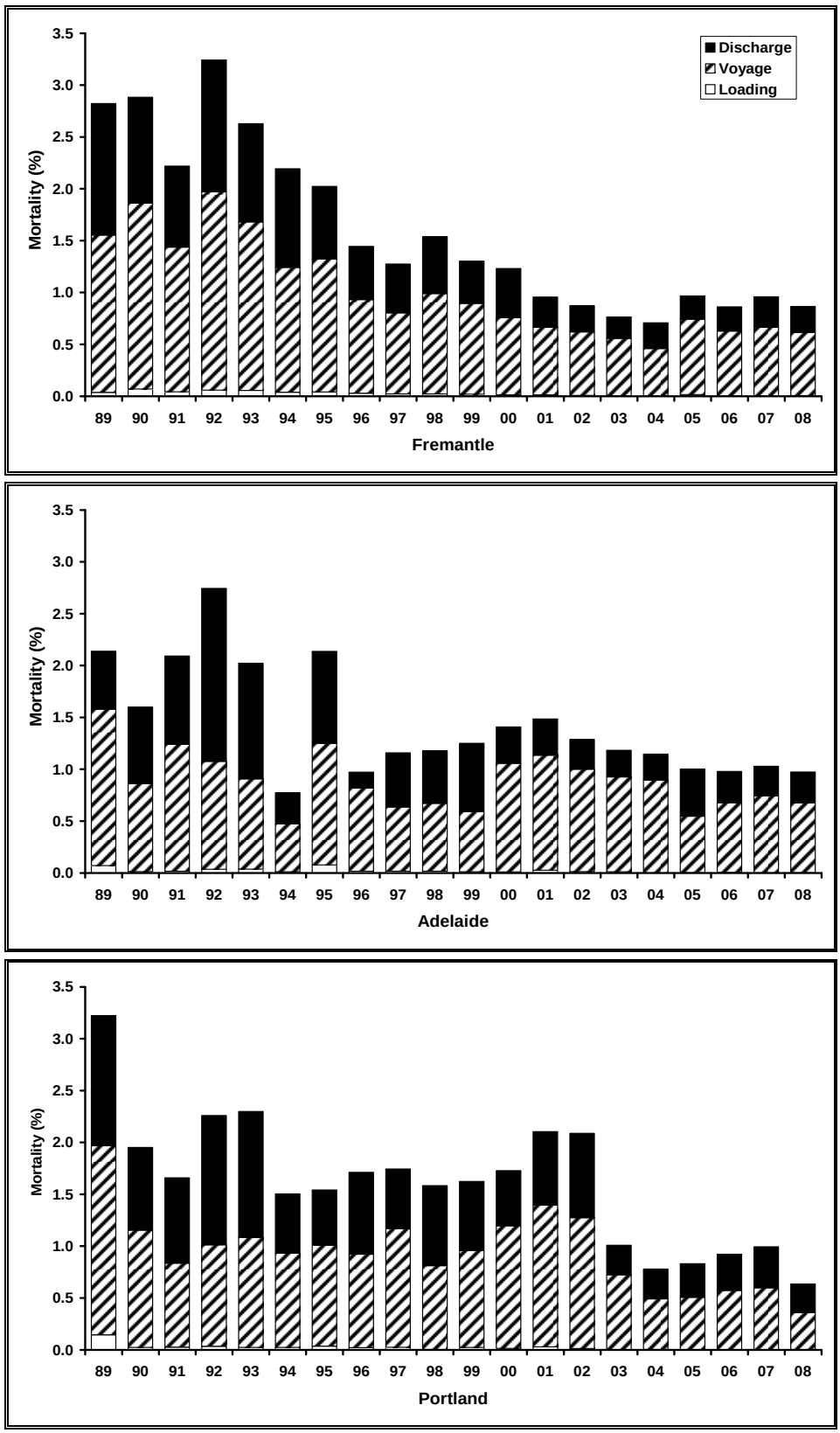

Figure 4 *Annual mortality for sheep exported from Fremantle, Adelaide and Portland to the Middle East since 1989*

4.1.5 Class of sheep

The mortality rates of various classes of sheep exported from Australia to the Middle East are shown in Table 4 and Figure 5. The highest overall mortality rates in 2008 were in ram hoggets, adult rams and ram lambs (1.4, 1.3 and 1.1% respectively). The high mortality in ram lambs from Portland occurred in one consignment of 194 lambs.

Table 4 Overall mortality (%) for classes of sheep exported from Fremantle, Adelaide and Portland to the Middle East in 2008

Class of sheep		Fremantle	Adelaide	Portland	Total
Wethers	adult	0.8	1.0	0.6	0.8
	hogget	0.6	0.5	0.2	0.6
	lamb	0.9	n/a	n/a	0.9
Rams	adult	1.3	1.4	1.4	1.3
	hogget	1.4	n/a	n/a	1.4
	lamb	1.1	n/a	5.7	1.1
Ewes	adult	1.0	n/a	n/a	1.0
	hogget	0.7	n/a	n/a	0.7
	lamb	0.6	n/a	n/a	0.6

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

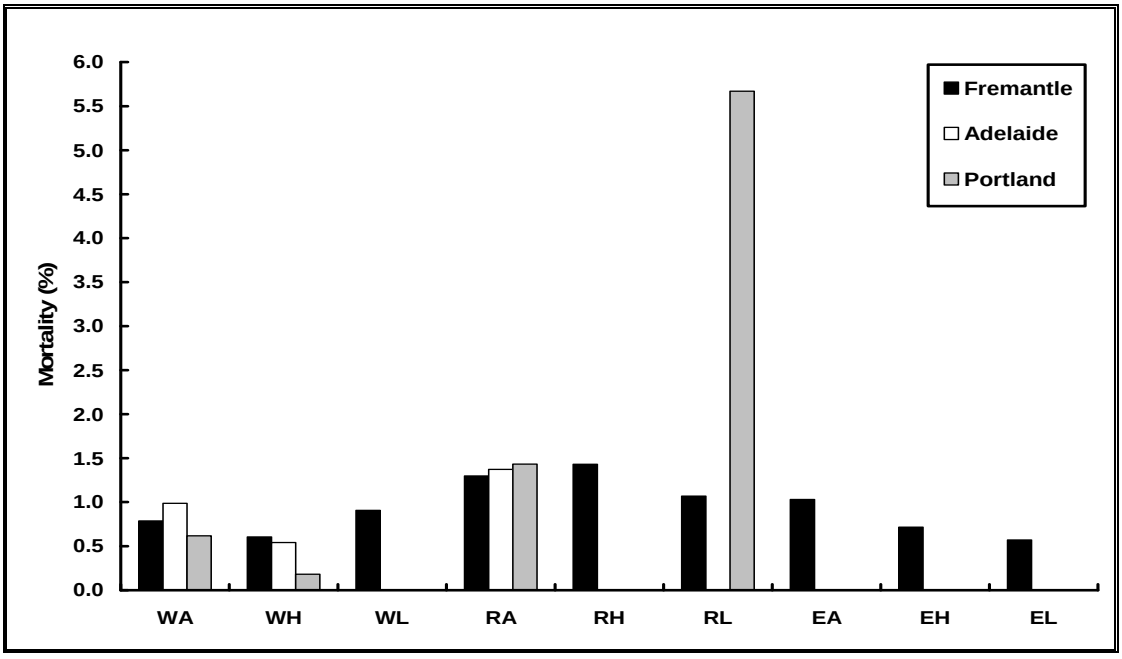

Figure 5 *Overall mortality (%) for classes of sheep exported from Fremantle, Adelaide and Portland to the Middle East in 2008*

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

Monthly mortality rates for voyages from Fremantle, Adelaide and Portland are shown in Table 5. From 2000 to 2002 inclusive, monthly mortality rates for shipments from Portland from May to October were substantially higher than for the annual mortality rate but have been similar since 2004.

Mortality rates were higher ($P < 0.05$) in the second half of 2008 compared with the first half in sheep exported from Fremantle (0.51% and 1.13%) and Adelaide (0.56% and 1.27%) but not for Portland (0.62% and 0.66%; Figure 6).

Table 5 Monthly mortality for all sheep exported from Fremantle, Adelaide and Portland to the Middle East from 2004 to 2008

		Year				
Port	Month	04	05	06	07	08
Fremantle	J	0.8	0.7	0.9	0.4	0.7
	F	0.5	0.6	0.8	0.5	0.5
	M	0.5	0.5	0.7	0.6	0.4
	A	0.4	0.7	0.5	0.4	0.4
	M	0.5	0.5	0.7	0.9	0.6
	J	0.9	0.9	0.8	0.5	0.6
	J	0.6	0.5	0.9	1.0	1.0
	A	0.9	1.4	1.1	1.4	1.5
	S	1.0	1.3	1.1	1.3	1.0
	O	0.8	1.4	0.9	1.4	0.9
	N	0.7	0.7	0.7	1.3	1.1
	D	0.6	1.0	0.8	0.8	1.1
	M – O*	0.8	1.2	0.9	1.1	1.0
	Total	0.7	1.0	0.9	1.0	0.9
Adelaide	J	1.2			0.6	
	F	1.3				0.6
	M			0.7	0.5	
	A		0.5	0.9	0.7	0.5
	M	0.5	0.9		0.6	0.7
	J	1.1			2.1	0.4
	J	0.7	1.4		0.5	1.2
	A	1.3	1.0	1.1	2.1	1.6
	S	1.3			1.0	
	O			1.2	1.2	
	N		1.1	0.9		1.2
	D				0.8	1.1
	M – O*	1.1	1.1	1.0	1.3	1.0
	Total	1.1	1.0	1.0	1.0	1.0
Portland	J		1.0		1.2	0.8
	F	0.8	0.4		0.8	0.6
	M	1.0		0.9	0.6	0.5
	A	0.8		0.6		0.6
	M	0.5		0.7	1.8	0.4
	J	1.0	0.5	1.4	0.7	
	J	0.7	1.1		2.5	1.4
	A			1.2	0.7	0.6
	S		0.7	1.1	0.6	
	O		1.5	1.2	0.8	0.4
	N	0.9	1.0	0.6	0.7	
	D		0.6	0.3	0.6	0.3
	M – O*	0.6	0.9	1.1	1.1	0.9
	Total	0.8	0.8	0.9	1.0	0.6

* May to October. In past years, shipboard mortalities were much higher from some Australian ports during winter months

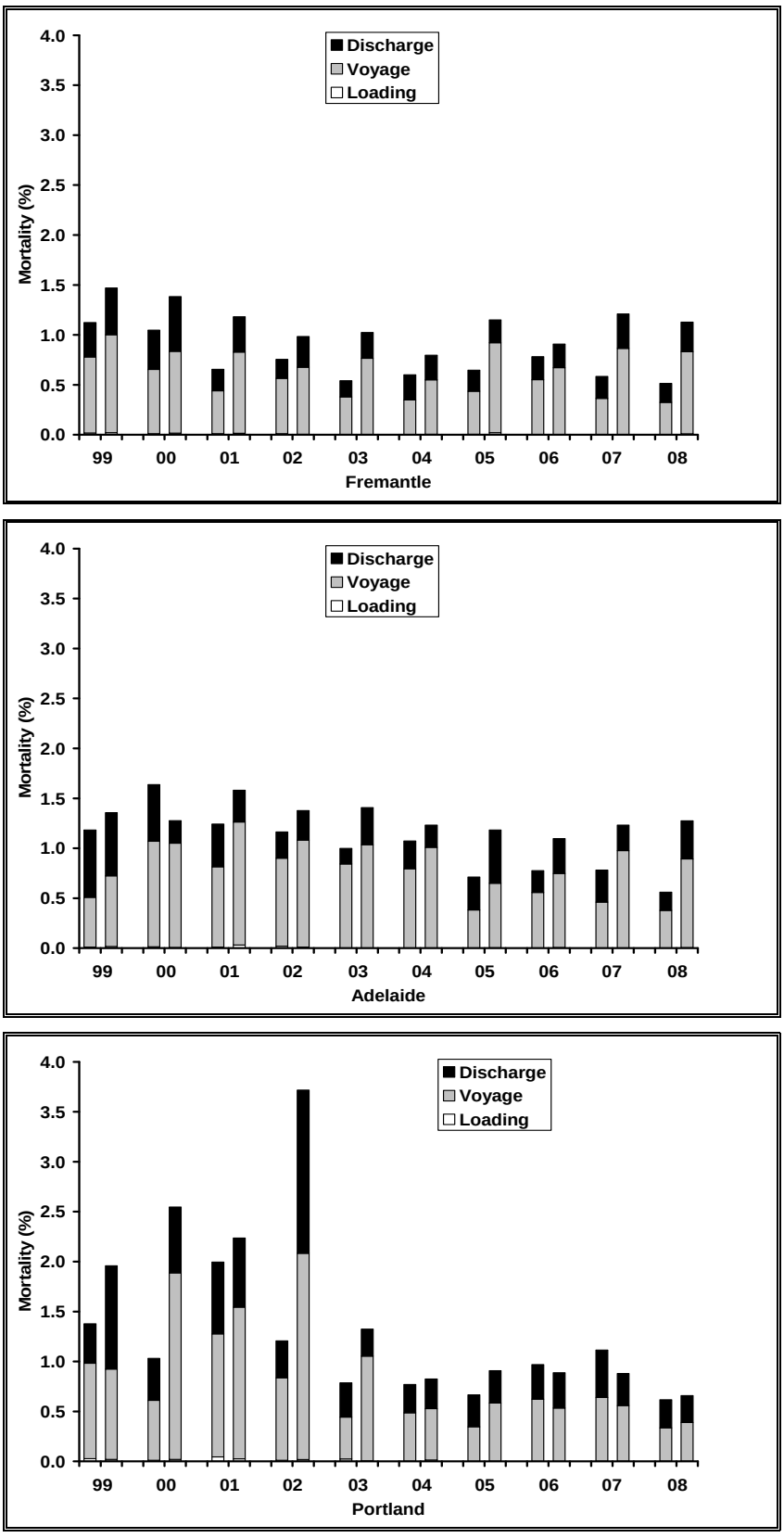

Figure 6 *Mortality (%) for sheep exported by sea from Fremantle, Adelaide and Portland to the Middle East for the first and second half of each year from 1999 to 2008*

In 2008, monthly mortality rates (total mortality as a proportion of total loaded for each month) in sheep exported from Fremantle were similar to the 5-year monthly mortality rates (Figure 7).

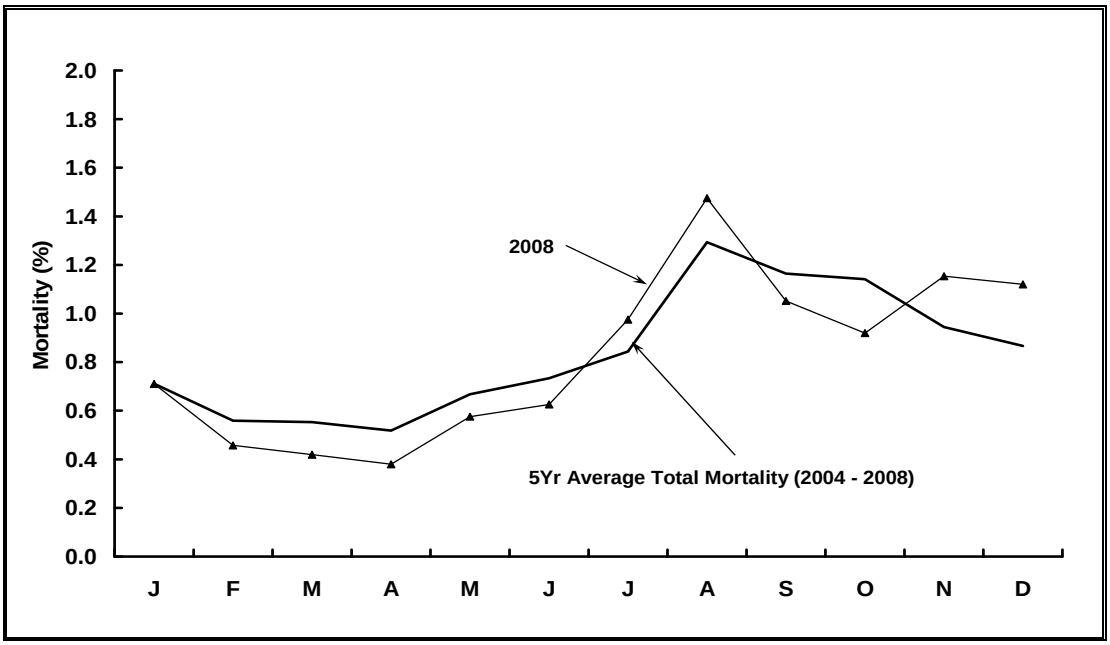

Figure 7 *Monthly mortality rates for shipments from Fremantle to the Middle East in 2008 and the 5-year monthly averages for the period 2004 to 2008*

4.1.7 Time of year and age of sheep

Figure 8 shows the monthly mortality rates (total mortality as a proportion of total loaded for each month) in wether adults, hoggets and lambs exported from Australia to the Middle East from 1997 to 2008. Figure 9 shows the mortality rates in the first and second half of the year for the same sheep over the same period. There were significantly more deaths ($P < 0.05$) in the second half of the year than in the first half for each year and each age category of sheep except for wether adults and hoggets in 2006.

Higgs et al (1991) identified a seasonal difference in mortality for adult wethers but not for wether hoggets and lambs. However, their data for this analysis was limited to 1989 only. The results below indicate that seasonal differences in mortality exist for wether hoggets and lambs as well as adults. Similar findings were observed for rams (results not presented). For ewes, the paucity of data in most years made conclusions unreliable.

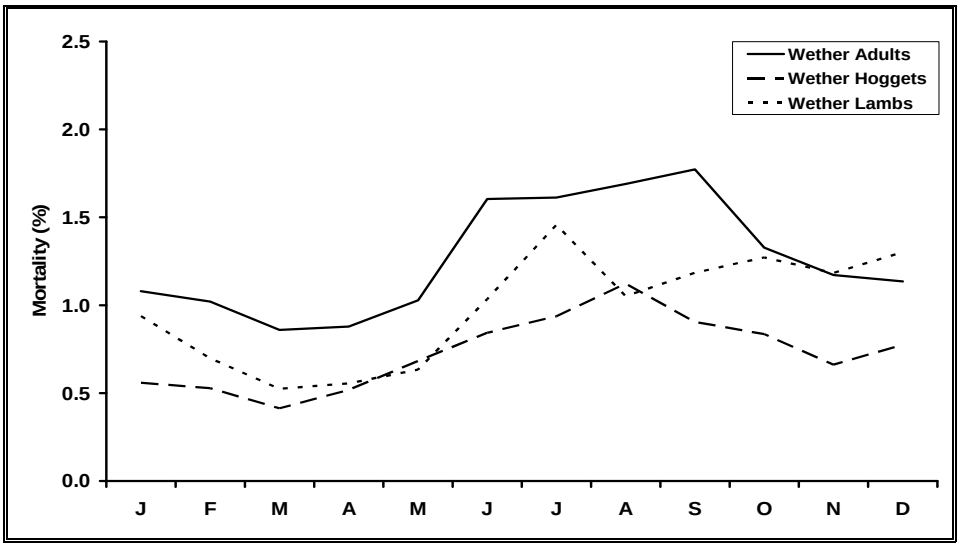

Figure 8 *Monthly mortality (%) for wether adults, hoggets and lambs exported by sea from Australia to the Middle East from 1997 to 2008*

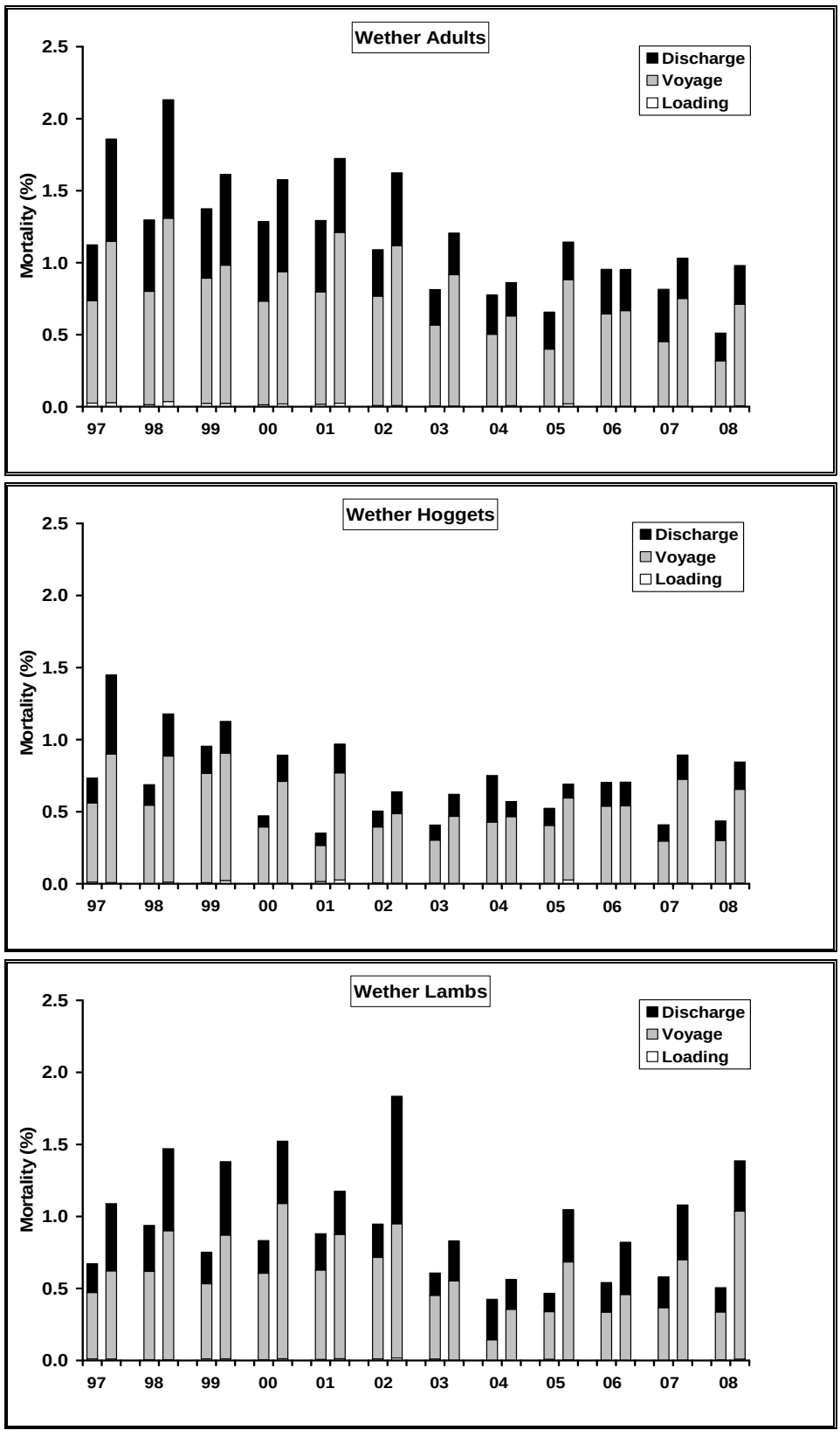

Figure 9 *Mortality (%) for wether adults, hoggets and lambs exported by sea from Australia to the Middle East for the first and second half of each year from 1997 to 2008*

Ship

The voyages of each ship were classified into low (mortality rate up to 1.0%), medium (mortality rate from 1.0 to 2.0%) and high (mortality rate greater than 2.0%) mortality categories for sheep exported to the Middle East from Fremantle (Table 6a), Adelaide (Table 6b) and Portland (Table 6c).

There was only one voyage in the "high" category in 2008, involving ship 33 and the port of Fremantle. Approximately 64% of voyages from Fremantle, 55% of voyages from Adelaide and 79% of voyages from Portland were in the "low" category.

Table 6a Number of voyages in low, medium and high mortality categories for ships loaded at Fremantle in 2007

	Mortality rate			
Ship (code)	Low <1.0%	Medium 1.0–2.0%	High >2.0%	Total
2	4	2	0	6
32	3	2	0	5
33	4	2	1	7
34	4	2	0	6
35	3	4	0	7
37	4	1	0	5
38	7	2	0	9
41	3	2	0	5
Total	32	17	1	50

Table 6b Number of voyages in low, medium and high mortality categories for ships loaded at Adelaide in 2008

	Mortality rate			
Ship (code)	Low <1.0%	Medium 1.0–2.0%	High >2.0%	Total
32	1	2	0	3
34	2	2	0	4
35	1	0	0	1
37	1	0	0	1
Total	5	4	0	9

Table 6c Number of voyages in low, medium and high mortality categories for ships loaded at Portland in 2008

	Mortality rate			
Ship (code)	Low <1.0%	Medium 1.0–2.0%	High >2.0%	Total
2	4	0	0	4
32	4	0	0	4
33	1	0	0	1
34	1	1	0	2
35	1	1	0	2
41	0	1	0	1
Total	11	3	0	14

4.2 Cattle

4.2.1 Performance trend

The number of cattle shipped from all ports in Australia to all destinations since 1995 as well as the trendline (linear regression) across those years is shown in Figure 10. Similarly, Figure 11 shows the number of cattle mortalities during sea transport since 1995. The number of cattle exported annually has varied from approximately 450,000 to 960,000, and the annual mortality has varied between 0.10 and 0.42%. The trend for numbers of cattle exported has been slightly upwards whereas the trend for annual mortality has been downward, with a greater decline for annual mortality.

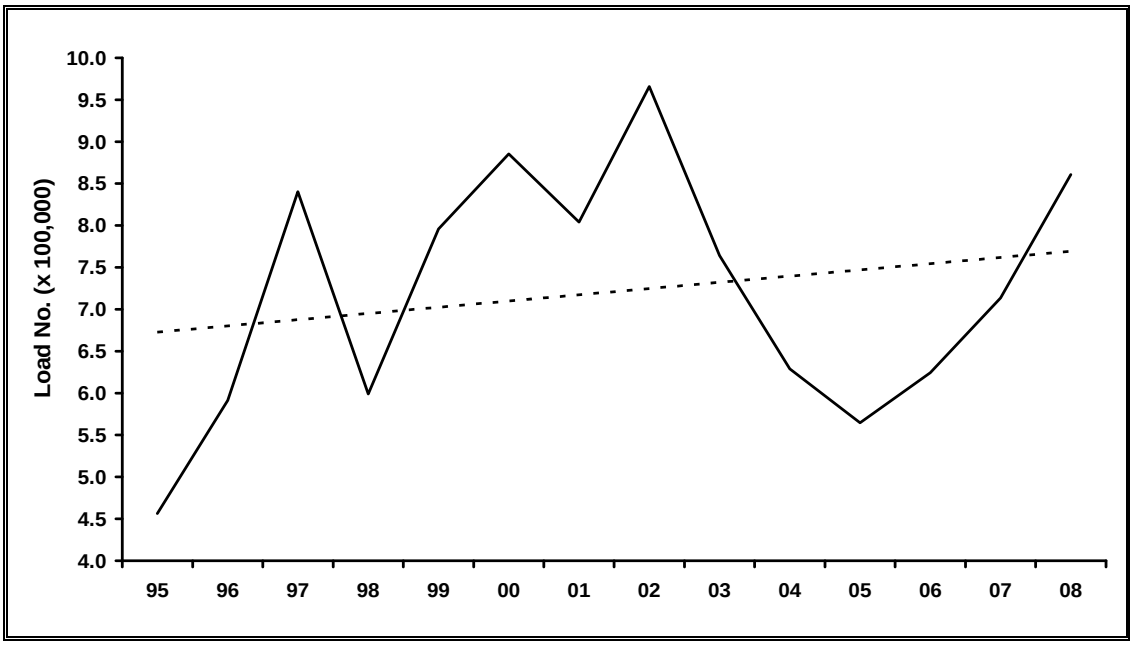

Figure 10 *Number of cattle exported by sea from Australia to all destinations since 1995*

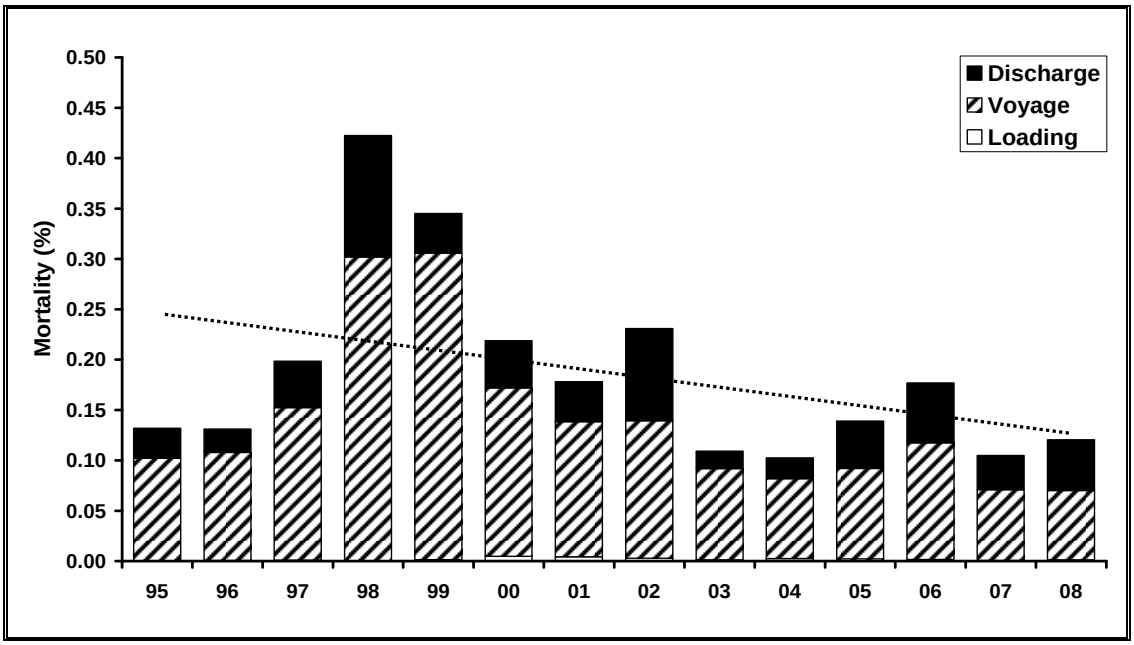

Figure 11 *Annual mortality of cattle exported by sea from Australia to all destinations since 1995*

4.2.2 Overview

The live cattle trade from Australia in 2008 was characterised by the large number of ports of loading in Australia and the regions to which the animals were shipped. This is in contrast to the live sheep trade where there were only three main ports of loading, and virtually all sheep were shipped to the Middle East.

There were 13 voyages in 2008 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 mortality rate among the 0.86 million cattle exported from Australia in 2008 was 0.12% (Table 7). This was higher than the 0.10% observed in 2007. The highest overall mortality rate on a regional basis was for exports to the Middle East/North Africa, while the lowest overall mortality rate was for exports to North-East Asia.

Previously, exports to South-East Asia were characterised by small consignments on short voyages. More recently, larger ships have been introduced which have involved loading and discharging at more than one port. The number of voyages to the region in 2008 was similar to 2007 (219 and 205 respectively).

Exports to North-East Asia were mainly steers exported to Japan and dairy cattle exported to China and Eastern Russia.

Almost half (43%) of voyages experienced no mortality during 2008.

Table 7 Mortality rates, number of voyages and number of cattle exported for voyages to major destination regions during 2008

Parameter	ME/N Africa	SE Asia	NE Asia	Mexico	Misc	Total
Voyages (No.)	46	219	19	3	11	298
Cattle (No.)	120,122	682,265	29,873	10,122	18,309	860,691
Mortality rate overall (%)	0.29	0.09	0.06	0.07	0.12	0.12
Mortality rate range (%)	0.0 – 0.8	0.0 – 1.9	0.0 – 0.4	0.0 – 0.1	0.0 – 0.2	0.0 – 1.9
Voyages with nil mortalities (No.)	19	93	10	1	4	127

4.2.3 Middle East

The live cattle trade to the Middle East has remained low over the last five years (Table 8). Overall mortality rates have remained below 0.5% since 1999 except for 2002 and 2006. In 2008, the mortality rate of 0.29% was second only to the 0.19% achieved in 2007.

Table 8 Mortality rates, number of voyages and number of cattle exported to the Middle East from 1995 to 2008

Year	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyages with nil mortalities (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	287,242	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 - 1.3	9
2005	38	90,808	0.34	0.0 – 1.0	12
2006	43	119,297	0.52	0.0 – 4.3	13
2007	41	74,256	0.19	0.0 – 0.5	16
2008	46	120,122	0.29	0.0 – 0.8	19

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

4.2.3.1 Port of loading

There were 4 ports of loading for voyages to the Middle East in 2008, and most cattle were exported from Fremantle, followed by Portland and Port Hedland (Table 9). Mortality rates in 2008 were highest from Fremantle, followed by Adelaide.

The voyages from each port were classified into various mortality categories as shown in Table 10. There were three voyages in the medium or high categories, two loaded at Fremantle and the other at Portland. No mortalities occurred on 47% of the voyages from Fremantle.

Table 9 Mortality rates, number of voyages and number of cattle exported from various ports to the Middle East for 2008

Port	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)
Fremantle	34	102,007	0.31	0.0 – 0.8
Adelaide	2	1,053	0.28	0.2 – 0.4
Portland	9	13,404	0.18	0.0 – 0.6
Port Hedland	1	3,658	0.08	n/a

Table 10 Number of voyages in nil, low, medium and high mortality categories for shipments from various ports to the Middle East for 2008

Port	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
Fremantle	16	16	2	0	34
Adelaide	0	2	0	0	2
Portland	3	5	1	0	9
Port Hedland	0	1	0	0	1
Total	19	24	3	0	46

4.2.3.2 Time of year

In 2008, monthly mortality rates (total mortality as a proportion of total loaded for each month) in cattle exported from all ports to the Middle East were similar to or below the 5-year monthly mortality rates except for March (Figure 12).

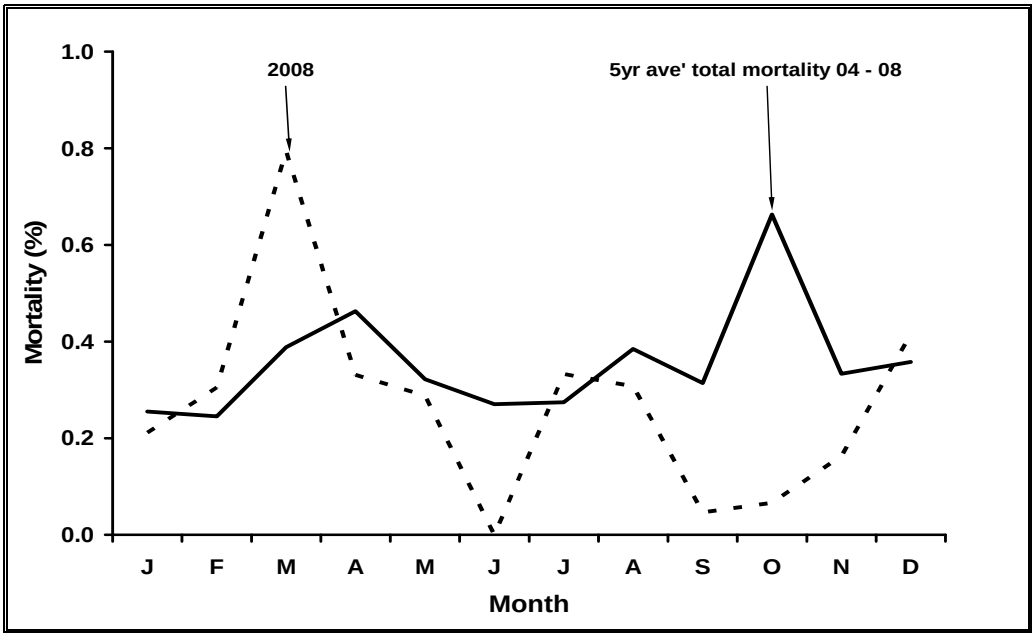

Figure 12 *Monthly mortality rates of cattle on voyages from all ports to the Middle East for 2008 and the 5-year monthly rates for the period 2004 to 2008*

4.2.3.3 Voyages from southern ports 1999 to 2008

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

The number of cattle exported from Fremantle and the mortality rate in 2008 was similar to 2006, after falling substantially in 2007 (Table 11). There have been few cattle exported from Adelaide since 2004.

Table 11 Mortality rates for cattle loaded at Fremantle, Adelaide or Portland from 1999 to 2008

Year	Fremantle			Adelaide			Portland		
	Voys (No.)	Cattle (No.)	Mort. (%)	Voys (No.)	Cattle (No.)	Mort. (%)	Voys (No.)	Cattle (No.)	Mort. (%)
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
2006	33	99,577	0.39	1	310	0.00	6	9,132	2.28†
2007	27	53,178	0.19	3	1,231	0.08	8	9,932	0.19
2008	34	102,007	0.31	2	1,053	0.28	9	13,404	0.18

* 0.74% if one high mortality voyage is excluded

† 0.20% if one high mortality voyage is excluded

4.2.3.4 Ship

The voyages of each ship from Australia to the Middle East were classified into the following mortality categories: nil (no mortalities reported); low (mortality rate up to 0.5%); medium (mortality rate from 0.5 to 1.0%); and high (mortality 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 12 shows the number of voyages in the various mortality categories for each ship. Nearly all voyages (93%) were in the nil or low categories. There were three voyages in the medium categories involving ships 33 and 34.

Table 12 Number of voyages in nil, low, medium and high mortality categories for shipments to the Middle East for 2008

Ship (code)	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
32	4	2	0	0	6
33	0	6	2	0	8
34	4	2	1	0	7
35	3	4	0	0	7
38	4	4	0	0	8
41	3	2	0	0	5
59	1	0	0	0	1
77	0	1	0	0	1
120	0	2	0	0	2
121	0	1	0	0	1
Total	19	24	3	0	46

4.2.3.5 Class of cattle

In 2008, the highest mortality rates occurred in beef cows (0.88%) followed by adult steers (0.52%) and beef heifers (0.47%; Table 13). There were 6,947 cattle on three voyages that could not be identified to class, and this group experienced a mortality rate of 0.06%.

Table 13 Mortality rates, number of voyages and number of cattle in various classes exported to the Middle East in 2008

Class	Voyages (No.)	Cattle (No.)	Mortality rate (%)	Mortality rate range (%)
Steer adult*	14	9,925	0.52	0.0 – 0.8
Bull adult*	33	88,714	0.27	0.0 – 0.8
Bull calf	1	4,221	0.33	n/a
Cow beef	2	457	0.88	0.0 – 0.9
Cow dairy	7	2,367	0.30	0.0 – 1.6
Heifer beef	6	4,079	0.47	0.0 – 0.9
Heifer dairy	6	3,412	0.09	n/a

* includes immature and mature animals (ie animals not classified as "calf")

4.2.4 South-East Asia

Approximately 0.68 million cattle were exported to South-East Asia in 2008 (Table 14). The mortality rate remained at 0.09% while the number of voyages to the region increased by 7%. No mortalities were reported on 42% of the voyages to the region. The mortality rate has remained below 0.1% since 2001.

Table 14 Mortality rates, number of voyages and number of cattle exported to South-East Asia from 1995 to 2008

Year	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyages with nil mortalities (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	217	465,498	0.05	0.0 – 1.8	118
2005	169	403,819	0.09	0.0 – 0.8	73
2006	166	452,516	0.09	0.0 – 1.0	66
2007	205	573,729	0.09	0.0 – 4.0	92
2008	219	682,265	0.09	0.0 – 1.9	93

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

4.2.4.1 Port of loading

Most cattle exported to South-East Asia in 2008 were loaded at Darwin (53%) followed by Broome (12%) and Townsville (11%, Table 15). The mortality rate was highest for cattle exported from Mourilyan.

The voyages from each port were classified into various mortality categories as shown in Table 16. All except four voyages were in the nil or low categories. There were two voyages in the high category involving the ports of Geraldton and Darwin.

Table 15 Mortality rates, number of voyages and number of cattle exported from various ports to South-East Asia in 2008

Port	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)
Townsville	5	75,873	0.10	0.0 – 0.1
Mourilyan	5	6,815	0.20	0.0 – 0.6
Karumba	7	10,489	0.04	0.0 – 0.1
Darwin*	97	348,762	0.10	0.0 – 1.1
Wyndham	21	51,866	0.05	0.0 – 0.2
Broome	36	80,900	0.06	0.0 – 0.3
Port Hedland	8	15,892	0.08	0.0 – 0.3
Geraldton	18	35,627	0.08	0.0 – 1.9
Fremantle*	21	37,128	0.15	0.0 – 0.8

* Note - one split-loaded voyage excluded: mortalities could not be determined by consignment (port of loading). Total mortality for this voyage was 0.20%

Table 16 Number of voyages in nil, low, medium and high mortality categories for shipments from various ports to South-East Asia for 2008

Port	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
Townsville	0	5	0	0	5
Mourilyan	1	3	1	0	5
Karumba	5	2	0	0	7
Darwin*	40	56	0	1	97
Wyndham	9	12	0	0	21
Broome	15	21	0	0	36
Port Hedland	4	4	0	0	8
Geraldton	9	8	0	1	18
Fremantle*	10	10	1	0	21
Total	93	121	2	2	218

* Note - one split-loaded voyage excluded: mortalities could not be determined by consignment (port of loading).

4.2.4.2 Time of year

Monthly mortality rates (total mortality as a proportion of total loaded for each month) for voyages to South-East Asia in 2008 were about 0.1% throughout the year except for February (Figure 13), and were similar to the 5-year average. Of fourteen voyages undertaken in February 2008, four voyages were above 0.4%, and contributed the bulk of the mortalities in the “peak” that month.

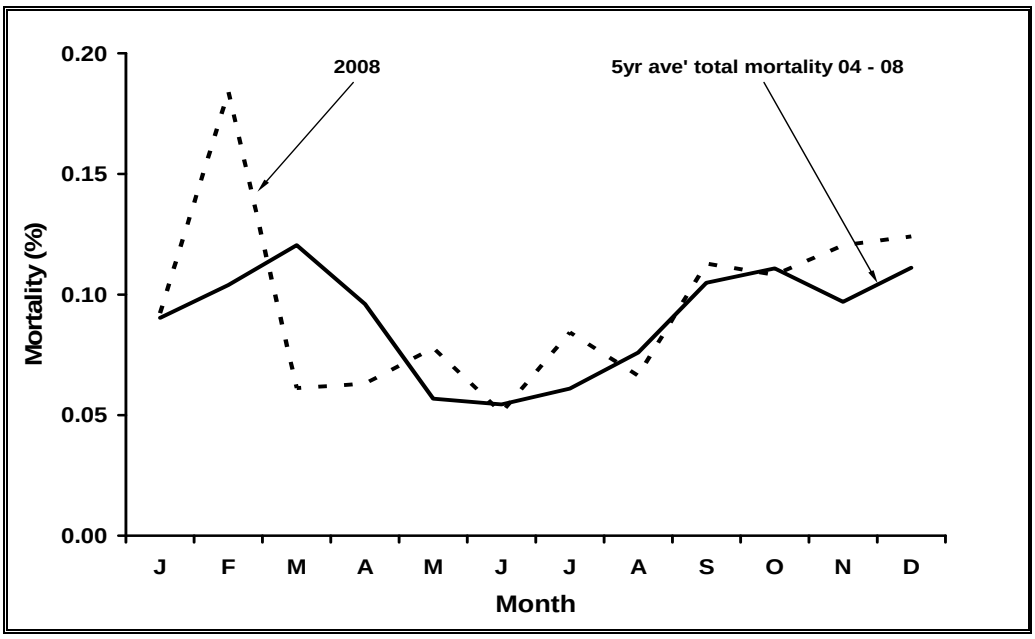

Figure 13 *Monthly mortality rates of cattle on voyages from all ports to South-East Asia for 2008 and the 5-year monthly rates for the period 2004 to 2008*

4.2.4.3 Ship

The voyages of each ship from Australia to South-East Asia were classified into various mortality categories as shown in Table 17. Nearly all (98%) voyages were in the nil or low mortality categories; two voyages in the high category involved ships 115 and 119.

Table 17 Number of voyages in nil, low, medium and high mortality categories for shipments to South-East Asia for 2008

Ship (code)	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
33	0	2	0	0	2
35	0	2	0	0	2
37	0	9	0	0	9
38	1	1	0	0	2
41	0	8	0	0	8
59	1	6	0	0	7
78	3	1	0	0	4
88	14	5	0	0	19
90	7	8	1	0	16
95	7	8	0	0	15
109	9	12	0	0	21
112	13	8	0	0	21
113	13	9	1	0	23
114	9	11	0	0	20
115	1	1	0	1	3
117	10	16	0	0	26
119	1	6	0	1	8
120	3	7	0	0	10
121	1	2	0	0	3
Total	93	122	2	2	219

4.2.4.4 Class of cattle

Most cattle exported to South-East Asia in 2008 could not be identified by class. Of those reported, the highest mortality rates occurred in beef cows (0.33%) followed by adult bulls (0.26%; Table 18).

Table 18 Mortality rates, number of voyages and number of cattle in various classes exported to the South-East Asia in 2008

Class	Voyages (No.)	Cattle (No.)	Mortality rate (%)	Mortality rate range (%)
Steer adult*	27	164,649	0.08	0.0 – 0.3
Bull adult*	25	18,360	0.26	0.0 – 3.0
Bull calf	4	2,716	0.22	0.0 – 0.8
Cow beef	20	18,402	0.33	0.0 – 2.7
Heifer beef	25	51,947	0.07	0.0 – 0.6
Heifer dairy	1	4,274	0.00	n/a

* includes immature and mature animals (ie animals not classified as "calf")

4.2.5 North-East Asia

The number of cattle exported to North-East Asia has continued to decrease since 2004. Live cattle exports fell by 14% in 2008 compared to 2007 (Table 19). Mortalities remained at the record low of 0.06% achieved in 2007. Prior to this the mortality rate has remained relatively constant for six years at about 0.1%.

Table 19 Mortality rates, number of voyages and number of cattle exported to North-East Asia from 1995 to 2008

Year	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyages with nil mortalities (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	50	95,534	0.10	0.0 - 0.8	12
2005	37	52,565	0.09	0.0 – 0.4	14
2006	26	37,963	0.12	0.0 – 1.3	11
2007	21	34,837	0.06	0.0 – 0.2	10
2008	19	29,873	0.06	0.0 – 0.4	10

4.2.5.1 Port of loading

Cattle were exported to North-East Asia mainly from Brisbane followed by Portland (Table 20). All cattle loaded at Brisbane were exported to Japan while those loaded at other ports were exported mainly to China. Two consignments went to Eastern Russia.

The voyages from each port were classified into various mortality categories as shown in Table 21 All voyages were in the nil or low categories.

Table 20 Mortality rates, number of voyages and number of cattle exported from various ports to North-East Asia for 2008

Port	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)
Fremantle	1	277	0.36	n/a
Portland	5	10,527	0.09	0.0 - 0.2
Brisbane	13	19,069	0.03	0.0 - 0.2

Table 21 Number of voyages in nil, low, medium and high mortality categories for shipments from various ports to South-East Asia for 2008

Port	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
Fremantle	0	1	0	0	1
Portland	1	4	0	0	5
Brisbane	9	4	0	0	13
Total	10	9	0	0	19

4.2.5.2 Time of year

Monthly mortality rates (total mortality as a proportion of total loaded for each month) for voyages to North-East Asia in 2008 were below 0.2% throughout the year except for June (Figure 14), and were similar to the 5-year average. The “peak” in June was the result of one mortality in a consignment of 277 cattle.

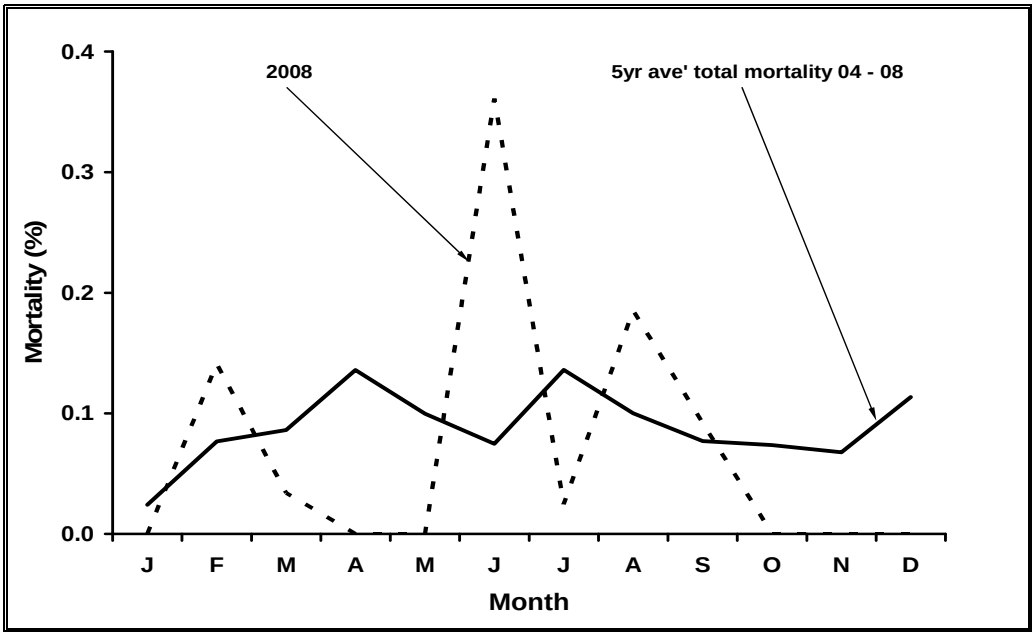

Figure 14 *Monthly mortality rates of cattle on voyages from all ports to North-East Asia for 2008 and the 5-year monthly rates for the period 2004 to 2008*

4.2.5.3 Ship

The voyages of each ship taking cattle 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 categories.

Table 22 Number of voyages in nil, low, medium and high mortality categories for shipments to North-East Asia for 2008

Ship (code)	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
59	1	1	0	0	2
87	8	3	0	0	11
95	0	2	0	0	2
119	1	3	0	0	4
Total	10	9	0	0	19

4.2.5.4 Class of cattle

Mortality rates for each class of cattle exported to North-East Asia during 2008 are presented in Table 23. The North-East Asian cattle trade comprised mainly steers exported to Japan and dairy heifers exported to China and Eastern Russia.

In 2008 the highest mortality rates occurred in dairy heifers (0.10%).

Table 23 Mortality rate, number of voyages and number of cattle in the classes exported to North-East Asia in 2008

Class	Voyages (No.)	Cattle (No.)	Mortality rate (%)	Mortality rate range (%)
Steer adult	13	18,612	0.03	0.0 - 0.2
Bull adult	1	32	0.00	n/a
Heifer beef	1	457	0.00	n/a
Heifer dairy	6	10,772	0.10	0.0 - 0.4

4.2.6 Mexico

The number of cattle exported to Mexico in 2008 fell by half while the mortality fell substantially (to 0.07%) when compared to 2007 (Table 24). Mortality rates have remained below 0.5% since 2001, with the exception of 2002. The majority of the cattle exported to Mexico in 2008 were dairy heifers.

Table 24 Mortality rates, number of voyages and number of cattle exported to Mexico from 1995 to 2008

Year	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyages with nil mortalities (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	20,478	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
2006	7	11,292	0.21	0.0 – 0.5	2
2007	7	21,719	0.23	0.1 – 0.4	0
2008	3	10,122	0.07	0.0 – 0.1	1

4.2.6.1 Port of loading

The majority of cattle exported to Mexico were loaded at Portland (Table 25).

Table 25 Mortality rate, number of voyages and number of cattle exported from various ports to Mexico in 2008

Port	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)
Portland	2	9,988	0.07	0.1 - 0.1
Fremantle	1	134	0.00	n/a

4.2.6.2 Ship

The voyages of each ship carrying cattle from Australia to Mexico were classified into various mortality categories as shown in Table 26. All voyages were in the nil or low mortality categories.

Table 26 Voyage numbers in nil, low, medium and high mortality categories for shipments to Mexico in 2008

	Mortality rate				
Ship (code)	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	Total
37	0	1	0	0	1
121	1	1	0	0	2
Total	1	2	0	0	3

4.2.6.3 Class of cattle

Mortality rates for the two classes of cattle exported to Mexico during 2008 are presented in Table 27. There were no deaths among the eight bulls exported.

Table 27 Mortality rate, number of voyages and number of cattle in the classes exported to Mexico in 2008

Class	Voyages (No.)	Cattle (No.)	Mortality rate (%)	Mortality rate range (%)
Bull adult	1	8	0.00	n/a
Heifer dairy	3	10,114	0.07	0.0 - 0.8

4.3 Goats

4.3.1 Performance trend

Figures 15 and 16 show the number of goats exported and the mortality rates during sea transport from all ports in Australia to all destinations since 1993 as well as the trendline (linear regression) across the years. The number of goats exported annually has varied between approximately 3,000 and 114,000, and the annual mortality has varied between 0.38 and 2.69%. The trend for the number of goats exported has been upward whereas the trend for annual mortality has been downward, with a greater decline for annual mortality.

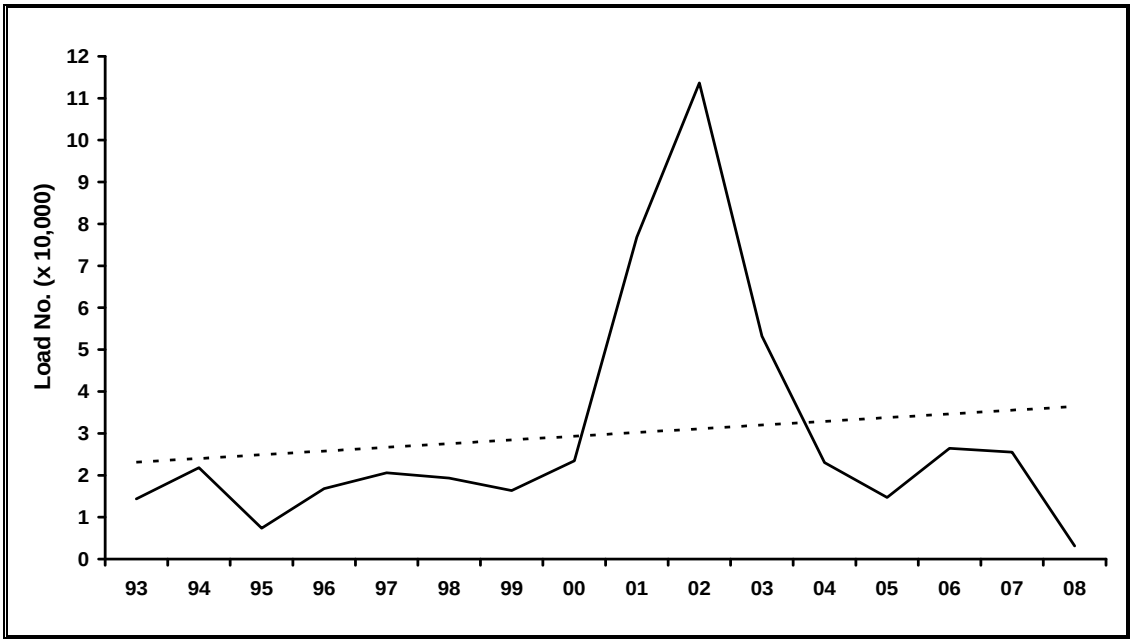

Figure 15 *Number of goats exported by sea from Australia to all destinations since 1993*

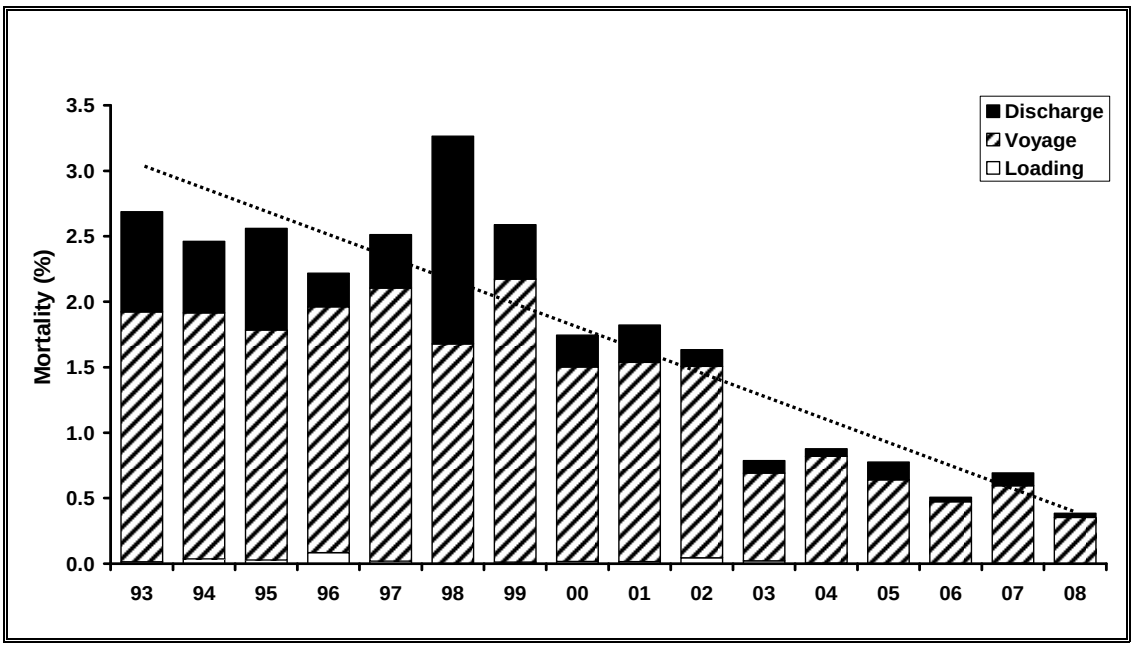

Figure 16 *Annual mortality of goats exported by sea from Australia to all destinations since 1993*

Overview

All goats exported by sea from Australia in 2008 were sent to South-East Asia. The overall mortality rate among the 3,180 goats was 0.50% (Table 28). This was lower than the mortality rate of 0.69% for 2007 (Table 29).

Table 28 Mortality rates, number of voyages and number of goats exported by sea during 2008

Parameter	SE Asia
Voyages (No.)	8
Goats (No.)	3,180
Mortality rate overall (%)	0.50
Mortality rate range (%)	0.0 – 2.9

4.3.2 South-East Asia

The number of goats exported by sea to South-East Asia peaked in 2002, but has fallen substantially since then (Table 29). The mortality rate in 2008 rose to 0.50% from 0.35% in 2007.

Table 29 Mortality rates, number of voyages and number of goats exported by sea to South-East Asia from 1993 to 2008

Year	Voyages (No.)	Goats (No.)	Mortality rate overall (%)	Mortality 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
2006	25	25,353	0.49	0.0 – 3.0
2007	21	21,204	0.35	0.0 – 1.1
2008	8	3,180	0.50	0.0 – 2.9

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

4.3.2.1 Port of loading

For voyages to South-East Asia in 2008, most goats were exported from Darwin, followed by Fremantle (Table 30). Mortality rates were higher from Fremantle.

The voyages from each port were classified into various mortality categories as shown in Table 31. Most (75%) voyages were in the low category. There was one voyage in each of the medium and high categories during 2008, both voyages originating from Fremantle.

Table 30 Mortality rates, number of voyages and number of goats exported from various ports to South-East Asia for 2008

Port	Voyages (No.)	Goats (No.)	Mortality rate overall (%)	Mortality rate range (%)
Darwin	3	1,817	0.11	0.0 – 0.2
Fremantle	5	1,363	1.03	0.0 – 2.9

Table 31 Number of voyages in low, medium and high mortality categories for shipments of goats from various ports to South-East Asia for 2008

Port	Mortality rate			Total
	Low <1.0%	Medium 1.0–2.0%	High >2.0%	
Darwin	3	0	0	3
Fremantle	3	1	1	5
Total	6	1	1	8

4.3.2.2 Ship

The voyages of each ship from Australia to South-East Asia were classified into low, medium and high mortality categories. There were no split voyages (loaded at two or more ports) involving goats in 2008.

Table 32 shows the number of voyages in the various mortality categories for each ship. Nearly all voyages were in the low category. There was one voyage in the high category during 2008.

Table 32 Number of voyages in low, medium and high mortality categories for shipments of goats to South-East Asia for 2008

Ship (code)	Mortality rate			Total
	Low <1.0%	Medium 1.0–2.0%	High >2.0%	
88	1	0	0	1
109	0	0	1	1
112	1	0	0	1
113	1	0	0	1
114	2	1	0	3
119	1	0	0	1
Total	6	1	1	8

5 Appendices

5.1 Appendix 1 - Sheep and cattle mortalities: research summary

To assist with interpretation of the results for sheep, the main findings from research conducted into the causes of mortality and the risk factors for sheep exported from Western Australia to the Middle East are summarised 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 mortality 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 mortalities during sea transport were inanition and salmonellosis (Richards *et al* 1989). These two causes accounted for about 75% of all mortalities aboard ship. The most important risk factors for sheep mortalities 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).

Mortality rates during the shipping phase varied widely between farm groups of sheep, with high mortality 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 mortality rates ranged from nil to 28% with half of all mortalities in only 14% of the farm groups. There were higher mortalities 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). Mortality 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 mortalities during the second half of the calendar year than in the first half.

Richards *et al* (1991) and Higgs *et al* (1991) postulated 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 mortality.

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 mortalities 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 mortalities were heat stroke, trauma and respiratory disease (Norris *et al* 2003). All of the mortalities 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 mortality 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.

5.2 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

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

Beatty, DT, Barnes, A, Taplin, R, McCarthy, M and Maloney, SK (2007) Electrolyte supplementation of live export cattle to the Middle East Aust J Exp Agric **47:** 119-124

5.3 Appendix 3 - Acknowledgements

The cooperation of ships' officers in recording details of daily mortalities is gratefully acknowledged.

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