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National livestock export industry sheep, cattle and goat transport performance report 2016

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Executive summary

The objective of this project was to summarise the performance of the livestock export industry in terms of mortality levels of sheep, cattle and goats exported by sea and air from Australia during 2016.

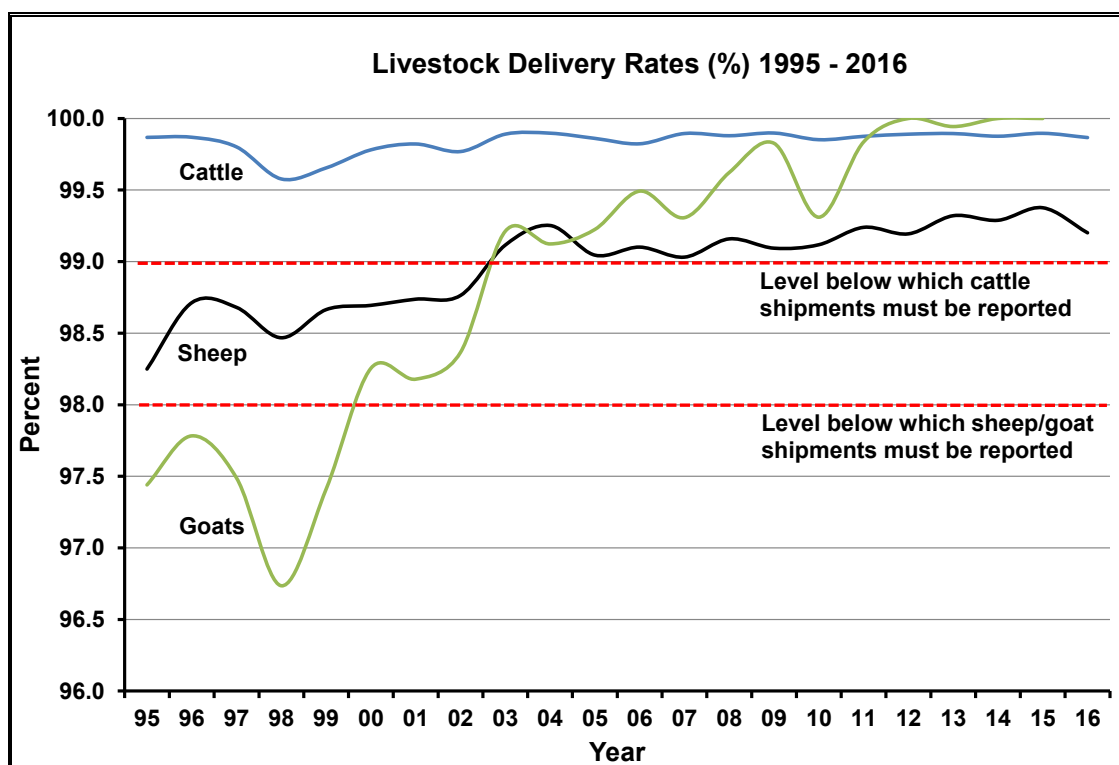
Industry stakeholders, government, animal welfare groups and the general public have a keen interest in monitoring performance in different sectors of the livestock export trade. This summary report provides the only comprehensive breakdown by species, time of year, ships, load ports and major destinations over the calendar year, along with summary analyses of trends over time.

The overall mortality rate for sheep during sea transport to all destinations during 2016 was 0.80% (14,182 mortalities in 1.78 million sheep exported). This was a substantial rise on the record low mortality rate of 0.62% for 2015. The main port of loading was Fremantle, which exported 1.59 million sheep with a mortality rate of 0.80% (12,779 mortalities), followed by Adelaide exporting 0.15 million sheep with a mortality rate of 0.72% (1,061 mortalities) and Portland which exported 0.04 million sheep with a mortality rate of 0.88% (340 mortalities).

The overall mortality rate for the 1.13 million cattle exported from Australia in 2016 was 0.13% (1,506 mortalities). This was a 30% rise on the mortality rate of 0.10% observed in 2015. The overall mortality rates on voyages to the Middle East/North Africa, North-East Asia and South-East Europe were 0.30% (219 mortalities in 0.07 million cattle exported), 0.14% (144 mortalities in 0.10 million cattle) and 0.29% (250 mortalities in 0.09 million cattle) respectively. The highest overall mortality rate on a regional basis was 2.29%, for exports to Mexico (153 mortalities in 7000 cattle exported), while the lowest overall mortality rate was 0.09% for exports to South-East Asia (740 mortalities in 0.86 million cattle exported).

No goats were exported by sea from Australia in 2016.

Percentages of sheep, cattle and goats successfully delivered by sea since 1995 are shown below.



For completeness, summary information regarding the 62,588 sheep, 6,060 cattle and 53,959 goats exported by air during 2016 has also been included in this report. These experienced overall mortality rates of 0.02% (10 mortalities), 0.00% (nil mortalities) and 0.04% (22 mortalities) respectively.

Contents

1	BACKGROUND	4
2	PROJECT OBJECTIVES	4
3	METHODOLOGY	4
3.1	Voyage	5
3.1.1	Load, Voyage and Discharge phases	5
4	RESULTS AND DISCUSSION	6
4.1	Sheep	6
4.1.1	Performance trend	6
4.1.2	Overview	7
4.1.3	Destination country	8
4.1.4	Middle East/North Africa	8
4.2	Cattle	22
4.2.1	Performance trend	22
4.2.2	Overview	23
4.2.3	Middle East/North Africa	24
4.2.4	South-East Asia	27
4.2.5	North-East Asia	31
4.2.6	South-East Europe	34
4.3	Goats	37
4.3.1	Performance trend	37
4.3.2	Overview	38
4.3.3	South-East Asia	38
4.4	Air Transport	39
4.4.1	Air transport of live sheep	39
4.4.2	Air transport of live cattle	41
4.4.3	Air transport of live goats	42
5	CONCLUSION AND RECOMMENDATIONS	44
5.1	Sheep, cattle and goats	44
6	APPENDICES	45
6.1	Appendix 1 – Research update	45
6.1.1	Heat load in sheep exported to Middle Eastern feedlots	45
6.1.2	Heat Management in the Middle East	45
6.1.3	Pinkeye on long haul cattle voyages	46
6.1.4	Within crate ventilation on board aircraft	46
6.1.5	LGAP implementation background and update	47
6.1.6	Further improving the environment on board livestock vessels	47
6.1.7	Stockperson's manual for export of livestock by air.	47
6.1.8	Backgrounding and feedlotting strategies to reduce inanition in sheep	48
6.2	Appendix 2 – Federal Department of Agriculture and Water Resources high-mortality investigations	49
6.3	Appendix 4 - Published studies	55
6.4	Appendix 5 - Acknowledgements	56

1 Background

The live export of sheep, cattle and goats makes a significant contribution to the Australian economy, valued at \$1,659 million in 2016, and provides employment in the many services that support this industry. The livestock export trade provides important support for the sheep, cattle and goat industries of Australia and is the only market outlet for producers in some areas of the country.

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

The Australian Government Department of Agriculture (DA) also presents mortality data, though in a different format, under ‘Reports to Parliament’ at their website:

<http://www.agriculture.gov.au/export/controlled-goods/live-animals/live-animal-export-statistics/reports-to-parliament>.

It should be noted that the DA mortality figures refer only to voyages for which data was *received* during the calendar year, in contrast to this current report which refers to data for all voyages which *departed* during the calendar year.

2 Project objectives

The project objectives were to:

- a) Produce a report which summarises the mortality of sheep, cattle and goats exported from Australia for the 2016 calendar year and provide an informed analysis of mortality trends in the livestock export industry;
- b) Maintain data and expertise to provide analysis and informed comment.

3 Methodology

The information in this report was obtained from ship Master’s Reports (which record livestock mortalities and other information about each voyage), other tailored shipboard records and from “Yellow Books”, which record more-detailed information about numbers of livestock mortalities (ports of loading and discharge, and daily mortality by type-age-sex categories over the loading, voyage and discharge phases) than is available from the Master’s Report.

This current report is for all voyages and flights which departed Australia during the calendar year 2016. Information on the number of sheep exported to various destination countries from ports in Australia was compiled from records supplied by ships and Livestock Export Companies. Information for livestock exported by air was provided by DAWR.

In recent years the significant rise in livestock exports to Turkey and the Black Sea caused an imbalance in the Miscellaneous exports category. A new destination region, South-East Europe, was introduced in 2012 to allow a more meaningful examination of exports to this region. South-East Europe includes ports in Turkey and the Black Sea

From 2012 onward, graphs and tables presenting long-term overviews have been restricted to a rolling ten-year basis. It is considered that the older data does not reflect the current state of the trade in terms of standards required of industry, ships participating and markets serviced.

Readers should be aware that additional mortality information for a particular year may be received after publication of that year’s summary report. Such information will be added to the database and used in subsequent analyses. Therefore, statistics for a particular year may vary slightly in subsequent reports from those originally published.

National livestock export industry sheep, cattle and goat transport performance report 2016

High-mortality voyages have always been included in relevant summary figures in this series of publications. It should be noted that in some areas of presentation inclusion of such voyages, usually resulting from exceptional circumstances (such as mechanical failure or trade dispute, and therefore not representing usual trade conditions), would distort consideration of long-term trends. Where such voyages have been excluded from analysis of trends, explanatory text or footnotes indicate the exclusion.

Beginning in the 2013 publication of this series, references are made to Federal Department of Agriculture and Water Resources investigations into exceptional voyages and flights mentioned in the report text. It should be noted that these DAWR reports have been available to the public for a number of years and that parties with an interest in the live export industry have been aware of this availability.

Further information regarding exceptional voyages can be found at 6.2 Appendix 2. Any external links provided are current up to the date of publication of this report.

In order to maintain confidentiality, individual ships are identified by codes in this report.

Summary information was produced using Statistix 10.0 (Analytical Software, 2015, Tallahassee, Florida USA).

3.1 Voyage

The majority of voyages by sea involve loading at one port and discharge at one port. But each year a number of voyages involve loading at multiple Australian ports (split-load voyages), and discharge at multiple destination ports, often in different countries. Where analyses involved split-load voyages, the consignments of livestock from each load port were considered as separate “voyages”, so that the definition of a “voyage” came to be “consignment from load port to discharge region”.

More recently shipboard reporting has become so comprehensive that in most cases it allows tracking of consignments from individual load ports to individual discharge ports. This is a great credit to the diligence of ships’ officers.

To take advantage of this comprehensive reporting, where it has been possible, all voyages have been split into separate “voyages” based on loading and discharge ports. This breakdown better reflects the actual conditions that occurred for the livestock consigned to those destinations.

It can be seen that a comprehensively reported voyage involving one or more load ports and an extended discharge phase over a number of ports, has the potential to generate numerous “voyages”. So, a ship might load at three ports and discharge at two ports, effectively generating six “voyages” if livestock were sent to each discharge port from each load port. In most cases the current high quality of the information supplied allows this close description of the actual conditions experienced.

So, the definition of “voyage” has almost completely shifted from “consignment from load port to discharge region”, to “consignment from load port to discharge port”. While this widens the scope for voyage analyses, results will continue to be reported in this series on the basis of discharge regions for the foreseeable future.

3.1.1 Load, Voyage and Discharge phases

The shipboard part of the export process is divided into three distinct phases; Load; Voyage and Discharge. These phases are precisely demarcated by dates and times.

Date and time for the end of loading marks the end of the Load phase and the beginning of the Voyage phase. Date and time for the beginning of discharging marks the end of the Voyage phase and the beginning of the Discharge phase.

In the few cases where a ship delivers livestock to more than one discharge port without providing comprehensive information, all the mortalities after the beginning of discharge at the first port through to the end of discharge at the last port have been combined into an overall Discharge phase.

4 Results and discussion

4.1 Sheep

4.1.1 Performance trend

Figures 1 and 2 show the number of sheep exported and the percentage of mortalities during sea transport from all ports in Australia to all destinations over the last decade as well as the trend line (linear regression) across those years. The 1.78 million sheep exported in 2016 was the lowest number exported since recording began in 1985. The number of sheep exported annually since 2007 has varied between 4.19 and 1.78 million, and the annual mortality has varied between 0.97 and 0.62%. The trend for numbers of sheep exported and annual mortality continues downward.

Figure 1 Number of sheep exported by sea from Australia to all destinations since 2007

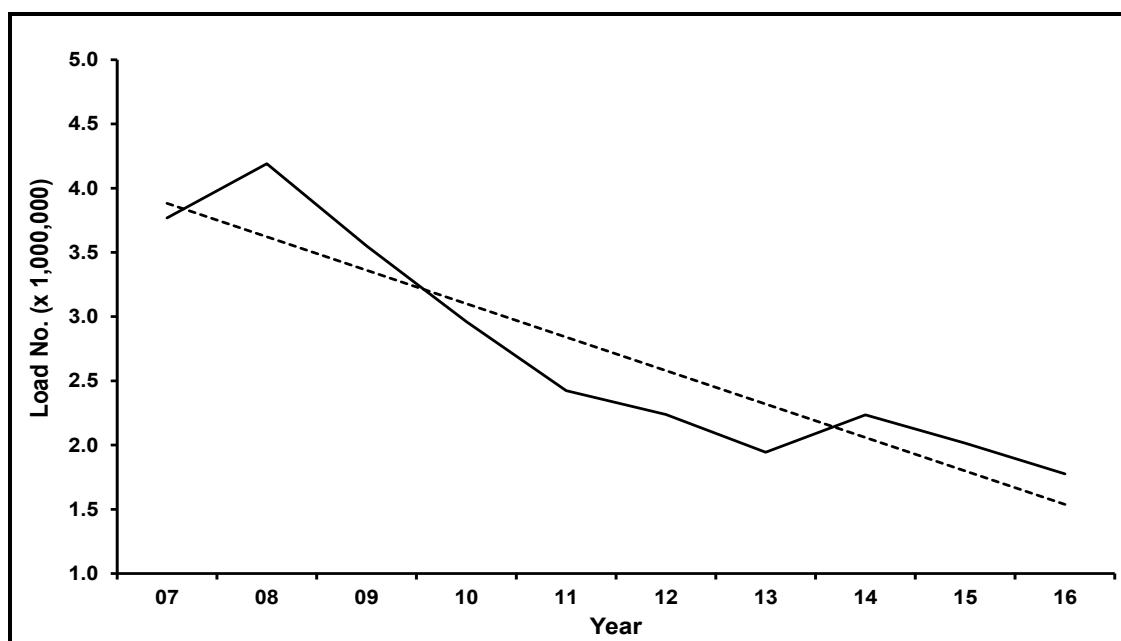
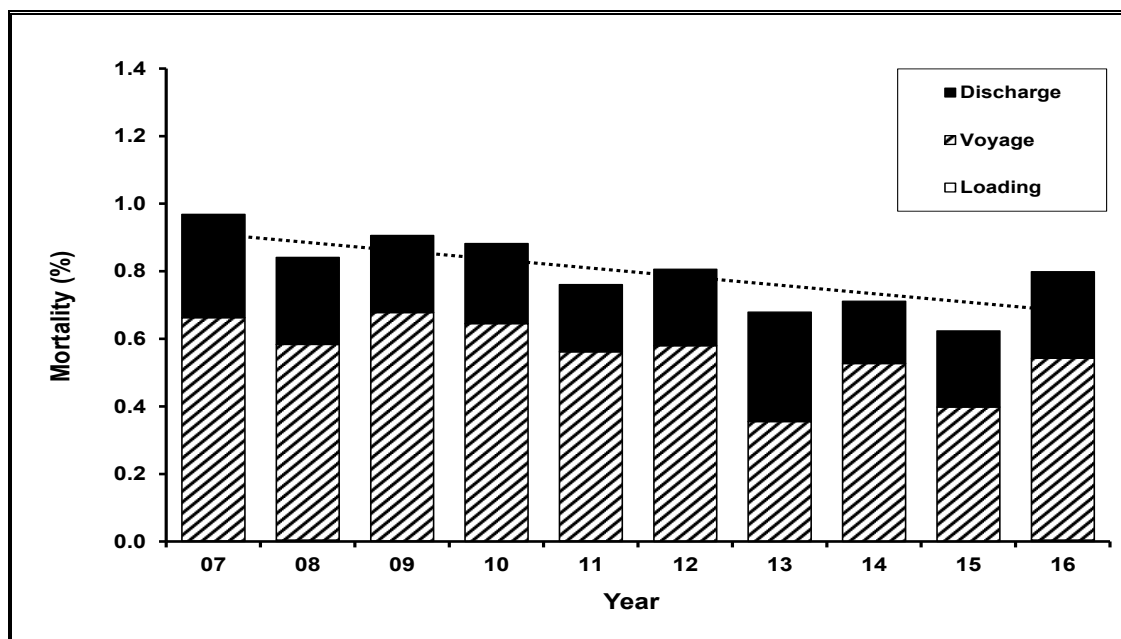


Figure 2 Annual mortality of sheep exported by sea from Australia to all destinations since 2007



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4.1.2 Overview

All sheep exported live by sea from Australia in 2016 were loaded either at Fremantle (89.5%), Adelaide (8.3%), or Portland (2.2%). The overall average voyage and discharge lengths were 16.72 and 4.66 days respectively (Table 1, below).

The shipboard part of the export process is divided into three distinct phases; Load; Voyage and Discharge. These phases are precisely demarcated by dates and times.

Date and time for the end of loading marks the beginning of the voyage phase. Date and time for the beginning of discharge marks the end of the voyage phase and the beginning of the discharge phase.

In the few cases where a ship delivers livestock to more than one discharge port without providing comprehensive information, all the mortalities after the beginning of discharge at the first port through to the end of discharge at the last port have been combined into an overall discharge phase. See the Methodology section of this report for a more detailed explanation of the voyage phases and the involvement of split-loading and split-discharging.

There were six voyages to the Middle East/North Africa in 2016 for which sheep were loaded at more than one port in Australia (split-load voyages). Mortalities for split-load voyages were attributed to the port of loading for all voyages in 2016. Where analysis involves split-load voyages, the consignments of sheep from each load port have been considered as separate "voyages".

There were 46 "voyages" of sheep to the Middle East/North Africa during 2016. This involved 36 ship journeys, six of which were split-loaded, and a further four of which were split for discharge.

1,758,898 sheep were exported to the Middle East/North Africa (99.1% of all sheep exported) and the average voyage length (voyage to first discharge port) for exports to this region was 17.15 days with 5.12 days for discharge (most voyages had multiple discharge ports). The overall mortality for these sheep was 0.80%.

Malaysia was the destination country for the 16,423 sheep (0.9% of all sheep exported) that were exported to South-East Asia on 5 voyages. The overall mortality rate for these sheep was 1.18% with an average voyage length of 13.23 days and an additional 0.92 days for discharge. These sheep will not be examined further in this report

Table 1 Mortality rates, number of voyages, voyage and discharge days, and number of sheep exported for voyages to major destination regions during 2016

Parameter	ME/N Africa	SE Asia	Total
Voyages (No.)	41	5	46
Sheep (No.)	1,758,898	16,423	1,775,321
Mortality rate overall (%)	0.80	1.18	0.80
Mortality rate range (%)	0.20 – 2.99*	0.72 – 1.76	0.20 – 2.99
Voyage days (Ave.)	17.15	13.23	16.72
Discharge days (Ave.)	5.12	0.92	4.66

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4.1.3 Destination country

Countries that imported Australian sheep in 2016 are shown in Table 2. The main importing countries were Kuwait (36% of all Australian sheep exports), followed by Qatar (30%) and UAE (9%).

Overall export numbers fell by 11.3% compared to 2015. Markets changed variously, but the biggest changes contributing to the overall fall in exports were for Bahrain, and Kuwait, which experienced falls of 100%, and 11%, respectively. South east Asia, Israel and Jordan experienced substantial rises in exports, by 47%, 38% and 31% respectively.

Table 2 Destination country for sheep exported from Australia during 2016

Country	Fremantle	Adelaide	Portland	Other	Total
Israel	115,405	2,972			118,377
Jordan	115,177	39,320			154,497
Kuwait	605,562	24,113	23,161		652,836
Lebanon	11,987				11,987
Oman	72,156	27,500	5,800		105,456
Qatar	506,436	51,000			557,436
U.A.E.	145,656	3,130	9,523	145	158,454
S.E. Asia	16,423			55,852	72,275
N.E. Asia				6,359	6,359
Other				232	232
Total	1,588,802	148,035	38,484	62,588	1,837,909

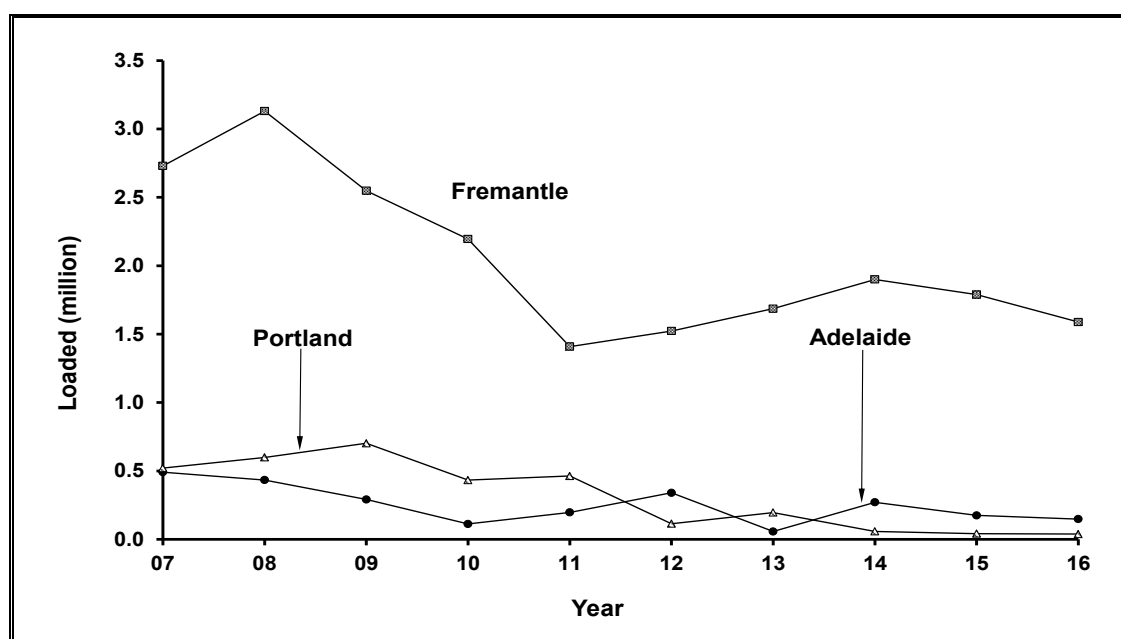
Note: figures include exports by air.

4.1.4 Middle East/North Africa

4.1.4.1 Port of loading

Most sheep exported by sea from Australia to the Middle East/North Africa during 2016 were loaded at Fremantle (89.5%, Figure 3) with smaller numbers loaded at Adelaide (8.3%), and Portland (2.2%).

Figure 3 Number of sheep exported by sea to the Middle East/North Africa from Fremantle (Western Australia), Portland (Victoria) and Adelaide (South Australia) since 2007



National livestock export industry sheep, cattle and goat transport performance report 2016

The number and class of sheep exported by sea to the Middle East/North Africa from Fremantle, Adelaide and Portland during 2016 are shown in Table 3. Overall numbers exported to the region in 2016 fell by 12.3% compared to 2015, with exports from Fremantle, Adelaide and Portland falling by 12.1%, 15.4% and 8.3 % respectively.

The main change in 2016 compared to 2015 was the substantial decrease in exports of adult wethers (-25.6%). This fall in adult wethers comprised decreases of -28.4%, -10.9% and -16.6% for Fremantle, Adelaide and Portland respectively.

The only increase of any note was a doubling of exports of ram lambs, wholly accounted for by Fremantle.

Table 3 The numbers and classes of sheep exported by sea to the Middle East/North Africa from Fremantle, Adelaide and Portland during 2016

Livestock		Fremantle	Adelaide	Portland	Total
Wethers	adults	684,116	143,913	34,961	862,990
	hoggets	204,001			204,001
	lambs	499,124	2,972		502,096
Rams	adults	41,415	495	3,523	45,433
	hoggets	4,663			4,663
	lambs	70,886	655		71,541
Ewes	adults	40,436			40,436
	hoggets	75			75
	lambs	27,663			27,663
Total	sheep	1,572,379	148,035	38,484	1,758,898

National livestock export industry sheep, cattle and goat transport performance report 2016

4.1.4.2 Mortality rates

The total mortality rate for all sheep exported to all destination regions during 2016 was 0.80% (Table 4), a substantial increase from the 0.62% observed in 2015.

Fremantle voyage and discharge mortality rates rose by 36% and 27% respectively compared to 2015 levels (Table 4 and Figure 4).

Adelaide voyage, discharge and overall mortality rates also rose, by 16%, 31% and 20% respectively.

Changes in parameters for Portland cannot be considered meaningful due to there being only one shipment in 2016.

One high-mortality voyage each for 2013 and 2014 will not be included in some analyses as the mortality was incurred under exceptional circumstances, and would distort the study of long term trends. Where this exclusion applies, text, tables and figures are appropriately annotated. Federal Department of Agriculture investigation summaries regarding these voyages are referred to in 6.2 Appendix 2.

There was one high mortality voyage investigation for 2016 which is also referred to in 6.2 Appendix 2. This voyage has been included in all analyses.

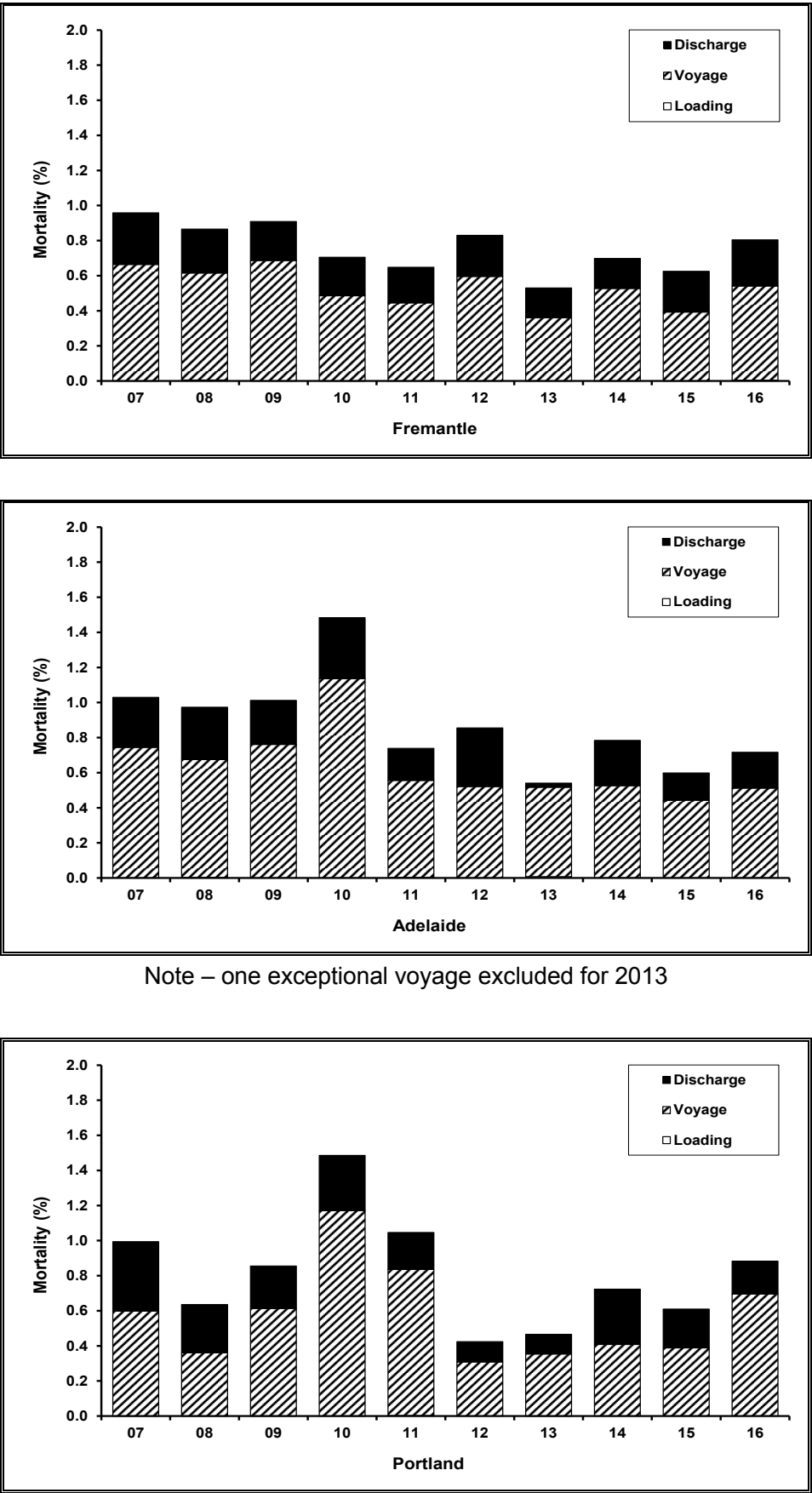
Table 4 Annual shipboard mortality rates for all sheep exported from Fremantle, Adelaide and Portland to the Middle East/North Africa, and Total mortality rate for all sheep exported to all destinations

	Year	Mortality rate (%)			
		Load	Voyage	Discharge	Total
Fremantle*	2012	0.00	0.60	0.23	0.83
	2013	0.00	0.36	0.17	0.53
	2014	0.00	0.53	0.17	0.71
	2015	0.00	0.39	0.23	0.63
	2016	0.01	0.53	0.26	0.80
Adelaide*	2012	0.00	0.53	0.33	0.86
	2013	0.00	0.17	5.61	5.79
	2014	0.00	0.53	0.26	0.78
	2015	0.00	0.44	0.16	0.60
	2016	0.00	0.51	0.21	0.72
Portland*	2012	0.00	0.31	0.12	0.42
	2013	0.00	0.35	0.11	0.47
	2014	0.00	0.41	0.32	0.72
	2015	0.00	0.39	0.22	0.61
	2016	0.00	0.70	0.19	0.88
Total**	2012	0.00	0.58	0.23	0.81
	2013	0.00	0.35	0.32	0.68
	2014	0.00	0.53	0.18	0.71
	2015	0.00	0.40	0.23	0.62
	2016	0.01	0.54	0.26	0.80

* Middle East/North Africa only

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

Figure 4 Annual mortality for sheep exported from Fremantle, Adelaide and Portland to the Middle East/North Africa from 2007 to 2016.



Note – one exceptional voyage excluded for 2013

4.1.4.3 Class of sheep

The mortality rates of various classes of sheep exported from Australia to the Middle East/North Africa are shown in Table 5 and Figure 5. The highest total mortality rate for 2016 was in lamb and adult rams (1.70% and 1.29% respectively), followed adult ewes (0.99%)(refer to Table 3 for numbers loaded).

Along with adult ewes, the ram classes have consistently been high over the last decade, their contribution to overall mortality being limited by their numbers exported. See further discussion at section 4.1.3.7 Implications of long-term seasonal mortality patterns.

Table 5 Overall mortality (%) for classes of sheep exported from Fremantle, Adelaide and Portland to the Middle East/North Africa in 2016

Class of sheep		Fremantle	Adelaide	Portland	Total
Wethers	adult	0.75	0.71	0.71	0.75
	hogget	0.53	n/a	n/a	0.53
	lamb	0.79	0.71	n/a	0.78
Rams	adult	1.37	0.81	0.51	1.29
	hogget	0.73	n/a	n/a	0.73
	lamb	1.70	1.53	n/a	1.70
Ewes	adult	0.99	n/a	n/a	0.99
	hogget	0.00	n/a	n/a	0.00
	lamb	0.84	n/a	n/a	0.84

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

* - a few deaths in a very small number loaded

Figure 5 Overall mortality (%) for classes of sheep exported from Fremantle, Adelaide and Portland to the Middle East/North Africa in 2016

WA = wether adults

WH = wether hoggets

WL = wether lambs

RA = ram adults

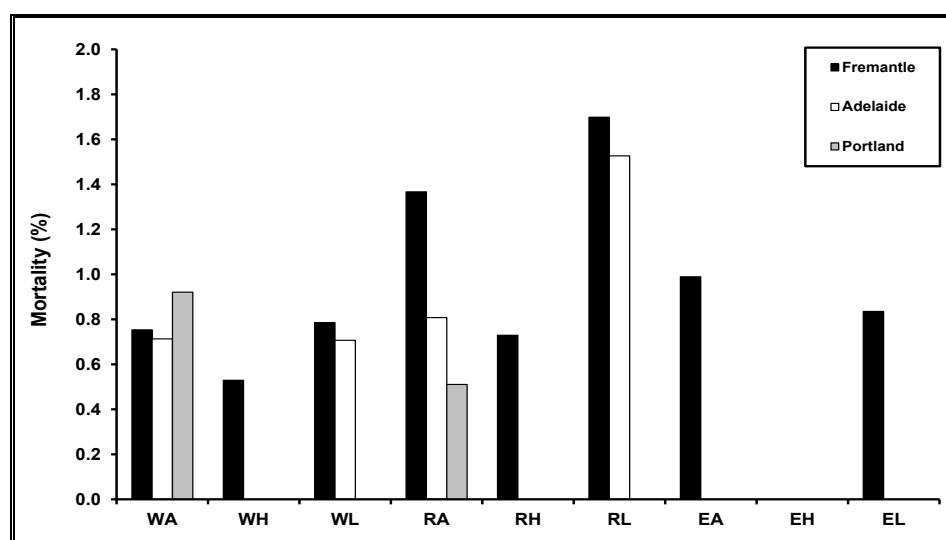
RH = ram hoggets

RL = ram lambs

EA = ewe adults

EH = ewe hoggets

EL = ewe lambs

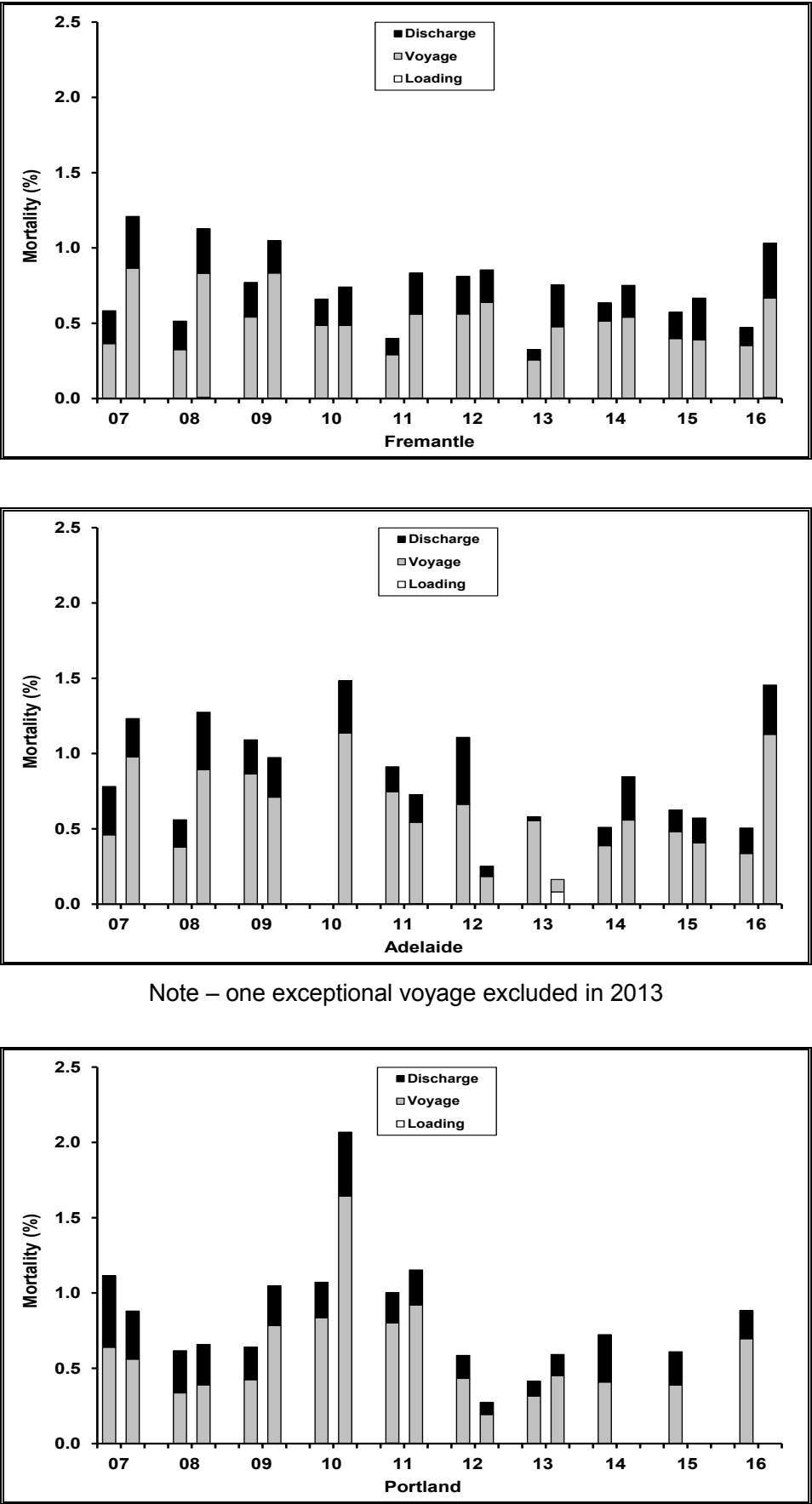


4.1.4.4 Time of year

Overall half-yearly mortality rates for sheep exported to the region were higher in the second half of the year compared with the first half. Both Fremantle and Adelaide sheep had significantly different ($P < 0.05$) mortality rates for the first and second halves of the year (0.47% and 1.03% respectively for Fremantle; 0.51% and 1.46% for Adelaide – see Figure 6).

For the third year in succession, Portland exported sheep only in the first half of the year.

Figure 6 Mortality (%) for sheep exported by sea from Fremantle, Adelaide and Portland to the Middle East/North Africa for the first and second half of each year from 2007 to 2016

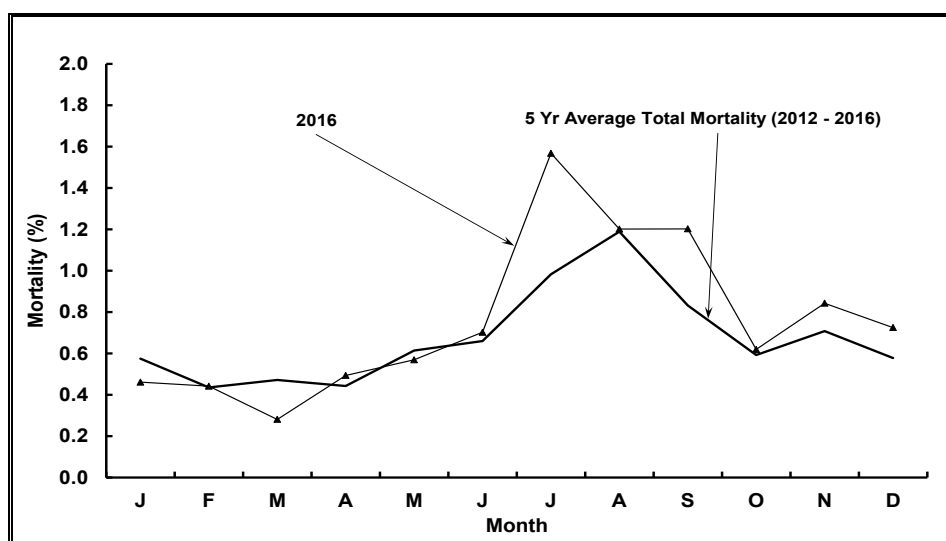


Note – one exceptional voyage excluded in 2013

National livestock export industry sheep, cattle and goat transport performance report 2016

In 2016, monthly mortality rates (total mortality as a proportion of total loaded for each month) in sheep exported from Fremantle approximated the 5-year average profile, apart from being substantially higher in July and September (Figure 7).

Figure 7 Monthly mortality rates for shipments from Fremantle to the Middle East/North Africa in 2016 and the 5-year monthly averages for the period 2012 to 2016



4.1.4.5 Time of year and age of sheep

Figure 8 shows the monthly mortality rates (total mortality as a proportion of total loaded for each month) in wether and ram adults, hoggets and lambs, and ewe adults and lambs exported from Australia to the Middle East/North Africa from 2007 to 2016. Results for ewe hoggets are not presented because of the paucity of data.

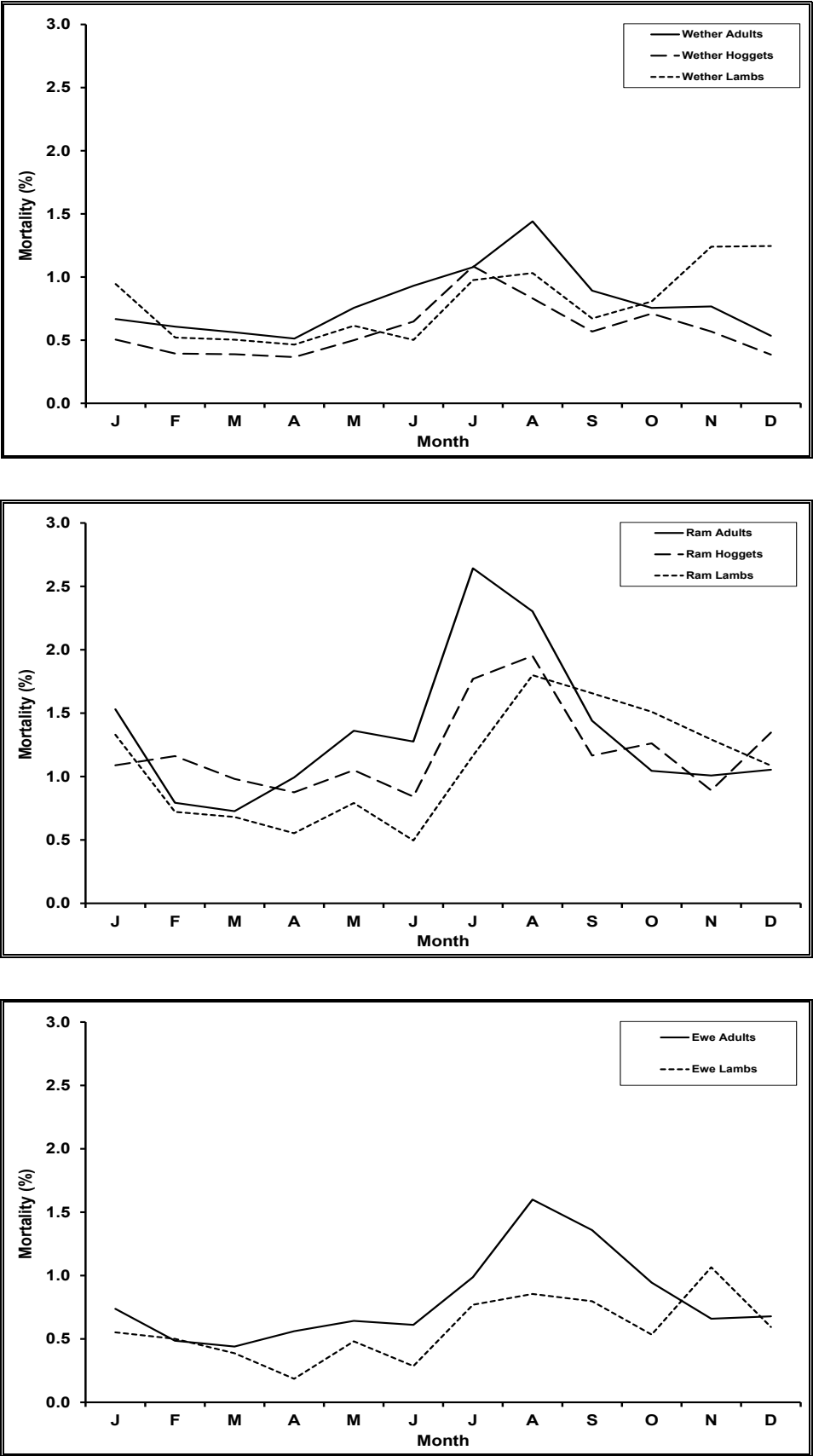
Figure 9 shows the mortality rates in the first and second half of the year for the wether classes from 2007 to 2016. There were significantly more deaths ($P < 0.05$) in the second half of the year than in the first half for each year and each age category of wethers, with the following exceptions: adult wethers in 2011, and all three wether classes in 2012.

The return to the expected pattern for all wether classes in 2013 was also evident in all three ram classes and in adult ewes (results not presented). In 2013 ewe lambs showed higher mortalities in the first half of the year, but the difference was not significant.

The reversal in the expected half-year mortality pattern that occurred in 2012 was quite remarkable, occurring in seven classes (all wethers, all rams and ewe lambs) out of the nine classes of sheep routinely examined in this report series. The return to the expected pattern in 2013 and continuing so has been quite definite.

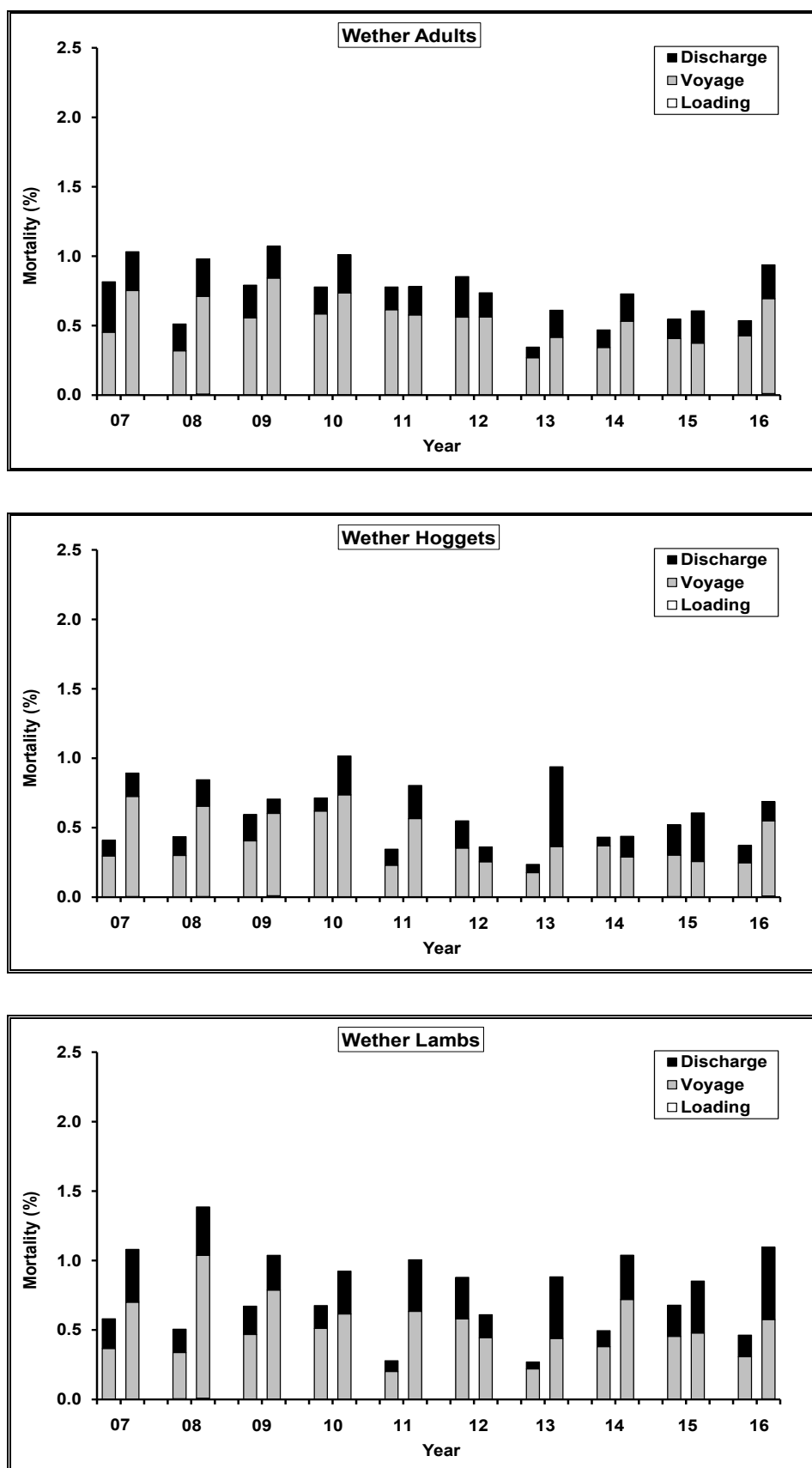
The results shown in Figures 8 and 9 for this current report and in previous reports in this series indicate that seasonal differences in mortality exist for wether hoggets and lambs as well as for adults. In general, similar findings were observed for ram classes and for ewe adults and lambs (half-year results for these classes are not presented here). For ewe hoggets, insufficient numbers are exported in most years to allow reliable conclusions to be made. See further discussion at section 4.1.3.7 Implications of long-term seasonal mortality patterns.

Figure 8 Monthly mortality (%) for wether and ram adults, hoggets and lambs, and ewe adults and lambs exported by sea from Australia to the Middle East/North Africa from 2007 to 2016 (note - one exceptional voyage each for 2013 and for 2014 excluded; see 6.2 Appendix 2).



National livestock export industry sheep, cattle and goat transport performance report 2016

Figure 9 Mortality (%) for wether adults, hoggets and lambs exported by sea from Australia to the Middle East/North Africa for the first and second half of each year from 2007 to 2016 (note – one exceptional voyage each for 2013 and for 2014 excluded; see 6.2 Appendix 2).



4.1.4.6 Class numbers and mortality rates over time

Adult wethers are the mainstay of the live sheep export trade, and, by sheer weight of numbers, the largest component of mortalities. This can be easily demonstrated by comparing class numbers exported over time and their corresponding mortality rates.

It can be seen that Wether Adults (WA) stand out as the main class exported, followed by Wether Lambs (WL), with Wether Hoggets (WH) and Ram Lambs (RL) sharing third position (Figures 10).

Figure 10 Numbers by class of sheep exported from Australia, 1997 to 2016

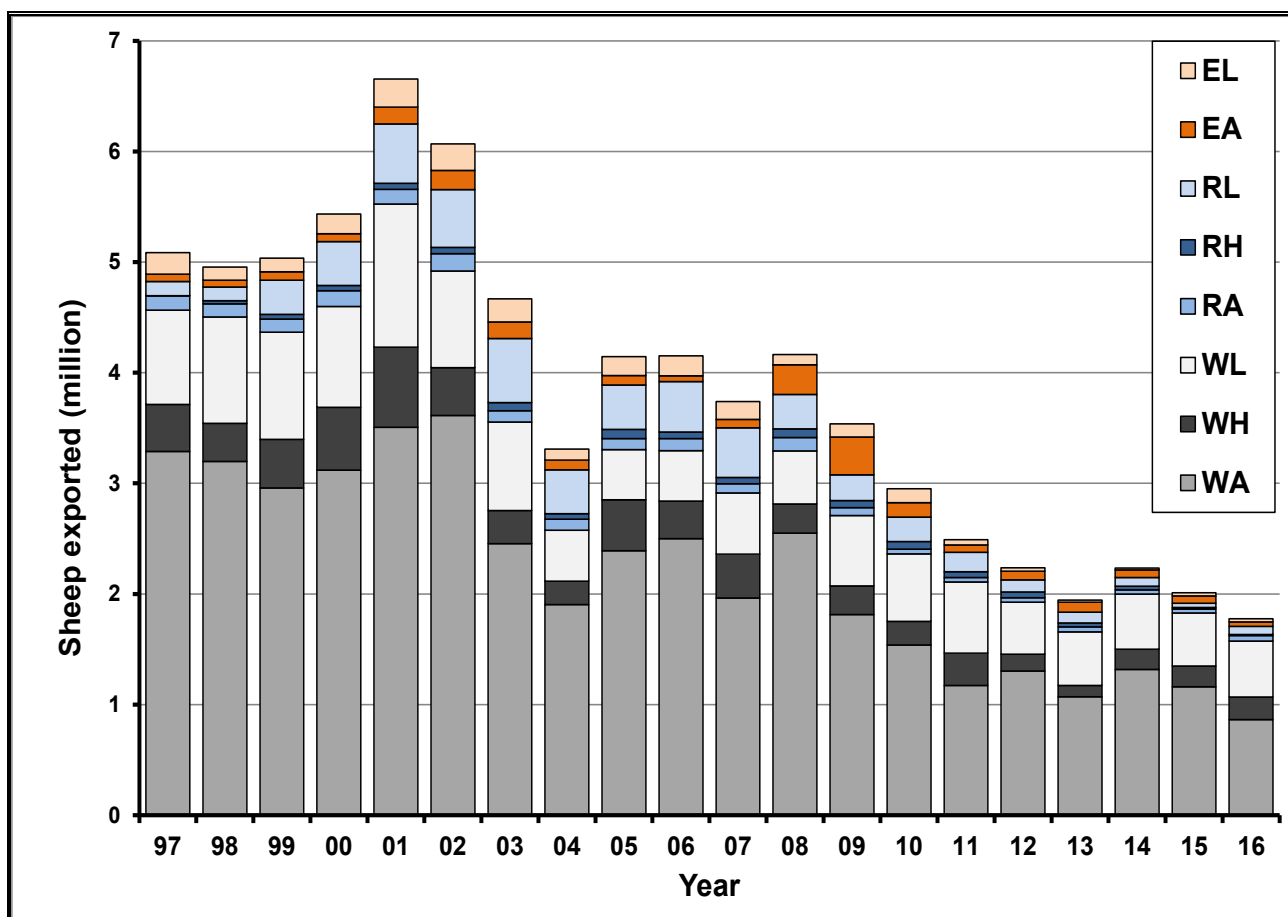
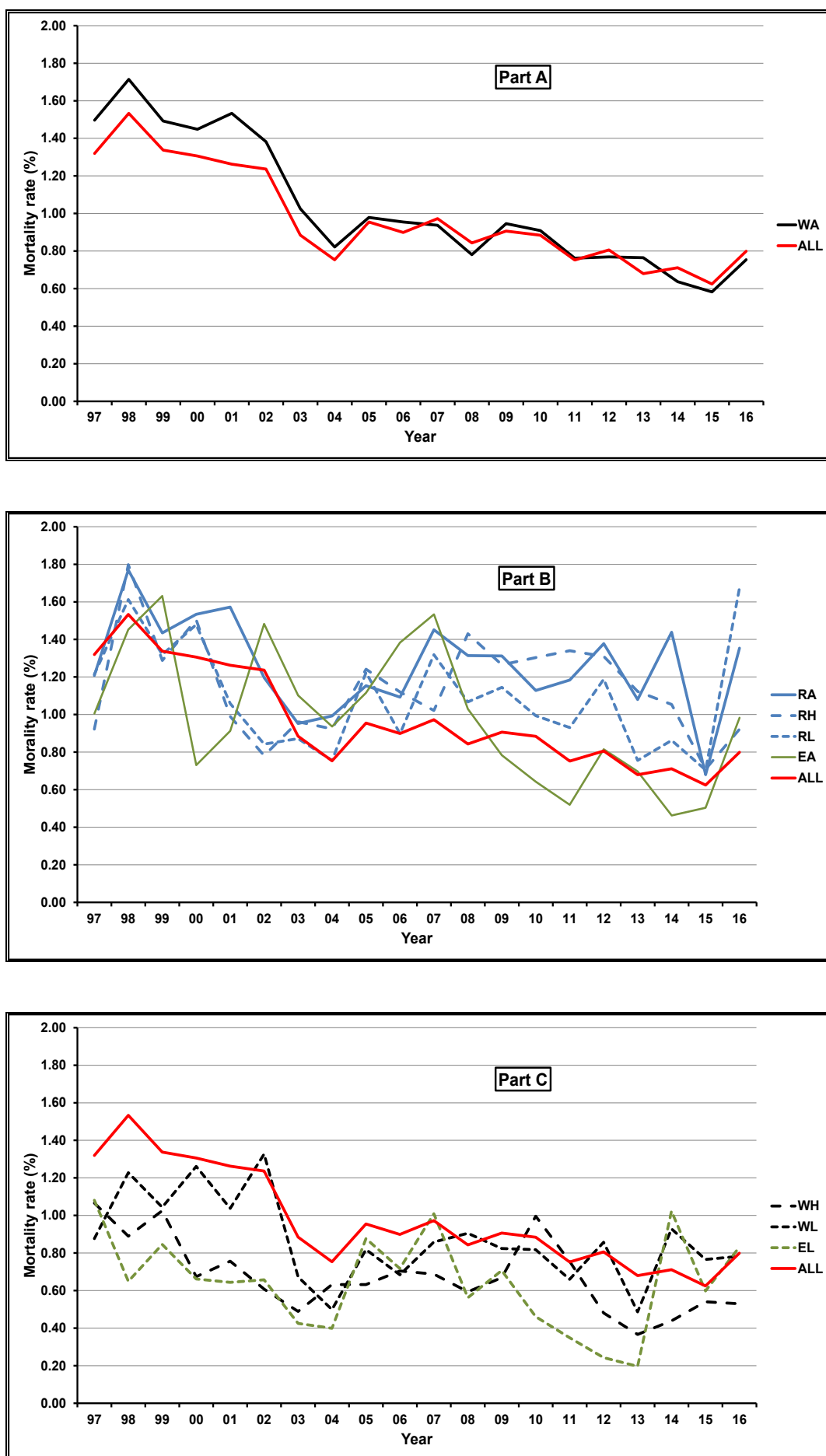


Figure 11, below, shows that the overall mortality rate is closely linked to the Adult Wether mortality (part A). It can also be seen that ram classes have had consistently high mortality rates over time, with Ram Adults (RA) nearly always at or near highest (Part B).

The Ewe Adults (EA) mortality rate has swung wildly over the time, but the three ram classes have remained the highest from 2008 onward, except in the case of Ewe Adults jumping slightly over Ram Lambs in 2016).

Wether Hoggets (WH) and Lambs (WL), and Ewe Lambs (EL) have been almost always lower than the overall average (Figure 11 Part C).

Figure 11 Mortality rate (%) by class of sheep exported from Australia, 1997 to 2016



4.1.4.7 Implications of long-term seasonal mortality patterns

Seasonal differences in mortality can be demonstrated for all classes of sheep studied in this series of reports except for ewe hoggets, which are not exported in sufficient numbers to bring reliable conclusions.

It is useful to compare the long-term mortality profiles of Adult Wethers, the main component of overall mortality rate, and Adult Rams, the class with the highest mortality rate.

Figures 12 and 13 show monthly mortality rates (total mortality as a proportion of total loaded for each month) over three periods, 1997-2003, 2004-2010 and 2011-2016, for Adult Wethers and Adult rams respectively. While the overall pattern for Adult Wethers has reduced more noticeably over time, these periods demonstrate the enduring stability of the seasonal difference.

Figure 12 Average monthly mortality rate (%) for Adult Wethers for three periods

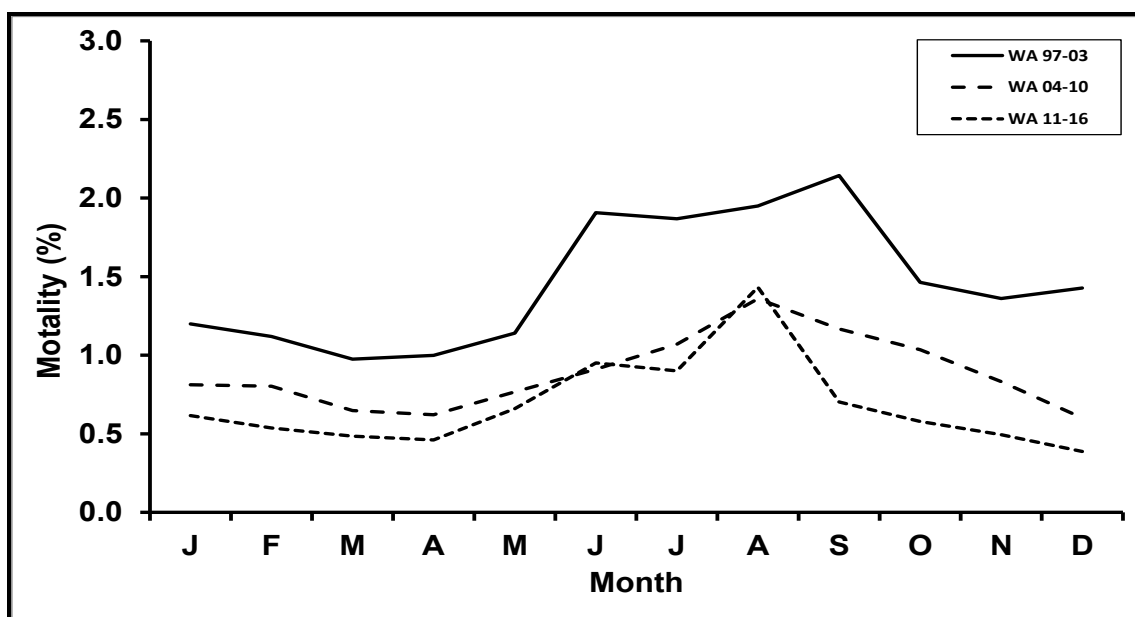
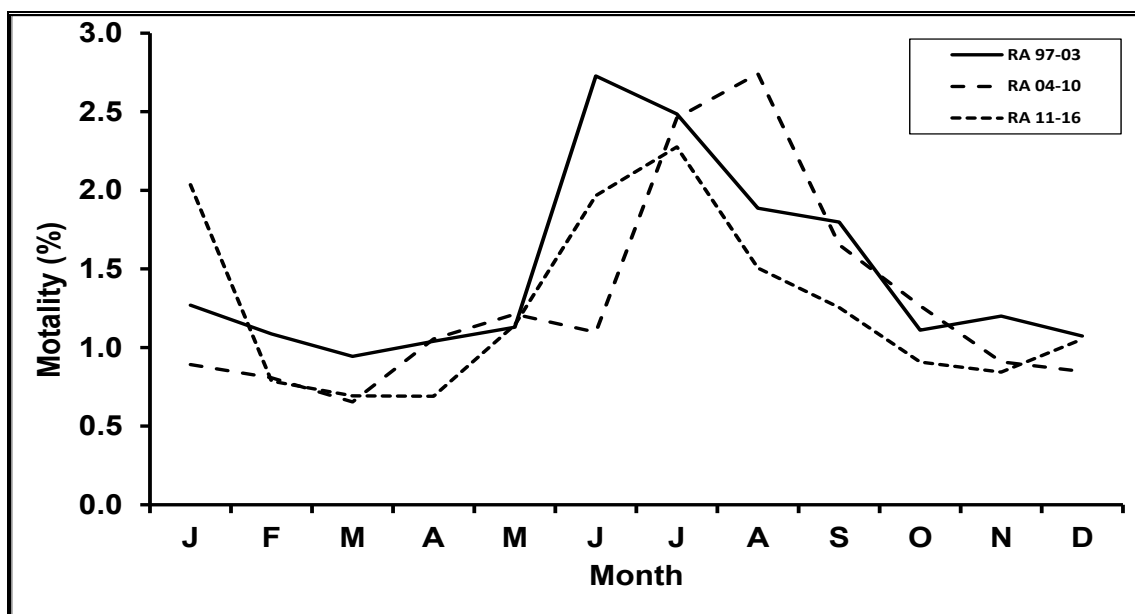


Figure 13 Average monthly mortality rate (%) for Adult Rams for three periods



National livestock export industry sheep, cattle and goat transport performance report 2016

It can be seen that there is a consistent seasonal difference, with the lowest mortality rates occurring in sheep loaded from February to May, and the highest occurring in those loaded from June through to September.

While the mortality rates of the ram classes particularly, and of Adult Ewes sporadically, have been highest, their impact on the overall mortality rate has been limited by the small numbers exported.

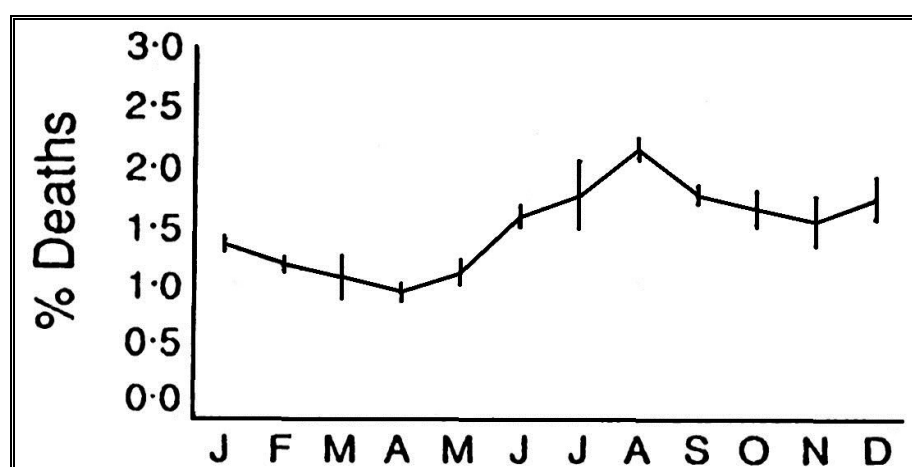
Nevertheless, overall mortality rate could be expected to increase if more sheep, and particularly more of the higher mortality classes, are exported between June and September.

With a constant annual cycle of exports, mortality rates and numbers would be expected to remain steady, but events such as the festivals of importing countries are not fixed in the calendar. As the Islamic calendar tracks forward by approximately 11 days each year, the requirement for suitable numbers and classes of sheep also advances each year.

It could be reasonably predicted that as exports for the festival of Eid Al Adha (mid-September in 2016) come forward into the highest mortality months of June - September, overall mortalities will rise significantly with the increased contribution of mortalities, particularly from ram classes. This might be expressed in a general rise over the at-risk period, or as an increase in the number of high mortality voyages breaching the reportable limits of DA / AMSA.

Higgs et al (1991) first documented in detail the seasonal mortality difference in relation to the Live Sheep Export Trade, and brought to light the enduring monthly mortality reverse 'tilde' pattern for adult wethers exported to the Middle East (Figure 14, below).

Figure 14 Average monthly voyage mortality rate (%) for Adult Wethers exported to the Middle East over 1985 to 1990



Since a similar established reverse 'tilde' pattern can be seen in other classes, the possibility of generating a rudimentary predictor of annual mortalities can be seen.

Forward-estimates of numbers and classes to be shipped and at what time of the year may be matched against the long-term mortality pattern to predict overall mortalities.

The reduced overall (reverse tilde) mortality pattern in the live sheep export trade is undoubtedly associated with the tendency towards exporting younger wethers to meet the changing market requirements, as well as improved ship design and management.

Ongoing research to improve live sheep exports, as outlined in sections 6.1 Appendix 1 and 6.3 Appendix 3, may in the future focus on "flattening" the overall reverse tilde pattern, or servicing the trade in a way that compensates for the peak mortality period of the year.

4.1.4.8 Ship

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

Approximately 77% of voyages from Fremantle, and 83% of voyages from Adelaide were in the “low” category.

There was only one voyage from Portland during 2016, and it fell in the low category.

There were two voyages in the “high” category in 2016, involving ships 32 and 50. One voyage is the subject of an investigation, as outlined in section 6.2 Appendix 2, while the other was part of a split-loading which had an overall mortality rate below 2% and so did not attract an investigation.

Table 6a Number of voyages in low, medium and high mortality categories for ships loaded at Fremantle in 2016

Ship (code)	Mortality rate			Total
	Low <1.0%	Medium 1.0–2.0%	High >2.0%	
32	6	1	1	8
33	1	0	0	1
34	7	2	0	9
35	4	0	0	4
43	1	1	0	2
45	1	0	0	1
46	3	2	0	5
47	1	0	0	1
48	1	0	0	1
50	1	1	0	2
Total	26	7	1	34

Table 6b Number of voyages in low, medium and high mortality categories for ships loaded at Adelaide in 2016

Ship (code)	Mortality rate			Total
	Low <1.0%	Medium 1.0–2.0%	High >2.0%	
32	1	0	0	1
35	2	0	0	2
46	1	0	0	1
50	1	0	1	2
Total	5	0	1	6

4.2 Cattle

4.2.1 Performance trend

The number of cattle shipped from all ports in Australia to all destinations since 2007 as well as the trend line (linear regression) across those years is shown in Figure 15. Figure 16 shows the number of cattle mortalities during sea transport since 2007. The number of cattle exported annually has varied from approximately 620,000 to 1,310,000, and the annual mortality has varied between 0.10 and 0.15%. The overall trend for numbers of cattle exported is upwards while the trend for annual mortality is slightly upward.

Figure 15 Number of cattle exported by sea from Australia to all destinations since 2007

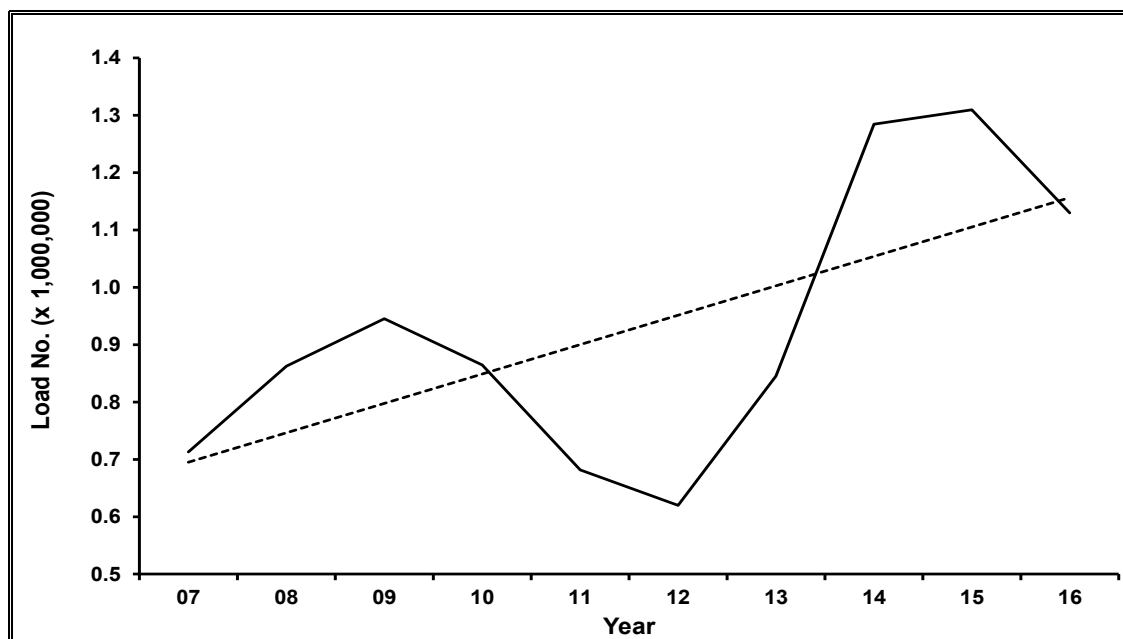
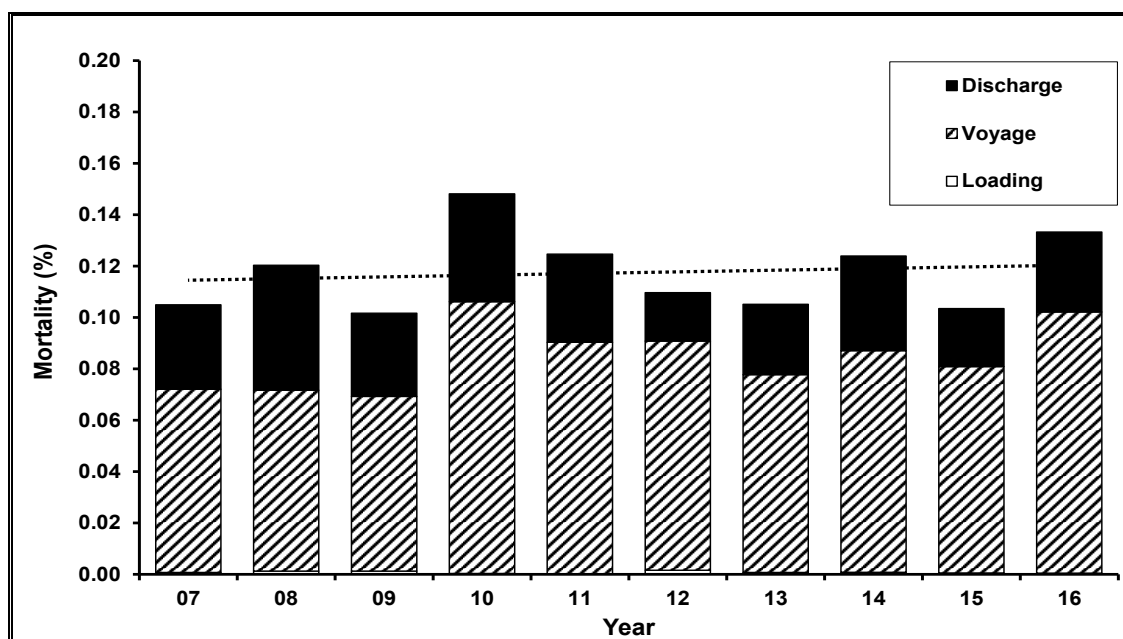


Figure 16 Annual mortality of cattle exported by sea from Australia to all destinations since 2007



4.2.2 Overview

The live cattle trade from Australia in 2016 was characterised by the large number of loading ports in Australia and regions to which the animals were shipped. This differs from the live sheep trade which has only three ports of loading, and nearly all sheep shipped to the Middle East/North Africa.

There were 347 cattle "voyages" during 2016. This involved 304 ship journeys, which was 11% less than in 2015. There were 28 voyages which were split for loading or discharge, and these generated a further 43 "voyages" as a result.

Where analysis involving split-load/discharge voyages has been performed, cattle consignments from each load port to each discharge port have been considered as separate "voyages". See the Methodology section of this report for a more detailed explanation of the voyage phases and the involvement of split-loading and split-discharging.

The overall number of cattle exported from Australia in 2016 fell by 14% compared to 2015, to 1.13 million (Table 7, below). The overall mortality rate in 2016 was 0.13%, a rise of 30% on the figure of 0.10% observed in 2015. 31% of all cattle voyages returned a nil mortality rate during 2016.

The highest overall mortality rate on a regional basis was for exports to Mexico (2.29%), while the lowest overall mortality rate was for exports to South-East Asia (0.09%). There were no exports to Miscellaneous destinations in 2016.

Exports to Mexico comprised one voyages carrying a total of 6,677 cattle with 153 mortalities (2.29%). Voyage and discharge days were an average of 22 and 3 days respectively. This voyages will not be examined further in this report, but a reference is made in Appendix 6.3.2.

The number of cattle exported to the Middle East/North Africa in 2016 fell by 27% compared to 2015, and the number of voyages fell by 10%. The mortality rate to the region rose from 0.25% in 2015 to 0.30% in 2016.

Exports to South-East Asia fell by 19% in 2016 compared to 2015, in a 200,000 head "correction" on the past few years. The number of voyages fell by 13%, from 310 in 2015 to 271 in 2016. Trade to South-East Asia accounted for 76% of all cattle exported in 2016.

Exports to South-East Asia involve a mix of smaller ships performing short single-load/single-discharge voyages, and larger ships which load and/or discharge at more than one port. In 2016 these larger vessels accounted for 34% of the cattle exported and 22% of the voyages made to South-East Asia.

Exports to North-East Asia in 2016 rose by 4% compared to 2015, and the mortality rate rose from 0.08% to 0.14%.

Exports to South-East Europe doubled year-on-year, while the mortality fell from 0.53% to 0.29%.

Table 7 Mortality rates, number of voyages, voyage and discharge days, and number of cattle exported for voyages to major destination regions during 2016

Parameter	ME/N Africa	SE Asia	NE Asia	Mexico	SE Europe	Total
Voyages (No.)	28	271	35	1	12	347
Cattle (No.)	72,721	861,074	102,487	6,677	86,846	1,129,805
Mortality rate o/all (%)	0.30	0.09	0.14	2.29	0.29	0.13
Mortality rate range (%)	0.00 – 0.72	0.00 – 1.42	0.00 – 0.64	n/a	0.08 – 0.65	0.00 – 2.29
Voyage days (Ave.)	17.77	7.96	17.28	22.00	24.71	10.32
Discharge days (Ave.)	4.33	1.47	0.75	3.00	1.97	1.65
Voyages with nil mortalities (No.)	14	86	8	0	0	108

National livestock export industry sheep, cattle and goat transport performance report 2016

4.2.3 Middle East/North Africa

The number of live cattle exported to the Middle East/North Africa during 2016 fell by 27% compared to 2015 (Table 8), and the number of voyages fell by 10%.

Overall mortality rates have remained at or below 0.5% over the last decade. In 2016 the mortality rate was 0.30%, slightly above the average across the decade of 0.26%.

Table 8 Mortality rates, number of voyages, average voyage and discharge length, and number of cattle exported to the Middle East/North Africa from 2007 to 2016

Year	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyage days	Discharge days	Nil mortality voyages (No.)
2007	41	74,256	0.19	0.00 – 0.54	16.43	4.23	16
2008	46	120,122	0.29	0.00 – 0.79	17.09	5.02	19
2009	41	98,183	0.33	0.00 – 1.78	15.37	4.62	13
2010	37	163,869	0.40	0.00 – 1.62	17.57	3.75	14
2011	28	80,180	0.17	0.00 – 0.67	17.91	3.14	10
2012	31	98,236	0.16	0.00 – 0.86	18.53	2.74	11
2013	33	121,780	0.17	0.00 – 0.44	19.28	3.99	12
2014	25	106,065	0.36	0.00 – 2.75	19.21	4.72	11
2015	31	99,558	0.26	0.00 – 0.78	19.10	3.21	12
2016	28	72,721	0.30	0.00 – 0.72	17.77	4.33	14

4.2.3.1 Port of loading

There were 3 ports of loading for voyages to the Middle East/North Africa in 2016, with the majority of cattle exported from Fremantle (Table 9). Mortality rates in 2016 were highest from Adelaide, followed by Fremantle and Portland.

The voyages from each port were classified into various mortality categories as shown in Table 10. There were two voyages in the medium or high categories, both loaded in Adelaide.

All voyages for Fremantle and Portland were in the nil or low categories.

Table 9 Mortality rates, number of voyages, average voyage and discharge length, and number of cattle exported from various ports to the Middle East/North Africa for 2016

Port	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyage days	Discharge days
Fremantle	22	57,806	0.26	0.00 – 0.45	16.28	4.82
Adelaide	2	9,237	0.69	0.63 – 0.72	24.69	3.15
Portland	4	5,678	0.09	0.00 – 0.29	22.55	2.25

Table 10 Number of voyages in nil, low, medium and high mortality categories for shipments from various ports to the Middle East/North Africa for 2016

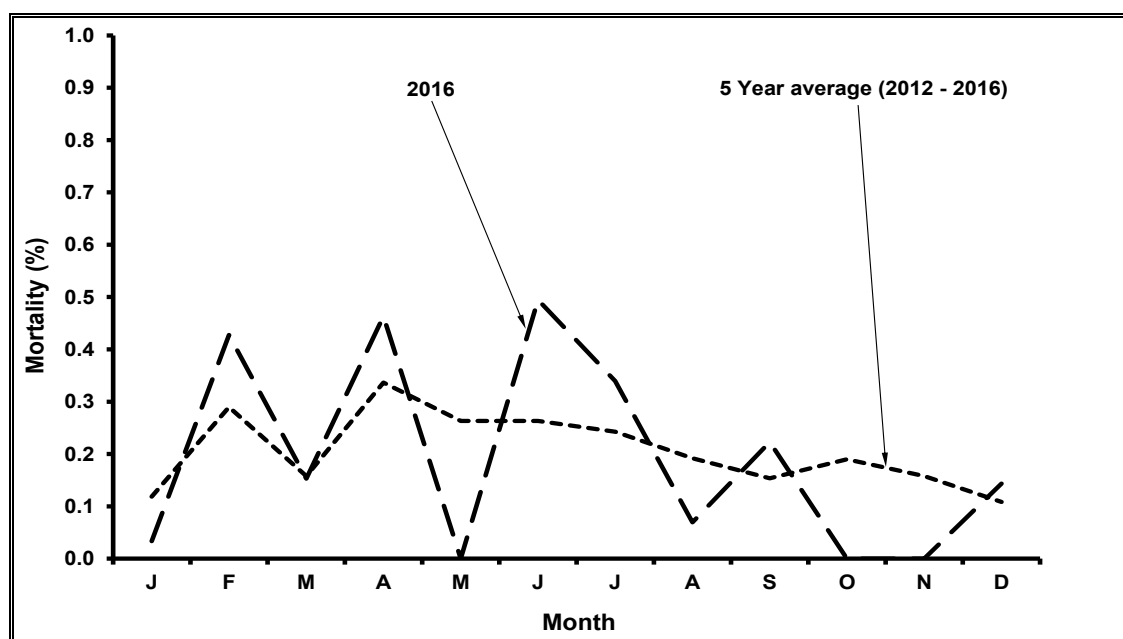
Port	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
Fremantle	12	10	0	0	22
Portland	2	2	0	0	4
Adelaide	0	0	2	0	2
Total	14	12	2	0	28

4.2.3.2 Time of year

In 2016, monthly mortality rates (total mortality as a proportion of total loaded for each month) in cattle exported from all ports to the Middle East/North Africa remained below 0.5% throughout the year except (Figure 17). Though it varied substantially in value, the monthly mortality rate profile for 2016 approximated the 5-year average except for the periods of May-June and October-November.

Note that one 2014 exceptional voyage has been excluded from the data. If this voyage was included, the January percentage for the 5-year average profile would have been 0.49%. A Federal Department of Agriculture investigation summary regarding this voyage is referred to in 6.2 Appendix 2

Figure 17 Monthly mortality rates of cattle on voyages from all ports to the Middle East/North Africa for 2016 and the 5-year average monthly rates for the period 2012 to 2016



4.2.3.3 Ship

The voyages of each ship carrying cattle from Australia to the Middle East/North Africa were classified into four mortality categories: nil (no mortalities); low (mortality rate up to 0.5%); medium (from 0.5 to 1.0%); and high (greater than 1.0%). Note that for this comparison, “voyage” equates to consignment from a port. If a ship loaded at two ports, then two “voyages” are shown, one for each port.

Table 11 shows the number of voyages in the various mortality categories for each ship. There were two voyages in the medium or high categories, involving ships 35 and 46. 93% of voyages were in the nil or low categories.

Table 11 Number of voyages in nil, low, medium and high mortality categories for shipments to the Middle East/North Africa for 2016

Ship (code)	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
32	4	1	0	0	5
33	0	1	0	0	1
34	5	0	0	0	5
35	1	2	1	0	4
43	1	2	0	0	3
45	0	2	0	0	2
46	0	3	1	0	4
47	3	1	0	0	4
Total	14	12	2	0	28

4.2.3.4 Class of cattle

In 2016, the highest overall class mortality rate occurred in adult bulls (0.33%; Table 12). Bull classes made up 53% of all cattle shipped to Middle East/North Africa in 2016.

Table 12 Mortality rates, number of voyages and number of cattle in various classes exported to the Middle East/North Africa in 2016

Class	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)
Bull adults*	18	38,491	0.33	0.00 – 0.90
Heifers beef	13	12,587	0.29	0.00 – 0.18
Bull weaners	1	5,462	0.15	0.00 – 0.31
Steer adults*	13	5,225	0.29	0.00 – 0.45
Heifers dairy	2	1,233	0.08	0.00 – 0.43

* may include young as well as mature animals (i.e. animals not separately classified as “weaner”)

National livestock export industry sheep, cattle and goat transport performance report 2016

4.2.4 South-East Asia

After the record-breaking 1.07 million cattle exported to South-East Asia in 2015, this market experienced a 200,000 head “correction, falling 19% to 0.86 million in 2016 (Table 13).

The mortality rate for voyages to the region rose to 0.09%, the number of voyages fell by 13%. A nil mortality rate was reported on 32% of the voyages to the region. The mortality rate has remained at or below 0.1% over the last decade, the average being 0.07%.

Table 13 Mortality rates, number of voyages, average voyage and discharge length, and number of cattle exported to South-East Asia from 2007 to 2016

Year	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyage days	Discharge days	Nil mortality voyages (No.)
2007	205	573,729	0.09	0.00 – 4.01	6.47	1.10	92
2008	219	682,264	0.10	0.00 – 1.93	6.33	1.14	93
2009	288	795,465	0.08	0.00 – 0.83	6.27	0.99	130
2010	202	551,761	0.04	0.00 – 0.44	6.47	0.86	105
2011	113	446,708	0.04	0.00 – 0.79	6.95	1.72	55
2012	127	361,383	0.04	0.00 – 0.80	6.71	1.32	63
2013	177	594,457	0.08	0.00 – 0.73	7.27	1.92	71
2014	266	995,138	0.08	0.00 – 3.52	7.66	1.55	96
2015	310	1,066,664	0.08	0.00 – 3.68	8.34	1.52	102
2016	271	861,074	0.09	0.00 – 1.42	7.96	1.47	86

4.2.4.1 Port of loading

Most cattle exported to South-East Asia in 2016 were loaded at Darwin (43%) followed by Townsville (26%) and Broome (12%, Table 14). The mortality rate was highest for cattle exported from Adelaide (0.41%) followed by Geraldton (0.13%), Fremantle (0.12%) and Townsville (0.11%).

The voyages from each port were classified into various mortality categories as shown in Table 15. 96% of voyages were in the nil or low categories in 2016. There were ten voyages in the medium and one in the high category.

The high mortality voyage involved the port of Townsville and is the subject of a high mortality investigation (section 6.2, Appendix 2).

Table 14 Mortality rates, number of voyages, average voyage and discharge length, and number of cattle exported from various ports to South-East Asia in 2016

Port	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyage days	Discharge days
Darwin	126	366,420	0.07	0.00 – 0.99*	6.54	1.12
Townsville	63	226,926	0.11	0.00 – 1.42*	9.64	1.51
Broome	28	100,816	0.05	0.00 – 0.18	6.33	2.16
Fremantle	25	93,811	0.12	0.00 – 0.91	12.37	2.78
Wyndham	9	27,427	0.02	0.00 – 0.14	6.12	1.31
Geraldton	8	19,108	0.13	0.00 – 0.61*	8.37	0.88
Karumba	8	12,750	0.07	0.00 – 0.43	9.01	0.59
Adelaide	1	6,362	0.41	n/a	16.16	7.51
Portland	2	5,554	0.04	0.03 – 0.06	10.88	0.57
Weipa	1	1,900	0.00	n/a	8.25	0.80

* exceptional voyage; see 6.2 Appendix 2

National livestock export industry sheep, cattle and goat transport performance report 2016

Table 15 Number of voyages in nil, low, medium and high mortality categories for shipments from various ports to South-East Asia for 2016

Port	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
Darwin	48	74	4	0	126
Townsville	8	51	3	1	63
Broome	12	16	0	0	28
Fremantle	5	18	2	0	25
Wyndham	7	2	0	0	9
Karumba	2	5	1	0	8
Geraldton	3	5	0	0	8
Portland	0	2	0	0	2
Adelaide	0	1	0	0	1
Weipa	1	0	0	0	1
Total	86	174	10	1	271

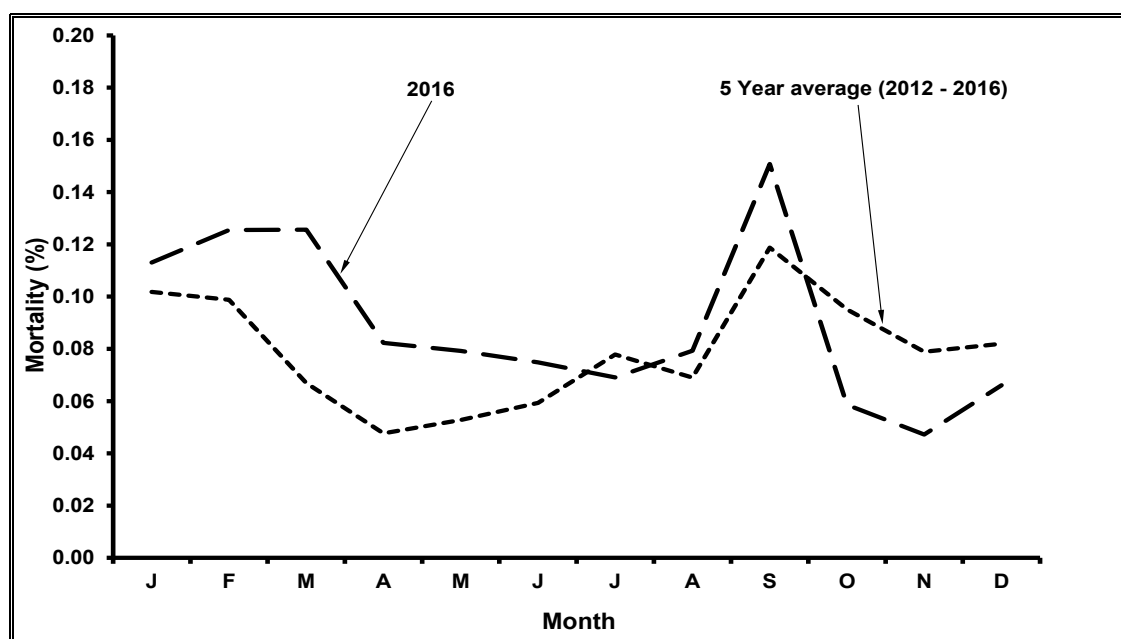
4.2.4.2 Time of year

Monthly mortality rates (total mortality as a proportion of total loaded for each month) for voyages to South-East Asia in 2016 were at or below 0.10% for the year except for the months of January through to March, and September (Figure 18).

While some voyages were higher than average in September, all were well below the reportable levels of 0.5% for voyages under 10 days duration and 1.0% for voyages of 10 days duration and over.

The monthly mortality rate profile for 2016 approximated that of the 5-year average.

Figure 18 Monthly mortality rates of cattle on voyages from all ports to South-East Asia for 2016 and the 5-year average monthly rates for the period 2012 to 2016



4.2.4.3 Ship

The voyages of each ship from Australia to South-East Asia were classified into various mortality categories as shown in Table 16. 96% of voyages were in the nil or low mortality categories. There were ten voyages in the medium and one in the high category involving ships 43, 45, 59, 95, 114, 123, 127 and 129.

The number of voyages to the region fell from 310 in 2015 to 271 in 2016, a decrease of 13%.

Ships with a carrying capacity of 6,000 or more head accounted for 22% of voyages to South-East Asia in 2016. They also accounted for 34% of cattle exported, 40% of mortality, 28% of voyage days and 46% of discharge days.

It should be noted that the larger ships often undergo more complex loading and discharging schedules which generate more “voyages”, as discussed in section 3.1 of the Methodology.

Table 16 Number of voyages in nil, low, medium and high mortality categories for shipments to South East Asia for 2016

Ship (code)	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
43	4	13	1	0	18
44	0	1	0	0	1
45	0	10	1	0	11
47	0	2	0	0	2
48	0	2	0	0	2
49	1	10	0	0	11
50	5	8	0	0	13
59	1	10	2	1	14
77	6	8	0	0	14
95	12	9	1	0	22
103	1	3	0	0	4
114	2	3	1	0	6
117	6	7	0	0	13
120	5	6	0	0	11
122	3	9	0	0	12
123	4	7	2	0	13
124	6	7	0	0	13
125	4	5	0	0	9
126	6	8	0	0	14
127	4	9	1	0	14
128	1	4	0	0	5
129	3	5	1	0	9
130	5	10	0	0	15
131	0	2	0	0	2
132	4	6	0	0	10
133	3	7	0	0	10
135	0	3	0	0	3
Total	86	174	10	1	271

4.2.4.4 Class of cattle

In 2016, 98.25% of cattle exported to South-East Asia were able to be identified by class. The 15,070 cattle that could not be identified to class were exported on 5 voyages, incurring a total mortality of 0.07%. These cattle will not be examined further in this section.

Adult steers and beef heifers comprised 49% and 23% respectively of all classes exported to the region in 2016 (Table 17).

The highest mortality rates occurred in dairy cows (0.24%) followed by beef cows (0.17%) and adult bulls (0.16%).

Note that high values for mortality rate ranges not included in voyage investigations mentioned at 6.2 Appendix 2, involved only a few deaths in small numbers loaded.

Table 17 Mortality rates, number of voyages and number of cattle in various classes exported to the South-East Asia in 2016

Class	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)
Steer adults*	229	422,036	0.09	0.00 – 1.52 [†]
Heifers beef	187	201,303	0.05	0.00 – 1.17 [†]
Bull adults*	138	96,738	0.16	0.00 – 2.02
Steer weaners	36	60,468	0.06	0.00 – 0.77
Cows beef	32	27,516	0.17	0.00 – 9.52
Heifers dairy	15	23,896	0.05	0.00 – 0.47
Bull weaners	20	9,535	0.07	0.00 – 0.75
Cows dairy	9	4,517	0.24	0.00 – 1.63

* may include young as well as mature animals (i.e. animals not separately classified as "weaner")

[†] exceptional voyage; see 6.2 Appendix 2

4.2.5 North-East Asia

The number of cattle exported to North-East Asia in 2016 rose by 4% compared to 2015 and the number of voyages rose by 9% (Table 18). The mortality rate has remained under 0.2% over the last decade, at an average of 0.11%.

The North-East Asia cattle trade is characterised by steers exported to Japan and heifers sent to China. Occasional shipments are made to Korea and North-Eastern Russia, but none occurred in 2016.

Table 18 Mortality rates, number of voyages, average voyage and discharge length, and number of cattle exported to North-East Asia from 2007 to 2016

Year	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyage days	Discharge days	Nil mortality voyages (No.)
2007	21	34,837	0.06	0.00 – 0.20	16.60	1.71	10
2008	19	29,873	0.06	0.00 – 0.36	17.51	1.04	10
2009	23	48,116	0.07	0.00 – 0.22	16.91	0.70	5
2010	34	69,638	0.08	0.00 – 0.33	18.25	0.62	10
2011	31	68,773	0.15	0.00 – 0.46	18.08	0.87	5
2012	30	74,941	0.17	0.00 – 0.70	17.55	0.76	7
2013	31	81,521	0.15	0.00 – 1.18	17.63	0.68	5
2014	39	123,583	0.14	0.00 – 2.04	17.47	0.76	10
2015	32	98,213	0.08	0.00 – 0.56	17.35	0.66	7
2016	35	102,487	0.14	0.00 – 0.64	17.28	0.75	8

4.2.5.1 Port of loading

The majority of cattle exported to North-East Asia in 2016 departed from Portland (75%), followed by Geelong (12%) and Brisbane (8%). As in 2015, there was the unusual addition of a voyage from Adelaide (Table 19). All cattle loaded at Brisbane were exported to Japan with the rest being exported to China.

The voyages from each port were classified into various mortality categories as shown in Table 20. During 2016 there was one voyage in the medium mortality category, while 97% of all voyages were in the nil or low categories.

Table 19 Mortality rates, number of voyages, average voyage and discharge length, and number of cattle exported from various ports to North-East Asia for 2016

Port	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyage days	Discharge days
Portland	20	76,413	0.16	0.00 – 0.64	16.98	0.76
Geelong	4	12,024	0.03	0.00 – 0.05	17.24	0.94
Brisbane	7	8,367	0.04	0.00 – 0.10	16.62	0.33
Adelaide	1	2,890	0.28	n/a	17.30	1.09
Fremantle	3	2,793	0.22	0.00 – 0.35	20.94	1.30

National livestock export industry sheep, cattle and goat transport performance report 2016

Table 20 Number of voyages in nil, low, medium and high mortality categories for shipments from various ports to North-East Asia for 2016

Port	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
Portland	1	18	1	0	20
Brisbane	4	3	0	0	7
Geelong	2	2	0	0	4
Fremantle	1	2	0	0	3
Adelaide	0	1	0	0	1
Total	8	26	1	0	35

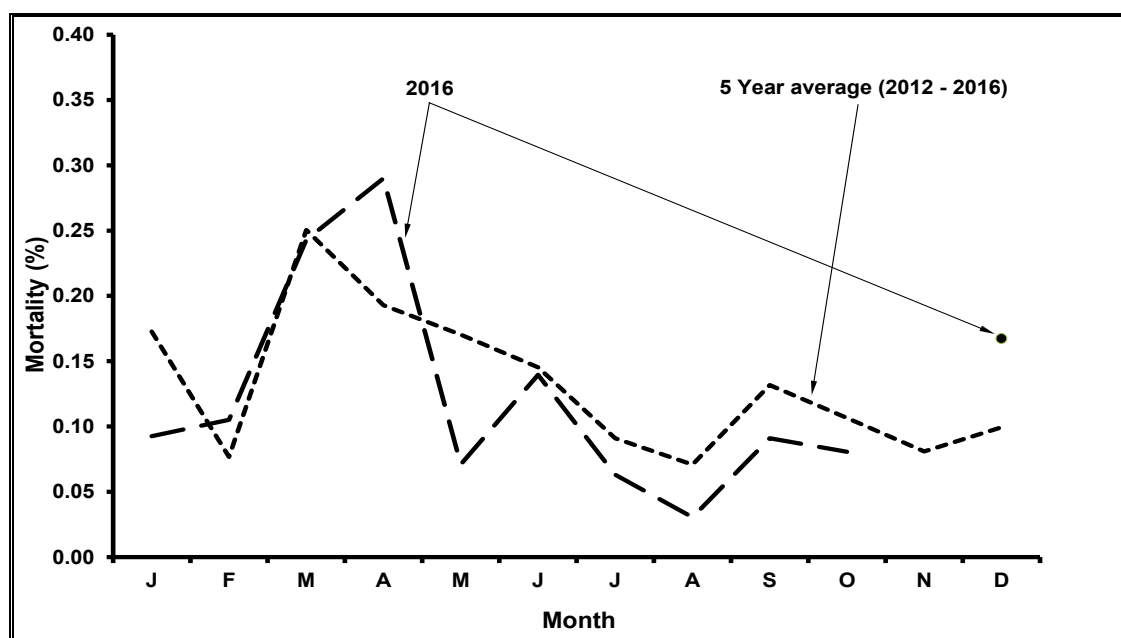
4.2.5.2 Time of year

Monthly mortality rates (total mortality as a proportion of total loaded for each month) for voyages to North-East Asia in 2015 were below 0.25% throughout the year except for the month of April.

The monthly mortality rate profile for 2016 approximated that of the 5-year average except for the months of January, April, May and December (Figure 19).

Note that one 2014 exceptional voyage has been excluded from the data. If this voyage was included, the January percentage for the 5-year average profile would have been 0.19%. A Federal Department of Agriculture investigation summary regarding this voyage is referred to in 6.2 Appendix 2

Figure 19 Monthly mortality rates of cattle on voyages from all ports to North-East Asia for 2016 and the 5-year average monthly rates for the period 2012 to 2016



National livestock export industry sheep, cattle and goat transport performance report 2016

4.2.5.3 Ship

The voyages of each ship taking cattle from Australia to North-East Asia were classified into various mortality categories as shown in Table 21.

During 2016 there was one voyage in the medium mortality category involving ship 59. There were 97% of voyages in the nil or low categories.

Table 21 Number of voyages in nil, low, medium and high mortality categories for shipments to North-East Asia for 2016

Ship (code)	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
45	1	0	0	0	1
47	0	2	0	0	2
48	1	1	0	0	2
49	0	2	0	0	2
59	0	0	1	0	1
77	1	0	0	0	1
103	0	3	0	0	3
115	3	3	0	0	6
120	1	1	0	0	2
127	0	1	0	0	1
128	1	4	0	0	5
130	0	1	0	0	1
132	0	3	0	0	3
133	0	2	0	0	2
135	0	3	0	0	3
	8	26	1	0	35

4.2.5.4 Class of cattle

Mortality rates for classes of cattle exported to North-East Asia during 2016 are presented in Table 22.

The North-East Asian cattle trade comprised mainly steers exported to Japan (8%) and heifer classes exported to China (83%).

The highest mortality rates occurred in adult bulls (0.64%) followed by beef heifers (0.30%).

Table 22 Mortality rate, number of voyages and number of cattle in the classes exported to North-East Asia in 2016

Class	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)
Heifers dairy	25	81,674	0.13	0.00 – 0.38
Steer adults*	10	13,159	0.08	0.00 – 0.16
Heifers beef	2	3,315	0.30	0.00 – 0.34
Bull adults*	1	3,119	0.64	n/a
Cows dairy	1	1,220	0.00	n/a

* may include young as well as mature animals (i.e. animals not separately classified as "weaner")

4.2.6 South-East Europe

The significant rise in livestock exports to Turkey and the Black Sea over the last decade initially had the effect of excessively boosting numbers of cattle exported to the Miscellaneous region. In 2012 a new destination region, South-East Europe, was introduced to allow a more meaningful examination of exports to this area.

The number of cattle exported to South-East Europe has increased significantly since 2009 while mortality rates have remained near 0.5% or less over the last decade, at an average of 0.34% (Table 23).

The mortality rate in cattle exported to South-East Europe was 0.29% in 2016. Numbers exported increased by 114% compared to 2015, with a three-fold increase in voyages to the region.

Table 23 Mortality rates, number of voyages, average voyage and discharge length, and number of cattle exported to South-East Europe from 2007 to 2016

Year	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyage days	Discharge days	Nil mortality voyages (No.)
2007	6	7,062	0.18	0.00 – 0.24	26.99	1.18	1
2008	8	14,341	0.11	0.00 – 0.23	25.42	1.17	1
2009	1	3,493	0.37	n/a	41.60	0.96	0
2010	11	78,673	0.44	0.00 – 0.83	25.08	5.03	1
2011	15	83,033	0.51	0.19 – 1.43	26.78	5.00	0
2012	14	75,170	0.28	0.00 – 0.87	28.78	3.58	1
2013	5	44,560	0.18	0.00 – 0.61	24.58	3.87	0
2014	5	54,006	0.47	0.34 – 0.60	25.62	3.88	0
2015	4	40,666	0.53	0.23 – 0.79	30.52	3.59	0
2016	12	86,846	0.29	0.08 – 0.65	24.71	1.97	0

4.2.6.1 Port of loading

All cattle exported to South-East Europe in 2016 were from the southern ports of Fremantle, Adelaide and Portland (Table 24). Most cattle were loaded at Fremantle (62%) followed by Portland (29%). The mortality rate was highest for cattle exported from Portland (0.47%).

The voyages from each port were classified into various mortality categories as shown in Table 25. There were no voyages in the high category in 2016

Table 24 Mortality rates, number of voyages, average voyage and discharge length, and number of cattle exported from various ports to South-East Europe in 2016

Port	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyage days	Discharge days
Fremantle	7	53,573	0.22	0.08 – 0.70	21.94	2.00
Portland	2	24,890	0.47	0.40 – 0.62	32.11	2.79
Adelaide	3	8,383	0.22	0.18 – 0.32	26.26	1.37

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Table 25 Number of voyages is nil, low, medium and high mortality categories for shipments from various ports to South-East Europe for 2016

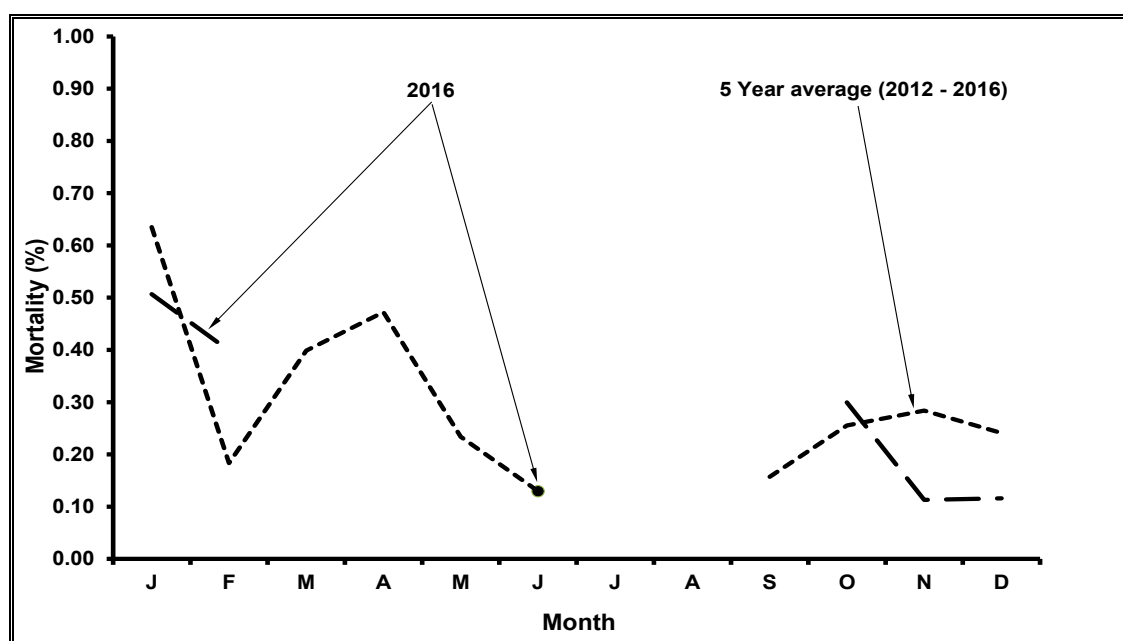
Port	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
Fremantle	0	6	1	0	7
Adelaide	0	3	0	0	3
Portland	0	1	1	0	2
Total	0	10	2	0	122

4.2.6.2 Time of year

Monthly mortality rates (total mortality as a proportion of total loaded for each month) for voyages to South-East Europe in 2016 were all at 0.5% or less (Figure 20).

Though the six months on which voyages occurred during 2016 were broken into three sections, it can be seen that the monthly mortality profile approximated the 5-year average in magnitude and spread across the year.

Figure 20 Monthly mortality rates of cattle on voyages from all ports to South-East Europe for 2016 and the 5-year average monthly rates for the period 2012 to 2016



4.2.6.3 Ship

The voyages of each ship taking cattle from Australia to South-East Europe were classified into various mortality categories as shown in Table 26. There were no voyages in the high category in 2016.

Table 26 Number of voyages in nil, low, medium and high mortality categories for shipments to South-East Europe for 2016

Ship (code)	Mortality rate				Total
	Nil 0.0%	Low >0.0–0.5%	Medium >0.5–1.0%	High >1.0%	
35	0	2	0	0	2
43	0	0	2	0	2
46	0	3	0	0	3
48	0	2	0	0	2
50	0	1	0	0	1
131	0	2	0	0	2
Total	0	10	2	0	12

4.2.6.4 Class of cattle

Mortality rates for each class of cattle exported to South-East Europe during 2016 are presented in Table 27. Bull classes exported to Turkey accounted for 61% of all cattle exported to South-East Europe during 2016, while steer classes exported to Russia accounted for a further 33%.

In 2016 the highest mortality rates occurred in adult steers (0.45%) followed by weaner steers (0.75%).

Table 27 Mortality rate, number of voyages and number of cattle in the classes exported to South-East Europe in 2016

Class	Voyages (No.)	Cattle (No.)	Mortality rate overall (%)	Mortality rate range (%)
Bull adults*	9	41,628	0.18	0.06 – 0.35
Steer adults*	5	32,712	0.45	0.18 – 0.65
Bull weaners	3	11,401	0.22	0.07 – 0.27
Steer weaners	1	1,105	0.36	n/a

* may include young as well as mature animals (i.e. animals not separately classified as "weaner")

4.3 Goats

4.3.1 Performance trend

Figures 21 and 22 show the number of goats exported and the mortality rates during sea transport from all ports in Australia to all destinations over the last decade as well as the trend line (linear regression) across those years.

The number of goats exported annually has varied between none and 26,000, and the annual mortality has varied between 0.00 and 0.69%. The trend for exports and annual mortality has continued downward.

Figure 21 Number of goats exported by sea from Australia to all destinations since 2007

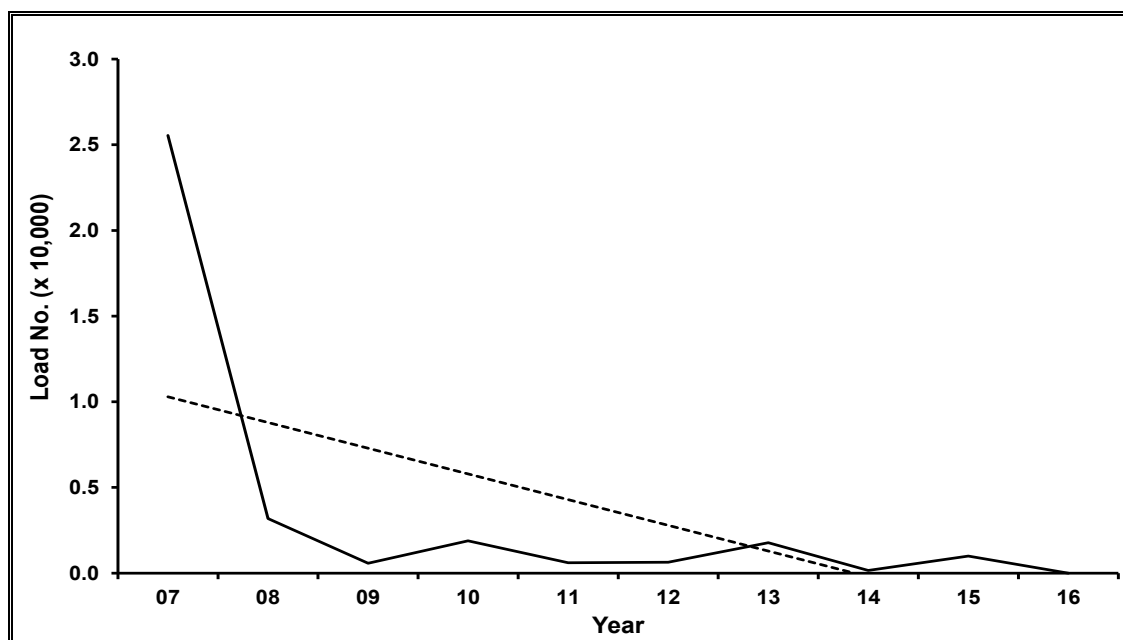
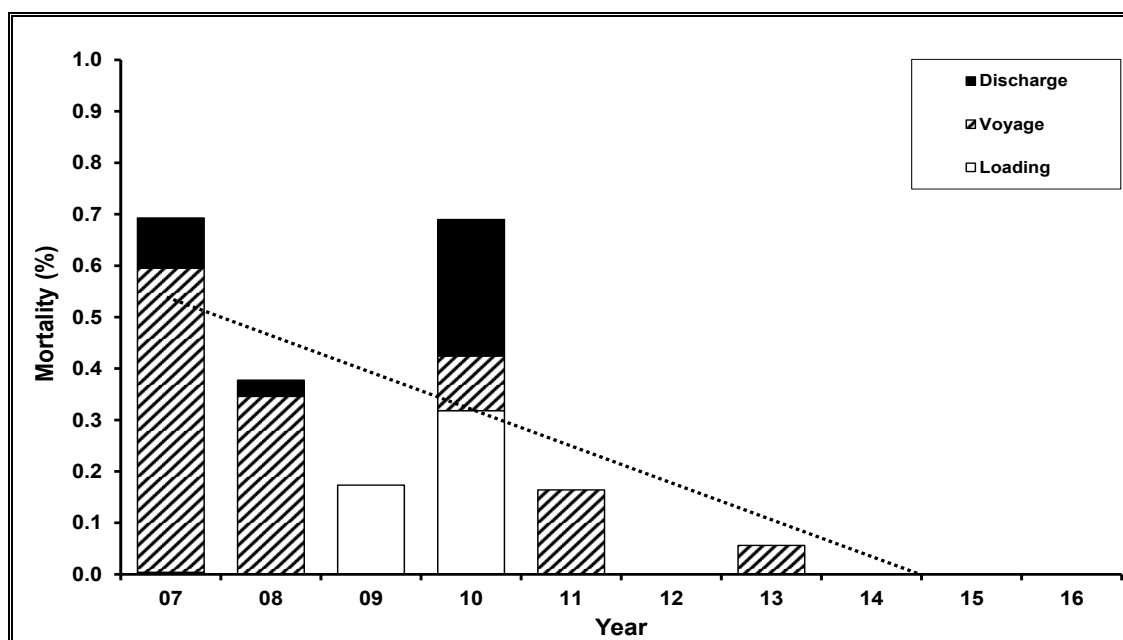


Figure 22 Annual mortality of goats exported by sea from Australia to all destinations since 2007



4.3.2 Overview

Historically, the live export of goats has mainly been to South-East Asia and the Middle East. The number of goats exported live by sea peaked at 113,651 in 2002.

While the air transport of goats has maintained a substantial presence since the 1990's, gradually this mode of carriage has expanded to take up almost the whole of live goat exports. Currently the majority of goats are transported by air to South-East Asia.

The seaborne export of goats has remained very low since 2008, making it difficult to present any meaningful analysis of trends. The few graphs / tables shown for this section of the report simply document the ongoing numbers exported and mortalities experienced.

There were no goats exported by sea from Australia in 2016. If a very small number of goats are exported by sea during 2017, this would constitute a decade of negligible participation and justify the deletion of section 4.3 from this series of annual reports.

4.3.3 South-East Asia

The number of goats exported by sea to South-East Asia has fallen substantially since peaking at 42,032 in 2002.

The mortality rate fell to 0.00% in 2012 (Table 28), the first time this figure has been achieved since this monitoring program began recording goat figures in 1993.

No goats were exported by sea during 2016.

Table 28 Mortality rates, number of voyages, average voyage and discharge length, and number of goats exported to South-East Asia from 2007 to 2016

Year	Voyages (No.)	Goats (No.)	Mortality rate overall (%)	Mortality rate range (%)	Voyage days	Discharge days	Nil mortality voyages (No.)
2007	25	25,546	0.69	0.00 – 12.50	9.17	2.01	5
2008	8	3,180	0.75	0.00 – 5.14	9.08	0.72	3
2009	2	577	0.17	0.00 – 0.25	9.78	0.75	1
2010	5	1,885	0.69	0.00 – 1.25	8.44	0.40	3
2011	1	610	0.16	n/a	10.02	0.35	0
2012	1	635	0.00	n/a	7.68	1.08	1
2013	3	1,776	0.06	0.00 – 0.14	7.76	1.69	2
2014	1	154	0.00	n/a	8.36	0.84	1
2015	2	1,000	0.00	n/a	6.55	0.74	2
2016	0	n/a	n/a	n/a	n/a	n/a	n/a

4.4 Air Transport

4.4.1 Air transport of live sheep

During 2016 air transport accounted for the 3.41% of live sheep exports (62,588 out of 1,837,909 sheep exported). The 62,588 sheep exported by air in 2016 represents a rise of 10% compared to 2015, and is the highest figure recorded over the 2008 to 2016 period.

Air transport of live sheep comprises a mix of breeding and slaughter types. In 2016, 81% of air-transported sheep were for slaughter.

4.4.1.1 Load point / destination

The loading points and destination countries for sheep transported by air from Australia in 2016 are shown in Table 29. The sheep were loaded at Perth, Adelaide, Melbourne and Sydney airports, each accounting for 51.1%, 30.1%, 15.6% and 3.2% of the number exported respectively.

The main importing countries for Australian sheep exported by air in 2016 were Malaysia (85.1%), China (10.2%) and Singapore (3.4%).

Table 29 Load point and destination country for sheep exported by air from Australia during 2016

Country	Adelaide	Melbourne	Perth	Sydney	Total
Malaysia	18,596	4,706	28,456	1,530	53,288
China		4,959	1,400		6,359
Singapore			2,100		2,100
Other	228	109		504	841
Total	18,824	9,774	31,956	2,034	62,588

SOURCE – Department of Agriculture and Water Resources

Other includes Argentina, Bangladesh, Brunei, Fiji, New Zealand, Philippines, Sarawak, UAE, Uruguay and Vietnam.

4.4.1.2 Mortalities

The reportable level for air-transported sheep is 2.0% or 3 sheep, whichever is the greater number of animals. There was one high mortality flight in 2009 (7.34%), 2013 (38.39%), 2014 (7.91%) and 2015 (18.66%). If these flights were excluded, the mortality rates for those years would have been 0.05%, 0.01%, 0.01% and 0.02% respectively. Note that references to Federal Department of Agriculture investigation reports into mortalities over 2% are included in 6.2 Appendix 2.

Sheep exported by air experienced 0.02% mortalities during 2016 (Table 30). The expected level of mortality is 0.03%.

For air transported sheep from 2008 to 2016, mortalities occurred on 2.6% of flights (32 of 1,255).

Table 30 Mortality rates and number of sheep exported by air to all destinations from 2008 to 2016

Year	Flights	Sheep (No.)	Total Mortalities (No.)	Mortality rate overall (%)
2008	88	11,667	0	0.00
2009	68	23,238	148	0.64
2010	82	21,201	3	0.01
2011	94	30,865	42	0.14
2012	120	23,688	0	0.00
2013	139	35,875	45	0.13
2014	162	39,227	177	0.45
2015	194	56,945	137	0.24
2016	308	62,588	10	0.02

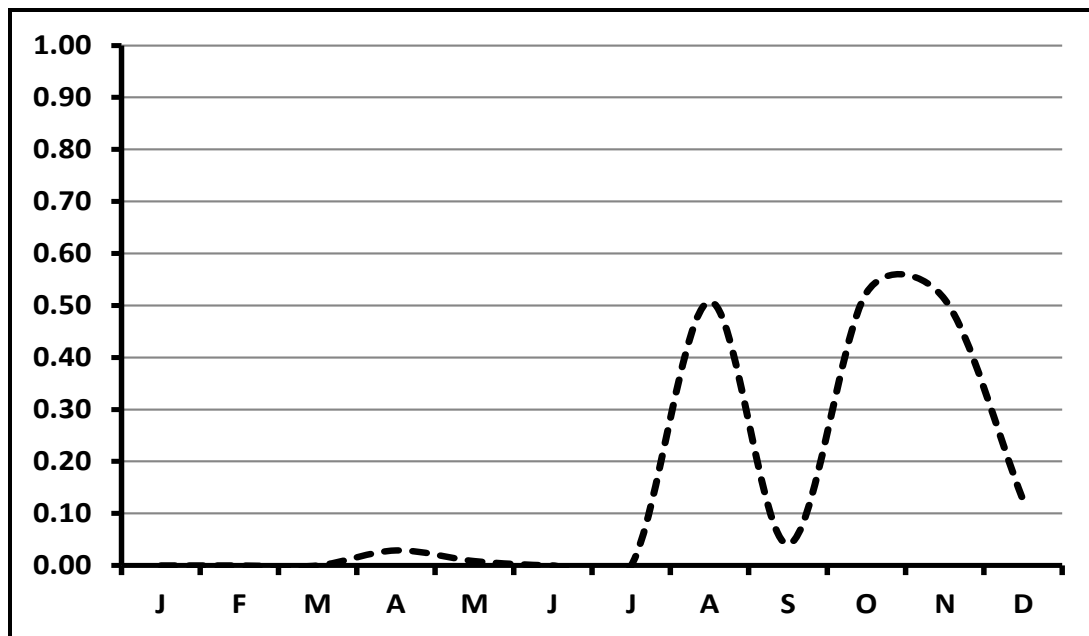
SOURCE – Department of Agriculture and Water Resources

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Over the period 2008 to 2016, mortalities were significantly higher in the second half of the year ($P < 0.05$, Figure 23), with 6 of the nine years being significantly different and two having no mortalities. The remaining year had a higher second-half mortality rate, but this was not significantly different.

All but 6 mortalities occurred in the second half of the year over the period.

Figure 23 Monthly mortality of sheep exported by air from Australia to all destinations since 2008



Mortalities were higher in slaughter sheep than breeder sheep ($P < 0.05$) with all but 3 mortalities occurring in slaughter types.

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4.4.2 Air transport of live cattle

During 2016 air transport accounted for 0.53% of live cattle exports (6,060 out of 1,135,865 cattle exported). The 6,060 cattle exported by air in 2016 represents a fall of 46.4% compared to 2015, and is the lowest figure recorded over the 2008 to 2016 period. Air transport of live cattle is almost exclusively confined to breeding types, but 2016 saw an unusually high 11% of slaughter cattle exported, an increase on the 7% seen in 2015

4.4.2.1 Load point / destination

Load points and destinations for cattle transported by air from Australia in 2016 are shown in Table 31.

Almost all cattle were loaded at Melbourne and Sydney airports, accounting for 66.6% and 28.2% respectively. The main importing countries for cattle exported by air in 2016 were Malaysia (28.6%), Indonesia (16.5%) and Taiwan (16.4%).

Table 31 Load point and destination country for cattle exported by air from Australia during 2016

Country	Adelaide	Brisbane	Melbourne	Sydney	Total
Malaysia	158		284	1,289	1,731
Indonesia			1,000		1,000
Taiwan			994		994
Japan			300	348	648
China			563		563
Vietnam			229	41	270
Philippines			240		240
Thailand		2	199	29	230
UAE			225		225
Brunei	155				155
Bangladesh				4	4
Total	313	2	4,034	1,711	6,060

SOURCE – Department of Agriculture and Water Resources

4.4.2.2 Mortalities

The reportable level for air-transported cattle is 0.5% or 3 cattle, whichever is the greater number of animals. There was one high mortality flight in 2008 (11.38%) and two in 2013 (6.45% and 15.26%). If these flights were excluded, the mortality rates for those years would have been nil. Note that references to Federal Department of Agriculture investigation reports into mortalities over 2% are included in 6.2 Appendix 2.

Cattle exported by air experienced nil mortality during 2016 (Table 32). The expected level of mortality is 0.01%. Mortalities occurred on 1.4% of flights over the 2008 to 2016 period (7 of 499).

Table 32 Mortality rates and number of cattle exported by air to all destinations from 2008 to 2016

Year	Flights	Cattle (No.)	Total Mortalities (No.)	Mortality rate overall (%)
2008	44	9,719	14	0.14
2009	62	9,315	0	0.00
2010	43	8,271	1	0.01
2011	48	8,738	0	0.00
2012	41	7,825	1	0.01
2013	54	9,691	67	0.69
2014	74	9,458	0	0.00
2015	76	11,315	2	0.02
2016	57	6,060	0	0.00

SOURCE – Department of Agriculture and Water Resources

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4.4.3 Air transport of live goats

Air transport has played a significant role in the export of live goats for many years, and during 2016 accounted for all live goat exports.

The 53,959 goats exported by air in 2016 represents a fall of 38% compared to 2015, and is the second lowest figure recorded over the 2008 to 2016 period.

Air transport of live goats comprises a mix of breeding and slaughter types, the majority of which are for slaughter. In 2016, 89.6% of air-transported goats were for slaughter.

4.4.3.1 Load point / destination

The loading points and destination countries for goats transported by air from Australia in 2016 are shown in Table 33.

The majority of these goats were loaded at Adelaide and Sydney airports, accounting for 49.4% and 31.1% respectively. The main importing countries in 2016 were Malaysia and UAE, which took 79.9% and 11.6% respectively of all goats exported by air.

Table 33 Load point and destination country for goats exported by air from Australia during 2016

Country	Adelaide	Melbourne	Perth	Sydney	Total
Malaysia	26,287	3,578	979	12,293	43,137
UAE		3,267		2,973	6,240
Sabah		1,856		395	2,251
Vietnam		727			727
Philippines				540	540
Sarawak				507	507
Brunei	380				380
Other		131		46	177
Total	26,667	9,559	979	16,754	53,959

SOURCE – Department of Agriculture and Water Resources
Other includes Fiji, Nepal and New Zealand

4.4.3.2 Mortalities

The reportable level for air-transported goats is 2.0% or 3 goats, whichever is the greater number of animals. For the years 2008 to 2016, there has been only one flight with a reportable mortality level. Note that a reference to the Federal Department of Agriculture investigation reports into this 2015 flight is included in 6.2 Appendix 2

Goats exported by air experienced 0.041% mortalities during 2016 (Table 34). The expected level of mortality is 0.01%. Mortalities occurred on 2.6% of flights (33 out 1,267) over 2008 to 2016.

Table 34 Mortality rates and number of goats exported by air to all destinations from 2008 to 2016

Year	Flights	Goats (No.)	Total Mortalities (No.)	Mortality rate overall (%)
2008	136	73,149	1	0.001
2009	199	81,571	0	0.000
2010	214	79,949	8	0.010
2011	99	51,487	1	0.002
2012	90	64,209	0	0.000
2013	111	74,484	9	0.012
2014	159	86,705	11	0.013
2015	129	86,925	74	0.085
2016	130	53,959	22	0.041

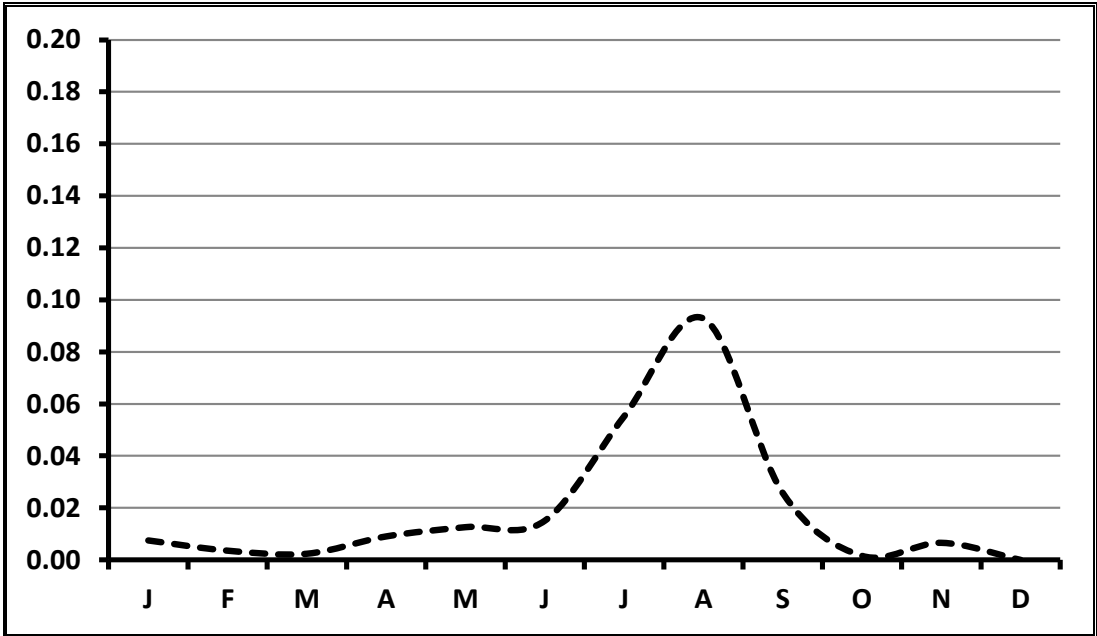
SOURCE – Department of Agriculture and Water Resources

National livestock export industry sheep, cattle and goat transport performance report 2016

Over the period 2008 to 2016, mortalities were significantly higher in the second half of the year ($P < 0.05$, Figure 24), but this broke down to the years 2008 to 2012 not being different, 2014 being significantly higher in the first half of the year, with the years 2013, 2015 and 2016 being significantly higher in the second.

Overall, 82% of mortalities occurred in the second half of the year over the period 2008 to 2016.

Figure 24 Monthly mortality of goats exported by air from Australia to all destinations since 2008



All mortalities for goats transported by air from 2008 to 2016 occurred in slaughter types, which comprised 86.2% of goats exported.

5 Conclusion and recommendations

5.1 Sheep, cattle and goats

This report successfully summarises the mortalities of sheep, cattle and goats exported live for the 2016 calendar year. Mortality trends were analysed and the overall mortalities for sheep and cattle exported by sea were shown to be 0.80%, 0.13%, while overall mortalities for sheep, cattle and goats exported by air were 0.02%, 0.00% and 0.04% respectively. No goats were exported by sea in 2016.

It is recommended that this project continue to be funded and to report on an annual basis in the future. This is the only comprehensive report of its type, providing breakdowns by ship, species, time of year, load ports and major destinations over the calendar year for both shipboard and air exports, as well as summary analyses of trends over time. The report is of interest and importance to a wide range of stakeholders, and while it is considered that the report effectively presents the Industry performance during the export shipment phase, it is further recommended that data held be turned to a broader range of analyses than those currently presented.

In the past much of the analysis for South-East Asia was derived from a version of the ship Master's Report (a voyage report that must be provided to the Australian Government for all shipments of livestock) that presented details meeting the reporting requirements of AMSA and DA. Unfortunately updates to the ship Master's Report have meant that we have had to seek Industry data for certain details that are now unavailable in the current version of the Master's Report. In 2016, 98.25% of cattle exported to South-East Asia could be identified by class, and the Industry cooperation facilitating this outcome is both laudable and very much appreciated.

Analysis over time for sheep, cattle and goats exported by air was introduced for the first time in 2013. The continuation of this information in 2016 completes the coverage of live exports for these species, allowing comparison between the sea and air export industries and analysis of air exports over the past nine years.

In the current format of this report, graphs and tables presenting long-term overviews have been restricted to a rolling ten-year basis. It is considered that the older data does not reflect the current state of the trade in terms of standards required of industry, ships participating and markets serviced.

In this report, the markets of Turkey and the Black Sea have been continued as the new destination region South-East Europe, first introduced in 2012. This reflects the fact that they are no longer minor, "miscellaneous" destinations, and that they don't fit the Middle East / North Africa region because of geographical and climatic differences.

It is recommended that the graph of "delivery success rates", first presented in the 2013 Executive Summary, be included on an ongoing basis.

It has long been the practise in this series of reports to include exceptional high-mortality voyages in summary data. Where more-detailed analyses are concerned, it has been the practise to exclude exceptional voyages if they bias the results that would be expected under normal industry conditions. Such exclusions have been annotated in relevant text, tables and figures.

It is recommended that reference to Federal Department of Agriculture investigations continue to be appended to this series of reports where exceptional voyages receive specific mention in the text or in footnotes. This recommendation also applies to exceptional flights.

Where mortality rate range data is presented in tables, the numbers shown have been extended to the second decimal place to illustrate differences that may be real but not apparent with numbers shown to one decimal place. It is recommended that this format, introduced in 2015 report, be maintained in future reports.

It is recommended that Industry information continues from 2015 as the source for the section regarding export destinations for sheep (Table 2, Section 4.1.4, p8).

6 Appendices

6.1 Appendix 1 – Research update

6.1.1 Heat load in sheep exported to Middle Eastern feedlots

This project has monitored shipments of sheep through the pre-embarkation feedlot, shipboard journey and subsequent lot-feeding in the ME. It has recorded body temperatures of sheep throughout this process to determine how sheep cope throughout the whole process and whether sheep are becoming compromised, with a view to then better manage animals.

To date the project has:

1. Gathered data on the internal temperatures of groups of sheep from a total of 6 shipments and the environmental conditions that they experienced as they undergo transition from Australia into Middle Eastern feedlots.
2. Gathered data, for the monitored shipments, on the pathophysiology of sheep clinically affected by disease during this transition and at the post-shipment feedlot, with blood and pathology samples analysed along with clinical signs and history of individual animals
3. Gathered data on other stressors such as feeding, management, and infectious disease during the process, by tracking of individual sheep through the pre-embarkation feedlot, during road transport to the port, on-board during the voyage to the Middle East, and then during their stay at the feedlot prior to slaughter
4. Related morbidity and mortality of the sheep to the gathered data, to surmise causes.

Phase two of this work has now commenced, firstly with the focus of supplementing sheep with electrolytes, when they experience sustained heat loads throughout the live export process into hot, humid destinations during the Middle Eastern summer.

Secondly, Middle Eastern environmental conditions will be monitored and also the responses of sheep given different shade types and other measures proposed to cool them.

All data collected from Phases one and two will be utilised to inform risk management and recommendations to limit compromises to health and welfare of the sheep, and to minimise losses.

Data collected during phase two indicates positive results have been achieved by the cooling methods trialled. See 6.1.2 “Heat Management in the Middle East”, below.

6.1.2 Heat Management in the Middle East

Heat load in sheep exported from Australia to the Middle East (ME) continues to have the potential to be a health and welfare concern. Therefore continued research in this area is paramount.

Research to date has provided information about the internal rumen temperatures (RT) of sheep exported from Western Australia to the Middle East at various times of the year, with comparison to environmental conditions.

Conclusions from phase one of work undertaken in 2014 (see 6.1.1 “Heat load in sheep exported to Middle Eastern feedlots”, above) suggests that lot-feeding in a hot, dry destination exposes sheep to high heat, but, with low humidity, provides satisfactory night time respite. Conversely, lot-feeding in a hot, humid destination exposes sheep to sustained periods of moderate to high wet bulb temperature.

Therefore the objectives of Phase two primarily focussed on monitoring environmental conditions and animal responses under different shade types and with additional measures to attempt to cool sheep.

Cooling interventions such as additional shade, increased air movement, and ground wetting were tested. There was a greater decrease in rumen temperature for sheep under double shade plus fans plus ground wetting than in control sheep kept under single shade.

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Environmental conditions were monitored at several ME feedlots throughout 2015 and findings indicated the need for further direct comparison and evaluation of different shade structures and interventions, which may potentially cool the sheep.

Work conducted over the ME summer of 2016 investigated further the effects of different shade structures in feedlots on the thermal load of sheep, and tested whether using fans and ground wetting in a humid environment will alter the internal rumen temperature of sheep exposed to those interventions.

The results from this work will provide advice on the construction and management of feedlots, and also list strategies that can be implemented in summer to reduce mortality and reduce the impact of heat exposure for sheep while in the feedlot.

The results of all phases of this research will be condensed into a “Tips and Tools” publication, but results will not be available until the completion of the current Phase three in June 2018

6.1.3 Pinkeye on long haul cattle voyages

The objectives of this project are:

1. To review current literature and gather epidemiological data from recent outbreaks of pinkeye
2. To identify microorganisms associated with the current syndrome and develop strategies for prevention

Scheduled Outcomes for the project are:

Defining the problem

Reviewing cattle eye-disease literature

Identifying the causes of pink-eye in exported cattle

Identifying environmental factors and husbandry practices that contribute to or mitigate severe eye-disease syndrome in export cattle

Test proposed solutions

The project will examine outbreaks of eye disease in pre-embarkation feedlots and on board vessels, with a focus on long-haul voyages.

Experiments to test the optimal use of immuno-therapeutic treatments and to better define the pathogen load of animals suffering eye-disease have been planned, but with options for suitable long-haul voyages being limited so far, the on-board testing continues to be delayed.

The Project began in May 2014, but the finish date continues under review.

6.1.4 Within crate ventilation on board aircraft

The aim of this project is to monitor and assess the ventilation conditions (carbon dioxide, ammonia, temperature and relative humidity) within animal crates during air transport, with a primary focus on short-haul flights.

Single, double and triple tier crates for relevant species (cattle, goats and/or sheep) have been investigated and the report will provide recommendations to optimise the welfare outcomes of animals during air export journeys.

The data collected during the project is intended to be incorporated into the Live Air Transport Risk Assessment model / decision-support tool known as LATSA.

Publication of the final report has been delayed pending further validation work.

6.1.5 LGAP implementation background and update

A fully implementable conformity assessment and certification program known as the Livestock Global Assurance Program (LGAP) was completed and successfully piloted.

LGAP was the result of research initiated in 2012 as to the potential role of quality assurance (QA) within the livestock export industry to support best practice, achieving ESCAS compliance and promoting continuous improvement.

LGAP aims to place requirements and consequences not just on exporters, but also on in-market importers, auditors, feedlots and abattoirs, by virtue of its positioning as a global conformity assessment program.

Adherence to LGAP's requirements would be verified through regular internal and external audits, under the control of Certification Bodies which would be approved and appointed by the LGAP Program Owner.

An implementation steering committee has been formed by the livestock export industry, and the complex process of considering implementation is currently underway.

Further details of LGAP can be found at: <http://www.livecorp.com.au/LC/files/e4/e433767f-6e3d-4588-88c2-0ef882260087.pdf>

6.1.6 Further improving the environment on board livestock vessels

The objectives of this project were:

1. To undertake a literature review to identify any innovations or developments that may direct research to improve environmental conditions within livestock vessels and facilities
2. Review and further develop the current best practice guidelines

An extensive literature review was undertaken with the major focus being on bedding management and air quality on livestock export vessels. Best practice management recommendations were developed.

The review is divided into three sections focusing on air quality and environmental monitoring (temperature, pad moisture and emissions), bedding management (management strategies and ventilation), and the issue of reporting (advances in environmental monitoring technology).

The project began in March 2014 and the final report is available at <https://www.mla.com.au/research-and-development/search-rd-reports/final-report-details/Research-LE/Bedding-management-and-air-quality-on-livestock-vessels-A-literature-review/3434>

6.1.7 Stockperson's manual for export of livestock by air.

The development of this manual targets exporters, operators and stockmen involved in the live air export industry, to assist in the planning and safe completion of each stage of the export process.

The step-by-step guide begins with the planning of a consignment, addresses each stage and concludes with procedures for disembarking, end-of-flight reporting and advice for managing stock in the destination country.

Tips and tools and benchmarks have been included to give specific advice and outline compulsory regulatory standards.

Drafting for this project is progressing with the final report expected by the end of 2017.

6.1.8 Backgrounding and feedlotting strategies to reduce inanition in sheep

A five-year research project on inanition in live export sheep funded by MLA, LiveCorp and matched dollar for dollar by Federal Government has focused on recommendations for improved practices for preparing animals for sea voyages.

The project investigated the leading causes of death of sheep while at sea, salmonella and inanition, and possible prevention strategies. To achieve this, researchers recorded the individual eating and drinking habits of approximately 16,000 sheep in the embarkation depot on ships' rations using RFID technology.

It was found that more than 90% of animals adapted quickly, eating and drinking for more than 30 minutes a day. However, the remainder were much slower to adapt to the conditions and ration on offer. Sheep that were reluctant to feed were also not attracted to various appetisers.

It was also concluded that the 8-10% of sheep that are slower to adapt, not eating and drinking for more than 30 minutes a day prior to the voyage, were considered high risk and therefore perhaps more susceptible to salmonella and/or not eating at all throughout the shipping phase. Of the remaining sheep there are approximately 2% in the groups that do not spend adequate time feeding per day.

The project began in 2010 and ended in 2016. It is intended that the full synopsis of results will be condensed into a "tips and tools" publication for industry in 2017.

6.2 Appendix 2 – Federal Department of Agriculture and Water Resources high-mortality investigations

The Australian Standards for the Export of Livestock (ASEL) define a reportable mortality level for sheep, cattle or goats on a voyage or air journey as the percentages listed below or 3 animals, whichever is the greater number of animals;

- Sheep and goats: 2%
- Cattle on a voyage less than 10 days: 0.5%
- Cattle on a voyage more than 10 days: 1%

In the interest of improved transparency of the Live Export Trade, where mortalities on a voyage or air journey exceed the reportable limits, the Federal Department of Agriculture, in agreement with the Live Export Industry Consultative Committee, has undertaken to publicize reports of investigations conducted.

The current publication refers to a number of these investigations conducted by the Department of Agriculture, listed below in order of reference. For each, the introduction to the report summary, the investigation findings, and the internet address of the full report is given.

It should be noted that the author took no part in these DAWR investigations, and so provides no comments on any of the findings or recommendations made.

Internet addresses provided were current at the date of publication.

1. 2016 voyage carrying sheep loaded at Fremantle (see sections 4.1.2, p10; 4.1.4.8, p21)

This voyage is undergoing investigation and the summary will be published on the DAWR internet site once it is completed.

2. 2013 voyage carrying sheep loaded at two ports(see sections 4.1.4.2, pp10, 11; 4.1.4.4, p13; 4.1.4.5, pp15, 16):

Mortality exceeded the reportable level in two consignments of sheep exported from Adelaide and Fremantle to Qatar and the United Arab Emirates in September 2013. The reportable level for sheep is two percent. In the Adelaide consignment the mortality rate was 7.28% while in the Fremantle consignment the mortality rate was 3.00%.

The main cause of mortalities for this voyage was heat stress, accounting for 97% of mortalities. Heat stress mortalities occurred on day 21 when the vessel encountered extreme weather conditions.

<http://www.agriculture.gov.au/export/controlled-goods/live-animals/livestock/regulatory-framework/compliance-investigations/investigations-mortalities/report-46>

National livestock export industry sheep, cattle and goat transport performance report 2016

3. 2014 voyage carrying sheep and cattle loaded at Fremantle (see sections 4.1.4.2, p10; 4.1.4.5, pp15, 16; 4.2.3.2, p25):

During this voyage, 165 of the 6,000 cattle loaded (2.75%) and 1,654 of the 42,550 sheep loaded (3.89%) were recorded as mortalities. This exceeds the reportable mortality level of one per cent for cattle on voyages of 10 days or greater duration and two percent for sheep, as prescribed by the Australian Standards for the Export of Livestock (ASEL).

The ship experienced mechanical failure, which slowed its progress and significantly extended the length of the voyage. Additional fodder of a different composition was loaded en route to ensure sufficient fodder was available for the remainder of the journey.

The investigation determined the cause of the majority of mortalities was ruminal acidosis as the result of a sudden change in fodder. Ruminal acidosis (also referred to as rumen lactic acidosis, grain overload, grain poisoning and acute indigestion) develops in sheep and cattle that have ingested large amounts of unaccustomed feeds rich in ruminally-fermentable carbohydrates (RAGFAR 2007).

<http://www.agriculture.gov.au/export/controlled-goods/live-animals/livestock/regulatory-framework/compliance-investigations/investigations-mortalities/cattle-sheep-israel-jordan-51#summary>

4. 2016 voyage carrying cattle loaded at Portland (see section 4.2.2, p23)

This voyage is undergoing investigation and the summary will be published on the DAWR internet site once it is completed.

5. 2016 voyage carrying cattle loaded at Townsville (see sections 4.2.4.1, p27; 4.2.4.4, p30):

On 17 March 2016, a consignment of slaughter cattle was exported by sea from Townsville to Vietnam.

There were 25 mortalities in this consignment of 1,764 cattle, a mortality rate of 1.42 per cent. This exceeds the reportable mortality level of 1.0 per cent for cattle on voyages greater or equal to 10 days duration as prescribed by the Australian Standards for the Export of Livestock (ASEL).

The main cause of mortalities on this voyage was that 14 cattle were unable to stand or walk (downer animals) and were euthanased, one additional downer animal was not euthanased and died overnight. Five cattle died from pneumonia, one from a broken leg and four others were reported as due to 'misadventure' due to unknown causes possibly smothering.

The department agreed with the exporter findings that wet conditions during preparation of this consignment contributed to lameness and downer animals resulting in euthanasia.

The DA's veterinary officer closed the registered premises due to the wet conditions until the yards dried out. No further action was taken by the department.

<http://www.agriculture.gov.au/export/controlled-goods/live-animals/livestock/regulatory-framework/compliance-investigations/investigations-mortalities/cattle-vietnam-report-61>

National livestock export industry sheep, cattle and goat transport performance report 2016

6. 2016 voyage carrying cattle loaded at Darwin (see section 4.2.4.1, p27):

On 14 March 2016, a consignment of feeder and slaughter cattle was exported by sea from Darwin to Vietnam. There were 13 mortalities in this consignment of 1,318 cattle, recording a mortality rate of 0.99 per cent. This exceeds the reportable mortality level of 0.5 per cent for cattle on voyages of less than ten days duration as prescribed by the Australian Standards for the Export of Livestock (ASEL).

The DA confirmed the cattle were prepared and loaded in accordance with ASEL requirements.

The DA's review did not find any information to link the mortalities to the preparation of the cattle in the registered premises or the loading of the vessel. The mortalities were all in heavier cattle from the same property of origin. These cattle had all arrived at the registered premises on 10 March 2016 and had additional time above the ASEL requirements of 24 hours in the registered premises prior to departure.

Based on information provided by the accredited stockperson on board and the exporter's review of the incident the likely cause of the mortalities was respiratory disease.

The department did not take any regulatory action against the exporter.

<http://www.agriculture.gov.au/export/controlled-goods/live-animals/livestock/regulatory-framework/compliance-investigations/investigations-mortalities/cattle-vietnam-report-60>

7. 2016 voyage carrying cattle loaded at Geraldton (see section 4.2.4.1, p27)

This voyage is undergoing investigation and the summary will be published on the DAWR internet site once it is completed.

8. 2014 voyage carrying cattle loaded at Portland (see section 4.2.5.2, p32)

On 20 February 2014, 2400 cattle were exported by sea from Portland to Tianjin (China). There were 49 mortalities on the voyage, a mortality rate of 2.04 per cent. This exceeds the 1.0 per cent reportable mortality level for cattle on voyages of ten days or greater as prescribed by the Australian Standards for the Export of Livestock (ASEL).

The mortalities in this consignment were a result of rough weather and high seas resulting in injuries to the cattle. These cattle were initially treated by the AAV on board and those that did not respond to treatment were euthanased. Eighteen cattle were responding to treatment but were rejected from discharge in Tianjin and were euthanased at that time.

<http://www.agriculture.gov.au/export/controlled-goods/live-animals/livestock/regulatory-framework/compliance-investigations/investigations-mortalities/cattle-china-report-52>

National livestock export industry sheep, cattle and goat transport performance report 2016

9. 2009 flight carrying sheep loaded at Perth (see section 4.4.1.2, p39):

There were 138 mortalities of the 1873 sheep loaded on the flight, equating to a mortality rate of 7.36%. The aircraft had two operating air conditioning packs and one air conditioning pack deactivated. Inadequate ventilation in the main cargo hold causing increased temperature, humidity and ammonia levels is suspected as the most likely cause of the mortalities.

Inadequate ventilation in the main cargo hold causing increased temperature, humidity and ammonia levels is suspected as the most likely cause of the mortalities. Triple tiered crates are routinely used by exporters to load sheep and goats without incident.

This report is no longer presented: it can be obtained by request from DAWR

10. 2013 flight carrying sheep loaded at Perth (see section 4.4.1.2, p39):

On 7 November 2013, 112 sheep were exported by air from Perth to Kuala Lumpur. There were 44 mortalities during the flight, a mortality rate of 39.3 percent. This exceeds the reportable mortality level for sheep of two percent as prescribed by the ASEL.

Inadequate ventilation is the most likely cause of the mortalities. The high mortality of sheep in the top tiers of the crates is consistent with inadequate ventilation causing increased temperature, humidity, carbon dioxide and ammonia levels during the flight.

There was no significant differences identified in the preparation and procedures used for this consignment compared with previous consignments.

<http://www.agriculture.gov.au/export/controlled-goods/live-animals/livestock/regulatory-framework/compliance-investigations/investigations-mortalities/sheep-malaysia-report-49>

11. 2014 flight carrying sheep loaded at Perth (see section 4.4.1.2, p39)

On 2 October 2014, 2,200 sheep were exported by air from Perth to Changi, Singapore. There were 174 mortalities during the flight, a mortality rate of 7.91 per cent. This exceeds the reportable mortality level for sheep of two percent as prescribed by the *Australian Standards for the Export of Livestock (Version 2.3) April 2011* (ASEL).

Inadequate ventilation is the most likely cause of the mortalities. The high mortality of sheep in the upper decks of the crates is consistent with inadequate ventilation causing increased temperature, humidity, carbon dioxide and ammonia levels during the flight.

There was no significant differences identified in the preparation and procedures used for this consignment compared with previous consignments.

<http://www.agriculture.gov.au/export/controlled-goods/live-animals/livestock/regulatory-framework/compliance-investigations/investigations-mortalities/sheep-singapore-report-53>

National livestock export industry sheep, cattle and goat transport performance report 2016

12. 2015 flight carrying sheep loaded at Sydney (see section 4.4.1.2, page 39):

On 8 August 2015, two consignments of sheep and goats were exported by air from Sydney to two separate destinations. There were 670 slaughter sheep and 1000 slaughter goats consigned to Kuala Lumpur, Malaysia and 833 breeding goats consigned to Kota Kinabalu, East Malaysia. During the flight between Kota Kinabalu and Kuala Lumpur, 125 mortalities were recorded from the 670 slaughter sheep loaded (18.66 per cent mortality) and 48 mortalities were recorded from the 1000 slaughter goats loaded (4.8 per cent mortality). This exceeds the reportable mortality level of two per cent for both species as prescribed by the Australian Standards for the Export of Livestock (Version 2.3) April 2011 (ASEL).

The investigation found that a period of inadequate ventilation is the most likely cause of the mortalities. During transit at Kota Kinabalu, there was failure in starting the auxillary power unit to run the ventilation system, delay in starting the backup ventilation and an extended period on the ground.

High mortalities in the upper decks of the crates is consistent with inadequate ventilation causing increased temperature, humidity, carbon dioxide and ammonia levels. The delay in starting the APU and extended period in transit in Kota Kinabalu is the most likely cause of inadequate ventilation.

<http://www.agriculture.gov.au/export/controlled-goods/live-animals/livestock/regulatory-framework/compliance-investigations/investigations-mortalities/sheep-goats-malaysia-report-59>

13. 2008 flight carrying cattle loaded at Melbourne (see section 4.4.2.2, page 41):

There were 14 mortalities of the 123 cattle loaded which equates to a mortality rate of 11.3 per cent. There were no mortalities for the sheep and goats that were also loaded on this aircraft.

The factors contributing to the cattle mortalities on board the aircraft were suffocation due to inadequate ventilation in the rear hold of the lower cargo compartment of the aircraft where the cattle were held.

The ventilation appears to have been adequate in the leg of the flight between Melbourne and Brisbane.

Inadequate ventilation in the lower cargo hold is infrequent and unpredictable but when it occurs may cause significant number of mortalities.

This report is no longer presented: it can be obtained by request from DAWR.

14. 2013 flight carrying cattle loaded at Melbourne (see section 4.4.2.2, page 41):

On 27 September 2013, 279 cattle were exported by air from Melbourne to Harbin (China). There were 18 mortalities on the flight, a mortality rate of 6.45 per cent. This exceeds the 0.5 per cent reportable mortality level for cattle on voyages less than 10 days as prescribed by the ASEL.

A definitive cause of the mortalities was not determined from this investigation. From the information available inadequate ventilation in the region of these two crates causing increased temperature, humidity, carbon dioxide and ammonia levels is suspected as the most likely cause of the mortalities. However an underlying cause for the reduced ventilation was not determined.

The investigation also found that the exporter load plan approved by the department is not always provided in a hard copy form to the airline.

<http://www.agriculture.gov.au/export/controlled-goods/live-animals/livestock/regulatory-framework/compliance-investigations/investigations-mortalities/report-47>

15. 2013 flight carrying cattle loaded at Melbourne (see section 4.4.2.2, page 41):

On 21 October 2013, 321 cattle were exported by air from Melbourne to Almaty (Kazakhstan). There were 49 mortalities during the flight, a mortality rate of 15.3 per cent. This exceeds the 0.5 per cent reportable mortality level for cattle on voyages less than 10 days as prescribed by the ASEL.

Inadequate ventilation within the double crates is the most likely cause of the mortalities. The high mortality of cattle in the upper decks of the crates is consistent with inadequate ventilation causing increased temperature, humidity, carbon dioxide and ammonia levels during the flight. There was no identified or known defect in the aircraft's ECS. The placement of double crates loaded side by side in one block may have impacted the airflow on the main deck to the point where it influenced the compartment's environmental conditions. Inadequate ventilation was further compounded by a stop in Singapore with a hot, humid climate.

There were no significant differences identified in the preparation and procedures used for this consignment compared with previous consignments that may have contributed to the mortalities.

<http://www.agriculture.gov.au/export/controlled-goods/live-animals/livestock/regulatory-framework/compliance-investigations/investigations-mortalities/report-48>

6.3 Appendix 4 - Published studies

A list of scientific and extension publications, relevant to the livestock export trade, is shown below in order of publication date.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Norris, RT, (2005) Transport of animals by sea *Rev Sci Tech Off Int Epiz* **24**: 673-681

Beatty, DT, Barnes, A, Taylor, E, Pethick, D, McCarthy, M and Maloney, SK (2006) Physiological responses of *Bos taurus* and *Bos indicus* cattle to prolonged, continuous heat and humidity *J Anim Sci* **84**: 972-985

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

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

National livestock export industry sheep, cattle and goat transport performance report 2016

Phillips, CJC, Pines, MK, Latter, M, Muller, T, Petherick, JC, Norman, ST and Gaughan, JB (2010) The physiological and behavioural responses of steers to gaseous ammonia in simulated long distance transport by ship J Anim Sci **88**: 3579-3589

Pines, MK and Phillips, CJ (2012) Accumulation of ammonia and other potentially noxious gases on live export shipments from Australia to the Middle East J Environ Monit **13**: 2798-2807

Stockman, CA, Barnes, AL, Maloney, SK, Taylor, E, McCarthy, M and Pethick, D (2012) Effects of prolonged exposure to continuous heat and humidity similar to long haul live export voyages in Merino wethers Anim Prod Sci **51**: 135-143

Australian Government Department of Agriculture, Fisheries and Forestry (2012) Australian standards for the export of livestock (version 2.3) and Australian position statement on the export of livestock (Note – this publication is now available for download onto mobile devices by entering “asel handbook app” into your internet browser and choosing the method most appropriate to you)

Pines, MK, Phillips, CJC (2013) Microclimatic conditions and their effects on sheep behaviour during a live export shipment from Australia to the Middle East J Anim Sci **91**: 4406–4416

Phillips, C (2016) The welfare risks and impacts of heat stress on sheep shipped from Australia to the Middle East Vet J **218**: 78-85

The Veterinary Handbook for Cattle, Sheep and Goats Application (2017) is available for download onto mobile devices at: <http://www.veterinaryhandbook.com.au/>

Moore SJ, Madin B, Norman G, and Perkins N (2015) Risk factors for voyage mortality in cattle during live export from Australia by sea Aust Vet J **93**: 339-348

The LiveCorp/MLA Livestock Export Program has developed a suite of Livestock Export user guides and manuals including:

“Management of unfit-to-load livestock. Guidelines for persons in charge and veterinarians involved in pre-embarkation live export inspections of cattle and sheep” (available for download at: <http://www.livecorp.com.au/LC/files/43/43727f94-7535-41ba-a6d7-8d68a97f1708.pdf>)

“Is it fit to load in the Middle East? A guide for the selection of animals fit to transport in the Middle East” (available for download at: <http://www.livecorp.com.au/LC/files/a3/a3c32633-97c8-4236-97f6-2eb3504a494a.pdf>)

“Is it fit to export? A guide to the supply of livestock for the Australian livestock export industry” (available for download at: <http://www.livecorp.com.au/LC/files/12/129d63e8-a979-48b2-abe5-c9c8d30e4871.pdf>)

6.4 Appendix 5 - Acknowledgements

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

The cooperation of Exporters, Shipping Agencies and Port Authorities for additional help in collating data is also gratefully acknowledged.

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