liveexport

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Mortality and morbidity risk factors for livestock during sea transport from Australia

Department of Agriculture
Government of Western Australia

Final Report prepared for MLA and Livecorp
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INTRODUCTION

Recent mortality events have highlighted the fact that compliance with the Australian Live Export Standards (ALES) within the Livestock Export Accreditation Program does not prevent the occurrence of such events. The structure of ALES and its implementation are to be reviewed and modified to ensure that compliance with the standards will deliver the animal welfare outcomes required. The review will recommend changes in line with a risk management approach. As part of this review, the Western Australian Department of Agriculture was invited to analyse existing mortality reports with a view to identifying the risk factors for mortality and morbidity of livestock during export.

Although industry mortality records are a useful source of information about risk factors, there are limits to the analysis that can be conducted. This is because information on some factors is not recorded (wind speed/direction, property of origin) or is not available in sufficient detail for analysis (temperature recorded only once daily) or there are gaps in the data (infrequent voyages from some loading ports). Mortality records during the shipping phase provide no information about the previous history and management of the livestock before loading onto the ship. Nevertheless, analysis of industry mortality records is an important step in identifying leads for further investigation.

Research into the live sheep trade has involved analysis of industry mortality records together with other techniques such as observational studies and experiments. These studies frequently started at the farm level and required examination of the sheep during lot-feeding and sea voyages. The research into the live sheep trade has been well documented in the scientific literature. Brief reference to the scientific findings about a particular risk factor is made in the present report where appropriate, and the reader is referred to the relevant paper/s for further information. Research into the causes of death of sheep, cattle and goats during sea transport from Australia has been based on epidemiological principles. The reader is referred to textbooks such as Martin, Meek and Willeburg (1987) or Thrusfield (1986) for an explanation of epidemiological principles and methods.

METHODS

The report used the following sources of information:

- Ship Master's reports. The current Master's report contains information about the name of the ship, loading and unloading ports, dates that loading/unloading began and finished, species and number of livestock loaded, total daily deaths by livestock species, temperature and relative humidity recorded at noon in the livestock house, and wind speed and direction at the ship's bridge.
- Yellow books. The yellow book contains information about the species and number of livestock loaded according to class (age-sex-breed categories), number of daily deaths by class and location aboard ship (deck and upper/lower tier within deck) from loading to unloading. This information is available for sheep and to a lesser degree cattle and goats on voyages to the Middle East and some other long haul voyages but not for voyages to south east Asia.
- Technical and scientific reports. For cattle, the Department of Agriculture conducted 4 research voyages from different ports in Australia to the Middle East between 1998 and 2001. A technical report was completed for each voyage and the results, together with analysis of industry mortality records, were collated in a scientific paper. For sheep, the Department conducted a substantial research program in the 1980s and early 1990s to determine the causes of deaths and the risk factors. The main findings have been published in refereed scientific papers and summarised in a booklet (Norris et al 1990a). For goats, the Department conducted a limited investigation in the early 1990s into the causes of deaths and risk factors on voyages to the Middle East and Malaysia.
- Past incident reports. The Department obtained reports from LiveCorp and AQIS relating to past incidents.

SHEEP

Overview

The live sheep trade from Australia involves 3 main ports of loading and virtually all sheep are exported to the Middle East. Most sheep deaths involve failure to eat the pelleted feed. This is an important difference from the live cattle trade where most cattle deaths are related to the hot humid conditions encountered during shipping. Considerable research has been undertaken into the causes of sheep deaths and the risk factors. The findings have been published in the scientific literature over the years and the key papers are listed in the Reference section of this report. An overview of the findings is

described in Norris et al (1990a) and is strongly recommended for those without the time to study the scientific papers.

Middle East

Causes of death

The causes of death in sheep during lot-feeding and shipping were described by Richards et al (1989). The main causes of death during lot-feeding were salmonellosis and miscellaneous diseases (commonly seen on farms). The main causes of death during shipping involving defined populations on 5 voyages were inanition and salmonellosis; the remaining deaths involved trauma and miscellaneous diseases. When these results were combined with subsequent research voyages, it was shown that approximately half of the deaths during shipping were from inanition and 25% were from salmonellosis. Heat stroke was not considered a significant cause of death during shipping (Richards et al 1989, Norris and Richards 1989).

Ship

The voyages of each ship since 1997 were classified into low, medium and high mortality categories for all sheep loaded at Fremantle, Adelaide or Portland (Table 1). Several ships have been scrapped in recent years and new ships have entered the trade. Consequently, the analysis was restricted to the years 1997 to 2002 inclusive. Approximately 12% of all voyages were in the high mortality category. Ships 2, 22 and 34 had 25% or more voyages in the high category whereas ships 37 and 74 had 75% or more voyages in the low category.

Table 1 Number of voyages in low (<1.0%), medium (1.0-2.0%) and high (>2.0%) mortality categories for ships loaded at Fremantle, Adelaide or Portland from 1997 to 2002

Ship	Mortality category						Total
	Low		Medium		High		
(code)	No	%	No	%	No	%	
37	7	78	1	11	1	11	9
74	3	75	1	25	0	0	4
20	25	74	9	26	0	0	34
30	26	72	10	28	0	0	36
31	27	68	13	33	0	0	40
36	2	67	1	33	0	0	3
35	13	62	8	38	0	0	21
7	33	61	15	28	6	11	54
1	30	56	20	37	4	7	54
99	7	54	6	46	0	0	13
33	18	47	18	47	2	5	38
93	9	47	10	53	0	0	19
13	21	38	23	42	11	20	55
34	10	36	9	32	9	32	28
27	14	30	30	65	2	4	46
2	15	29	23	44	14	27	52
32	16	28	34	59	8	14	58
22	12	27	19	42	14	31	45
23	1	20	3	60	1	20	5
9	2	15	10	77	1	8	13
Total	291	46	263	42	73	12	627

Port of loading

The shipboard part of the export process was divided into three phases: loading; voyage to the first port of unloading; and discharge (Norris and Richards 1989). 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 were included in the discharge phase.

The total death rate for shipments from Fremantle was lower in 2002 compared to previous years and was due to reduced death rates during the voyage and discharge phases (Table 2). The death rates for

sheep exported from Fremantle in 2002 were the lowest recorded since the start of the mortality surveillance system in 1985 (Figure 1).

The total death rates for shipments from Portland were higher in 2001 and 2002 compared to previous years. The increase was due to increased death rates during the loading and voyage phases.

The Relative Risk of death on voyages from Portland compared to Fremantle was 1.4 (1.4 –1.4) in 2000, 2.2 (2.2-2.2) in 2001 and 2.4 (2.3-2.4) in 2002 while the relative risk of death on voyages from Adelaide compared to Fremantle was 1.1 (1.1-1.2, 95% CI) in 2000, 1.5 (1.5-1.6) in 2001 and 1.5 (1.5-1.5) in 2002.

Table 2 Annual death rates during the shipboard phase for sheep exported from Fremantle, Adelaide and Portland

	Mortality rate (%)			
	Load	Voyage	Discharge	Total
Fremantle				
2000	0.01	0.74	0.47	1.23
2001	0.01	0.65	0.29	0.96
2002	0.01	0.61	0.26	0.88
Adelaide				
2000	0.01	1.05	0.35	1.41
2001	0.03	1.11	0.35	1.48
2002	0.01	1.01	0.30	1.32
Portland				
2000	0.01	1.18	0.53	1.73
2001	0.04	1.36	0.71	2.10
2002	0.01	1.27	0.82	2.09
Total				
2000	0.01	0.82	0.48	1.31
2001	0.02	0.87	0.38	1.26
2002	0.01	0.84	0.39	1.24

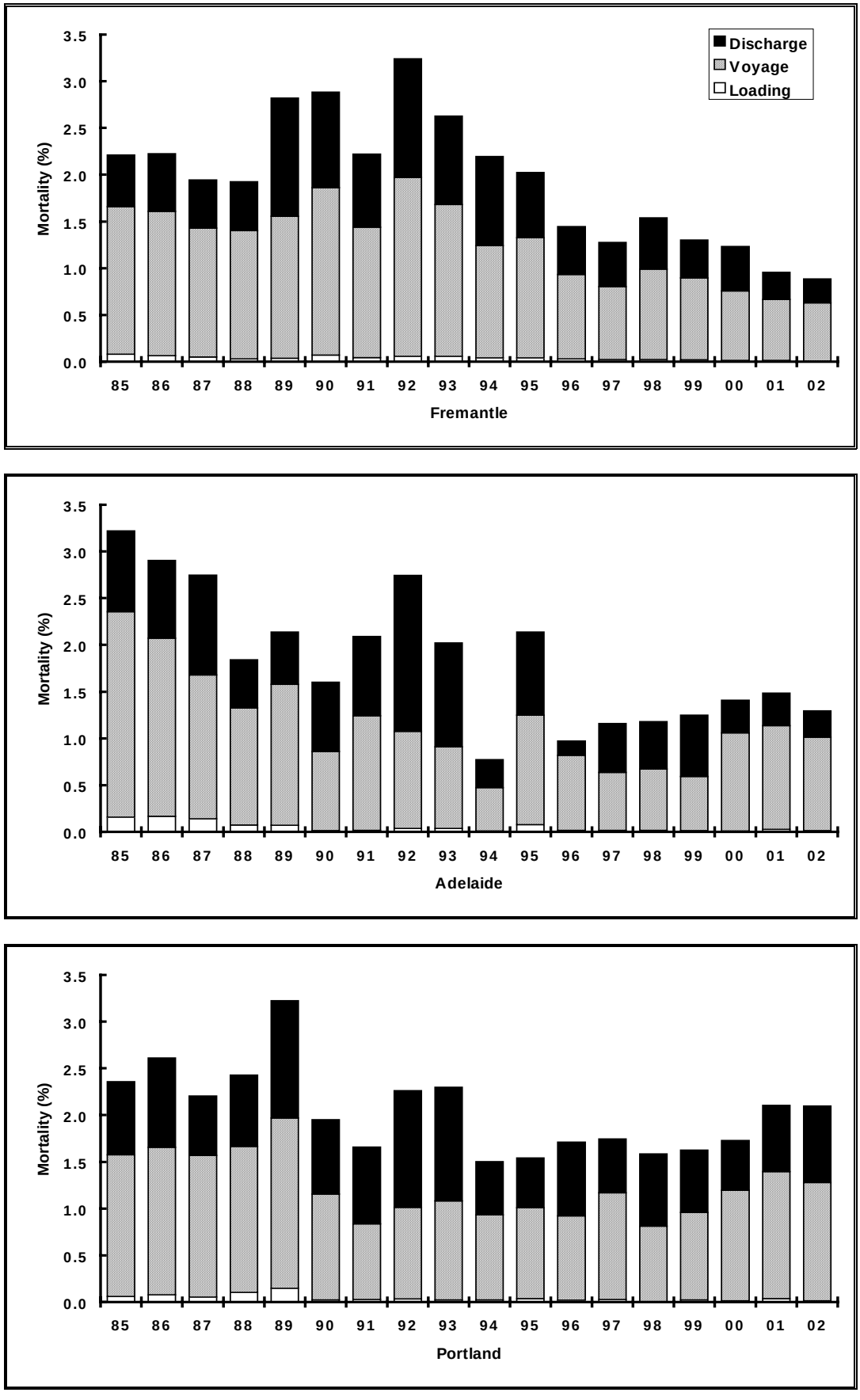

Figure 1 *Annual mortality of sheep exported from Fremantle, Adelaide and Portland to the Middle East since 1985*

Time of year

Death rates in sheep exported from Fremantle have been consistently higher in the second half of the year than the first half since 1985 (Figure 2). Norris and Richards (1989) demonstrated that there was a seasonal difference in death rates. Higgs et al (1991) confirmed this observation and explained how season, together with age and fatness, contributed to mortalities during shipping. Richards et al (1991) demonstrated differences in the metabolic profile of sheep exported in the first half of the year compared to the second half of the year.

The seasonal difference is evident in both voyage and discharge mortality, and the difference was more pronounced in the early 1990s. Research on ships and in Middle East feedlots has indicated that failure to eat is the main cause of death in these phases of the export process (Richards et al 1989, Brightling and Lightfoot 1994).

There was also evidence of increased death rates in the second half of the year on voyages from Adelaide and Portland, although the trend was not as consistent as on voyages from Fremantle (see Attachment 1). This suggests that the seasonal cycles that affect death rates from Fremantle (Higgs et al 1991, Richards et al 1991) also occur on voyages from Adelaide and Portland.

The Relative Risk of death (and 95% confidence intervals) on voyages in the second half of the year compared to the first half in 1998, 2000 and 2002 from Fremantle were 1.77 (1.74-1.80), 1.32 (1.30-1.35) and 1.30 (1.27-1.33), from Adelaide were 1.10 (1.03-1.19), 0.78 (0.74-0.83) and 1.19 (1.15-1.23) and from Portland were 1.93 (1.86-2.01), 2.47 (2.38-2.56) and 3.08 (3.01-3.16).

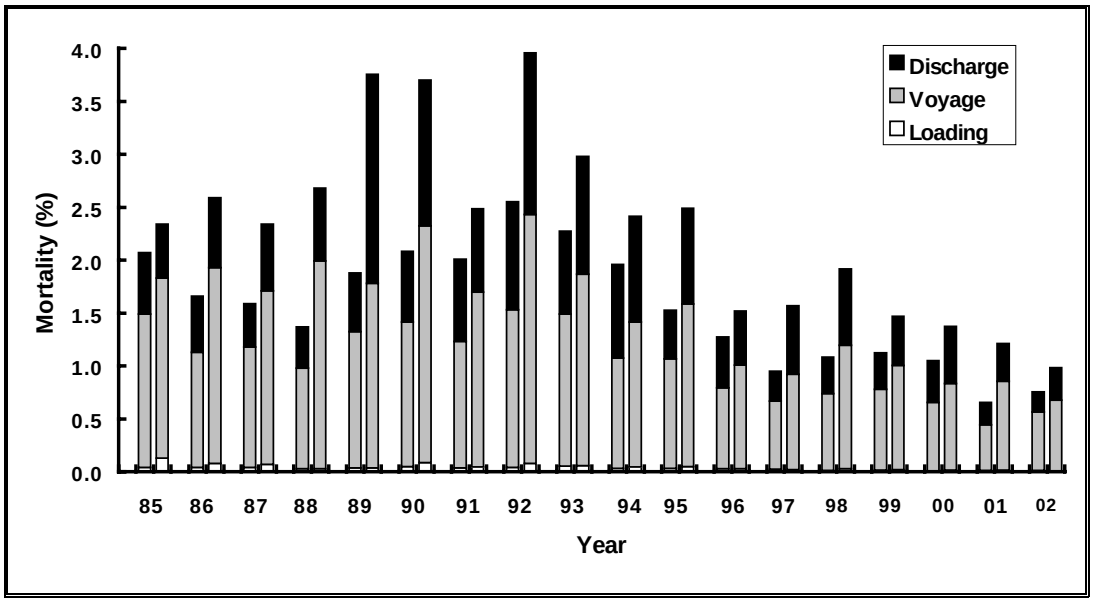

Figure 2 *Mortality (%) for sheep exported by sea from Fremantle to the Middle East for the first and second half of each year from 1985 to 2002*

The monthly death rate during 2002 and moving 5-year average (1998-2002) in all sheep exported from Fremantle, Adelaide and Portland are shown in Figure 3a, 3b and 3c respectively. There was a trend for higher death rates from Portland in July and August 2002, and this was also apparent in the 5-year average. Investigations indicate that salmonellosis was involved in the extra deaths from Portland in these months.

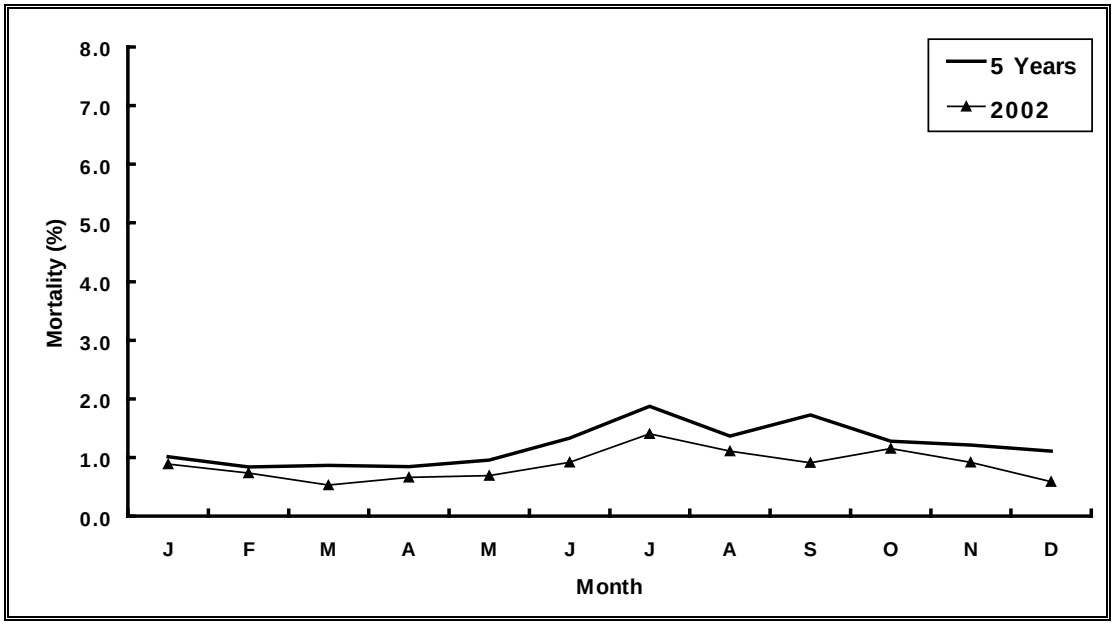

Figure 3a *Monthly mortality during 2002 and moving 5-year average in sheep exported from Fremantle to the Middle East*

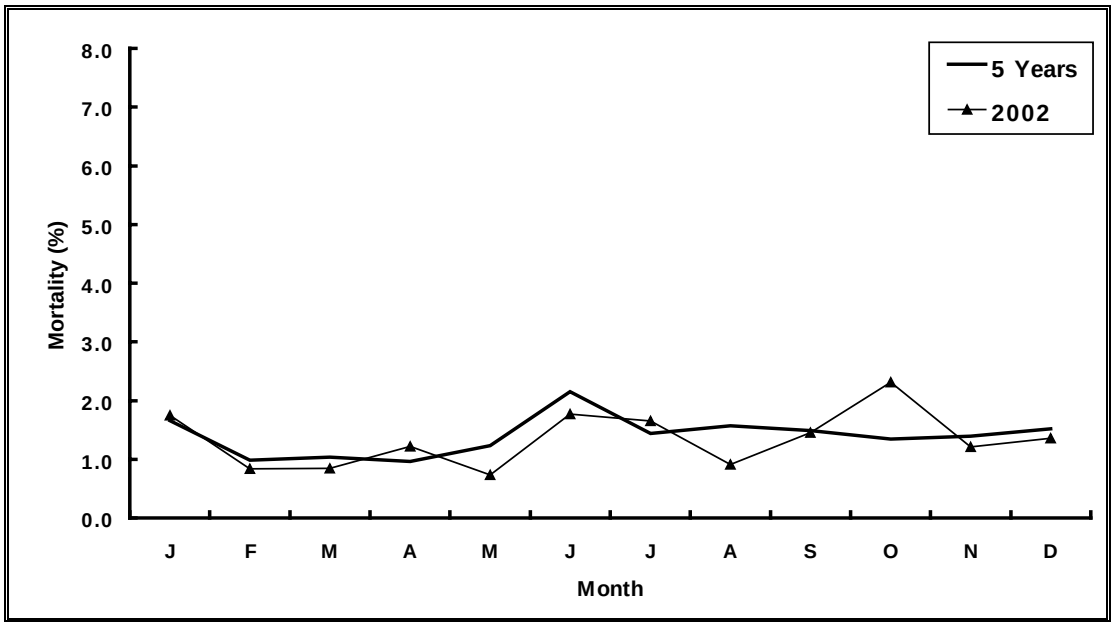

Figure 3b *Monthly mortality during 2002 and moving 5-year average in sheep exported from Adelaide to the Middle East*

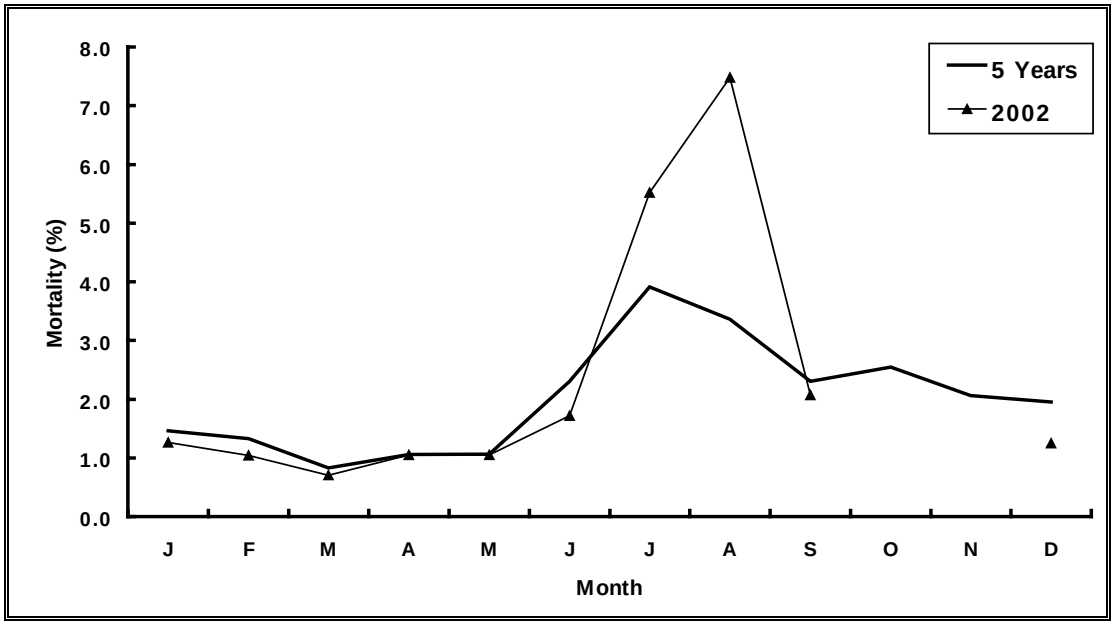

Figure 3c *Monthly mortality during 2002 and moving 5-year average in sheep exported from Portland to the Middle East*

Class of sheep

The death rates of different classes (age-sex categories) of sheep on voyages from Fremantle, Adelaide and Portland from 1997 to 2002 are shown in Table 3 (more detailed information is shown in Attachment 2). See Higgs et al (1991) and the section below on seasonal cycles for an explanation of the reason for differences in mortality according to age.

Table 3 Death rates (%) of different classes of sheep exported from Fremantle, Adelaide and Portland from 1997 to 2002

Class of sheep		Fremantle		Adelaide		Portland	
		mean	sem*	mean	sem	mean	sem
Wethers	adult	1.4	0.1	1.3	0.1	1.9	0.1
	hogget	0.9	0.1	0.9	0.2	1.0	0.2
	lamb	1.0	0.0	1.5	0.1	1.9	0.
Rams	adult	1.7	0.2	1.4	0.1	2.9	0.5
	hogget	1.1	0.1	0.6	0.2	n/a	n/a
	lamb	1.0	0.1	1.6	0.2	7.1	3.6
Ewes	adult	1.3	0.1	1.0	0.6	1.4	0.2
	hogget	1.3	0.7	n/a	n/a	n/a	n/a
	lamb	0.8	0.1	1.6	0.7	0.8	0.31

n/a not applicable
* standard error of mean

Failure to eat

Research has shown that failure to eat predisposes sheep to death from inanition and from salmonellosis during shipping (Norris et al 1989b); the Relative Risk and 95% confidence limits of death from inanition was 6.9 (3.5, 13.7) and from salmonellosis was 5.9 (3.0, 11.5). However, it should be noted that most non-feeders begin eating within the first few days of loading onto the ship (Norris et al 1989b, Norris et al 1990b, Norris et al 1992) and that there is no practical way to accurately identify sheep that do not eat during lot-feeding.

Sheep that had not eaten in the feedlot were identified for special management during actual or simulated shipping. In one study, Norris et al (1990b) found that provision of extra feed trough space or *ad lib* feeding did not increase the proportion of sheep that ate during simulated shipping compared to controls. In the second study, Norris et al (1990b) found that separation of feedlot non-feeders during actual shipping did not reduce the number of non-feeders or death rate during the voyage compared to controls.

Seasonal cycles

Research has shown that death rates are higher in adult wethers in fat condition exported during the second half of the year and, conversely, death rates are lower in adult wethers in lean condition exported during the first half of the year (Higgs et al 1991, Richards et al 1991). The reason 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. Any sheep which is not eating during the export process therefore has a better chance of survival. 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 (see Higgs et al 1991, Richards et al 1991 and Norris et al 1990a for further details).

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

Farm of origin

Death rates during the shipping phase vary 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 (Higgs et al 1999). There were more deaths in the zone of higher rainfall and longer pasture-growing season.

Although there has been some investigation into farm-of-origin factors, research has not identified the factors involved (see next section). Farm-of-origin factors are considered responsible for most of the variation in mortality during shipping.

Other pre-embarkation factors

Farm and transport

Factors for which no association (or no consistent association) with mortality was shown include: distance trucked from farm to 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, time of shearing and rainfall zone of the farm of origin (Norris et al 1989b). Logistic regression was used in these analyses. See Norris et al (1989b) for interpretation and qualification of these findings.

Feedlot

There was no difference in shipboard mortality between sheep previously lot-fed in sheds or paddocks during autumn and spring (Norris et al 1989b). There was no difference in the proportion of non-feeders or in body weights during simulated shipping between groups of sheep previously lot-fed for 3 days, 8 days or 13 days (Norris et al 1992).

Other shipping factors

Open and enclosed decks

Norris and Richards (1989) found that there were more deaths in enclosed decks than open decks in all voyages of one ship (ship 1) and most voyages of two other ships but there was no consistent pattern in the remaining six ships studied.

Comparison of death rate in open and enclosed decks was based on voyages of adult wethers from Fremantle to the first port of unloading in the Middle East from 1997 to 2002. The analysis was conducted on this data set to avoid confounding with port of loading, class of sheep, and management factors outside the control of the ship during the discharge phase. The number of voyages where the

death rates in open and enclosed decks were significantly different are shown for each ship in Table 4. For ships with more than 10 voyages, there was a trend for more deaths in enclosed decks than open decks on ships 1, 7, 30 and 34.

Table 4 The number of voyages where the death rate of adult wethers exported from Fremantle to the Middle East from 1997 to 2002 was higher in open decks (P < 0.05), not different, or higher in enclosed decks (P < 0.05)

Ship	Open > Enclosed		NS*		Enclosed > Open		Total
(code)	No	%	No	%	No	%	
9	0	0	0	0	2	100	2
37	0	0	1	20	4	80	5
33	2	22	1	11	6	67	9
93	0	0	4	50	4	50	8
13	9	32	8	29	11	39	28
7	4	12	17	52	12	36	33
34	2	18	5	45	4	36	11
30	2	9	13	59	7	32	22
1	5	11	26	58	14	31	45
35	2	100	0	0	0	0	2
99	2	50	2	50	0	0	4
Total	28	17	77	46	64	37	169

* not significantly different

Upper and lower tiers

Comparison of death rate in upper and lower tiers was based on voyages of adult wethers from Fremantle to the first port of unloading in the Middle East from 1997 to 2002. The number of voyages where the death rates in upper and lower tiers were significantly different are shown for each ship in Table 5. Although there was a trend for more deaths in upper tiers than lower tiers, there was no difference in mortality between upper and lower tiers on the majority of voyages. For ships with more than 10 voyages, there was a trend for more deaths on upper tiers than lower tiers on ships 33, 30, 22 and 27.

Table 5 The number of voyages where the death rate of adult wethers exported from Fremantle to the Middle East from 1997 to 2002 was higher in upper tiers (P < 0.05), not different, or higher in lower tiers (P < 0.05)

Ship	Upper > Lower		NS		Lower > Upper		Total
(code)	No	%	No	%	No	%	
9	3	50	2	33	1	17	6
35	3	50	3	50	0	0	6
33	6	43	5	36	3	21	14
30	11	41	14	52	2	7	27
2	10	37	7	26	10	37	27
22	4	36	7	64	0	0	11
27	6	33	9	50	3	17	18
99	1	33	2	67	0	0	3
34	4	29	9	64	1	7	14
13	4	12	21	64	8	24	33
7	3	8	28	78	5	14	36
1	2	4	39	81	7	15	48
23	0	0	3	100	0	0	3
20	0	0	5	56	4	44	9
93	0	0	7	88	1	13	8
Total	57	22	161	61	45	17	263

The observations regarding more deaths in enclosed decks and/or upper tiers indicate that location on the ship is a risk factor, at least for some ships. For example, ship 30 showed a trend for more deaths on enclosed decks and on upper tiers. This may suggest that further investigation of the reasons is required. However, it should be noted that most voyages (72%) of ship 30 were below 1.0% and all were below

2.0% (Table 1). This suggests that there would be little reduction in overall mortality if research was successful in identifying and eliminating the factors responsible on ship 30.

Mortality profiles
Norris and Richards (1989) identified several different types of mortality profiles (number of deaths per 10,000 sheep loaded per day of voyage to first port); daily death rate peaked early in the voyage and then declined in 31% of voyages, increased steadily with day-of-voyage in 22%, was relatively constant at a high or low level in 41% or fluctuated markedly so the profile was a mixture of the other patterns. Point epidemics (mortality spike) were observed with death rates in six shipments exceeding 30 per 10,000 per day and returning to half that level within 1 or 2 days.

Temperature and relative humidity
Temperature and relative humidity are recorded daily in the livestock house and a single daily record is provided in the ship Master's report. There is no record of air flow in the livestock house. These parameters vary during the day and between different areas of the livestock house. Consequently, it was considered that there was no value in attempting to relate daily mortality to a single daily record of temperature and relative humidity as provided in the ship Master's report.

Incident reports
Voyage incident reports since June 2002, produced by AQIS, for voyages of the Cormo (July), Corriedale (July), Al Shuwaikh (July, September) and Al Messilah (August) were reviewed. The stated causes of death were failure to eat, salmonellosis and heat stroke, and the predisposing factors included preparation in open feedlots at Portland, hot humid weather and mechanical failure (in one case).

Ship vs sheep comparison
Providing that the voyage is "routine" (ie no mechanical failure, no extremes of weather), the evidence indicates that sheep factors (class, age, fatness, farm-of-origin, etc) have a greater influence on the voyage death rate than ship factors (deck, tier, pen, ventilation, etc). A "low" voyage death rate can be obtained by loading low risk sheep and a "high" voyage death rate can be obtained by loading high risk sheep, under similar environmental and management conditions on the same ship. Support for this statement is given in the following example.

In 1987 there were several shipments exclusively of wether hoggets to Algeria, in addition to routine shipments mainly of adult wethers to the Arabian Gulf. The death rates were consistently low (approximately 1%) on voyages to Algeria regardless of ship compared to relatively high death rates (above 2%) to the Arabian Gulf despite the longer voyages to Algeria (30 days vs 12-18 days).

The voyage mortality profile for 4 voyages of one ship in 1987 is shown in Figure 4. The death rates in hogget wethers shipped to Algeria were less than adult wethers shipped to the Arabian Gulf ($P < 0.001$), and a similar pattern was seen on other ships. There were no design changes to the ship between voyages, and shipboard environment and management factors were not considered sufficient to account for these results.

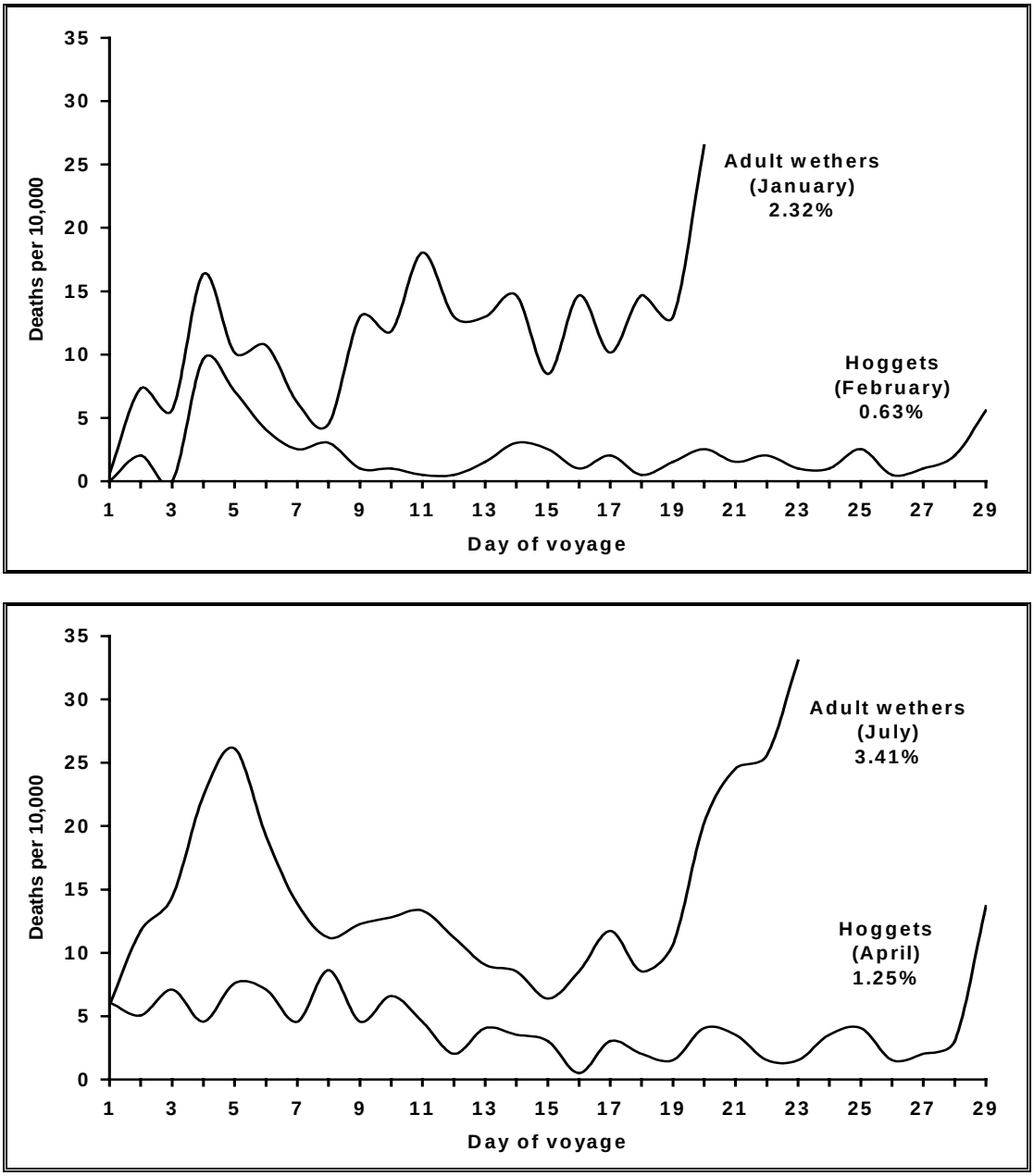

Figure 4 *Daily death rates to the first port of discharge on consecutive voyages of one ship in 1987*

Summary

- About 1.3% of sheep exported by sea from Australia die on the ship.
- The main causes of sheep deaths were inanition (failure to eat) and salmonellosis. These two causes accounted for about 75% of all deaths aboard ship.
- Death rates varied widely between farm groups of sheep and about half of all deaths were in only 14% of the farm groups.
- The most important risk factors for sheep deaths were failure to eat pelleted feed, farm-group of sheep, age, season of the year, fatness, duration between leaving the farm and unloading in the Middle East, and occasionally temperature and relative humidity.
- Although most sheep begin eating pelleted feed in the feedlot or aboard ship, a few become persistent non-feeders, and it is these animals that are most likely to die. Giving them abundant quantities of feed did not reduce the number of persistent non-feeders.
- Age, fatness and time of year predispose to mortality. These factors are related to the biological clock, present in all sheep, that governs a variety of functions such as appetite and metabolic rate.
- The annual death rate in recent years has been falling for shipments loaded at Fremantle and rising for shipments loaded at Portland.

CATTLE

Overview

Cattle are exported from Australia to many countries. For the purpose of this report, the countries were grouped as follows: the Middle East (including North Africa), south east Asia, north east Asia and Mexico. The causes of cattle deaths on voyages to the Middle East and the main predisposing factors have been described by Norris et al (2003). The main cause of death on voyages to the Middle East is heat stroke (hyperthermia), and is closely related to the inability of *Bos taurus* cattle particularly those from south eastern Australia to adapt to the hot humid conditions encountered aboard ships. In contrast, voyages to other regions have only occasionally been accompanied by a veterinarian and there has been no systematic investigation of the causes of death. Consequently, this report deals separately with the 4 main regions as shown in Table 6.

Exports to south east Asia were mainly to Indonesia and the Philippines and were characterised by small consignments on short voyages with very low death rates. Voyages to the Middle East, mainly Egypt, involved longer duration and higher death rates ($P < 0.05$, Chi-square test) than those to south east Asia. The longest voyages were to Mexico, and they had the highest overall death rate. Voyages to north east Asia were mainly to Japan.

Table 6 Number of voyages and cattle exported, death rates and voyage duration for shipments to major destination regions from 1995 to 2002

Factor	Middle East	SE Asia	NE Asia	Mexico	Total*
Voyages (No.)	643	2,891	86	32	3,671
Cattle (No.)	1,627,373	4,065,622	115,867	87,651	5,915,321
Death rate (%)	0.50	0.12	0.20	0.76	0.23
Relative risk	4.2	1	1.7	6.3	
Mean (SD) days of voyage	21.4 (4.7)	7.5 (2.2)	18.3 (3.0)	25.8 (4.9)	
Mean (SD) number of cattle per voyage	2530.9 (3026.1)	1406.3 (579.9)	1347.3 (274.9)	2739.1 (2945.9)	

* Includes shipments to all destinations.

Middle East

Recent exports

The live cattle trade to the Middle East expanded rapidly between 1995 and 1998, with the number of voyages and number of cattle exported doubling every year (Table 7). Despite the rapid expansion of the trade over this period, the death rate remained remarkably constant at approximately 0.7% annually before falling by half in 1999. The likely reasons for this reduction include increased exports from northern Australia relative to southern Australia from 1998 compared to earlier years, increased *Bos indicus* content of northern cattle, reduced death rates from southern Australia as well as other factors (see "Discussion" in Norris et al 2003).

Table 7 Death rates, number of voyages and number of cattle exported to the Middle East from 1995 to 2002

Year	Voyages (No.)	Cattle (No.)	Death rate (%)	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	118	262,432	0.69	0.0 – 41.5*	22
1999	113	316,964	0.35	0.0 – 3.3	26
2000	98	274,639	0.42	0.0 – 8.0	22
2001	101	287,447	0.33	0.0 – 5.0	27
2002	102	265,005	0.61	0.0 – 35.0*	33

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

Arabian Gulf vs Red Sea

Death rates for cattle exported to the Arabian Gulf were compared with those to the Red Sea, based on voyages from southern Australia. The years 1999 to 2002 were selected because of a change in livestock density following a high mortality incident in June 1998. Death rates for cattle exported from Fremantle, Adelaide or Portland were not different between the Arabian Gulf and the Red Sea in 1999 or 2000 (Table 8) but there was a significantly higher death rate to the Arabian Gulf than the Red Sea in 2001 and 2002 ($P < 0.01$, Chi-square test). However, the death rate was lower to the Arabian Gulf than to the Red Sea in 2002 ($P < 0.01$) if one high mortality incident is excluded.

Table 8 Death rates for cattle exported to the Arabian Gulf or Red Sea from Fremantle, Adelaide or Portland between 1999 and 2002

	Arabian Gulf			Red Sea		
Year	Voys (No.)	Cattle (No.)	Dead (%)	Voys (No.)	Cattle (No.)	Dead (%)
1999	15	1,686	0.30	51	185,045	0.49
2000	18	1,786	0.67	45	152,338	0.61
2001	25	8,347	1.08	48	153,334	0.44
2002	36	20,421	3.25*	53	155,152	0.50

* Death rate 0.26% if the Becrux incident is excluded

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 9 shows the number of voyages in the various mortality categories for each ship. For ships with 10 or more voyages, most voyages of ships 27, 13, 1, 30 and 32 were in the nil or low mortality categories.

Table 9 Number of voyages in nil (0%), low (>0.0-0.5%), medium (>0.5-1.0%) and high (>1.0%) mortality categories for shipments to the Middle East from 1995 to 2002

Ship	Mortality category								Total
	Nil		Low		Medium		High		
(code)	No	%	No	%	No	%	No	%	
3	2	100	0	0	0	0	0	0	2
7	8	100	0	0	0	0	0	0	8
9	6	75	0	0	0	0	2	25	8
27	17	63	5	19	3	11	2	7	27
13	27	61	6	14	1	2	10	23	44
1	9	60	3	20	2	13	1	7	15
30	6	60	1	10	0	0	3	30	10
32	26	59	7	16	5	11	6	14	44
34	5	50	1	10	3	30	1	10	10
51	3	50	1	17	2	33	0	0	6
77	2	50	1	25	1	25	0	0	4
37	3	43	3	43	0	0	1	14	7
79	2	33	2	33	2	33	0	0	6
92	1	33	1	33	1	33	0	0	3
100	9	32	19	68	0	0	0	0	28
22	9	18	23	45	15	29	4	8	51
35	4	17	16	67	3	13	1	4	24
78	3	14	11	52	3	14	4	19	21
72	4	14	21	72	3	10	1	3	29
99	2	13	12	80	1	7	0	0	15
95	3	11	21	78	1	4	2	7	27
75	5	10	37	77	6	13	0	0	48
11	1	10	4	40	3	30	2	20	10
33	3	7	20	44	16	36	6	13	45
93	1	7	10	67	4	27	0	0	15
59	1	3	19	66	2	7	7	24	29
17	0	0	0	0	0	0	1	100	1
18	0	0	0	0	1	100	0	0	1
29	0	0	6	67	2	22	1	11	9
31	0	0	37	56	24	36	5	8	66
36	0	0	1	25	1	25	2	50	4
54	0	0	1	100	0	0	0	0	1
56	0	0	0	0	1	100	0	0	1
65	0	0	0	0	0	0	1	100	1
68	0	0	0	0	2	67	1	33	3
71	0	0	2	50	0	0	2	50	4
73	0	0	2	100	0	0	0	0	2
82	0	0	1	100	0	0	0	0	1
84	0	0	1	17	4	67	1	17	6
86	0	0	2	67	0	0	1	33	3
89	0	0	0	0	1	50	1	50	2
103	0	0	1	100	0	0	0	0	1
Total	162	25	298	46	113	18	70	11	643

Port of Loading

For voyages to the Middle East, the greatest number of cattle were exported from Fremantle, followed by Portland and Darwin (Table 10). Excluding ports with 2 or less voyages, death rates were highest from Portland, followed by Adelaide and Fremantle. Death rates were low from northern loading ports except for Karumba where unusual circumstances applied to both voyages from this port (deaths were due to tick fever on one voyage and the other involved an unusually long voyage with engine breakdown and port visits en route).

Table 10 Death rates of cattle exported from various ports to the Middle East from 1995 to 2002

Port*	Voyages (No.)	Cattle (No.)	Death rate (%)	Deaths range (%)
Townsville	14	143,353	0.2	0.1 – 0.4
Karumba	2	2,296	1.7	0.8 – 3.3
Darwin	66	177,423	0.2	0.0 – 1.8
Wyndham	17	52,484	0.2	0.0 – 1.1
Broome	30	69,635	0.1	0.0 – 0.6
Port Hedland	24	86,557	0.1	0.0 – 0.3
Dampier	2	3,715	0.4	0.2 – 0.6
Geraldton	10	19,445	0.2	0.0 – 0.8
Fremantle	328	620,644	0.5	0.0 – 11.1
Bunbury	2	1,421	36.7	1.2 – 41.5
Esperance	1	296	0.0	n/a
Adelaide	58	146,544	0.5	0.0 – 2.9
Portland	69	216,888	1.1	0.0 – 35.0
Devonport	10	26,823	0.4	0.1 – 0.9

* ports are ordered anti-clockwise from Townsville

Loading region (north vs south)

Death rates were compared between ports in the north and south of Australia for voyages to the Middle East (Norris et al 2003), except for 1995 and 1996 when there were insufficient voyages from northern ports for comparison. The death rate from southern ports has been approximately 3 times higher than from northern ports since 1998 (Table 11). Except for 1999, there were approximately twice as many cattle exported from southern ports as from northern ports each year.

Table 11 Death rates, number of voyages and number of cattle exported from northern and southern regions to the Middle East from 1997 to 2002. Relative risk shows risk of death in cattle loaded from southern areas compared to northern areas

Year	Region	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Relative risk (95% CI)
2002	North	9	76,705	0.20	
	South	90	175,589	0.82	4.1* (3.5,4.9)
2001	North	18	86,202	0.13	
	South	77	172,061	0.47	3.6 (3.0,4.4)
2000	North	22	89,156	0.19	
	South	68	157,843	0.61	3.4 (2.9,4.0)
1999	North	39	123,097	0.18	
	South	65	172,243	0.50	2.8 (2.4,3.3)
1998	North	46	88,041	0.28	
	South	71	186,094	0.89	3.2 (2.8,3.7)
1997	North	11	26,704	0.43	
	South	51	109,374	0.75	1.8 (1.4,2.2)

North: Ports north of 20^{o} latitude south.
South: Ports south of 31^{o} latitude south.
* RR = 2.41 (2.0,2.9) if Becrux excluded

Time of Year

Monthly death rates were compared between selected northern and southern ports (same ports as in previous section) from 1995 to 2002. Monthly death rates from southern ports were well above 1% in May and June (Figure 5). The large error bar in June indicates that death rates were highly variable in this month. Death rates from northern ports were less than 0.5% throughout the year, except for February and December. Death rates from northern ports were lower than from southern ports each month except for January, February and December. There have been no voyages from northern ports between November and February in recent years.

It should be noted that mean monthly death rates from southern ports were consistently below 0.9% throughout 2001 and below 0.7% in 2002 (if one exceptional voyage is excluded) which indicates that caution is needed when interpreting Figure 5. In other words, it should not be assumed that the trend for higher death rates from southern ports during winter months has continued in recent years.

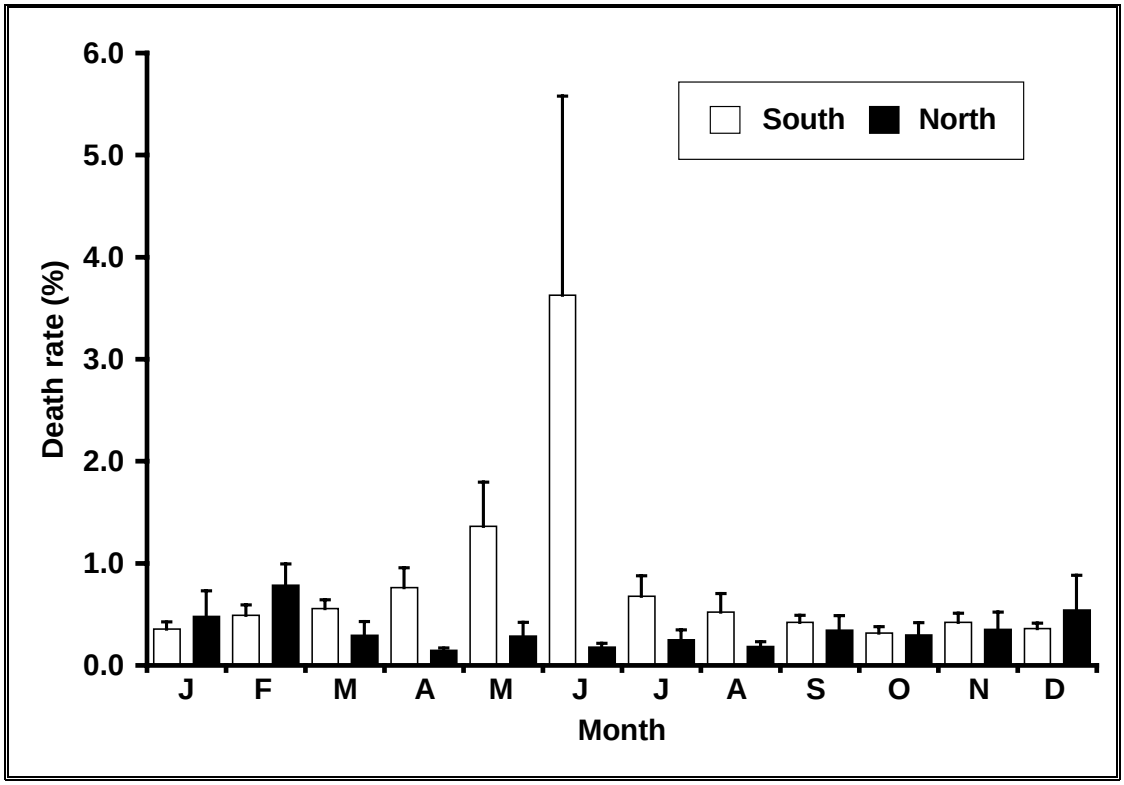

Figure 5 *Monthly death rate (mean ± sem) of cattle on voyages from southern and northern ports to the Middle East from 1995 to 2002*

Voyages from southern ports 1999 to 2002

Additional analysis was conducted for the main southern ports of Fremantle, Adelaide and Portland because of the higher death rates from these ports compared to northern ports. The years 1999 to 2002 were selected because of changes in stocking density following a high mortality incident in June 1998. Death rates of cattle were highest from Portland and lowest from Fremantle, and this was consistent in each year (Table 12). Cattle exported from Portland have more than twice the risk of death compared to cattle exported from Fremantle (Table 12a) while cattle exported from Adelaide have approximately 1.5 times the risk of death compared to Fremantle.

Table 12 Death rates for cattle loaded at Fremantle, Adelaide or Portland from 1999 to 2002

	Fremantle			Adelaide			Portland		
Year	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*

* 0.74 if the Becrux voyage is excluded

Table 12a Relative risk of cattle deaths on voyages from Adelaide and Portland compared with Fremantle from 1999 to 2002

Year	Adelaide Relative risk (95% CI)	Portland Relative risk (95% CI)
1999	1.6 (1.3-1.9)	2.5 (2.2-2.9)
2000	1.5 (1.3-1.9)	2.3 (2.0-2.7)
2001	1.5 (1.2-1.9)	2.4 (2.0-2.8)
2002	1.3 (1.1-1.6)	5.6 (5.0-6.4)*

* 2.1 (1.8-2.4) if the Becrux voyage is excluded

There were relatively few voyages from Adelaide or Portland in any individual month. Therefore, in order to investigate mortality trends due to time-of-year, voyages from Adelaide and Portland were combined and compared with Fremantle. Death rates were higher on voyages from Adelaide/Portland than Fremantle between February and June, and there was a sharp rise in death rate in June for voyages from Adelaide/Portland (Table 13 and Figure 6). The results for each year separately are presented in Attachment 3.

Table 13 Death rates by month for cattle loaded at Fremantle or Adelaide and Portland combined to the Middle East from 1999 to 2002

Month	Fremantle			Adelaide & Portland		
	Voys (No.)	Loaded (No.)	Dead (%)	Voys (No.)	Loaded (No.)	Dead (%)
January	22	44,507	0.39	9	34,240	0.44
February	21	61,696	0.25	9	18,488	0.79
March	16	19,455	0.46	18	60,595	0.82
April	8	6,993	0.21	15	40,112	0.84
May	11	7,461	0.94	6	9,189	1.71
June	9	2,125	0.66	6	13,439	4.97
July	9	12,523	0.87	6	8,959	0.63
August	10	12,748	0.25	5	8,472	0.68
September	18	27,322	0.37	3	4,302	0.44
October	22	48,371	0.44	5	10,724	0.57
November	24	88,639	0.40	8	13,978	0.40
December	23	74,555	0.21	13	42,364	0.79

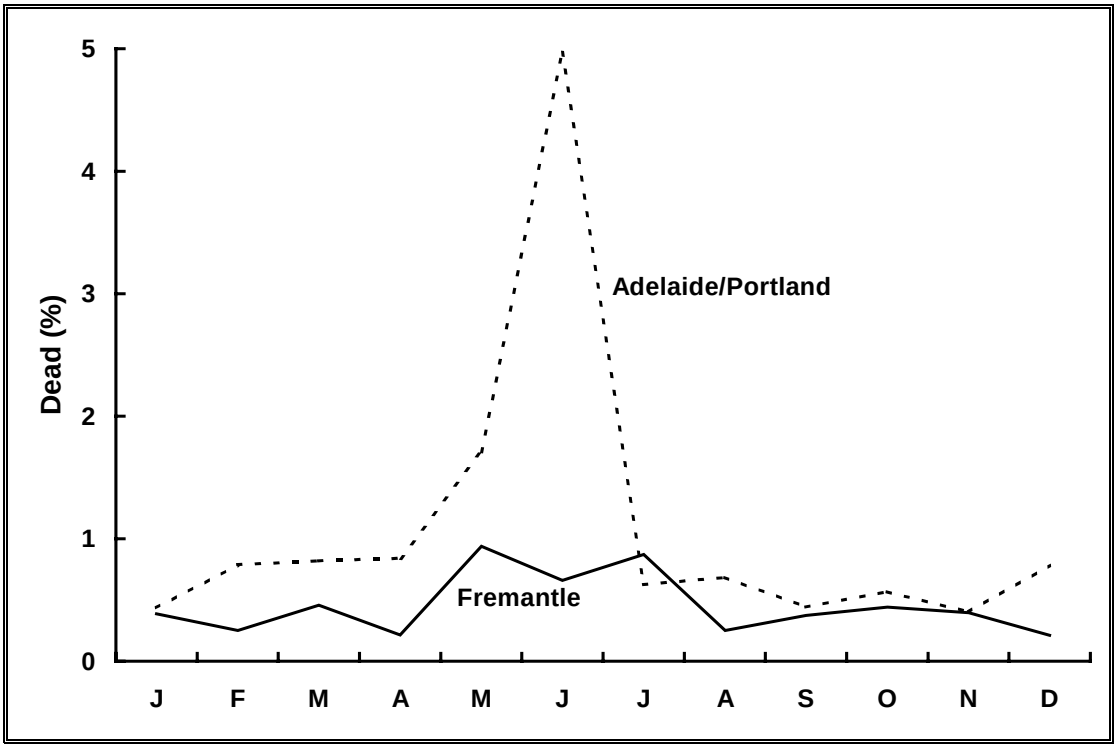

Figure 6 *Death rates by month for cattle loaded at Fremantle or Adelaide and Portland combined from 1999 to 2002*

Causes of death

Four research voyages, undertaken between December 1998 and April 2001, were each accompanied by a veterinarian to observe the cattle and to conduct detailed necropsies of any that died during the voyage (Norris et al 2003). The details are summarised in Table 14. The cattle pens on both ships involved in these studies were fully enclosed and relied on artificial ventilation, except for 1466 cattle carried on the main (open) deck on voyage 2. The ventilation systems on both ships forced air into the decks at a minimum of 20 air changes per hour, and the outlets were located on the hull sides of the decks.

Table 14 Information relating to four voyages of cattle from Australia to the Middle East.

Observation	Voyage 1	Voyage 2	Voyage 3	Voyage 4
Date (month/year)	12/98	5/99	9/00	4/01
No. of cattle	12966	4905	15081	13291
Vessel	A	B	A	A
Load port(s)	Fremantle	Port Hedland & Fremantle	Port Hedland & Broome	Adelaide & Portland
Duration (days)	18	21	23	20
Destination	Libya	Jordan	Egypt	Egypt

The death rates in voyages 1 to 4 were 0.34%, 0.65%, 0.12% and 0.79% respectively. Heat stroke was the most frequently recorded cause of death overall and on voyages 2 and 4 (Table 15). All of the deaths from heat stroke were in *Bos taurus* breeds and occurred in the latter half of the voyage. Affected animals, particularly on voyage 4, tended to be very fat with long hair coats that were matted with manure. Many of these animals were panting heavily with antemortem rectal temperatures greater than 41.5^{o}C.

Table 15 Death rates (number and number per 10,000 cattle loaded) in cause-specific mortality categories during four research voyages to the Middle East.

	Voyage								
	1		2		3		4		
Category	No.	No. per 10,000	No.	No. per 10,000	No.	No. per 10,000	No.	No. per 10,000	Total
Heat Stroke	1	0.8	9	18.4	4	2.7	44	33.1	58
Trauma	6	4.6	2	4.1	6	4.0	35	26.3	49
Respiratory disease	14	10.8	9	18.4	1	0.7	10	7.5	34
Enteric disease	9	6.9	3	6.1	2	1.3	8	6.0	22
Septicaemia	5	3.9	4	8.2	0	0.0	0	0.0	9
Miscellaneous	1	0.8	3	6.1	1	0.7	3	2.3	8
No Diagnosis	8	6.2	2	4.1	4	2.7	5	3.8	19
Total	44		32		18		105		199

Breed

On voyages 1 to 3, the cattle were classified into major breed types, based on phenotype, and death rate was recorded for each type (Norris et al 2003). When more than 1000 head of a major breed type were loaded, the death rates were: Angus-Murray Grey 0.28% (13 dead/4500 loaded), Hereford 0.21% (8/3700) and Brahman 0.06% (2/3250; P = 0.09, Chi-square test) on voyage 1; mixed *Bos taurus* 0.99% (29/2928), Brahman 0.19% (3/1600; P < 0.01) on voyage 2; and Shorthorn 0.22% (10/4500), Droughtmaster 0.05% (3/5500) and Brahman 0.09% (4/4600; P < 0.05) on voyage 3.

The following two paragraphs refer to the effects of breed on respiratory rate. Although the current section of the report deals with mortality, it was considered that this was the most appropriate place to present the respiratory rate information and the effects of breed.

On voyage 2, 16 pens were chosen for respiratory rate observations to cover a range of the pen types and breeds on the ship (Norris et al 2003). The breeds were Brahman, Droughtmaster, Hereford and Shorthorn (observations were made on Friesian cattle also but this breed was excluded from analysis because of gaps in the data). Counts were made daily but not on day 18 because of the priority given to necropsies. The wet and dry bulb temperatures were recorded at the same time daily for at least one pen of each breed. A linear mixed model was fitted to the repeated respiratory rate observations. The model incorporated random effects for animals and fixed effects for day, breed, temperature, relative humidity (wet bulb temperature) and interactions. The significance of the fixed effects was assessed using a Wald statistic.

Breed and temperature were each significantly (P < 0.001) associated with respiratory rate. There was no additional effect associated with relative humidity (P = 0.370 unadjusted for temperature; P = 0.148 adjusted for temperature). The highest respiratory rates (adjusted for temperature) were in Hereford and Shorthorn (mean, 78.2 and 73.8 respirations per min, respectively), which were higher than Droughtmaster (55.1; P < 0.05) which were higher than Brahman (40.1; P < 0.05) cattle. The respiratory rate for all cattle increased by 5.7 per min for each increase of $1^{O}C$ in ambient temperature above $25^{O}C$. The mean (± SEM) dry bulb temperature was 31.4 ± $0.3^{O}C$ and the mean relative humidity was 80.6 ± 0.8%.

Morbidity

Estimates of the number of cattle affected with different ailments during the voyage were made by the research veterinarian on 4 voyages. The estimates are necessarily subjective because they were made by 4 different people, there were no objective criteria, and the priority was given to necropsies. For these reasons, this section was not included in the paper of Norris et al (2003). The results are shown in Table 16.

Table 16 Various conditions of ill health (per cent affected) seen during voyages of cattle to the Middle East

Condition	Voyage 1	Voyage 2	Voyage 3	Voyage 4
Hyperthermia			hundreds	70
Snotty nose	0.8		1.2	25
Lameness/swollen legs or feet	5	0.8	0.3	24
Scours	0.2		0.8	8
Shy feeder		0.2	0.8	0.6
Bloat	0.1		0.1	0.1
Pneumonia		0.1	0.2	0.3
Pinkeye	2	0.3	0.1	0.5
Miscellaneous				1.1

Signs of hyperthermia included panting, mouth breathing and loss of appetite, and were most pronounced during the most humid weather. The British and European breed cattle were affected much more than the tropically-adapted types. Animals with any phenotypically recognisable characteristics of *Bos indicus* breeding appeared to be unaffected by the heat. Clinical signs were more pronounced in fatter, long-coated animals.

Most cases of heat stress and pneumonia seemed to occur in the central lanes where ventilation (airflow) was weaker compared to the outside lanes. The more crowded pens of cattle were observed to show the stronger signs of heat stress.

'Snotty noses' began to appear on day 3 of voyage 4 and swept through the ship affecting thousands of animals over the next week. Most recovered quickly but there were some residual cases which showed necrosis of the muzzle epithelium, and would slobber (salivate) profusely. They also had ocular and nasal discharges. The nasal discharges would often be heavily blood stained and were initially serous but would progress to become mucopurulent. Some developed severe respiratory distress that responded to antibiotic treatment.

There were many cases of lameness caused by trauma and/or infection. Washing down the decks occurred every 3 to 4 days. This unavoidably caused disturbance among the cattle and probably contributed to some of the injuries that occurred. Lameness and swollen legs were also caused by punctured, overworn and under run soles, and infection of abrasions and ulcers of the lower limbs.

The miscellaneous category included: animals with the head caught in pen bars (0.8%), shy feeders (0.6%), pink eye (0.5%), pneumonia (0.3%), knuckling of hind legs (0.3%) and bloat (less than 0.1%).

It has not been possible to relate morbidity results to predisposing factors because of the lack of objective criteria on routine voyages. The above information should be taken as a general guide to the main morbidity categories, and detailed studies undertaken on those specific categories of interest.

Incident reports

Thirteen reports were examined for voyages undertaken by AQIS approved veterinarians and 2 stockmen to the Middle East in the second half of 1998 (see Attachment 4 for details). The voyages were undertaken following the MV Charolais Express incident in June 1998. There was substantial variation in the scope and detail provided in the reports; one consisted of two pages of text with statements such as "Shorthorn cattle were sometimes affected by the heat" whereas another report described the gross findings for each necropsy. Such variation between reports and the lack of a standard protocol made interpretation of findings very difficult. These limitations led to the studies described by Norris et al (2003). Nevertheless, the reports indicated that *Bos taurus* breeds were struggling to cope with the hot humid conditions encountered during voyages; clinical signs of heat stress were observed, and death from heat stress was diagnosed.

The incident reports for the voyage of the MV Becrux produced by LiveCorp and by AQIS were reviewed to identify risk factors. The reports concluded that the cause of death was heat stroke and this was mainly predisposed by breed (*Bos taurus*) and time of year (cold-adapted cattle unable to adapt to extremely hot, humid conditions of Middle East summer). For further information, refer to the particular report.

Ship vs cattle comparison

A ship may have a relatively high death rate voyage if cattle are loaded in southern Australia but the death rate may be very low if cattle are loaded in northern Australia. Ship A loaded cattle in Port Hedland and Fremantle in May 1999, and the death rate to the Middle East was 0.19% and 1.07% respectively. The same vessel loaded cattle in Darwin and Fremantle in May 2001, and the death rate to the same region was 0.11% and 1.55% respectively. Ship B loaded cattle in Adelaide and Portland in April 1999, and the death rate was 0.9%. The same ship loaded cattle in Townsville in July 1999 and the death rate was 0.06%. Ship B loaded cattle in Portland in April 2000 and the death rate was 0.94%. In May 2000, the ship loaded at Townsville and the death rate was 0.18%. Although there may have been some variation in shipboard environment and management factors on different voyages of the same ship, they are not considered sufficient to account for these results.

Unless there is a mechanical failure on the ship or other obvious explanation, voyage mortality results are influenced more by the type of cattle loaded (*Bos taurus* vs *Bos indicus* content) and the port than the ship.

Mexico

Recent exports

The number of cattle and number of voyages to Mexico (Table 17) have been considerably less than to the Middle East or south east Asia since 1995 (refer to Tables 7 and 22). Voyage death rates have also been higher than to the Middle East or south east Asia.

Table 17 Death rates, number of voyages and number of cattle exported to Mexico from 1995 to 2002

Year	Voyages (No.)	Cattle (No.)	Death rate (%)	Death rate range (%)	Voyages with nil deaths (No.)
1995					
1996	2	4,359	0.67	0.6 – 1.0	0
1997	3	6,960	1.80	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

Ship

The trade to Mexico has involved 7 ships of which only 3 made more than 2 voyages (Table 18). Seven (22%) voyages involved a death rate greater than 1%.

Table 18 Number of voyages in nil (0%), low (>0.0-0.5%), medium (>0.5-1.0%) and high (>1.0%) mortality categories for shipments to Mexico from 1995 to 2002

Ship	Mortality category								Total
	Nil		Low		Medium		High		
(code)	No	%	No	%	No	%	No	%	
75	1	33	2	67	0	0	0	0	3
22	4	27	3	20	5	33	3	20	15
31	0	0	1	13	5	63	2	25	8
71	0	0	0	0	1	100	0	0	1
76	0	0	2	100	0	0	0	0	2
77	0	0	0	0	0	0	1	100	1
92	0	0	0	0	1	50	1	50	2
Total	5	16	8	25	12	38	7	22	32

Port of Loading

Most cattle exported to Mexico were loaded at Portland and the death rate was less than from Fremantle ($P < 0.01$). Voyages were on average 3 days longer from Fremantle (mean 24.0, range 19-26 days) than from Portland (mean 21.8, range 14-34 days).

Table 19 Death rates by port for cattle exported to Mexico from 1995 to 2002

Port	Voyages[a] (No.)	Cattle (No.)	Death rate (%)	Deaths range (%)
Fremantle	11	6,853	1.0	0.0 – 3.0
Adelaide	1	470	0.6	n/a
Portland	18	59,165	0.7	0.1 – 4.8

a Excludes voyages where deaths could not be identified to a particular port.

Time of year

The majority of voyages departed in May or November, and there was no apparent seasonal difference in death rate to Mexico.

Table 20 Death rates by month for cattle loaded at Fremantle, Adelaide or Portland to Mexico from 1995 to 2002

Month	Voys (No.)	Loaded (No.)	Dead (%)
January	2	3,086	0.10
February	1	1,863	0.32
March	0		
April	2	3,979	0.35
May	7	12,637	0.51
June	0		
July	0		
August	2	4,927	1.12
September	0		
October	4	4,375	0.89
November	9	27,759	0.69
December	3	7,862	1.46

Table 21 Death rates, number of voyages and number of cattle in various classes exported to Mexico from 1995 to 2002*

Class	Voyages (No.)	Cattle (No.)	Death rate (%)	Death rate range (%)
Bull adult	1	20	5.0	n/a
Heifer beef	2	246	0.0	n/a
Heifer dairy	3	11,659	0.8	0.7 – 3.0

* Recording of mortality by class began only in July 2002

South East Asia

Death rates have generally been very low on the short voyages to south east Asia from 1995 to 2002 (Table 22) and very few (4%) of the 2,891 voyages were in the medium to high mortality category (Table 23). Cattle were exported from many ports around Australia (Table 24). There was a trend for higher death rates ($P < 0.01$) on voyages departing during summer months compared to winter months (Figure 7).

Table 22 Death rates, number of voyages and number of cattle exported to south east Asia from 1995 to 2002

	Voyages (No.)	Cattle (No.)	Death rate (%)	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	299,501	0.16	0.0 – 8.8	127
1999	326	462,540	0.34	0.0 – 74.7*	162
2000	384	586,569	0.11	0.0 – 5.3	168
2001	309	468,381	0.08	0.0 – 5.0	138
2002	354	634,642	0.07	0.0 – 8.5	186

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

Table 23 Number of voyages in nil (0%), low (>0.0-0.5%), medium (>0.5-1.0%) and high (>1.0%) mortality categories for shipments to south east Asia from 1995 to 2002

Ship*	Mortality category								Total
	Nil		Low		Medium		High		
(code)	No	%	No	%	No	%	No	%	
5	70	50	64	46	4	3	1	1	139
6	18	60	12	40	0	0	0	0	30
18	45	74	16	26	0	0	0	0	61
26	23	72	8	25	1	3	0	0	32
29	13	68	6	32	0	0	0	0	19
51	68	50	66	49	1	1	0	0	135
52	56	52	46	43	4	4	2	2	108
53	15	41	21	57	0	0	1	3	37
54	40	56	29	40	2	3	1	1	72
55	48	45	55	52	3	3	0	0	106
56	26	49	24	45	1	2	2	4	53
57	0	0	1	50	1	50	0	0	2
59	29	64	16	36	0	0	0	0	45
62	16	64	9	36	0	0	0	0	25
63	76	51	60	41	8	5	4	3	148
64	59	46	57	44	12	9	1	1	129
65	41	67	18	30	2	3	0	0	61
68	64	67	26	27	5	5	0	0	95
69	65	51	47	37	6	5	9	7	127
70	36	77	11	23	0	0	0	0	47
71	35	48	36	49	1	1	1	1	73
72	4	57	3	43	0	0	0	0	7
73	1	33	2	67	0	0	0	0	3
74	53	62	32	37	0	0	1	1	86
75	4	25	12	75	0	0	0	0	16
76	19	50	19	50	0	0	0	0	38
77	5	19	20	74	1	4	1	4	27
78	31	43	40	56	1	1	0	0	72
82	48	43	64	57	0	0	0	0	112
83	35	61	19	33	1	2	2	4	57
84	26	46	28	50	1	2	1	2	56
85	10	50	8	40	2	10	0	0	20
86	49	56	38	44	0	0	0	0	87
88	62	51	56	46	1	1	3	2	122
89	31	63	18	37	0	0	0	0	49
90	37	39	53	55	3	3	3	3	96
92	31	70	13	30	0	0	0	0	44
93	6	50	6	50	0	0	0	0	12
95	16	50	16	50	0	0	0	0	32
97	60	54	44	39	7	6	1	1	112
98	89	60	50	34	9	6	1	1	149
99	11	42	15	58	0	0	0	0	26
100	19	73	7	27	0	0	0	0	26
101	24	51	22	47	1	2	0	0	47
102	25	69	11	31	0	0	0	0	36
103	4	67	2	33	0	0	0	0	6
104	1	14	6	86	0	0	0	0	7
Total	1544	53	1234	43	78	3	35	1	2891

* Ships with less than 2 voyages not shown

Table 24 Death rates, number of voyages and number of cattle exported from various ports to south east Asia from 1995 to 2002

Port*	Voyages (No.)	Cattle (No.)	Death rate overall (%)	Death rate range (%)
Townsville	217	400,857	0.06	0.0 – 1.1
Mourilyan	39	46,239	0.30	0.0 – 8.5
Weipa	15	23,339	0.15	0.0 – 0.8
Karumba	256	330,300	0.07	0.0 – 0.9
Darwin	1,511	2,131,42	0.11	0.0 – 74.7
Wyndham	204	319,028	0.05	0.0 – 0.6
Broome	245	352,862	0.09	0.0 – 2.4
Port Hedland	84	97,361	0.07	0.0 – 1.1
Geraldton	145	148,560	0.06	0.0 – 23.6
Fremantle	166	203,513	0.35	0.0 – 6.1
Adelaide	3	3,986	0.13	0.0 – 0.3

* Ports with less than 2 voyages are not shown

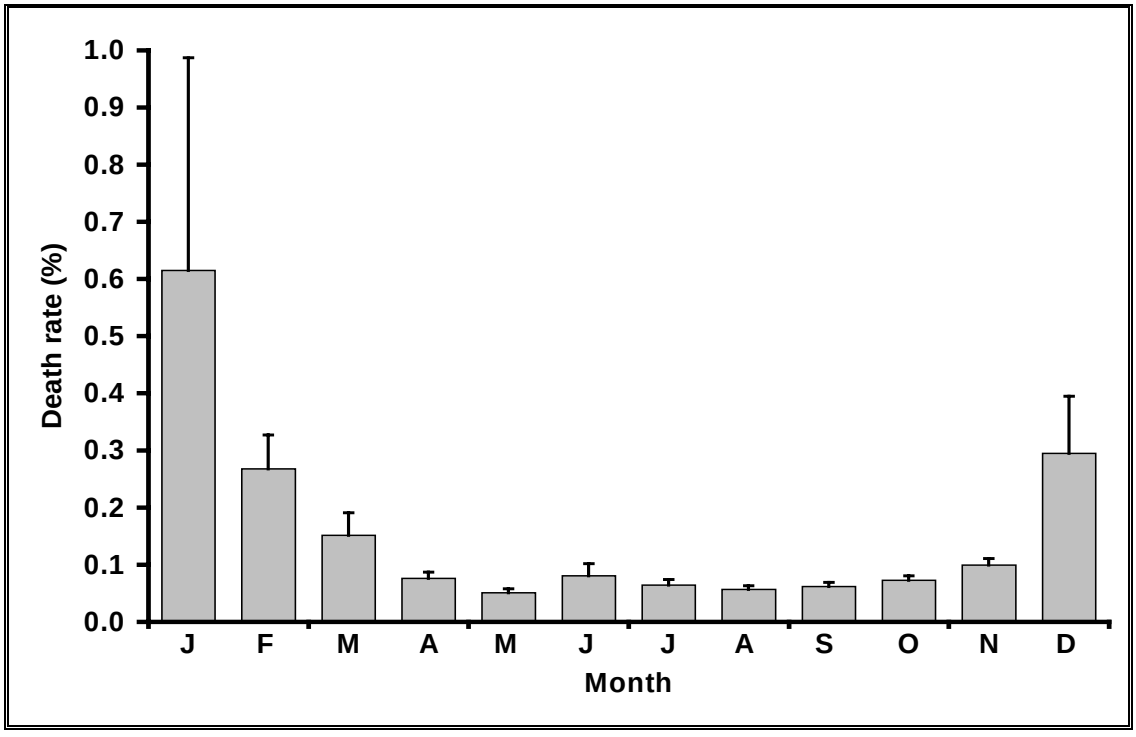

Figure 7 *Death rates by month for cattle exported from various ports to south east Asia from 1995 to 2002*

North East Asia

The export of cattle to north east Asia has been relatively consistent in terms of the number of cattle exported, number of voyages and annual death rate (Table 25).

Table 25 Death rates, number of voyages and number of cattle exported to north east Asia from 1995 to 2002

	Voyages (No.)	Cattle (No.)	Death rate (%)	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

Nearly all of the cattle exported to north east Asia were loaded at Brisbane (Table 26). Voyages from Brisbane (mean 16.7, range 14-21 days) were 5 days shorter than from Portland (mean 22.0, range 19-25 days); the voyage from Darwin was 15 days. There was no evidence of a seasonal trend in death rates on voyages from Brisbane (Figure 8).

Table 26 Death rates by port for cattle exported to north east Asia from 1995 to 2002

Port	Voyages (No.)	Cattle (No.)	Death rate (%)	Deaths range (%)
Brisbane	76	102,866	0.2	0.0 – 1.2
Darwin	1	1,378	0.2	n/a
Fremantle	1	288	0.3	n/a
Portland	8	11,335	0.5	0.0 – 2.6

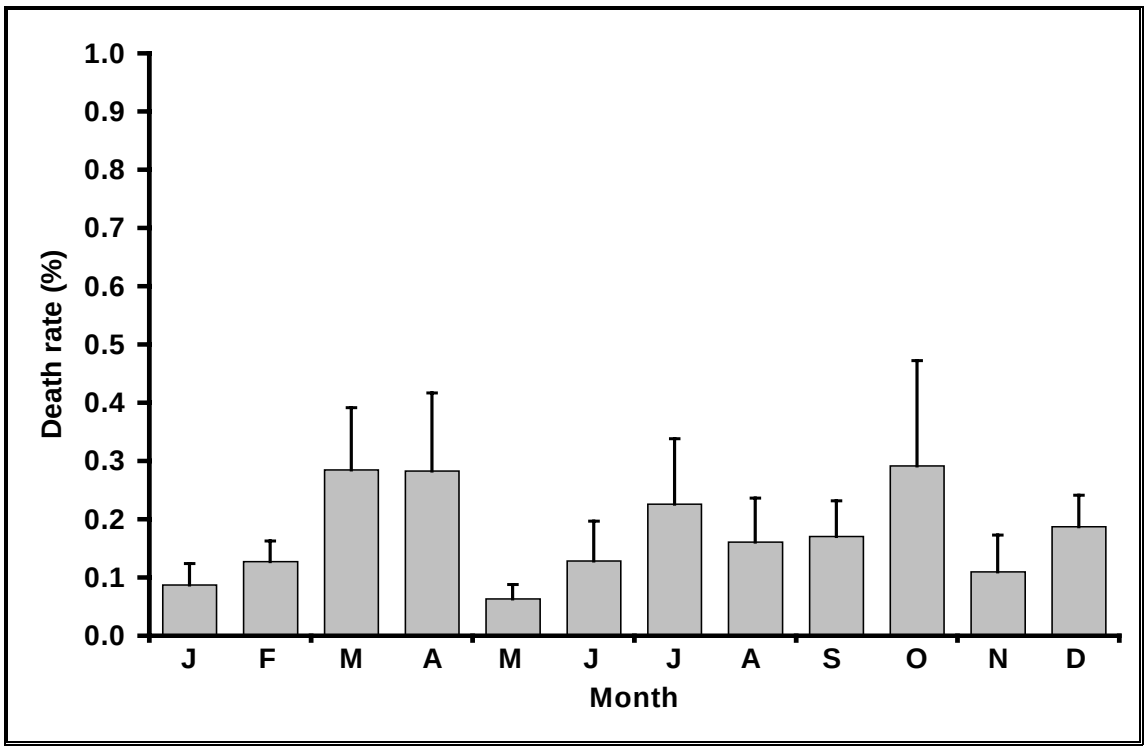

Figure 8 *Death rates by month for cattle exported from Brisbane to north east Asia from 1995 to 2002*

Summary

- About 0.2% of all cattle exported by sea from Australia die on the ship.
- Death rates from 1995 to 2002 were highest on voyages to Mexico (0.76%) followed by voyages to the Middle East (0.50%).
- The main cause of death in cattle exported to the Middle East is heat stroke.
- Cattle exported to the Middle East from southern ports have approximately 3 times the risk of death compared to cattle exported from northern ports.
- *Bos indicus* cattle tolerate the hot humid conditions aboard ship much better than *Bos taurus* cattle.
- Cattle exported to the Middle East from Portland have more than twice the risk of death compared to cattle exported from Fremantle.

GOATS

Overview

Goats are exported mainly to the Middle East and Asia with smaller numbers exported to Mauritius and Mexico. The causes of death and the risk factors were investigated in the early 1990s. These investigations involved 2 voyages each to the Middle East and to Malaysia to post mortem goats that died. The live goat export industry is based on the capture and "domestication" of feral animals from pastoral areas.

The countries of destination for goats were grouped into major regions as shown in Table 27. Exports to south east Asia were mainly to Malaysia and were characterised by small consignments on short voyages. Voyages to the Middle East involved longer duration and larger consignments than those to south east Asia. The death rate to the Middle East was higher than to south east Asia ($P < 0.01$).

Table 27 Number of voyages and goats exported, death rates and voyage duration for shipments to major destination regions from 1999 to 2002

Factor	Middle East	SE Asia	Mexico	Mauritius	Total
Voyages (No.)	78	140	1	7	226
Goats (No.)	124,800	97,307	239	7,146	229,492
Death rate (%)	2.12	1.39	0.00	0.11	1.78
Mean (SD) days of voyage	23.0 (4.0)	8.4 (1.9)	26	13.6 (1.4)	
Mean (SD) number of goats per voyage	1600 (3,328)	695 (552)	239	1021 (796)	

Middle East

Recent exports

The number of goats exported live to the Middle East was relatively low through much of the 1990s but showed a sharp increase in the last three years (Table 28). The annual death rate was not related to the number of goats exported.

Table 28 Death rates, number of voyages and number of goats exported to the Middle East from 1993 to 2002

Year	Voyages (No.)	Goats (No.)	Death rate (%)	Death rate range (%)
1993	15	6,861	3.85	0.0 – 7.2
1994	16	13,948	2.99	0.0 – 67.4
1995	4	2,526	0.32	0.0 – 6.5
1996	9	9,760	2.15	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	2.79	0.0 – 7.6
2000	12	6,310	2.08	0.0 – 8.0
2001	36	43,624	2.15	0.0 – 9.0
2002	23	69,419	2.03	0.0 – 3.4

Port of loading

Adelaide, Fremantle and Portland were the main loading ports for goats exported to the Middle East and accounted for 98% of total exports (Table 29). The death rate from Adelaide was less than from Fremantle ($P < 0.01$). Approximately 36% of voyages from Fremantle were greater than 2% compared to 12% of voyages from Adelaide (Table 30).

Table 29 Death rates of goats exported from various ports to the Middle East from 1999 to 2002

Port	Voyages[a] (No.)	Goats (No.)	Death rate (%)	Deaths range (%)
Darwin	1	746	0.0	n/a
Port Hedland	2	1,361	0.7	0.0 – 0.9
Fremantle	42	45,523	2.2	0.0 – 8.0
Adelaide	26	53,627	1.7	0.0 – 9.0
Portland	8	24,289	3.1	0.0 – 3.4

Table 30 Number of voyages in low, medium and high mortality categories for goats exported from various ports to the Middle East for 1999 to 2002

Port	Low <1.0%	Medium 1.0–2.0%	High >2.0%	Total
Darwin	1	0	0	1
Port Hedland	2	0	0	2
Fremantle	12	15	15	42
Adelaide	13	10	3	26
Portland	4	2	2	8
Total	32	27	20	79

Time of year

There was no evidence of a seasonal difference in death rate of goats exported to the Middle East (Figure 9).

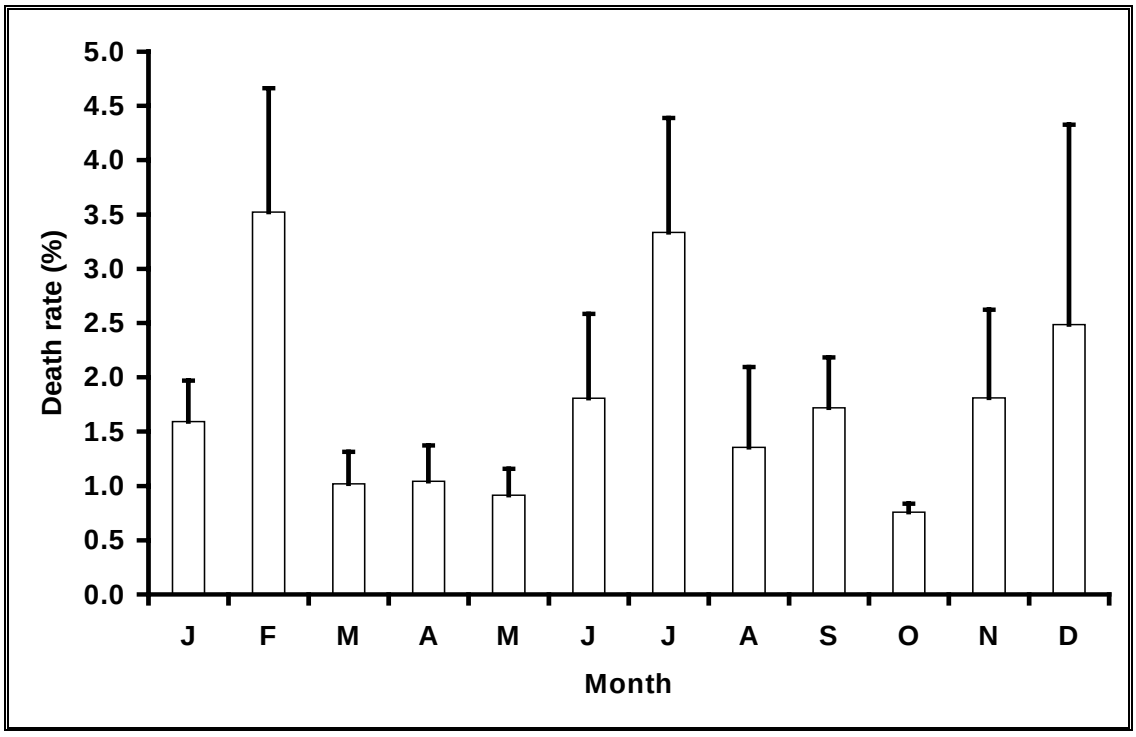

Figure 9 *Monthly death rates (mean ± sem) for goats exported from Australia to the Middle East from 1999 to 2002*

South East Asia

Recent exports

The number of goats exported live to south east Asia has increased over the last three years (Table 31). The annual death rate was not related to the number of goats exported.

Table 31 Death rates, number of voyages and number of goats exported to south east Asia from 1993 to 2002

Year	Voyages (No.)	Goats (No.)	Death rate (%)	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	1.36	0.0 – 6.9
2002	49	42,032	1.04	0.0 – 9.9

Port of loading

Broome was the main port of loading for goats exported to south east Asia followed by Geraldton and Darwin (Table 32). The death rate from Broome was higher than from Darwin and Port Hedland ($P < 0.01$).

Table 32 Death rates of goats exported from various ports to south east Asia from 1999 to 2002

Port	Voyages[a] (No.)	Goats (No.)	Death rate (%)	Deaths range (%)
Townsville	4	2,650	1.96	0.0 – 9.1
Weipa	1	118	6.78	n/a
Darwin	44	17,341	0.72	0.0 – 2.6
Wyndham	2	520	0.0	n/a
Broome	41	31,092	2.26	0.0 – 9.9
Port Hedland	10	10,652	0.81	0.0 – 1.9
Geraldton	22	23,858	0.88	0.0 – 2.2
Fremantle	17	11,822	1.45	0.0 – 5.0

Table 33 Number of voyages in low, medium and high mortality categories for goats exported from various ports to south east Asia for 1999 to 2002

Port	Low <1.0%	Medium 1.0–2.0%	High >2.0%	Total
Townsville	3	0	1	4
Weipa	0	0	1	1
Darwin	31	10	3	44
Wyndham	2	0	0	2
Broome	21	10	10	41
Port Hedland	7	3	0	10
Geraldton	13	7	2	22
Fremantle	10	4	3	17
Total	87	34	20	141

Time of year

There was no evidence of a seasonal difference in death rate of goats exported to the south east Asia (Figure 10).

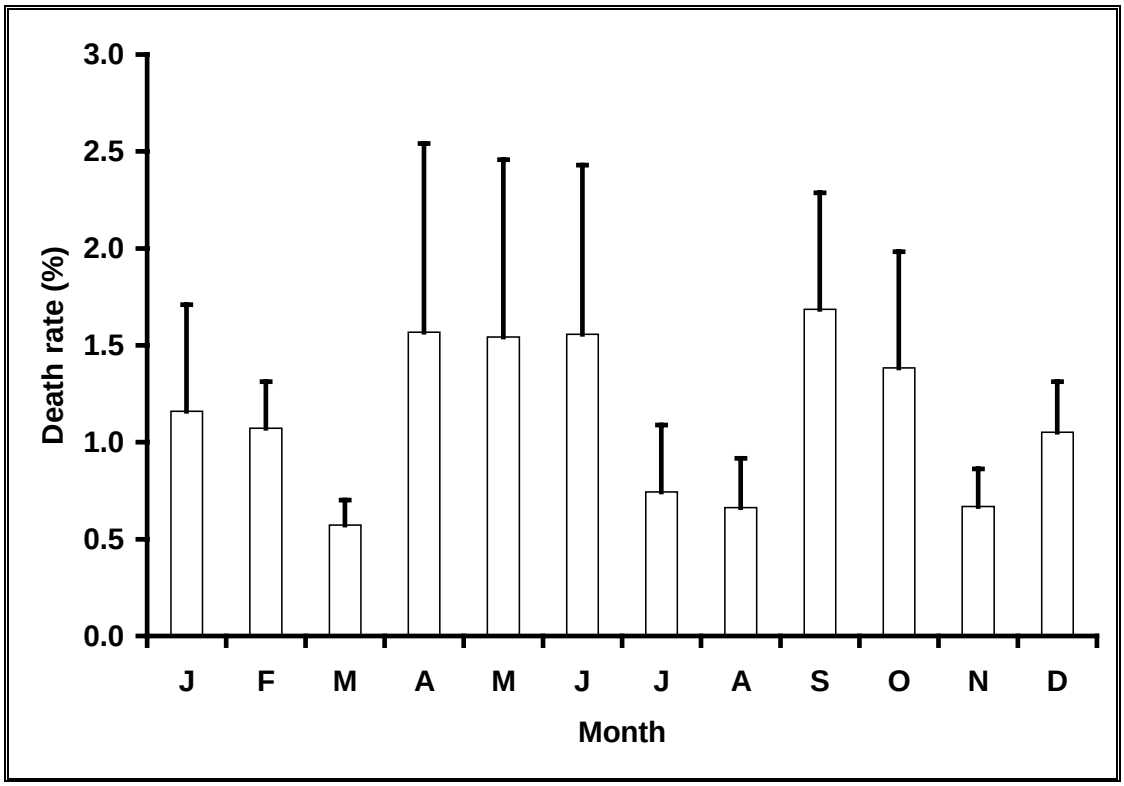

Figure 10 *Monthly death rates (mean ± sem) for goats exported from Australia to south east Asia from 1999 to 2002*

Mauritius

There have been relatively few goats exported to Mauritius and the death rate has been low in recent years (Table 34).

Table 34 Death rates, number of voyages and number of goats exported to Mauritius from 1996 to 2002

Year	Voyages (No.)	Goats (No.)	Death rate (%)	Death rate range (%)
1996	3	1,854	3.94	1.0 – 7.7
1997	0			
1998	0			
1999	0			
2000	1	2,160	1.62	n/a
2001	5	3,532	1.05	0.0 – 4.9
2002	2	2,200	0.36	0.0 – 1.0

Causes of death

The causes of death shown in Table 35 refer to investigations in the early 1990s involving post mortem examination of goats in pre-export yards, during 4 voyages to the Middle East and Asia and during post-arrival quarantine in Malaysia. The information in the table and the comments below were taken (with minor editing) from the report by Chris Hawkins.

Table 35 Main causes of death in goats in pre-export yards, during sea transport to the Middle East and Asia, and in a quarantine feedlot in Malaysia

Category	No.	%
Salmonellosis	66	27.4
Inanition +/- secondary salmonellosis	36	14.9
Pasteurellosis/Bronchopneumonia	23	9.6
Coccidiosis	14	5.8
Abomasal Ulceration	12	5.0
Septicaemia	9	3.8
Enterotoxaemia	8	3.3
Miscellaneous	33	13.7
Autolysis	13	5.4
No diagnosis made	27	11.2
Total	241	100

It is important to note that the pattern of diseases seen differed between lot-feeding, during sea transport to the Middle East and Asia, and in the quarantine feedlot in Malaysia. The three main causes of death during lot-feeding were: salmonellosis (38% of 71 deaths), inanition (30%) and coccidiosis (17%). The three main causes of death during sea transport were: enteric disease (42% of 97 deaths), respiratory disease (26%) and abomasal ulceration (9%). The main causes of death in the feedlot in Malaysia were: enteric disease (31% of 34 deaths), respiratory disease (24%) and inanition (24%). While enteric disease remained the most frequent diagnosis in all three phases, respiratory disease, which was low in the feedlot, was the second most frequently diagnosed cause of death on board ship, and in quarantine.

Deaths from *Salmonella* related conditions were more common in goats which had been in feedlots for longer periods. The rate of excretion of *Salmonella* in the faeces of goats during domestication could increase dramatically in a very short time: from 7% on first sampling, to 30% when sampling 5 days later.

Contributing factors

The following comments were taken from the report by Chris Hawkins.

Age of goats

Where age distribution was known, older bucks (ie 8 teeth = full mouth) were over-represented amongst the deaths. That is, more old bucks died than would be expected than by random occurrences. On some voyages, this same trend was apparent in 6 tooth bucks.

Weight Changes

Goats which were maintaining or increasing their weight during the feedlot period prior to shipping were more likely to survive than goats which lost weight. Goats which maintained or gained weight during shipping were again more likely to survive than those which lost weight during the voyage.

Appetite

From the use of dyed pellets, goats observed to be eating in the feedlot were also found to be eating on board ship, and these goats had a higher survival rate than goats not observed to be eating.

Body Condition

The predominant body score of goats which died was low - usually score 1. From assessments of dead goats in study groups (cohorts) it was apparent that many of these goats had been in better body condition at the time of shipping, and had lost condition during the voyage.

Domestication period

Because of the small numbers of goats in most shipments, it was frequently not possible to attach a statistical significance to findings surrounding differing periods of domestication. However, a number of important features did emerge:

- There was a strong linear relationship between the length of time in the feedlot, and deaths. This relationship was statistically significant, highly so on some voyages and there was very little deviation from linearity - that is, the major determinant of deaths was primarily related to the time in the feedlot, with little confounding effect of other variables. This trend was evident from 10 days upward, with increasing deaths beyond 10 days.
- Weight loss occurred in all age groups following entry to feedlots. However, the *percentage* weight loss was greatest in young goats (0 teeth). With young goats, this loss appeared to be recovered by the time they boarded ship, and deaths in this age groups were lower than for goats with 6 adult incisors or full mouthed.
- Infectious diseases were amplified with longer domestication periods. *Salmonella* and coccidia activity (excretion) increased with longer domestication. These two diseases were responsible for a large number of deaths, and may have played a part in others. A number of the deaths associated with pneumonia appeared histologically to be linked with *Salmonella*.
- Very short domestication periods (under 5 days) were associated with a low acceptance of pellet rations. However, this did not appear to affect the survival of goats during the voyage.

Pen space

Space available on ships for goats appeared adequate, and usually greater than the minimum recommended by AQIS. However there was a significant relationship between increasing space available and deaths; more deaths occurred where there was more space per goat. This anomalous finding may be related to buck behaviour; more space allowed more vigorous butting activity, leading to dominant bucks alienating less dominant bucks from feed and water.

Summary

- About 2.0% of all goats exported by sea from Australia die on the ship.
- Death rates from 1999 to 2002 were highest on voyages to the Middle East (2.1%) followed by voyages to south east Asia (1.4%).
- The main causes of death in goats exported to the Middle East and south east Asia were enteric disease and respiratory disease.
- There was a strong linear relationship between the length of time in the feedlot, and deaths during shipping.
- There was no apparent seasonal difference in death rate of goats exported to the Middle East or to south east Asia.

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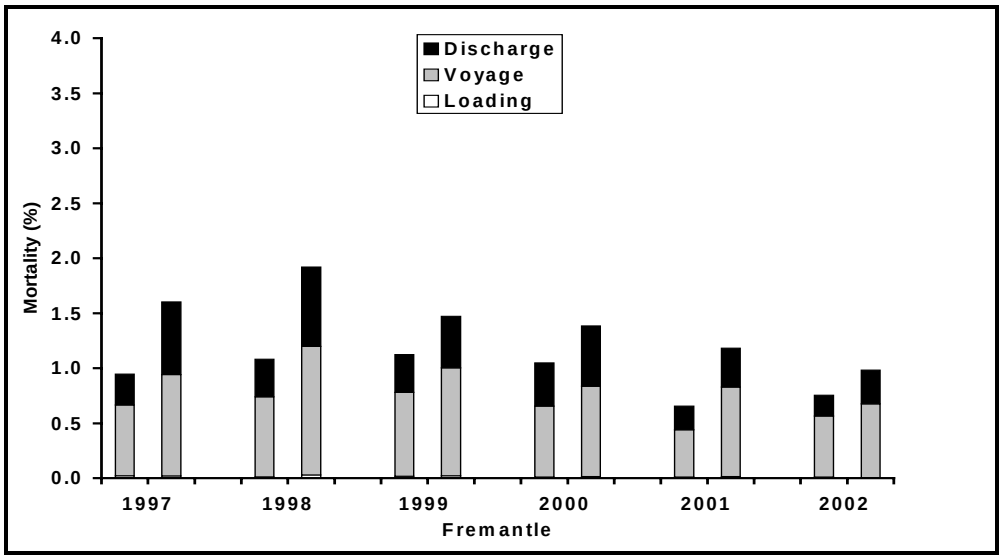
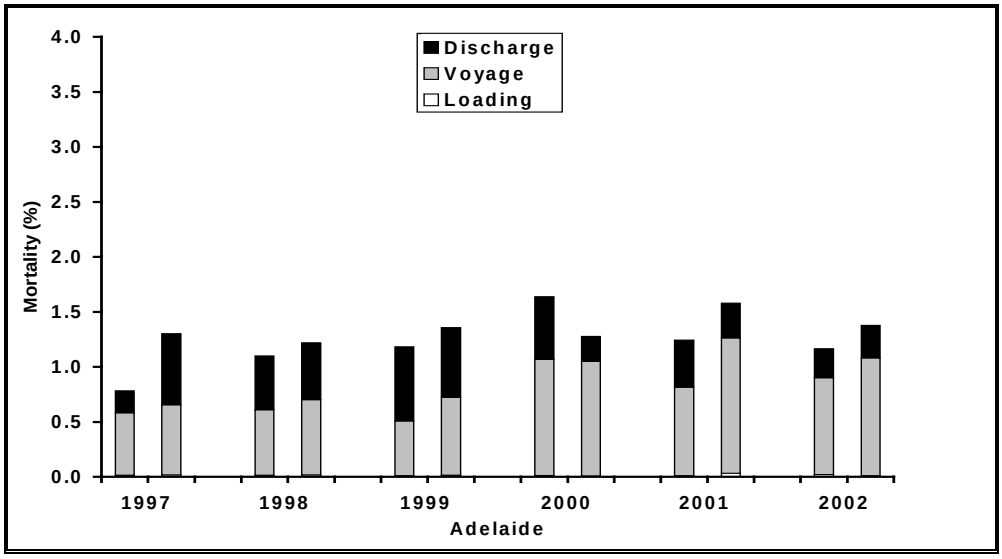
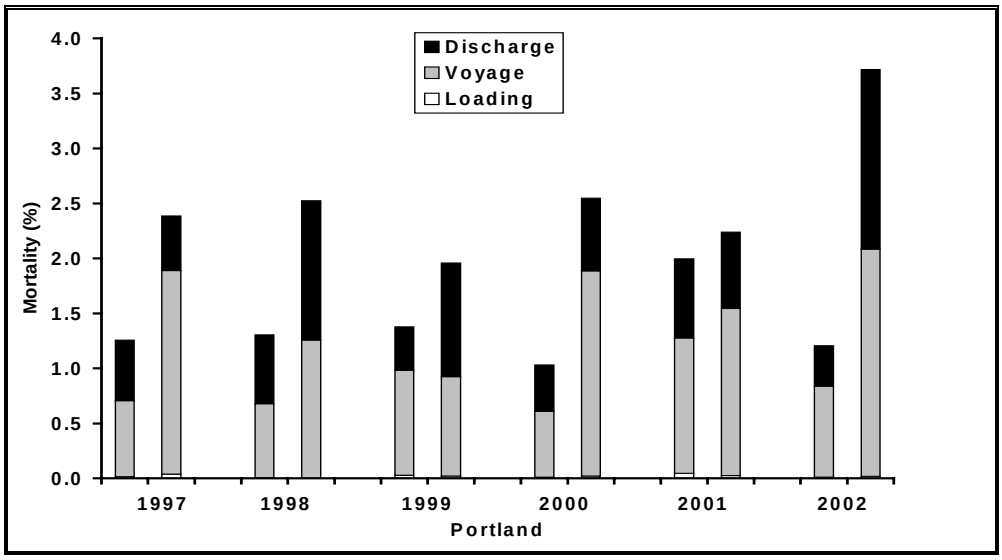
Attachment 1

Sheep death rates during loading, voyage to first port and at discharge in the first and second half of the year on shipments to the Middle East from Fremantle, Adelaide and Portland from 1997 to 2002







Attachment 2

Mortality (mean & standard error) and number of shipments of different classes of sheep exported to the Middle East from Fremantle, Adelaide and Portland from 1997 to 2001

	FREMANTLE				ADELAIDE				PORTLAND			
Class	No. of shipments	No. of sheep	Mean (%)	sem (%)	No. of shipments	No. of sheep	Mean (%)	sem (%)	No. of shipments	No. of sheep	Mean (%)	sem (%)
WA	341	10,831,810	1.39	0.07	50	1,942,936	1.25	0.09	52	3,172,352	1.86	0.14
WH	130	2,099,379	0.90	0.07	19	250,234	0.86	0.2	14	128,765	1.00	0.24
WL	320	4,014,907	0.97	0.04	32	350,187	1.42	0.17	47	597,219	1.84	0.39
RA	238	436,837	1.57	0.17	40	69,524	1.27	0.12	47	88,862	2.41	0.36
RH	64	156,564	1.18	0.13	5	4,755	0.43	0.20	n/a	n/a	n/a	n/a
RL	217	1,444,340	1.12	0.08	28	45,685	1.71	0.28	7	4,525	10.05	5.48
EA	109	308,295	1.19	0.08	2	2,479	0.13	0.13	5	1,187	1.20	0.30
EH	23	42,018	1.12	0.45	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
EL	92	466,861	0.71	0.10	4	4,616	1.14	0.71	3	12,349	0.58	0.32

Class

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

Attachment 3

Cattle death rates by month on voyages to the Middle East from Fremantle or Adelaide/Portland combined for each of 1999, 2000 and 2001

Fremantle	1999			2000			2001		
Month	Voys	Loaded	Dead %	Voys	Loaded	Dead %	Voys	Loaded	Dead %
J	7	16538	0.36	7	15337	0.55	4	5979	0.17
F	5	11367	0.37	4	6195	0.26	7	25992	0.23
M	4	5887	0.39	2	4188	0.17	3	1430	0.63
A	1	96	2.08	1	67	0.00	3	3116	0.13
M	4	5144	0.66	2	1948	1.03	2	1303	1.53
J	1	929	0.11	2	187	4.81	2	198	0.51
J	2	6668	0.48	2	6857	1.28	3	5174	0.41
A	0	0	0.00	3	1472	0.07	3	2415	0.66
S	3	6262	0.57	5	7108	0.38	4	6676	0.28
O	6	12235	0.26	7	13842	0.37	4	7175	0.54
N	4	18442	0.31	4	13912	0.35	8	32882	0.45
D	7	28145	0.20	5	23576	0.23	4	11881	0.08
Adelaide/ Portland	1999			2000			2001		
Month	Voys	Loaded	Dead %	Voys	Loaded	Dead %	Voys	Loaded	Dead %
J	3	18487	0.37	2	12720	0.53	1	100	0.00
F	4	10583	0.90	1	2229	0.36	2	4316	0.60
M	4	17276	0.75	5	14450	1.00	4	20967	0.81
A	6	19540	0.80	3	9183	0.91	4	7546	1.07
M	1	155	0.00	2	6594	2.06	0	0	0.00
J	0	0	0.00	0	0	0.00	2	2918	0.58
J	0	0	0.00	1	4795	0.92	3	665	0.75
A	0	0	0.00	1	2752	0.84	2	3049	0.85
S	0	0	0.00	0	0	0.00	1	2177	0.28
O	1	199	0.50	0	0	0.00	3	9841	0.59
N	1	3087	0.19	1	100	0.00	2	5102	0.29
D	2	5691	1.27	3	6612	0.42	2	779	0.39

Attachment 4

Analysis of Veterinary Voyage Reports

Extracted from a report by RT Norris and JH Creeper
March 1999

Introduction

From late August 1998, the Australian Quarantine & Inspection Service required that shipments of cattle from Australia to the Middle East region be accompanied by a veterinarian or a stockman. A number of reports arising from these voyages were made available for analysis.

Results

A total of 13 reports were examined, involving 11 different ships, 9 veterinarians and 2 stockmen (Table 7). Ship 84 was accompanied 3 times (Voyages 1, 10 and 13) by 3 different veterinarians. Vet 2 undertook Voyage 2 and Voyage 12. Most voyages began in August or September, and five of them were from southern ports. Egypt was the main destination. The breed(s) of cattle were described on 7 of the voyages but there was no estimate of the number of cattle in each breed on any voyage.

The numbers of cattle deaths and the number loaded are shown in Table 7. There were relatively few deaths from northern ports. Voyages where there were more than 40 deaths all originated from southern ports. There was a good description of the gross pathology at necropsy on Voyages 4, 6 and 12, limited description on Voyages 5, 7 and 13, and none on the remaining voyages. Samples were collected for subsequent examination (mainly tissues fixed in formalin for histopathology) on some voyages, few were examined in a laboratory, and no useful information resulted.

Several conditions were diagnosed clinically or on the basis of gross pathology at necropsy. The main conditions are listed in Table 7. Where there was sufficient information available, the frequency of each condition is shown either as a percentage (based on the estimated prevalence in live animals) or as a number (based on the number of deaths diagnosed at necropsy). However in many cases, the condition was observed but there was no information to indicate the frequency, and such cases are indicated by a “Y” in the table. The main conditions are described in more detail below, together with other observations about the management of the cattle.

Table 7. Summary information about voyages accompanied by an Australian veterinarian or stockman to the Middle East

Voyage	1	2	3	4	5	6	7	8	9	10	11	12	13
Ship	84	75	68	59	73	22	78	82	31	84	51	33	84
Vet/S-man	Vet 1	Vet 2	S-man 1	Vet 3	Vet 4	Vet 5	Vet 6	S-man 2	Vet 7	Vet 8	Vet 9	Vet 2	Vet 10
Departure	Apr-98	Aug-98	Aug-98	Aug-98	Aug-98	Sep-98	Sep-98	Sep-98	Sep-98	Sep-98	Oct-98	Oct-98	Nov-98
Port	Darwin	Pt H/Wynd	Broome	Portland	Dampier/ Broome	Fremantle	Broome	Darwin	Adel/F'tle	Dampier	Broome	Fremantle	Fremantle
Destination	Egypt	Egypt	Egypt	Aqaba	Egypt	Egypt	Egypt	Egypt	Aqaba	Egypt	Egypt	Aqaba	Egypt
Cattle-breed	Brahman-X			H/ford, Angus, S/horn, Santa	Brahman, Bmn-X Santa, S/horn	H/ford, Angus, M/grey, S/horn, Lim, Sim, Brahman	D-mr, S/horn, D-mr/Bmn-X		S/horn Friesian				H/ford-, S/horn-X, D-mr
Mortality	6/2098	2/3502	5 R/888	20/1541	3/1330	15/3412	3/2062	5/??	45/7000	10/2050	2/1254	55/4698	48/2290
PM-details	Nil	Nil	Nil	Detailed	Some	Detailed	Some	Nil	Nil	Nil	Nil	Detailed	Some
Lameness	Y	0.2%	Y	1	Y	0.5%	0.5%	Y	4%	1%	1%	0.2%	0.2%
Shy feeder		0.03%		4	Y	0.7%	0.4%		2%		0.4%	0.8%	Y
Heat stress	Y			12	S/horn	Y	Y		Y	Y	Y	Y	Y
Pneumonia												Y	Y
Pink eye		0.5%					6%		1%	6%	Y	0.6%	2%
Bloat		0.06%				Y					0.1%		
Scours						0.1%			4%		0.6%		Y
Feed (kg/hd)			7	10	7			9-11		7	7		
Water (L/hd)				20-30	27			20-38			26		22-35

Table 8. Cause of death based on gross necropsy findings

Cause of death	Voyage 4	Voyage 6	Voyage 7	Voyage 12*
Pneumonia		1	1	23
Heat stress	12	4		23
Rumenitis				27
Lameness/trauma	1	1	1	4
Inanition	4	3	1	1
Calving				12
No diagnosis	3	3		1
Total	20	12	3	53

* Note: more than one condition seen at necropsy (consequently, total number of conditions exceeds total number of cattle deaths).

Lameness/trauma was observed on all voyages within the first few days after loading. Lameness/trauma includes deaths from broken limbs or animals unable to rise, as well as less severe cases that recovered. The prevalence of the problem was frequently not quantified but ranged up to 4% on Voyage 9.

Shy feeder (inanition) cases were observed on 8 voyages. When detected, animals were moved to hospital pens and offered hay/chaff in addition to pelleted feed. Again, the prevalence was frequently not quantified but ranged up to 2% on Voyage 9. Inanition was considered the second most frequent cause of death on Voyages 4 and 6 (Table 8).

Heat stress was responsible for 12/20 deaths on Voyage 4. This involved an incident in an area of Deck 1 on Ship 59. In the opinion of Vet 3, "temperature alone did not seem to be the critical factor since far higher temperatures were experienced later in the voyage without the same result. The most respiratory distress was observed in pens with "sub-optimal ventilation" (close to the engine room). Reducing the number of cattle in these pens diminished the signs of distress, but the signs continued even when as few as 2-3 head remained in difficult pens".

On Voyage 6, the major problems with heat stress began when Ship 22 entered the Gulf of Aden and the Red Sea. The temperature and relative humidity in the cattle pens reached the mid-30sC^{o} and 80% or more. The cattle showed "poor fodder consumption, rapid respiratory rates (above 120/min) and severe open mouth panting. Water consumption doubled that of the initial days of the voyage, and the animals' condition seemed to melt away. A few animals collapsed. The response to cooler less humid weather was very marked, with a huge increase in fodder consumption".

On Voyage 9, about 75% of all deaths occurred in the first 48 hours in the Red Sea.

On Ship 84 (Voyage 13), cattle with signs of heat stress in an area of Deck 2 improved when moved elsewhere and otherwise healthy animals moved into this area developed signs of heat stress. On a previous voyage of the same ship (Voyage 10) Vet 8 commented that ventilation needed to be improved, particularly on Deck 2.

Breed Brahmans, Brahman-infused and Santa Gertrudis cattle travelled well on Voyage 5, but Shorthorn cattle were "panting when none of the other cattle around them were" regardless of which deck they were on. The Brahman cattle on Voyage 6 were less affected by heat stress than *Bos taurus* breeds; the respiratory rates of the Brahman cattle did not exceed approximately 80/min compared to in excess of 120/min for the *Bos taurus* breeds. The Brahman cattle "camped" closely together and did not seem to trample over each other as much as the *Bos taurus* breeds.

Electrolytes were used on several voyages and some veterinarians considered that the electrolytes conferred a benefit to the cattle. However, there was no objective assessment of the benefits of using electrolytes, and no description of the ingredients in the electrolytes used.

Stocking density the cattle on Voyage 6 were loaded at 15% below the Australian Maritime Safety Authority (AMSA) standard. This allowed animals to "rest later in the trip when it got hotter as the whole pen could lie down", and the cattle were easier to observe.

Feed consumption was recorded for six voyages, and averaged 7 kg/hd/day on four voyages (Table 7). On Voyage 3, feed intake averaged 7 kg per head from day 7 onwards increasing up to 10 kg/hd on day 23. On Voyage 4, feed consumption remained constant at approximately 10 kg/hd from day 3 onward.

Water consumption was recorded on five voyages and ranged from 20 to 38 L/hd/day. Water intake averaged 20L/hd in the first 5 days of Voyage 4 and increased steadily up to 30L/hd on day 21 (discharge).

Water supply was limiting on Ship 73 (Voyage 5) such that the ship needed to take on additional water at Djibouti. Before taking on additional supplies, water was offered once daily (consumption was approximately 35 tonnes daily), and after additional supplies were loaded, water was offered twice daily (consumption was 45 tonnes). Ship 73 has now been scrapped.

Water consumption on Voyage 8 increased steadily from 18 to 33L/hd by day 8 and remained steady at about that level until increasing to 36 to 38L/hd during the last 4 days of the voyage.

Quality control was lacking on some voyages. On Voyage 12, 12 deaths were attributable to difficulties with calving (Table 8). Before discharge at the completion of Voyage 11, several "obviously old, heavy bullocks" were rejected by importing authorities as having 6 teeth or more. Doubts about the upper age of the cattle resulted in importers requiring individual animals to be "mouthed" to determine their age. The lack of facilities on the ship for this purpose, resulted in stress and injury to some of the cattle and the ship's personnel.

Discharge facilities were poor at Egypt for Voyage 5 with cattle unloaded onto the back of a small truck, from which two trucks were loaded simultaneously from each side. The sides of the small truck were not firmly fixed and were only 150 cm high. Five cattle jumped out of the discharge area; two drowned, one broke its leg and another died after falling from the discharge area.

Curfew at discharge authorities at Adibiya, Egypt ordered a complete withdrawal of feed and water during discharge at the end of Voyage 7 under the threat that discharge would be suspended. This resulted in cattle on the ship being without water for up to 18 hours in hot conditions. Veterinary authorities at Egypt also imposed a feed and water curfew at the end of Voyage 11.

Discussion & Conclusions

Although the veterinarians and stockmen described their findings as they considered appropriate, there was substantial variation in the scope and detail provided in the reports examined. For example, one report consisted of two pages of text with statements such as "Shorthorn cattle were sometimes affected by the heat". Conversely, another report contained a reasonable description of the gross findings for each necropsy together with objective assessments of some of the health conditions affecting the cattle. Such a variation between reports makes interpretation of findings and comparisons between voyages very difficult for others.

There is a need for a standardised method for such voyages. The method should aim at recording objective measurements where possible so that a performance history can be built up over time. This will allow comparison with other voyages as appropriate and will allow the effects of changes in management to be assessed objectively.

If it is required that veterinarians accompany cattle shipments in future, it is imperative that they are thoroughly briefed beforehand. The briefing should clearly indicate the purpose of the study and the information that is to be collected on the voyage. This should include an explanation of the standardised method, and the current state of knowledge regarding cattle ill health/mortality/welfare problems. Some knowledge of epidemiology (problem definition and identification of causes) and pathology would be a distinct advantage. Limited training should be provided if necessary.

There is also a need for a thorough de-briefing after each voyage to discuss the findings and to clarify details where necessary. The findings from each voyage should be reviewed by an appropriate person/group who would consider making further recommendations to improve the welfare of the cattle.

The standardised method should include a suitable description of the gross pathology of animals necropsied, together with a procedure for examination of suitable samples at the diagnostic laboratory. Laboratory examination of samples is an essential step in reaching a diagnosis for many diseases. For example, "rumenitis" may easily be confused with post mortem change which occurs rapidly in the hot humid conditions found during sea transport. Even an experienced pathologist would require laboratory examination of rumen tissue before confirming a diagnosis of rumenitis. Mis-diagnosis of some conditions may result in (potentially) expensive and unnecessary changes in management that are ineffectual in improving the welfare of the cattle.

The reports indicate that *Bos taurus* breeds are struggling to cope with the hot humid conditions encountered during sea transport. Clinical signs of heat stress were observed, and death from heat stress was diagnosed. However, further investigation is needed to determine whether there are differences in breed susceptibility to heat stress. A useful parameter to measure could be respiratory rate.

Although poor ventilation was frequently considered to predispose to heat stress, it was recognised that the problem is multi-factorial. Except in cases of extremely high temperature and relative humidity, it was considered that temperature and relative humidity were less important than air flow. There is a need to define the minimum ventilation standards required for cattle during sea transport and to ensure that ships meet such standards, particularly when carrying *Bos taurus* breeds from southern ports during the Australian winter. It may be useful to examine research findings from the North American cattle industry or from the pig and poultry industries.

On one ship the same deck was identified as a problem area on separate voyages. This vessel has a poor record on other voyages. Further investigation of the ship is needed, and appropriate

prevention strategies should be implemented before the onset of the northern hemisphere summer.

There are serious animal welfare problems involved during discharge at Egypt. The imposition of a curfew on feed and water exposes the industry to another mortality incident, particularly during hot weather. Immediate action is required to resolve this problem.

Unloading facilities at Egypt are inadequate to handle the cattle in a manner that does not increase the risk of injuries or death. Consideration should be given to the design and use of an unloading trailer such as the MOVOR that was deployed at various Gulf ports for unloading sheep from Australia.

There is a need to improve quality control of the cattle exported. Improved procedures are needed to ensure that cattle in an advanced stage of pregnancy are not exported. Cattle should be within importers' specifications, particularly for age, thus avoiding the need for restraint and examination of individual animals before discharge.