

National livestock exports mortality summary 2003

LIVE.220

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1 INTRODUCTION

The live export of sheep and cattle makes a significant contribution to the Australian economy, returning over \$1 billion in 2002/03 and providing employment in services that support this industry. The live export trade provides important support for the sheep and cattle industries of Australia and is the only market outlet for producers in some areas of the country.

This report provides summary information about mortalities in sheep and cattle during sea transport from Australia. The information is obtained from ship Masters' reports which record livestock deaths and other information about the voyage, and also from "Yellow Books" which record more detailed information about numbers of livestock deaths.

The main purpose of the report is to allow industry, government and others to monitor mortality trends in the live sheep and cattle trades. The report also lists relevant published studies. As in previous reports, codes are used where appropriate in order to maintain confidentiality.

2 SHEEP

2.1 Overview

Most sheep exported live by sea from Australia are sent to the Middle East and are mainly loaded at Fremantle, Adelaide and Portland. Some sheep are exported to other regions, mainly South-East Asia.

The following results are based on analysis of ship Masters' reports which were to hand in April 2004 and also "Yellow Books" which record more detailed information about the number of sheep deaths. Some results, such as the number of sheep exported, may differ slightly from other sources of information.

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

The main causes of sheep deaths are inanition (failure to eat) and salmonellosis. These two causes accounted for about 75% of all deaths aboard ship. The most important risk factors for sheep deaths are failure to eat 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.

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

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 does not reduce the number of persistent non-feeders.

Age, fatness and time of year predispose to mortality. 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. 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 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.

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 and deaths among immature sheep.

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 and time of shearing on the farm. In addition, there was no difference in shipboard mortality between sheep previously lot-fed in sheds or paddocks during autumn and spring. 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.

2.2 Port of loading

The number of sheep exported by sea from Fremantle, Adelaide and Portland during 2003 is shown in Table 1. Compared with 2002, total sheep exports decreased by 24% with the biggest decrease from Portland (45%) followed by Adelaide (37%) and Fremantle (11%). Exports of adult wethers and wether hoggets fell by 30% whereas exports of ram lambs increased by 11%.

Table 1 The number of sheep exported by sea from Fremantle, Adelaide and Portland during 2003

| Livestock | Fremantle / other WA ports | | Adelaide | Portland | Total | |
|--------------|----------------------------|------------------|----------------|----------------|----------------|------------------|
| | Middle East | S.E. Asia | Middle East | Middle East | | |
| Wethers | adults | 1,233,787 | 5,334 | 601,415 | 540,699 | 2,381,235 |
| | hoggets | 247,005 | 0 | 0 | 51,283 | 298,288 |
| | lambs | 533,873 | 7,260 | 145,088 | 77,335 | 763,556 |
| Rams | adults | 50,728 | 12,277 | 26,479 | 11,587 | 101,071 |
| | hoggets | 64,538 | 0 | 5,313 | 2,639 | 72,490 |
| | lambs | 508,232 | 3,027 | 63,305 | 4,469 | 579,033 |
| Ewes | adults | 138,234 | 0 | 280 | 6,936 | 145,450 |
| | hoggets | 0 | 0 | 0 | 0 | 0 |
| | lambs | 203,559 | 0 | 1,403 | 0 | 204,962 |
| Total | sheep | 2,979,956 | 27,898* | 843,283 | 694,948 | 4,546,085 |

* Includes 910 ram adults exported to China

Most sheep exported by sea from Australia during 2003 were loaded at Fremantle (66% of all sheep, Figure 1) with smaller numbers loaded at Adelaide (19%) and Portland (15%).

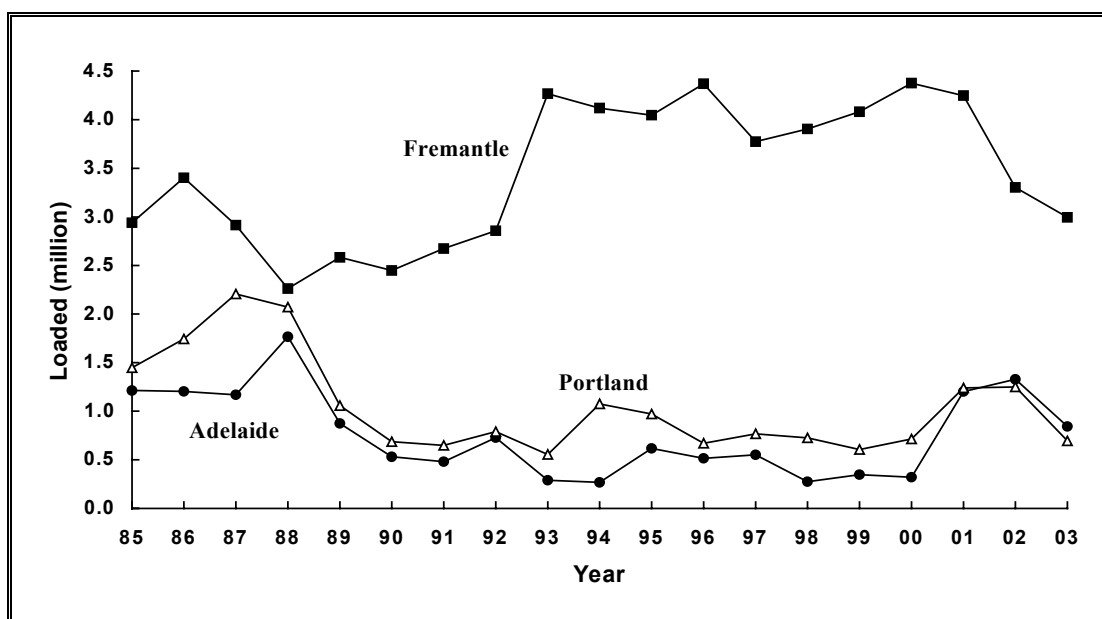


Figure 1 Numbers of sheep exported by sea from Fremantle (Western Australia), Portland (Victoria) and Adelaide (South Australia) since 1985

2.3 Destination

The main importing countries for Australian sheep in 2003 are shown in Table 2. Saudi Arabia was the main market (32% of all sheep) followed by Kuwait (29%) and Jordan (10%). Compared with 2002, exports decreased to the following destinations: Egypt (down by 90%), Israel (40%), United Arab Emirates (38%), Oman (31%) and Qatar (25%).

Table 2 Destination country for sheep exported from Fremantle/WA, Adelaide and Portland during 2003

| Country | Fremantle/WA | Adelaide | Portland | Total |
|----------------|------------------|----------------|----------------|------------------|
| Bahrain | 145,046 | 48,792 | 197,530 | 391,368 |
| Egypt | 15,730 | 0 | 0 | 15,730 |
| Israel | 98,443 | 56,734 | 0 | 155,177 |
| Jordan | 369,708 | 85,489 | 14,261 | 469,458 |
| Kuwait | 755,968 | 266,923 | 308,350 | 1,331,241 |
| Lebanon | 17,189 | 0 | 0 | 17,189 |
| N.E. Asia | 910 | 0 | 0 | 910 |
| Oman | 161,938 | 13,500 | 55,440 | 230,878 |
| Qatar | 123,832 | 0 | 70,025 | 193,857 |
| Saudi Arabia | 1,106,083 | 345,620 | 16,572 | 1,468,275 |
| S.E. Asia | 26,988 | 0 | 0 | 26,988 |
| UAE | 186,019 | 26,225 | 32,770 | 245,014 |
| Miscellaneous* | 126 | 0 | 0 | 126 |
| Total | 3,007,980 | 843,283 | 694,948 | 4,546,211 |

* Includes sheep exported to Brazil and New Zealand by air from Perth

2.4 Death rates

There were 42 voyages to the Middle East in 2003 for which sheep were loaded at more than one port in Australia (split-load voyages) and mortalities for split-load voyages were attributed to the port of loading where possible. The consignments of sheep from each load port have been considered as separate voyages.

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

The total death rate for all sheep exported to all destination regions during 2003 was 0.88% (Table 3) or 1.00% if the deaths on the MV Cormo Express are included after it was rejected at Saudi Arabia. Whether the additional deaths involved in this incident are included or not, the total mortality is a new record low.

There were 23 shipments to South-East Asia, and the death rate was 0.12% out of 29,320 sheep loaded. There was one shipment to North-East Asia (China) involving 910 rams and none died.

For voyages to the Middle East, if the deaths on the MV Cormo Express after it was rejected at Saudi Arabia are included, the discharge mortality for all shipments from Fremantle was 0.38% and the total mortality was 0.94%. The total death rate for shipments from Portland fell by more than half in 2003 compared to the previous two years, and involved a substantial reduction in discharge mortality (Figure 2). Death rates from Adelaide continued to fall.

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

| | Year | Death 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 |
| | 2003 | 0.00 | 0.56 | 0.21† | 0.77† |
| 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 |
| | 2003 | 0.01 | 0.93 | 0.26 | 1.20 |
| 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 |
| | 2003 | 0.00 | 0.72 | 0.29 | 1.01 |
| Total* | 2000 | 0.01 | 0.82 | 0.47 | 1.31 |
| | 2001 | 0.02 | 0.86 | 0.38 | 1.26 |
| | 2002 | 0.01 | 0.84 | 0.39 | 1.24 |
| | 2003 | 0.01 | 0.65 | 0.23† | 0.88† |

* Total includes all sheep exported from Australia to all destinations

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

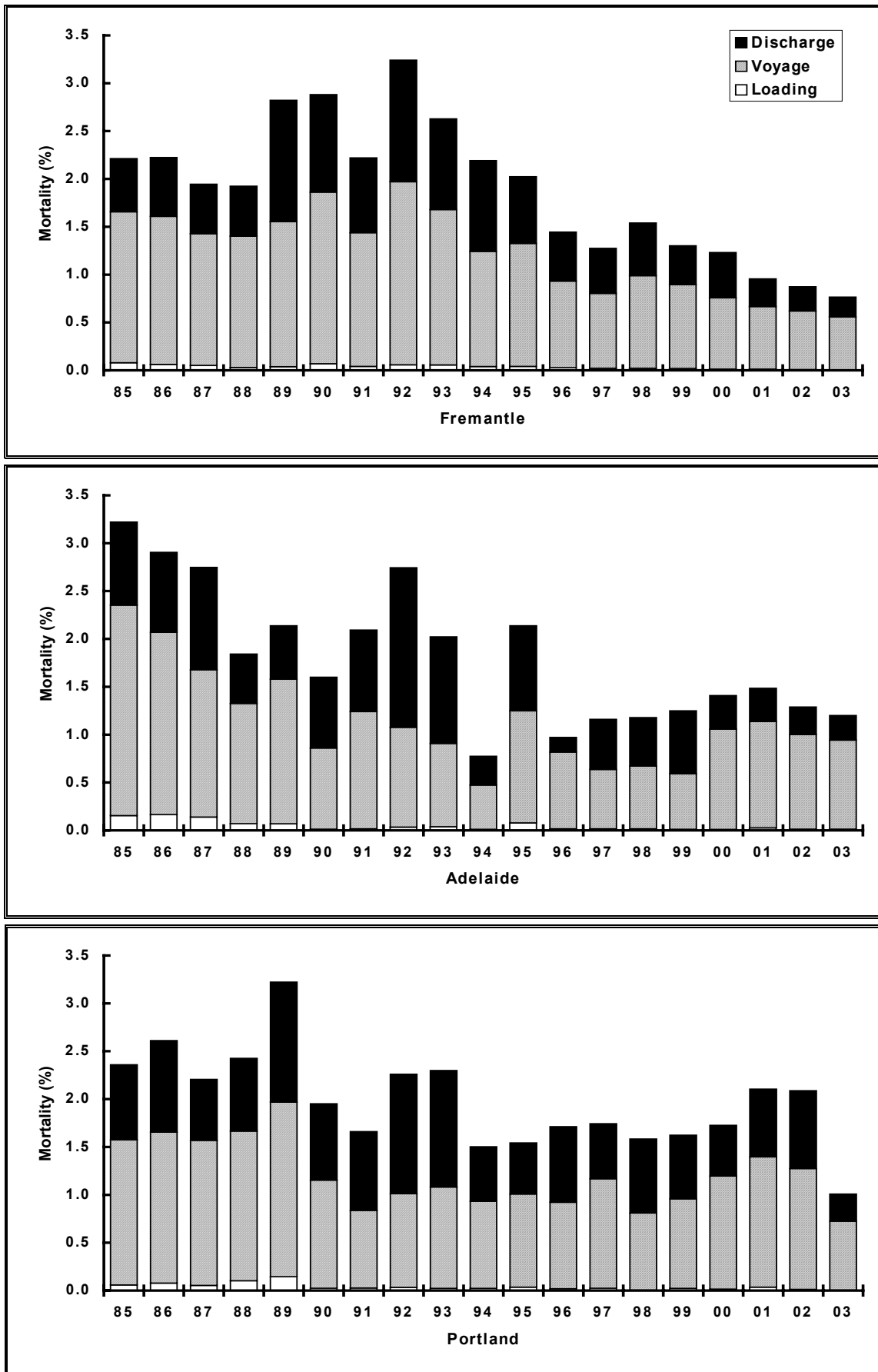


Figure 2 Annual mortality for sheep exported from Fremantle, Adelaide and Portland to the Middle East since 1985

2.5 Class of sheep

The death rates of various classes of sheep exported from Australia to the Middle East are shown in Table 4 and Figure 3. Although death rates were highest in ram hoggets, adult ewes and adult rams exported from Portland, there were relatively few animals in these categories exported from Portland (Table 1).

Table 4 Overall mortality (%) for classes of sheep exported from Fremantle, Adelaide and Portland to the Middle East in 2003

| Class of sheep | | Fremantle | Adelaide | Portland | Total |
|----------------|--------|-----------|----------|----------|-------|
| Wethers | adult | 0.9 | 1.3 | 1.1 | 1.0 |
| | hogget | 0.5 | n/a | 0.6 | 0.5 |
| | lamb | 0.6 | 0.9 | 0.8 | 0.7 |
| Rams | adult | 1.1 | 1.0 | 1.4 | 1.1 |
| | hogget | 0.9 | 1.3 | 2.0 | 1.0 |
| | lamb | 0.9 | 0.9 | 1.1 | 0.9 |
| Ewes | adult | 1.1 | 0.7 | 1.5 | 1.1 |
| | hogget | n/a | n/a | n/a | n/a |
| | lamb | 0.4 | 1.0 | n/a | 0.4 |

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

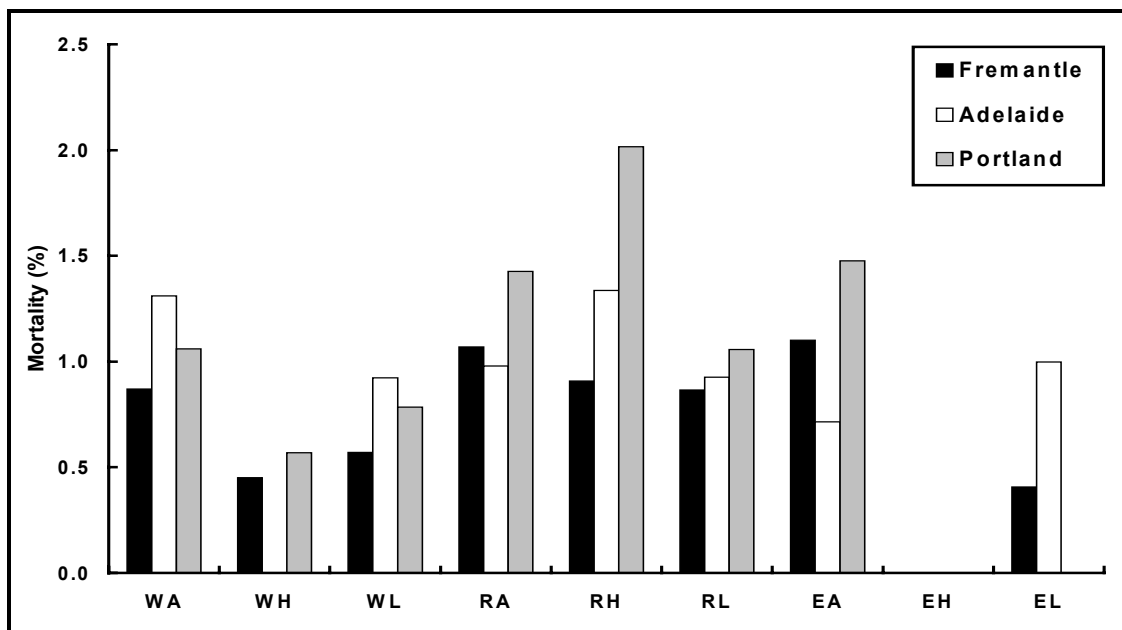


Figure 3 Overall mortality (%) for classes of sheep exported from Fremantle, Adelaide and Portland to the Middle East in 2003

WA = wether adults
RA = ram adults
EA = ewe adults

WH = wether hoggets
RH = ram hoggets
EH = ewe hoggets

WL = wether lambs
RL = ram lambs
EL = ewe lambs

2.6 Time of year

The monthly death rate during 2003 and the moving 5-year average (proportion of all deaths divided by number loaded) for sheep exported from Fremantle, Adelaide and Portland are shown in Figure 4a, 4b and 4c respectively. The monthly death rate in 2003 was below the moving 5-year average in most months of the year for sheep exported from Fremantle and Portland, and was well below the 5-year average from June to October for Portland.

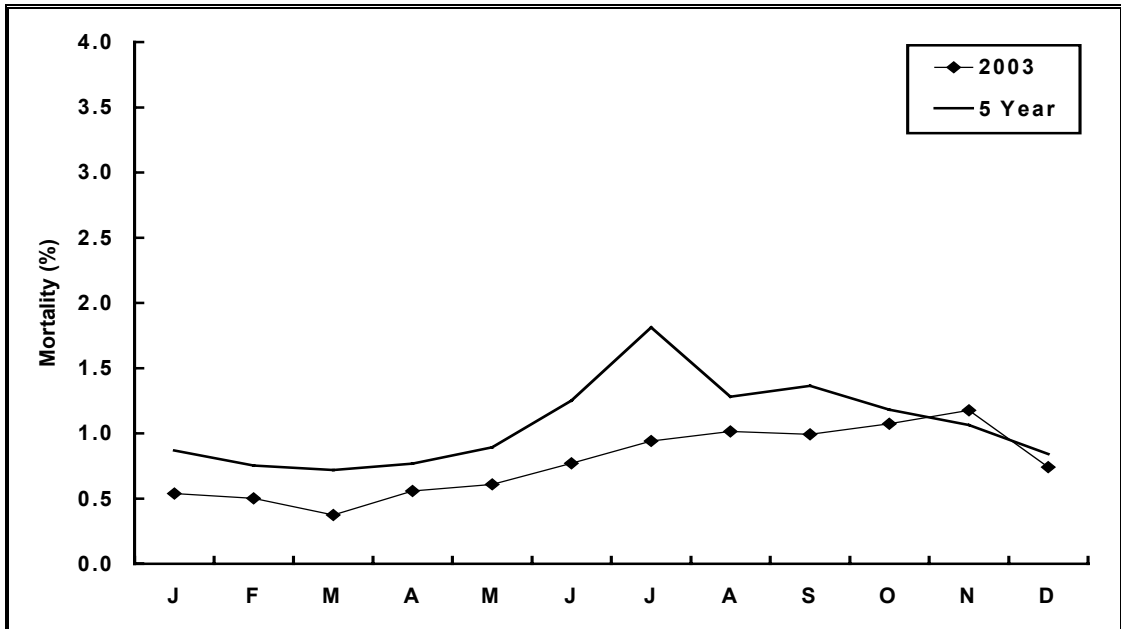


Figure 4a Monthly mortality during 2003 and moving 5-year average in sheep exported from Fremantle to the Middle East

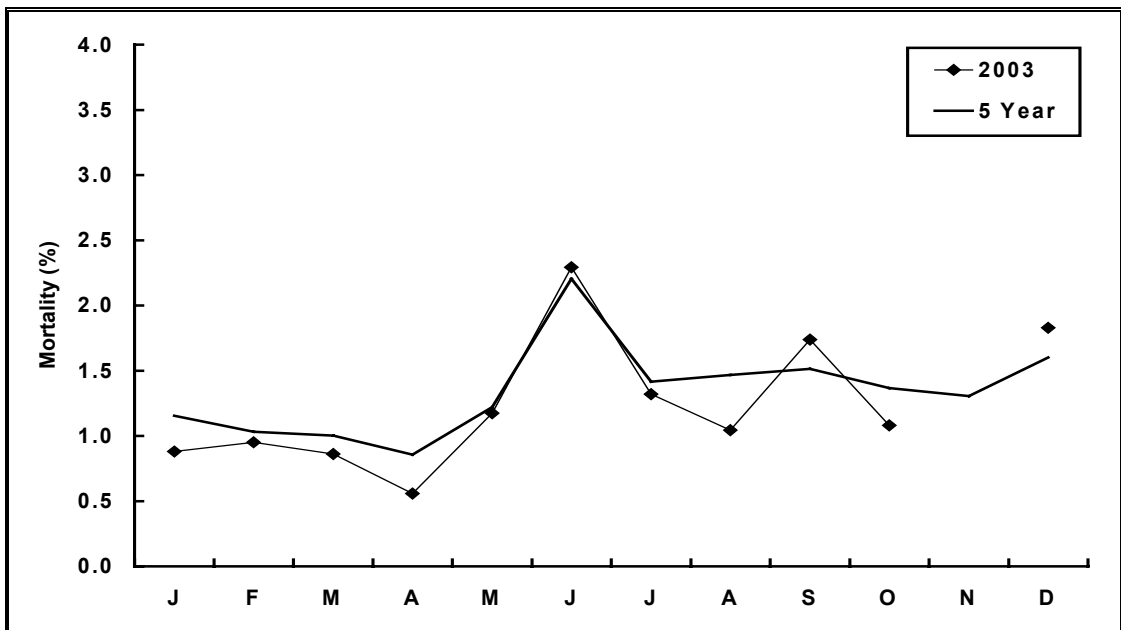


Figure 4b Monthly mortality during 2003 and moving 5-year average in sheep exported from Adelaide to the Middle East

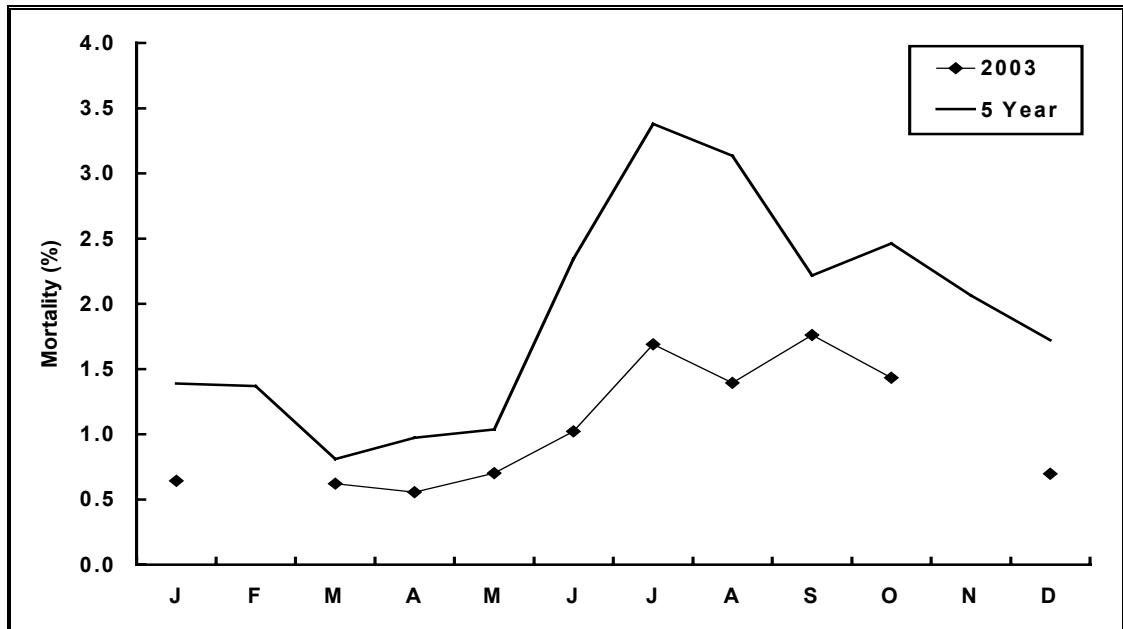


Figure 4c Monthly mortality during 2003 and moving 5-year average in sheep exported from Portland to the Middle East

Death rates were higher ($P < 0.01$) in the second half of 2003 compared with the first half in sheep exported from Fremantle, Adelaide and Portland (Figure 5). This observation is consistent with previous years for voyages from Fremantle, and research on ships and in Middle East feedlots has indicated that most of the deaths are due to inanition and salmonellosis.

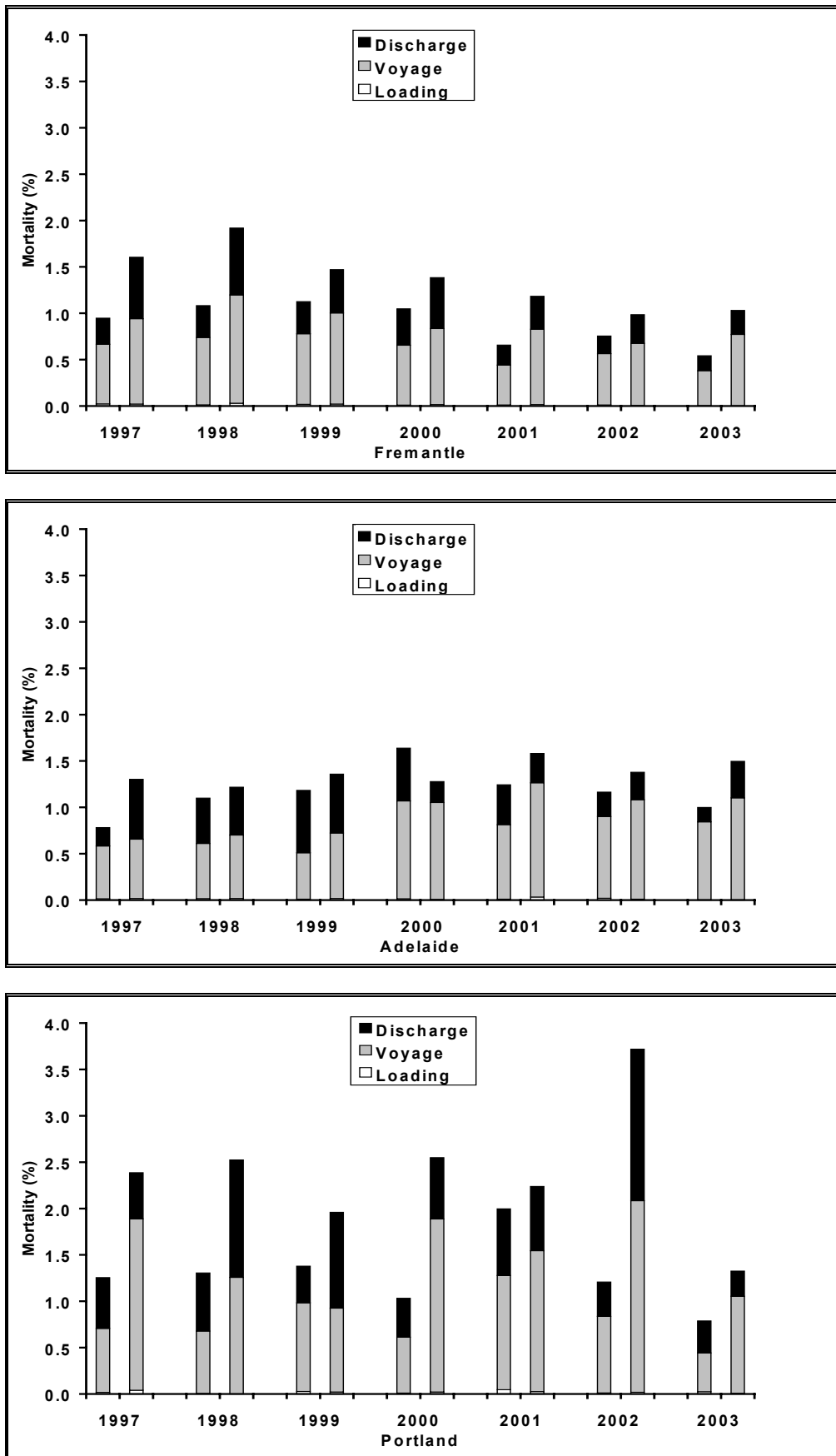


Figure 5 Mortality (%) for sheep exported by sea from Fremantle, Adelaide and Portland to the Middle East for the first and second half of each year from 1997 to 2003

2.7 Ship

The voyages of each ship were classified into low, medium and high mortality categories for sheep exported to the Middle East from Fremantle (Table 5a), Adelaide (Table 5b) and Portland (Table 5c). There were two voyages from Adelaide classified as "high mortality", one from Portland and none from Fremantle during 2003. Approximately 74% of voyages from Fremantle, 55% of voyages from Portland and 48% of voyages from Adelaide were in the "low" category.

Table 5a Number of voyages in low, medium and high mortality categories for ships loaded at Fremantle in 2003

| Ship (code) | Mortality rate | | | Total |
|----------------|----------------|--------------------|---------------|-------|
| | Low <1.0% | Medium 1.0–2.0% | High >2.0% | |
| 1 | 3 | 0 | 0 | 3 |
| 2 | 5 | 1 | 0 | 6 |
| 7 | 6 | 3 | 0 | 9 |
| 13 | 1 | 0 | 0 | 1 |
| 20 | 4 | 0 | 0 | 4 |
| 22 | 6 | 0 | 0 | 6 |
| 27 | 2 | 0 | 0 | 2* |
| 31 | 1 | 0 | 0 | 1 |
| 32 | 4 | 3 | 0 | 7 |
| 33 | 1 | 2 | 0 | 3 |
| 34 | 4 | 1 | 0 | 5 |
| 35 | 3 | 2 | 0 | 5 |
| 36 | 1 | 0 | 0 | 1 |
| 37 | 7 | 1 | 0 | 8* |
| 74 | 0 | 1 | 0 | 1 |
| 93 | 0 | 3 | 0 | 3 |
| Total | 48 | 17 | 0 | 65 |

* One split-loaded voyage excluded: mortalities could not be determined by consignment

Table 5b Number of voyages in low, medium and high mortality categories for ships loaded at Adelaide in 2003

| Ship (code) | Mortality rate | | | Total |
|----------------|----------------|--------------------|---------------|-------|
| | Low <1.0% | Medium 1.0–2.0% | High >2.0% | |
| 2 | 0 | 1 | 0 | 1 |
| 7 | 1 | 0 | 1 | 2 |
| 13 | 2 | 0 | 0 | 2 |
| 20 | 2 | 2 | 0 | 4 |
| 22 | 1 | 1 | 0 | 2 |
| 27 | 2 | 1 | 0 | 3* |
| 32 | 0 | 2 | 1 | 3 |
| 35 | 2 | 2 | 0 | 4 |
| Total | 10 | 9 | 2 | 21 |

* One split-loaded voyage excluded: mortalities could not be determined by consignment

Table 5c Number of voyages in low, medium and high mortality categories for ships loaded at Portland in 2003

| Ship (code) | Mortality rate | | | Total |
|----------------|----------------|--------------------|---------------|-------|
| | Low <1.0% | Medium 1.0–2.0% | High >2.0% | |
| 2 | 2 | 1 | 0 | 3 |
| 7 | 0 | 1 | 0 | 1 |
| 32 | 4 | 0 | 1 | 5 |
| 34 | 3 | 3 | 0 | 6 |
| 37 | 1 | 2 | 0 | 3* |
| Total | 10 | 7 | 1 | 18 |

* One split-loaded voyage excluded: mortalities could not be determined by consignment

3 CATTLE

3.1 Overview

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

The following results are based on analysis of ship Masters' reports which were to hand in April 2004 and also "Yellow Books" which record more detailed information about the number of cattle deaths. Some results, such as the number of cattle exported, may differ slightly from other sources of information.

There were 31 voyages in 2003 for which cattle were loaded at more than one port in Australia. Mortalities for split-load voyages were attributed to the port of loading where possible. Where analysis involving split-load voyages has been performed, the consignments of cattle from each load port have been considered as separate voyages.

The overall death rate among the 0.76 million cattle exported from Australia in 2003 fell to 0.11% (Table 6), less than half the death rate of 0.24% in 2002. The highest overall death rate was to the Middle East/North Africa followed by the North-East Asia, while the lowest death rate was to South-East Asia. Exports to South-East Asia were mainly to Indonesia and Malaysia, and were characterised by small consignments on short voyages with very low death rates. Voyages to the Middle East, mainly Israel, involved longer duration and higher death rates than those to other regions. The number of cattle exported to North-East Asia in 2003 was 3-fold higher than in 2002 while the number of cattle exported to the Middle East fell by more than half.

Table 6 Death rates, number of voyages and number of cattle exported for voyages to major destination regions during 2003

| Parameter | ME/N Africa | SE Asia | NE Asia | Mexico | Total |
|-------------------------------|-------------|-----------|-----------|-----------|-----------|
| Voyages (No.) | 52 | 306 | 36 | 1 | 395 |
| Cattle (No.) | 106,080 | 587,716 | 66,861 | 2,558 | 763,215 |
| Death rate overall (%) | 0.45 | 0.05 | 0.12 | 0.08 | 0.11 |
| Death rate range (%) | 0.0 – 2.0 | 0.0 – 2.2 | 0.0 – 1.1 | 0.1 – 0.1 | 0.0 – 2.2 |
| Voyages with nil deaths (No.) | 18 | 190 | 10 | 0 | 218 |

3.2 Middle East

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 at approximately 0.7% annually before falling by half in 1999. The number of cattle exported to the Middle East in 2003 fell by more than half compared to the previous 5 years. The death rate in 2003 was 0.45%, a reduction of 26% on the death rate in 2002.

Table 7 Death rates, number of voyages and number of cattle exported to the Middle East from 1995 to 2003

| | Voyages (No.) | Cattle (No.) | Death rate overall (%) | Death rate range (%) | Voyages with nil deaths (No.) |
|------|------------------|-----------------|---------------------------|-------------------------|----------------------------------|
| 1995 | 11 | 14,557 | 0.67 | 0.0 – 2.1 | 2 |
| 1996 | 36 | 65,066 | 0.65 | 0.0 – 5.0 | 14 |
| 1997 | 62 | 137,869 | 0.67 | 0.0 – 4.2 | 15 |
| 1998 | 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 |
| 2003 | 52 | 106,080 | 0.45 | 0.0 – 2.0 | 18 |

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

3.2.1 Port of loading

For voyages to the Middle East, most cattle were exported from Fremantle, followed by Adelaide and Portland (Table 8). Death rates in 2003 were highest from Adelaide (0.70%), followed by Fremantle (0.45%) and Portland (0.35%). The death rate and the number of cattle loaded at Portland in 2003 fell by more than 80% compared to the previous year.

The voyages from each port were classified into various mortality categories as shown in Table 9. Five voyages out of 52 (9.6%) were in the high category and involved the ports of Adelaide and Fremantle.

Table 8 Death rates, number of voyages and number of cattle exported from various ports to the Middle East for 2003

| Port | Voyages (No.) | Cattle (No.) | Death rate overall (%) | Death rate range (%) |
|--------------|------------------|-----------------|---------------------------|-------------------------|
| Broome | 1 | 4,027 | 0.05 | n/a |
| Port Hedland | 1 | 6,657 | 0.34 | n/a |
| Fremantle | 32 | 68,167 | 0.45 | 0.0 – 2.0 |
| Adelaide | 9 | 16,083 | 0.70 | 0.0 – 1.61 |
| Portland | 9 | 11,146 | 0.35 | 0.0 – 0.99 |

Table 9 Number of voyages in nil, low, medium and high mortality categories for shipments from various ports to the Middle East for 2003

| Port | Mortality rate | | | | Total |
|--------------|----------------|------------------|---------------------|---------------|-------|
| | Nil 0.0% | Low >0.0–0.5% | Medium >0.5–1.0% | High >1.0% | |
| Broome | 0 | 1 | 0 | 0 | 1 |
| Port Hedland | 0 | 1 | 0 | 0 | 1 |
| Fremantle | 14 | 11 | 5 | 2 | 32 |
| Adelaide | 1 | 4 | 1 | 3 | 9 |
| Portland | 3 | 3 | 3 | 0 | 9 |
| Total | 18 | 20 | 9 | 5 | 52 |

3.2.2 Time of year

Monthly death rates were below 1% throughout the year (Figure 6). There was only one voyage to the Middle East from a northern port in 2003, which resulted in a 0.05% mortality rate.

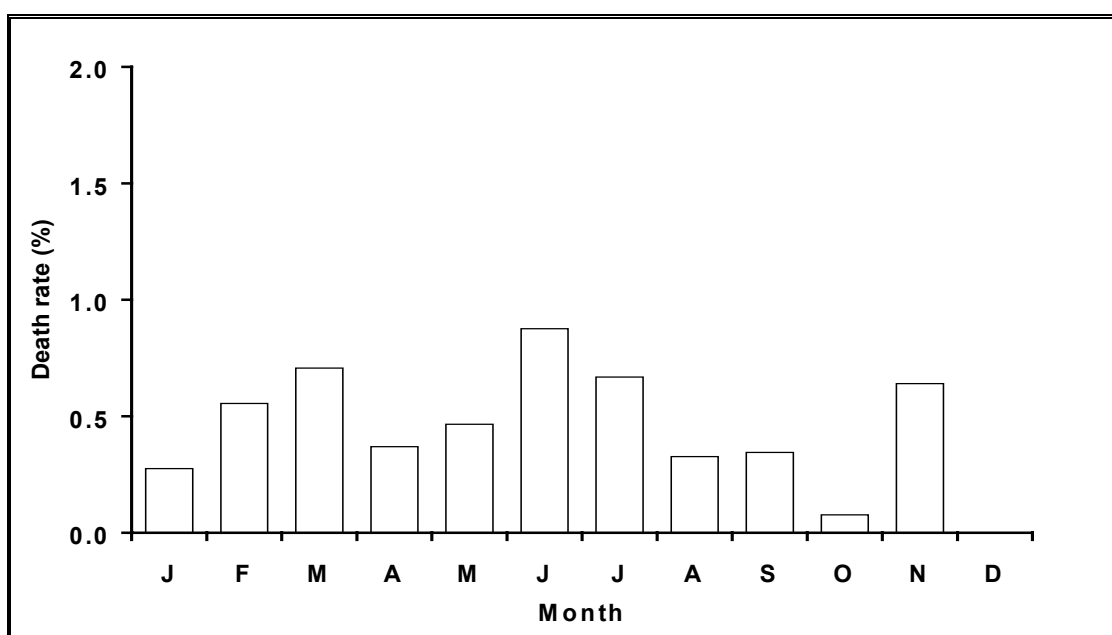


Figure 6 Monthly death rate of cattle on voyages to the Middle East for 2003

3.2.3 Voyages from southern ports 1999 to 2003

Additional analysis was conducted for the ports of Fremantle, Adelaide and Portland because of the higher death rates on voyages from these ports compared to northern ports in recent years. Death rates of cattle were highest from Portland and lowest from Fremantle, and this was consistent in each year until 2003 (Table 10); cattle exported from Portland had more than twice the risk of death compared to cattle exported from Fremantle (Table 11) while cattle exported from Adelaide had approximately 1.5 times the risk of death compared to Fremantle. In 2003, the death rate and the number of cattle loaded at Portland fell by more than 80% compared to the previous year.

Table 10 Death rates for cattle loaded at Fremantle, Adelaide or Portland from 1999 to 2003

| Year | Fremantle | | | Adelaide | | | Portland | | |
|------|------------|--------------|----------|------------|--------------|----------|------------|--------------|----------|
| | Voys (No.) | Cattle (No.) | Dead (%) | Voys (No.) | Cattle (No.) | Dead (%) | Voys (No.) | Cattle (No.) | Dead (%) |
| 1999 | 43 | 103,290 | 0.33 | 10 | 30,139 | 0.51 | 14 | 45,087 | 0.83 |
| 2000 | 45 | 94,787 | 0.43 | 7 | 19,158 | 0.66 | 13 | 40,748 | 1.01 |
| 2001 | 48 | 104,404 | 0.34 | 11 | 22,274 | 0.53 | 16 | 35,797 | 0.82 |
| 2002 | 57 | 103,914 | 0.36 | 17 | 25,035 | 0.47 | 15 | 46,624 | 2.03* |
| 2003 | 50 | 68,167 | 0.45 | 9 | 16,083 | 0.70 | 9 | 11,146 | 0.35 |

* 0.74% if one high mortality voyage is excluded

Table 11 Relative risk of cattle deaths on voyages from Adelaide and Portland compared with Fremantle from 1999 to 2003

| Year | Adelaide | Portland |
|------|------------------------|------------------------|
| | Relative risk (95% CI) | 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)* |
| 2003 | 1.5 (1.3-1.9) | 0.8 (0.6-1.1)** |

* 2.1 (1.8-2.4) if one high mortality voyage is excluded

** not significantly different from Fremantle

3.2.4 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 2003 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 12) 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. In 2003, the death rate was significantly higher to the Red Sea than to the Arabian Gulf ($P < 0.01$).

Table 12 Death rates for cattle exported to the Arabian Gulf or Red Sea from Fremantle, Adelaide or Portland between 1999 and 2003

| Year | Arabian Gulf | | | Red Sea | | |
|------|--------------|--------------|----------|------------|--------------|----------|
| | 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 |
| 2003 | 27 | 9,801 | 0.20 | 23 | 85,595 | 0.51 |

* Death rate 0.26% if one high mortality incident is excluded

3.2.5 Class of cattle

Recording of death rates for each class of cattle loaded began in July 2002. The highest death rates occurred in bull calves followed by adult bulls (Table 13).

Table 13 Death rates, number of voyages and number of cattle in various classes exported to the Middle East in 2003

| Class | Voyages (No.) | Cattle (No.) | Death rate (%) | Death rate range (%) |
|--------------|---------------|--------------|----------------|----------------------|
| Steer adult | 23 | 18,429 | 0.24 | 0.0 - 0.2 |
| Bull adult | 35 | 48,365 | 0.45 | 0.0 - 1.6 |
| Bull calf | 10 | 31,858 | 0.62 | 0.0 - 1.2 |
| Cow dairy | 8 | 2,690 | 0.33 | 0.0 - 1.4 |
| Heifer beef | 2 | 789 | 0.00 | n/a |
| Heifer dairy | 7 | 3,706 | 0.32 | 0.0 - 1.3 |

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

3.2.6 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 14 shows the number of voyages in the various mortality categories for each ship. Most voyages of most ships were in the nil or low mortality categories. There were 5 (9.6%) voyages in the high category; this involved ships 13, 22, 27, and 37.

Table 14 Number of voyages in nil, low, medium and high mortality categories for shipments to the Middle East for 2003

| Ship (code) | Mortality rate | | | | Total |
|-------------|----------------|------------------|---------------------|---------------|-------|
| | Nil 0.0% | Low >0.0–0.5% | Medium >0.5–1.0% | High >1.0% | |
| 1 | 3 | 0 | 0 | 0 | 3 |
| 13 | 1 | 2 | 2 | 1 | 2 |
| 22 | 0 | 2 | 1 | 1 | 4 |
| 27 | 1 | 1 | 1 | 1 | 4 |
| 31 | 0 | 1 | 0 | 0 | 1 |
| 32 | 5 | 3 | 0 | 0 | 8 |
| 33 | 0 | 3 | 1 | 0 | 4 |
| 34 | 5 | 0 | 2 | 0 | 7 |
| 35 | 0 | 7 | 2 | 0 | 9 |
| 37 | 2 | 3 | 2 | 2 | 9 |
| 74 | 1 | 0 | 0 | 0 | 1 |
| Total | 18 | 20 | 9 | 5 | 52 |

3.3 South-East Asia

Nearly 0.6 million cattle were exported to South-East Asia in 2003 (Table 15) and the death rate was 0.05%, down slightly from previous years. No deaths were reported on almost two thirds of the voyages to the region. The death rate from 1995 to 2003 has remained low at approximately 0.1% annually except in 1999 when the death rate was 0.34% (or 0.16% if one exceptionally high mortality voyage was excluded).

Table 15 Death rates, number of voyages and number of cattle exported to South-East Asia from 1995 to 2003

| | Voyages (No.) | Cattle (No.) | Death rate overall (%) | Death rate range (%) | Voyages with nil deaths (No.) |
|------|---------------|--------------|------------------------|----------------------|-------------------------------|
| 1995 | 365 | 430,653 | 0.11 | 0.0 – 8.5 | 206 |
| 1996 | 415 | 505,777 | 0.05 | 0.0 – 1.2 | 280 |
| 1997 | 507 | 678,585 | 0.09 | 0.0 – 1.7 | 277 |
| 1998 | 229 | 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 |
| 2003 | 306 | 587,716 | 0.05 | 0.0 – 2.2 | 190 |

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

3.3.1 Port of loading

Most cattle exported to South-East Asia were loaded at Darwin followed by Broome (Table 16). The death rates from each port were 0.1% or less.

Table 16 Death rates, number of voyages and number of cattle exported from various ports to South-East Asia for 2003

| Port | Voyages (No.) | Cattle (No.) | Death rate overall (%) | Death rate range (%) |
|--------------|---------------|--------------|------------------------|----------------------|
| Brisbane | 2 | 3,617 | 0.05 | 0.0 - 0.1 |
| Townsville | 24 | 59,151 | 0.04 | 0.0 - 0.7 |
| Mourilyan | 1 | 977 | 0.10 | n/a |
| Weipa | 1 | 2,362 | 0.00 | n/a |
| Karumba | 23 | 36,350 | 0.02 | 0.0 - 0.1 |
| Darwin | 137 | 260,422 | 0.04 | 0.0 - 2.2 |
| Wyndham | 26 | 56,404 | 0.04 | 0.0 - 0.5 |
| Broome | 38 | 77,301 | 0.05 | 0.0 - 0.2 |
| Port Hedland | 7 | 13,694 | 0.06 | 0.0 - 0.2 |
| Geraldton | 18 | 24,993 | 0.04 | 0.0 - 0.2 |
| Fremantle | 29 | 52,445 | 0.08 | 0.0 - 0.7 |

3.4 North-East Asia

The number of cattle exported to North-East Asia increased 3-fold in 2003 compared to previous years (Table 17). Despite the large increase in exports, the death rate has remained relatively constant at about 0.1%.

Table 17 Death rates, number of voyages and number of cattle exported to North-East Asia from 1995 to 2003

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

3.4.1 Port of loading

The main port of loading for cattle exported to North-East Asia was Portland followed by Brisbane (Table 18). The cattle loaded at Portland were exported to China and those loaded at Brisbane were exported to Japan.

Table 18 Death rates, number of voyages and number of cattle exported from various ports to North-East Asia for 2003

| Port | Voyages (No.) | Cattle (No.) | Death rate overall (%) | Death rate range (%) |
|-------------|---------------|--------------|------------------------|----------------------|
| Portland | 16 | 40,371 | 0.12 | 0.0 - 0.8 |
| Port Kembla | 1 | 847 | 0.00 | n/a |
| Brisbane | 14 | 20,354 | 0.06 | 0.0 - 0.1 |
| Fremantle | 4 | 3,058 | 0.29 | 0.0 - 1.1 |

One split-loaded voyage excluded: mortalities could not be determined by consignment

3.5 China

Although considered part of North East Asia for the purposes of this report, China is reported separately because of the rapid growth in exports of dairy cattle to this country (Table 19).

Table 19 Death rates, number of voyages and number of cattle exported to China from 1995 to 2003

| | Voyages (No.) | Cattle (No.) | Death rate overall (%) | Death rate range (%) | Voyages with nil deaths (No.) |
|------|---------------|--------------|------------------------|----------------------|-------------------------------|
| 1995 | 0 | | | | |
| 1996 | 0 | | | | |
| 1997 | 1 | 1,290 | 2.56 | n/a | n/a |
| 1998 | 0 | | | | |
| 1999 | 0 | | | | |
| 2000 | 0 | | | | |
| 2001 | 1 | 1,363 | 0.07 | n/a | n/a |
| 2002 | 6 | 8,407 | 0.25 | 0.0 - 0.7 | 0 |
| 2003 | 18 | 43,152 | 0.13 | 0.0 - 0.8 | 3 |

3.5.1 Port of loading

Nearly all of the cattle exported to China in 2003 were loaded at Portland (Table 20).

Table 20 Death rates, number of voyages and number of cattle exported from various ports to North-East Asia for 2003

| Port | Voyages (No.) | Cattle (No.) | Death rate overall (%) | Death rate range (%) |
|-----------|---------------|--------------|------------------------|----------------------|
| Portland | 16 | 40,371 | 0.12 | 0.0 - 0.8 |
| Fremantle | 1 | 550 | 0.00 | n/a |

One split-loaded voyage excluded: mortalities could not be determined by consignment

3.5.2 Class of cattle

Recording of death rates for each class of cattle exported to China was only introduced after July 2003. The results to the end of the year indicate that the death rate in dairy heifers was 0.1% (Table 21).

Table 21 Death rate, number of voyages and number of cattle in the class exported to China in the second half of 2003

| Class | Voyages (No.) | Cattle (No.) | Death rate (%) | Death rate range (%) |
|--------------|------------------|-----------------|-------------------|-------------------------|
| Heifer dairy | 8 | 20,507 | 0.10 | 0.0 - 0.3 |

4 GOATS

4.1 Overview

The live goat trade from Australia is characterised by the export of animals to the Middle East and South-East Asia. The three main southern ports of loading are Fremantle, Adelaide and Portland.

The following results are based on analysis of ship Masters' reports which were to hand in April 2004 and also "Yellow Books" which record more detailed information about the number of goat deaths. Some results, such as the number of goats exported, may differ slightly from other sources of information.

The overall death rate among the 52,600 goats exported from Australia in 2003 was 0.8% (Table 22). Although there were twice as many goats exported to South-East Asia than the Middle East, the death rate was not different between the two regions ($P > 0.05$).

Table 22 Death rates, number of voyages and number of goats exported by sea for voyages to major destination regions during 2003

| Parameter | ME/N Africa | SE Asia | NE Asia | Total |
|------------------------|-------------|-----------|---------|-----------|
| Voyages (No.) | 16 | 41 | 1 | 57 |
| Goats (No.) | 16,552 | 36,048 | 597 | 52,600 |
| Death rate overall (%) | 0.88 | 0.76 | 0.00 | 0.80 |
| Death rate range (%) | 0.0 – 1.7 | 0.0 – 3.1 | n/a | 0.0 – 3.1 |

The number of goats exported to all destinations from the 3 main southern ports since 1993 is shown in Figure 7. More than 40,000 goats were exported by sea from Portland in 2002 but the number declined in 2003.

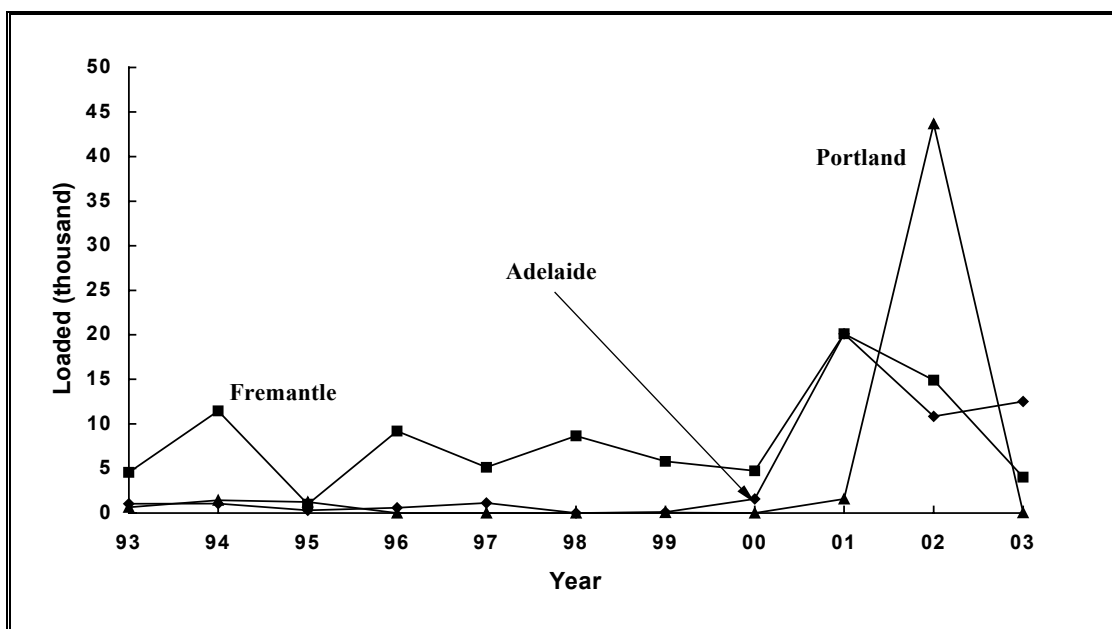


Figure 7 Number of goats ('000) exported by sea from Fremantle (Western Australia), Adelaide (South Australia) and Portland (Victoria) since 1993

The annual death rate of goats exported from Australia in 2003 was the lowest since 1993 (Figure 8).

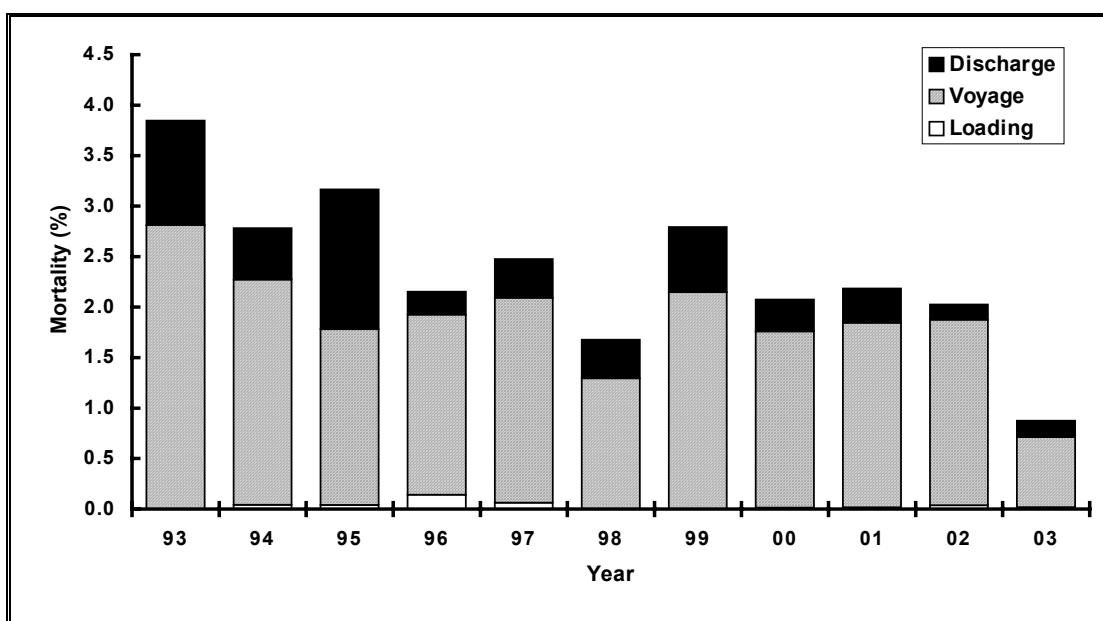


Figure 8 Annual mortality of goats exported by sea from all ports in Australia to all destinations since 1993

4.2 Middle East

Large numbers of goats were exported to the Middle East in 2001 and 2002 (Table 23). The death rate has remained at approximately 3% since 1994 before falling to less than 1% in 2003. The number of goats exported to the Middle East in 2003 declined substantially compared to the previous 2 years.

Table 23 Death rates, number of voyages and number of goats exported by sea to the Middle East from 1993 to 2003

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

4.2.1 Port of loading

All goats exported to the Middle East in 2003 were loaded at southern ports, and most were loaded at Adelaide, followed by Fremantle and Portland (Table 24). Death rates in 2003 were highest from Fremantle (1.20%), followed by Adelaide (0.77%) and Portland (0.0%). The voyages from each port were classified into various mortality categories as shown in Table 25. There were no voyages in the high category.

Table 24 Death rates, number of voyages and number of goats exported from various ports to the Middle East for 2003

| Port | Voyages (No.) | Goats (No.) | Death rate overall (%) | Death rate range (%) |
|-----------|---------------|-------------|------------------------|----------------------|
| Fremantle | 6 | 4,008 | 1.20 | 0.0 – 1.7 |
| Adelaide | 9 | 12,524 | 0.77 | 0.0 – 1.29 |
| Portland | 1 | 20 | 0.00 | n/a |

Table 25 Number of voyages in low, medium and high mortality categories for shipments from various ports to the Middle East for 2003

| Port | Mortality rate | | | Total |
|-----------|----------------|-----------------|------------|-------|
| | Low <1.0% | Medium 1.0–2.0% | High >2.0% | |
| Fremantle | 4 | 2 | 0 | 6 |
| Adelaide | 6 | 3 | 0 | 9 |
| Portland | 1 | 0 | 0 | 1 |
| Total | 11 | 5 | 0 | 16 |

4.2.2 Ship

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

Table 26 shows the number of voyages in the various mortality categories for each ship. Most voyages of most ships were in the nil or low mortality categories. There were no voyages in the high category in 2003.

Table 26 Number of voyages in low, medium and high mortality categories for shipments to the Middle East for 2003

| Ship (code) | Mortality rate | | | Total |
|-------------|----------------|-----------------|------------|-------|
| | Low <1.0% | Medium 1.0–2.0% | High >2.0% | |
| 2 | 1 | 0 | 0 | 1 |
| 7 | 1 | 0 | 0 | 1 |
| 13 | 1 | 0 | 0 | 1 |
| 20 | 5 | 1 | 0 | 6 |
| 27 | 2 | 2 | 0 | 4 |
| 32 | 0 | 1 | 0 | 1 |
| 35 | 0 | 1 | 0 | 1 |
| 37 | 1 | 0 | 0 | 1 |
| Total | 11 | 5 | 0 | 16 |

4.2.3 Time of year

The monthly death rate during 2003 and the moving 5-year average (proportion of all deaths divided by number loaded) in all goats exported to the Middle East are shown in Figure 9. The monthly death rate in 2003 was considerably less than the 5-year average; there were no goats exported in February or from October to December 2003.

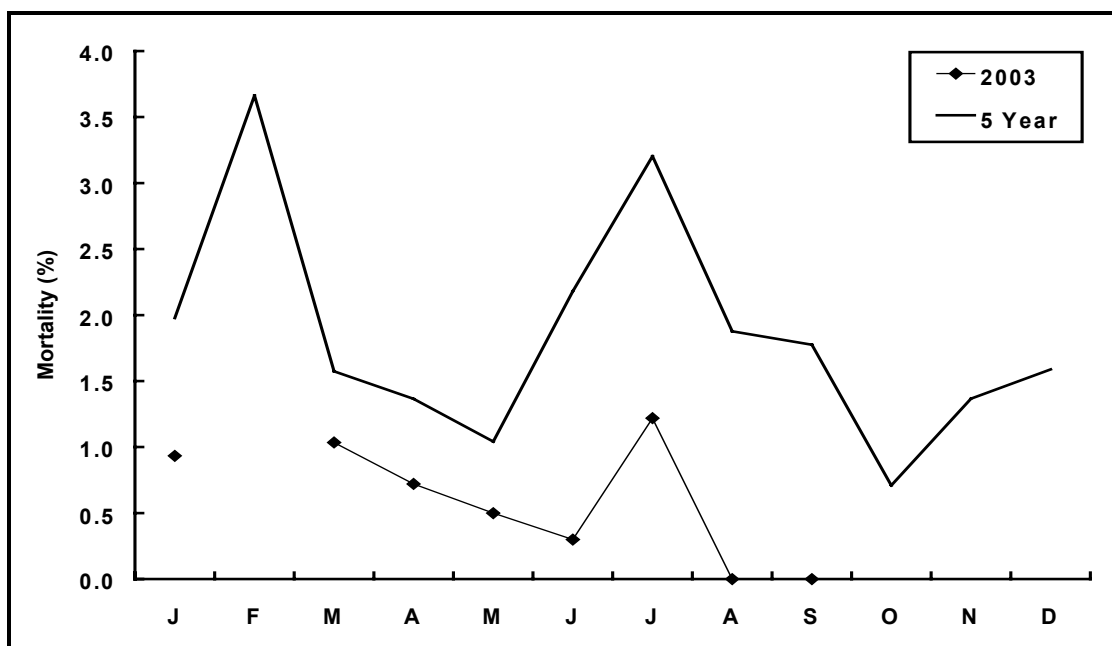


Figure 9 Monthly mortality during 2003 and moving 5-year average in goats exported to the Middle-East

4.3 South-East Asia

The number of goats exported by sea to South-East Asia increased substantially in 2001 compared to previous years (Table 27). The number of goats exported by air from Perth is also shown in the table for comparison but is not discussed further. The death rate in 2003 fell to 0.76%, a reduction of 28% on the death rate in 2002.

Table 27 Death rates, number of voyages and number of goats exported by sea to South-East Asia from 1993 to 2003

| | Voyages (No.) | Goats (No.) | Death rate overall (%) | Death rate range (%) | Goats exported by air (No.) |
|------|------------------|----------------|---------------------------|-------------------------|--------------------------------|
| 1993 | 17 | 7,497 | 1.63 | 0.0 - 4.7 | 1,921 |
| 1994 | 19 | 7,867 | 1.89 | 0.0 - 5.5 | 7,153 |
| 1995 | 11 | 4,818 | 2.24 | 0.0 - 7.8 | 10,420 |
| 1996 | 12 | 5,208 | 1.73 | 0.0 - 4.1 | 13,939 |
| 1997 | 26 | 14,363 | 2.53 | 0.0 - 7.0 | 13,691 |
| 1998 | 14 | 10,698 | 4.55 | 0.0 - 28.8* | 7,455 |
| 1999 | 19 | 10,143 | 2.44 | 0.0 - 5.0 | 17,698 |
| 2000 | 28 | 14,728 | 1.65 | 0.0 - 8.7 | 13,439 |
| 2001 | 45 | 31,150 | 1.37 | 0.0 - 6.9 | 9,742 |
| 2002 | 49 | 42,032 | 1.05 | 0.0 - 9.9 | 4,775 |
| 2003 | 41 | 36,048 | 0.76 | 0.0 - 3.1 | 807 |

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

4.3.1 Port of loading

For voyages to South-East Asia, most goats were exported from Darwin, followed by Fremantle and Geraldton (Table 28). Death rates in 2003 were highest from Port Hedland (1.48%), followed by Geraldton (1.36%) and Broome (0.62%).

The voyages from each port were classified into various mortality categories as shown in Table 29. Two voyages out of 41 were in the high category and involved the ports of Darwin and Wyndham.

Table 28 Death rates, number of voyages and number of goats exported from various ports to South-East Asia for 2003

| Port | Voyages (No.) | Goats (No.) | Death rate overall (%) | Death rate range (%) |
|--------------|------------------|----------------|---------------------------|-------------------------|
| Darwin | 15 | 10,216 | 0.43 | 0.0 - 3.1 |
| Wyndham | 3 | 1,364 | 0.15 | 0.0 - 3.1 |
| Broome | 8 | 4,960 | 0.62 | 0.0 - 1.5 |
| Port Hedland | 3 | 4,180 | 1.48 | 0.0 - 1.7 |
| Geraldton | 5 | 6,379 | 1.36 | 0.0 - 1.6 |
| Fremantle | 7 | 8,949 | 0.54 | 0.0 - 1.8 |

Table 29 Number of voyages in low, medium and high mortality categories for shipments from various ports to South-East Asia for 2003

| Port | Mortality rate | | | Total |
|--------------|----------------|--------------------|---------------|-------|
| | Low <1.0% | Medium 1.0–2.0% | High >2.0% | |
| Darwin | 13 | 1 | 1 | 15 |
| Wyndham | 2 | 0 | 1 | 3 |
| Broome | 7 | 1 | 0 | 8 |
| Port Hedland | 1 | 2 | 0 | 3 |
| Geraldton | 2 | 3 | 0 | 5 |
| Fremantle | 5 | 2 | 0 | 7 |
| Total | 30 | 9 | 2 | 41 |

4.3.2 Ship

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

Table 30 shows the number of voyages in the various mortality categories for each ship. Most voyages of most ships were in the nil or low mortality categories. There were 2 (4.9%) voyages in the high category; both involved ship 88.

Table 30 Number of voyages in low, medium and high mortality categories for shipments to South-East Asia for 2003

| Ship (code) | Mortality rate | | | Total |
|----------------|----------------|--------------------|---------------|-------|
| | Low <1.0% | Medium 1.0–2.0% | High >2.0% | |
| 55 | 1 | 1 | 0 | 2 |
| 59 | 1 | 0 | 0 | 1 |
| 63 | 2 | 0 | 0 | 2 |
| 77 | 1 | 0 | 0 | 1 |
| 86 | 1 | 0 | 0 | 1 |
| 88 | 3 | 0 | 2 | 5 |
| 97 | 6 | 1 | 0 | 7 |
| 99 | 10 | 0 | 0 | 10 |
| 100 | 2 | 0 | 0 | 2 |
| 102 | 1 | 0 | 0 | 1 |
| 103 | 1 | 0 | 0 | 1 |
| 104 | 1 | 7 | 0 | 8 |
| Total | 30 | 9 | 2 | 41 |

4.3.3 Time of year

The monthly death rate during 2003 and the moving 5-year average (proportion of all deaths divided by number loaded) in all goats exported to the Middle East are shown in Figure 10.

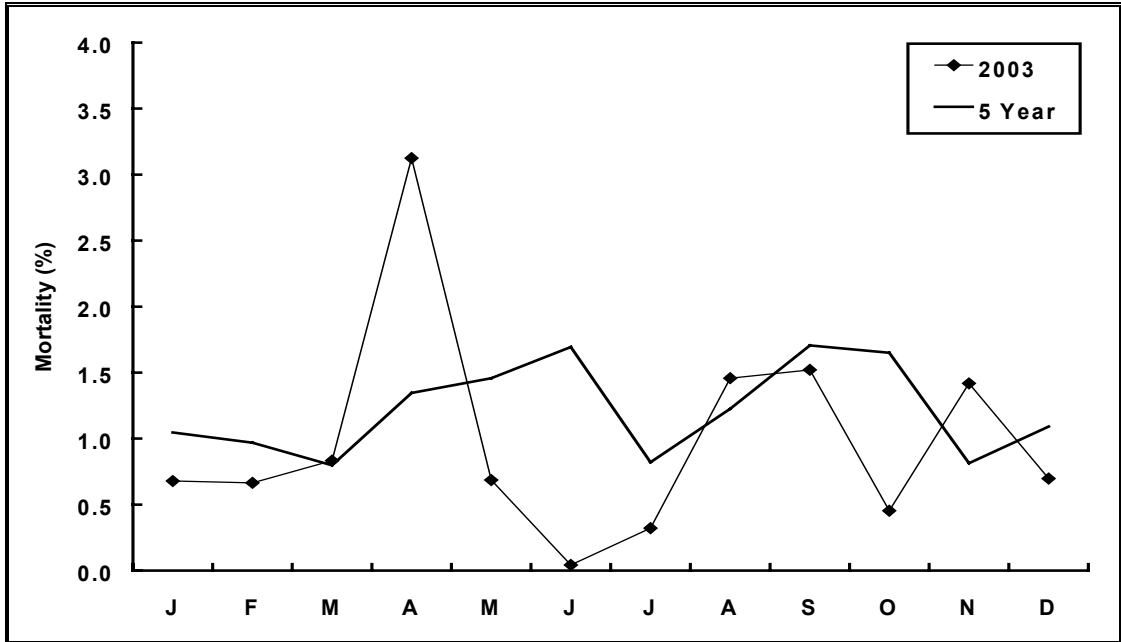


Figure 10 Monthly mortality during 2003 and moving 5-year average in goats exported to South-East Asia

5 PUBLISHED STUDIES

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

1. McDonald, C.L., Gittins, S.P. and Rowe, J.B. (1988) Effect of time of year and prior feeding experience on feeding behaviour of sheep as if for export. *Proc. Aust. Soc. Anim. Prod.* **17**: 226-229.
2. 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
3. Norris, RT, Richards, RB and Dunlop, RH (1989) An epidemiological study of sheep deaths before and during export by sea from Western Australia *Aust Vet J* **66**: 276-279
4. Norris, RT, Richards, RB and Dunlop, RH (1989) Pre-embarkation risk factors for sheep deaths during export by sea from Western Australia *Aust Vet J* **66**: 309-314
5. 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
6. Kelly, A.P. (1990) Health and welfare research in the live sheep export trade. Vic. Dept. of Agric. and Rural Affairs.
7. 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
8. Norris, RT, Richards, RB and Higgs, ARB (1990) Research on the health, husbandry and welfare of sheep during live export West Aust Dept of Agric Bulletin 4209
<http://www.agric.wa.gov.au/agency/pubns/journalofag/v31/LiveSheepExport.htm>
9. 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
10. Thomas, KW, Kelly, AP, Beers, PT and Brennan, RG (1990) Thiamine deficiency in sheep exported live by sea *Aust Vet J* **76**: 215-218
11. 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
12. Norris, RT (1991) Studies of factors affecting sheep deaths during lot-feeding and sea transport PhD Thesis, Murdoch University, Perth
13. 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
14. Norris RT, Richards RB and Norman, GJ (1992) The duration of lot-feeding of sheep before sea transport *Aust Vet J* **69**: 8-10
15. Scharp, DW (1992) Performance of Australian wethers in Arabian Gulf feedlots after transport by sea *Aust Vet J* **69**: 42-43
16. Higgs, ARB, Norris, RT and Richards, RB (1993) Epidemiology of salmonellosis in the live sheep export industry *Aust Vet J* **70**: 330-335
17. Richards, RB, Norris, RT and Higgs, ARB (1993) Distribution of lesions in ovine salmonellosis *Aust Vet J* **70**: 326-330
18. 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
19. Brightling, A and Lightfoot, JS (1994) Management of Australian sheep in the Middle East *Aust Meat and Livestock Corp Inkata Press, Melbourne*
20. 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
21. 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
22. 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

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