Final report

Shipboard provision of animal health equipment and medications

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Abstract

Appropriate treatment of sick or injured livestock is essential to ensuring the health and welfare of livestock on land and those being exported by sea.

This body of work developed a set of recommendations to consider when updating the Australian Standards for the Export of Livestock (ASEL) requirements for shipboard provisions of animal health equipment and medications. Following an update of ASEL requirements, complementary guidelines should be developed to help exporters in meeting these requirements, by assisting them in determining the most appropriate shipboard equipment and medications to load based on the assessed animal health risks for each voyage.

The effectiveness of ASEL requirements and the animal welfare outcomes it aims to ensure is inherently linked to the regulatory framework; therefore, this work also considers the relevant wider regulatory framework and makes recommendations to allow the ASEL requirements for shipboard provisions to be effective in ensuring good animal welfare outcomes.

Executive summary

This body of work developed a set of recommendations for the live export industry, the Australian government Department of Agriculture, Water and the Environment (the department), and the Australian Standards for the Export of Livestock (ASEL) technical committee to consider when updating ASEL requirements for shipboard provisions of animal health equipment and medications.

Recommendation 1: Defining syndromes
The syndromes which are used to describe and report animal health issues during the livestock export process have clear definitions that are agreed upon by government and industry.

Recommendation 2: Defining groups of animals
The terms used to describe groups of animals in the livestock export process have clear definitions that are agreed upon by government and industry.

Recommendation 3: Performance indicators
Animal-days-at-risk should be used by industry and government when calculating animal health and welfare performance indicators to monitor or regulate the livestock export industry.

Recommendation 4: Systematic risks
Areas of greater systematic risk in the livestock export process should be determined, by government and/or industry, through comparing the prevalence of specific animal health issues within the livestock export industry with other Australian land-based production systems.

Recommendation 5: Export supply chain medication plan
An export supply chain medication plan should be incorporated into the exporter's business process. This should contain information on antimicrobial stewardship, provide directions for selecting the most appropriate medications, and information on the use of medications within their export supply chain.

Recommendation 6: Consignment animal health assessment
A Consignment Animal Health Assessment process (CAHA) should be conducted for each consignment at the time the exporter is developing the Standard Export Plan (SEP) into a Consignment Specific Export Plan (CSEP).

A CAHA process identifies animal health risks through considering each individual consignment specifics including the groups of animals (type, lines, etc.) being loaded, their background history, the vessel and operational constraints, the port of loading, the destination port, market requirements, etc. This allows group-level animal health risks mitigation measures to be developed and implemented.

Recommendation 7: Minimum provisions of medications for sea export voyages with cattle and sheep

The following table is recommended as the standards for the provision of animal health medications to the Australian Standards for the Export of Livestock Technical Advisory Committee.

Product type	Specific items	Species	Provisions required per 1000 animal days [AC]	Medication must be included to treat major syndromes or diseases
Analgesics/anti-inflammatories including corticosteroids	Injectable anti-inflammatories	Cattle	4.5 doses [B]	-
		Sheep	0.1 doses [B]	-
	Local anaesthetic	Cattle	1ml (minimum 50ml)	-
		Sheep	0.1ml	-
Injectable antimicrobials		Cattle	4.5 doses [B]	1 - Respiratory disease
				2 - Musculoskeletal conditions and injuries
				3 - Eye disease
		Sheep	0.1 doses [B]	1 - Musculoskeletal conditions and injuries
				2 - Enteric disease
Sedatives		Cattle	0.5 doses [B]	-
		Sheep	0.1 doses [B]	-
Topical wound treatment		Cattle	1 treatment	Musculoskeletal conditions and injuries
		Sheep	0.1 treatment	Musculoskeletal conditions and injuries Flystrike
Supportive products	Metabolic solutions	Cattle	1 treatment	-

Recommendation 8: Minimum provisions of equipment for sea export voyages with cattle and sheep

The following table is recommended as the standards for the provision of animal health equipment to the Australian Standards for the Export of Livestock Technical Advisory Committee.

Equipment	Item	Consignment type	Detail	Number per vessel	Equipment per on-board staff [A]	Redundancy
Personal Protective Equipment[B]	Examination gloves	All	More than 50	-	1	-
	Obstetrical gloves	All	More than 50	1	-	-
	Eye protection	All	For use with drug administration and euthanasia	-	1	1
	Ear protection	All	For use with euthanasia	-	1	1
Handling equipment	Portable head bale	Cattle	Light weight, able to be moved around the ship and secured as needed	1	-	-
	Rope halter	Cattle	-	1	-	-
	Nose grips	Cattle	-	1	-	1
	Ropes for handling	Cattle	-	2	-	1
	Cattle talker/slapper	Cattle	Appropriate for low stress stock handling	4	1	1
Identification	Marker	Sheep	Stock identification marker		1	1
Diagnostic equipment	Thermometers	All	-	2	-	1
	Meat temperature gauge	All	To determine post-mortem muscle carcase temperature	1	-	-
	Multi-test dipstick	All	More than 50	1	-	-
	Small post-mortem	All	2 post-mortem knives plus steel and sharpening stone	2	-	-
Site preparation	Antiseptic	All	1 litre of chlorhexidine,	1	-	-

Equipment	Item	Consignment type	Detail	Number per vessel	Equipment per on-board staff [A]	Redundancy
			iodine or equivalent			
	Isopropanol, methylated spirits, or equivalent	All	1 litre of methylated spirits or equivalent	1	-	-
Surgical equipment	Small suture kit	All	Scalpel blades, scalpel handle, needle drivers, forceps, needles, and suture material	1	-	-
Treatment equipment	Pole syringe devices or equivalent	Cattle	Examples: MasterJect or Westergun		1	2 plus parts[D]
	Sheep bottle mount injection device	Sheep	Examples: NJ Phillips Automatic BMV Injector	-	1	1 plus parts[D]
	Syringes	Cattle	Syringes suitable for pole syringe device	0.5 per 1000 animal days[C]		10
		Cattle	20 ml or above	2 per 1000 animal days[C]	-	-
		Cattle	10ml or below	2 per 1000 animal days[C]	-	
		Sheep	10 ml and above	0.05 per 1000 animal days[C]	-	-
		Sheep	5 ml or below	0.01 per 1000 animal days[C]	-	-
	Needles	Cattle	Suitable for pole syringe device and loaded medications	1 per 1000 animal days[C]		20
		Cattle	Needles suitable for manual injection	2 per 1000 animal days[C]	-	-

Equipment	Item	Consignment type	Detail	Number per vessel	Equipment per on-board staff [A]	Redundancy
		Sheep	Needles for bottle mount injection device	0.02 per 1000 animal days[C]		20
		Sheep	Needles suitable for manual injection	0.05 per 1000 animal days[C]	-	-
	GIT equipment	All	Stomach tube	1	-	-
		Cattle	Bloat trocar/cannula	1	-	-
	Hoof equipment	Cattle	Hoof knife or pincers	1	-	-
		Cattle	Hoof blocks and glue	10	-	-
		Sheep	Foot secateurs	1	-	
	Obstetrical equipment	All pregnant breeder consignments	Mechanical assistance device	1	-	-
			Obstetrical chains/ropes	1	-	-
			Prolapse needle & prolapse tape	1	-	-
			Obstetrical lubricant	5 litres	-	-
	Wound equipment	All	Cotton wool	2 rolls	-	-
		All	Vetwrap or equivalent	2 rolls	-	-
		All	Elastoplast, PVC duct tape, or equivalent	2 rolls	-	-
Euthanasia equipment	Captive-bolt device	All	-	1	-	1 plus parts[D]
	Cartridges	Cattle	Suitable for weight/type of livestock	4 per 1000 animal days[C]	-	-
		Sheep	Suitable for weight/type of livestock	1 per 1000 animal days[C]	-	-

[A] On-board staff refers to AAVs and stockpersons
[B] This is not inclusive of all OH&S equipment that might be required for the exporter to provide a safe work environment
[C] 1000 animal days at sea is the number of animals multiplied by the number of days at sea divided by 1000
[D] 1 complete spare device plus spare parts to rebuild the minimum number of devices required on board
* Further consideration is required when applying the recommendations to voyages with days at sea greater than 20

Recommendation 9: Diagnostic equipment

The department provides clear guidelines to the industry on how to meet Australia's importing requirements for diagnostic samples obtained from Australian livestock during sea transport to the importing country.

Recommendation 10: Animal health equipment and medication guidelines

Following an update of ASEL requirements, complementary guidelines should be developed to help exporters in meeting these requirements by assisting them in determining the most appropriate shipboard equipment and medications to load based on the assessed animal health risks for each voyage.

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1. Definitions

Term	Definition
Australian Accredited Veterinarian (AAV)	A veterinarian who is accredited by the Australian government under Part IIA of the *Export Control Act 1982* to conduct duties in relation to the export of livestock, in accordance with relevant Australian and importing country requirements.
Approved arrangement (AA)	An approved arrangement refers to the documented system, agreed to between an exporter and the department, to manage compliance with ASEL, relevant legislation and the importing country requirements during the sourcing, transportation, preparation, and export of livestock. The approved arrangement covers the species, classes, importing countries and modes of transport the exporter uses to export livestock, and describes the business systems and procedures to ensure compliance with all relevant requirements.
Approved Export Program (AEP)	An exporter's program of activities, approved by the Secretary, for AAVs preparing livestock consignments for export or accompanying livestock consignments on ships.
Australian Standards for the Export of Livestock (ASEL)	At the time of writing ASEL version 2.3 was enforce: the standards represent the basic animal health and welfare requirements for the conduct of livestock exports, which the Australian government require exporters to meet. ASEL 3.0 had been released for adoption on 1 November 2020
Australian Pesticides and Veterinary Medications Authority (AVPMA)	
Class	For this document, class refers to the end purpose of the livestock, where it may be breeder, feeder, or slaughter. The term breeder includes any subsets of this class such as productive heifers.
Consignment Specific Export Plan (CSEP)	An export plan specific to the individual characteristics of a consignment. This is developed from the Standard Export Plan and includes all relevant documents to the consignment.
The department	The Australian Government Department of Agriculture, Water and the Environment.
Export Advisory Notice (EAN)	Issued by the department for advice, or guidance, or instructions to exporters of livestock and livestock reproductive material, on how to comply with importing country requirements, or Australian government legislation, or Department administrative requirements.
Exporter	A holder of a livestock export licence under the AMLI Act.
Importing country requirements (ICR)	Requirement set by a government body in an importing country that must be met in order for a product to be imported into that country. These are normally identified in an agreed protocol for that commodity or in an import permit associated with the consignment.
Independent observer (IO)	The department administers an independent observer program for livestock export voyages by sea to provide additional assurance on the effectiveness of the exporter arrangements in managing animal welfare.
Industry	Refers to the livestock export industry as a whole.
Livestock Export Program (LEP)	LiveCorp and MLA have a strong collaboration through the joint Livestock Export Program to improve animal health and welfare, supply chain efficiency and market access.
LiveCorp	LiveCorp is a non-for-profit service provider to the livestock export industry. It provides technical services and research, development, and extension.
Livestock export licence	Licence to export livestock granted by the Secretary or their delegate following the satisfaction of certain criteria in accordance with the *Australian Meat and Live-Stock Industry Act 1997* (AMLI Act).
Livestock	Cattle, sheep, goats, deer, buffalo, and camelids (camels, llamas, alpacas, and vicunas), including the young of an animal of those kinds.
Manual of Importing Country Requirements (MICoR)	A website that sets out the requirements that exporters and the department must meet for products and commodities to be accepted for import into specific overseas countries. (http://micor.agriculture.gov.au/Pages/defult/aspx)
Meat and Livestock Australia (MLA)	MLA is the declared industry marketing body and the industry research body under sections 60(10 and 60(2) of the *Australian Meat and Live-Stock Industry Act 1997* (AMLI Act).
National Livestock Identification System (NLIS)	Australia's system for the identification and traceability of cattle, sheep, and goats.
Notice of Intention (NOI)	The notice of intention to export livestock, received by the Department from an exporter.

On-board staff	LiveCorp Accredited Stockpersons and Australian Accredited Veterinarians (AAVs)
Property Identification Code (PIC)	The code allocated by state/territory governments to a property used for agricultural purpose.
Protocol (or Health protocol)	A government to government agreement on the importing country requirements
Public Chemical Registration Information System (PubCRIS)	
Registered premises (RP)	A holder of a licence, under the Export Control Act, that allows preparation of livestock for export by sea.
Standard Export Plan (SEP)	A detailed plan showing how exporters will meet all relevant Australian government legislation, standards and importing country requirements (outside of those covered in the approved arrangement) for the market, species, class, and mode of transport for which it intends to export.
Service provider	Transport company, stock agents, AAVs, wharf employees, registered premises owners and operators, exporter representatives or any contractors associated with an export consignment.
Tracking Animal Certification for Export (TRACE)	The IT system which manages the booking processes for consignments of livestock exported from Australia, as well as applications for livestock export licences, registered premises and AAVs.

2. Background

Appropriate treatment of sick or injured livestock is essential to ensuring the health and welfare of livestock being exported by sea.

Under the current legislation, all sea voyages are required to have at least one LiveCorp Accredited Stockperson on the vessel (Australian government). The stockperson is responsible for the health and welfare of the livestock. Additional to the stockperson, some voyages are also required to have an Australian Accredited Veterinarian (AAV) on board (Australian government). On these voyages, it is the AAV who has overall responsibility for the animal health and welfare of the livestock.

The overall mortality rate for livestock during sea voyages has been recognised as low for many years. The ASEL 2.3 notifiable incident threshold for mortalities was between 0.5% and 2% depending on the species and voyage length. High mortality events do occur but are infrequent. In 2008, in a report investigating respiratory disease (Perkins, 2008), it is acknowledged:

> *The low mortality rates in export cattle mean that care must be exercised in designing any project aiming to describe causes of death because of the large number of voyages that must be studied to describe causes of death with confidence. A project that is limited to collection of data only from voyages that are accompanied by project personnel is likely to be inefficient, expensive and produce results of little value. A critical part of this shift is a move to the development of systems designed for industry to collect valid and credible mortality data in a sustainable manner beyond the completion of this project.*

As the Australian society and industry extend their aims to consider overall welfare of livestock during sea voyages, the collection of a wide range of valid and creditable data on animal welfare outcomes is of increasing importance. Valid data and resulting credible animal welfare information rely on a sustainable system for collection; at the time of writing such a system is yet to be implemented by industry and government.

The lack of such a system limits the accuracy in determining what animal health conditions or diseases occur on board. However, currently available information should be assessed if it is credible[*], valid[†], and reliable[‡]; if so should be used to inform recommendations to mitigate health and welfare risks to the livestock through requirements for shipboard provisions of animal health equipment and medications.

The limited systematic collection of animal welfare data is a major constraint to accurately determining the industry wide animal health risks and how robust this project's recommendations will be for the industry. To somewhat overcome this constraint, validation of the recommendations was conducted with experienced shipboard veterinarians, stockpersons, exporters, and other key figures within the industry.

[*] credible: results of research are believable
[†] validity: findings reflect the underlying truth
[‡] reliability: findings are similar when repeated across different voyages and using different observers

The recommendations from this body of work aim to inform the Australian Standards for the Export of Livestock (ASEL) technical committee when updating the ASEL requirements for provisions of shipboard animal health equipment and medications.

In the 2014 Review of ASEL (Shiell et al., 2014), recommendations were made about issues arising from the current regulatory structure. These included:

- *ASEL should follow a 'standards and guideline' format, clearly defining mandatory standards and optional guidelines*
- *components of the current ASEL which are prone to frequent change (for example, livestock treatments, veterinary kit) should not be enshrined within the standard but should be covered by complementary guidelines.*

As such, following an update of ASEL requirements, complementary guidelines should be developed to help exporters meet these requirements, by assisting them in determining the most appropriate shipboard equipment and medications to load based on the assessed animal health risks for each voyage.

In the 2019 ASEL review (Technical Advisory Committee, 2019) the Technical Advisory Committee, with departmental support (Australian government, 2019b), recommended *that 'Mandatory veterinary medicines and equipment' be updated following completion of the LiveCorp project on shipboard drug use, which will have findings for broader veterinary requirements* would be implemented through the ASEL version 3.

The effectiveness of ASEL requirements, and the animal welfare outcomes they aim to ensure, are inherently linked to the regulatory framework; therefore, this work also considers the relevant wider regulatory framework and makes recommendations to allow the ASEL requirements for animal health equipment and medications to be effective in ensuring good animal welfare outcomes.

3. Project objectives

To review the current knowledge of shipboard diseases and the medications used for their treatment so recommendations can be made to improve the current ASEL 2.3 “minimum veterinary supplies A4.1.8-A4.1.9” from the next ASEL update.

To recommend information to be included in guidelines and/or reference material to ensure stockpersons and AAVs have access to best practice knowledge that is operationally useful at sea to improve animal health management during export voyages.

To deliver the above objectives for updating the shipboard animal health equipment and medications requirements the following will be determined:

- What are the most appropriate available veterinary medicines, registered in Australia, to accompany livestock exported by sea?
- What is the appropriate equipment to accompany livestock exported by sea?
- Strategies to mitigate animal health risks include ensuring appropriate amount of equipment and medications are available.

4. Methodology

Inappropriate shipboard provisions of animal health equipment and medications increase the risk of the following outcomes:

- poor animal welfare due to the inability to treat conditions that are medically treatable
- drug residues and/or tissue damage are detected in an importing country after slaughter and are associated with treatment during the export voyage
- antimicrobial resistance is detected in animals after export, and if detected, a suspected association with inappropriate antimicrobial usage on the vessel
- unsafe work environment due to lack of appropriate equipment.

To develop standards to mitigate these risks and ensure appropriate shipboard provision of animal health equipment and medications, the following questions were identified as important to answer. These questions form the approach and structure of this review process:

- For each livestock species, what are the expected syndromes or diseases that occur on vessels that are treatable with medications?
- For each livestock species, what are the general operational constraints, including antimicrobial stewardship, to providing shipboard medication treatments?
- For each livestock species, what medications are registered for use in Australia and are the drug classes appropriate to treat expected syndromes or disease that occur on vessels?
- For each livestock species, what minimum amount of medication is required that can be justified based on analysis of available data?
- For each livestock species, what minimum equipment is required for treatment of expected syndromes or diseases?

4.1 Literature review – Expected major syndromes or disease

For each livestock species, what are the expected syndromes or diseases that occur on vessels that are treatable with medications?

Determining the most common animal health conditions or diseases experienced on vessels gives us information on the major risks to the livestock health and welfare during sea voyages. Identifying these major risks allows recommendations to be made to improve the ASEL requirements for shipboard provisions of animal health equipment and medications.

A literature review was conducted to gain an understanding of the most common animal health conditions or diseases that occur on vessels exporting livestock by sea. This focused on information available from:

- key livestock export industry resources
- Meat & Livestock Australia (MLA) and LiveCorp funded livestock export industry research reports
- other non-livestock export MLA funded research reports
- peer-reviewed published scientific literature
- Australian government data and mortality investigation reports.

The unique characteristics of shipboard operations, access to voyages, and access to voyage data which is mostly commercial-in-confidence, has resulted in published information based on real voyage data being almost exclusively found in industry funded research reports. Additionally, due these unique issues many of published peer-reviewed papers that contain animal observation data, stem from these same industry funded research projects.

More details on the methodology or results exist in the industry funded research report and/or PhD thesis than in the associated peer-review published papers. Although peer-review is important, in this instance the industry funded research reports are in general more informative and are of more use. Due to this and the relatively small size of the industry, only a brief formal systematic literature review of published peer-review literature is warranted.

This review focusses on cattle and sheep as they are the vast majority of livestock exported from Australia. Relatively low numbers of buffalo are exported each year, and goats have not been exported from Australia by sea since 2015, therefore these species are only considered where appropriate or if significant information existed.

4.1.1. Key industry resources

There were four key industry resources identified and reviewed for relevant information. The information identified within these resources was taken as the starting point for development of the project recommendations.

Veterinary Handbook for Cattle, Sheep, & Goats (Jubb. T et al., 2019) and associated report Live Export Veterinary Disease Handbook (Perkins and Jubb, 2012)

This resource collates information in a manner that was designed to help shipboard personnel prevent, treat, and control risks to animal health and welfare on the vessel. The Veterinary Handbook outlines most, if not all, the major and minor conditions that occur during livestock exports; this is the current reference material for the industry.

Live export - Best practice use of veterinary drugs (Rolls and Campbell, 2008)

This resource was first published in 2004 and last revised in 2008; it is a comprehensive list of veterinary drugs that are used in the livestock export industry and includes some general background information on the different drug classes and uses.

Stockman's Handbook Transport of Cattle by Sea Short & Long Haul Voyages (Ainsworth, 2008)

This resource gives an overview of the information relevant to stockpersons managing the animal health and welfare of cattle on a livestock export vessel.

LiveCorp Handbook for shipboard stockmen and veterinarians - Sheep and goats (Lightfoot, 2008)

This resource gives an overview of the information relevant to stockpersons managing the animal health and welfare of sheep or goats on a livestock export vessel.

4.1.2. Industry funded research reports

A literature review of the livestock export industry funded research was conducted, this also included other funded research reports from similar livestock industries. This literature review was conducted using multiple methods to ensure all relevant MLA research was identified, these included:

- MLA Research and Development webpage search for all research reports listed under the live export topic
- obtaining research project lists from MLA for live export, feedlot, and animal health and welfare projects
- identifying other literature from the reference lists of reviewed reports.

4.1.3. Peer-reviewed and other published scientific literature

Published peer-reviewed scientific literature was searched through the Medline complete database. The search was conducted using Boolean/Phrase terms: export, Australia AND live. The search was restricted to journal publication between 2010 and 2020.

Other published literature was identified through industry resources, a general Google scholar search, and the author's contemporary knowledge of recent publications.

4.1.4. Publicly available Australian government data

Within the quantitative publicly available data, mortality data is the only information provided that is relevant to animal health. Mortality investigation reports for sheep and cattle between 2006 to 2011/12 have been previous analysed and summarised in the *Scoping study export of sheep from southern ports to the Middle East in winter months* (Shiell et al., 2013) report and in the previous *Review of ASEL* (Shiell et al., 2014) report.

Since the previous summaries, and during the last 8 years, there have been many changes to the Australian regulations governing the industry within Australia and within the importing countries. These changes have been aimed at improving animal welfare and as such, the frequency of major syndromes or diseases is likely to have changed. An analysis of mortality reports was conducted focussing more on recent livestock mortality investigation and identifying the frequency of causes leading to mortality events.

Where possible, animal days at risk were calculated by species, as described in (Perkins et al., 2015a)

$$\boldsymbol{animal\ days\ at\ risk} = total\ animals\ at\ risk \times voyage\ duration$$

$$\boldsymbol{total\ animals\ at\ risk} = number\ of\ animals\ loaded - \frac{1}{2}(number\ of\ deaths)$$

Voyage mortality incidence[§] rates were calculated, expressed as deaths per 1,000 animal days, using the formula:

$$\boldsymbol{voyage\ mortality\ incidence\ rate} = \frac{number\ of\ deaths}{animal\ days\ at\ risk} \times 1000$$

The voyage mortality incidence rate provides a measure that is adjusted for voyage duration. It can be used to compare voyages of differing durations, and to compare the relative importance of different drivers of mortality risk.

Antibiotic treatment incidence rates were calculated and, where possible, expressed as treatments per 1,000 animal days using the formula:

$$\boldsymbol{antibiotic\ treatment\ incidence\ rate} = \frac{number\ of\ treatments}{animal\ days\ at\ risk} \times 1000$$

§ Incidence – number of new cases/events in a defined population within a specific period
Prevalence – cases/events existing at a specific point in time

4.1.4.1 Departmental mortality investigation reports

The Department of Agriculture, Water and the Environment publishes reports** on investigations into voyages that reach a mortality rate equal to or greater than the reportable level. Summaries of the department's mortality investigations are available from the department's website (Australian government, 2020b).

Mortality reports were accessed from the department's website and information was collated from the earliest available reports in 2013 to 2019 (report numbers 43-81). Excel was used to collate the following information:

- investigation number
- year
- species
- destination
- AAV on board
- relevant information to animal welfare
- duration
- mortality count
- number animals in consignment
- number of antibiotic treatments
- number of anti-inflammatory treatments
- department required increase in medication to be loaded on next voyage

4.1.4.2 Live Animal Export Statistics

The "All Livestock Exports" report can be obtained from the department's website which consists of a single spreadsheet. The report provides data at a consignment level which is compiled from information included on the export permit and health certificate that are issued by the department to exporters at the time of departure. The variables included in the report for each consignment are:

- mode of transport
- month and year of departure
- state of departure
- port of loading
- species
- class of livestock
- destination country
- number of animals

4.1.4.3 Reports to Parliament

Every six months, the Minister for Agriculture tables a report from the department to Parliament that includes livestock mortalities on every sea voyage. The report is compiled from information provided to the department by the ship masters, as required by the Marine Orders Part 43 under subsection 425(1AA) of the Navigation Act 1912. The reported data is at the ship level and may include multiple consignments together. The variables included in each report to parliament are:

- departure date
- exporter licence holder(s)
- loading port(s)
- destination port(s)
- duration (days)
- discharge date
- For each species the:
  - number of animals loaded
  - number of mortalities (Loss)
  - mortality percentage.

** In these reports, the voyage length is taken from the Master of the vessel's report. The voyage length, with regard to a species, is measured from completion of loading in Australia until completion of discharge at the last overseas port.

Each six month Report to Parliament was downloaded from the department's website (Australian government, 2020e). Each file was then imported into R : A language and environment for statistical computing (R Core Team, 2019) and merged together to create a single dataset. Both R and Stata (StataCorp, 2015) statistical software programs were used to analyse the data.

Voyage/consignment mortality incidence rates were calculated to better understand voyages that posed a higher risk to animal health and therefore, possibly had a higher requirement for medications. Comparisons were made between mortality incidence rates from reports to parliament and rates associated with mortality investigations.

4.2 Medications

Developing recommendations for the minimum provision of medications on vessels exporting livestock by sea was conducted in the following sections.

4.2.1. Operational constraints

For each livestock species, what are the general operational constraints, including antimicrobial stewardship, to providing shipboard medication treatments?

4.2.1.1. Shipboard environment

Major shipboard environmental constraints were determined initially from personal on-board experience and through direct communication with other shipboard AAVs and stockpersons. These constraints were used to identify what information was to be extracted from the registered medicines review to provide a useful summary that identifies medications suitable for shipboard use.

Shipboard environmental constraints were then validated through consultation with industry in the second stage of this project. Experienced AAV and stockpersons' input was sought through the industry bodies.

4.2.1.2. Antimicrobial Stewardship

Australian Antimicrobial stewardship resources were sought from The Australian Veterinary Association and the Australian government. Additional relevant reference resources were identified through an internet search. Where required, authors of reference resources were contacted to gain further understanding of the scope, purpose, and how the resource was developed.

4.2.2. Available registered medications – Australian Pesticides and Veterinary Medicines Authority review

For each livestock species, what medications are registered for use in Australia and what drug classes are appropriate to treat expected syndromes or disease that occur on vessels?

4.2.2.1. Public Chemical Registration Information System

The Australian Pesticides and Veterinary Medicines Authority (APVMA) Public Chemical Registration Information System (PubCRIS) was used to obtain a list of all products registered for use in cattle, sheep, goats, and buffalo. The PubCRIS search field was restricted to 'host' and the following species were used as search terms: 'Cattle', 'Sheep', 'Goats', and 'Buffalo'. A list of products for each species was exported as a .csv file and imported into R: A language and environment for statistical computing (R Core Team, 2019). Products that were deemed irrelevant to this review using the PubCRIS field 'product types' were removed from the datasets. These products were grouped by active ingredient and product type.

For each animal species, the remaining product types were then reviewed individually, manually examined to consolidate duplicates, and grouped together by related active ingredients. A review of the active ingredients was conducted for consistency with the product type, and those that were inconsistent were removed. Each remaining active ingredient, or group of related active ingredients, were then further individually reviewed to provide summary information relevant to operational constraints and the syndromes or diseases expected on livestock export voyages.

4.2.3. Data analysis for quantity of medications

For each livestock species, what minimum amount of medication is required and can be justified based on analysis of available data?

There was insufficient data available to conduct an analysis that would provide results representative of the livestock export industry.

4.3. Animal health equipment

For each livestock species, what minimum equipment is required for treatment of expected syndromes or diseases?

Animal health equipment and other resources vary on each vessel and often between voyages.

Working safely with livestock on vessels requires significant consideration of Occupational Health and Safety issues and animal welfare requirements. Consideration is important because the majority of a voyage occurs where human medical assistance is difficult to access.

The ability to restrain and treat livestock is limited by the type of livestock being exported and the shipboard environment, the infrastructure, facilities, and equipment available on the individual vessel. What is possible in a shipboard environment might be significantly different to what is considered best practice on land, on a farm, or in a feedlot.

An initial list of minimum provisions of animal health equipment was obtained by combining the requirements from ASEL version 2.3 (Australian government, 2011) and the recommendations from the Review of Australian Standards for the Export of Livestock: Working Draft - Reformatted Standards (Technical Advisory Committee, 2018).

4.3.1. Key industry resources

Additions to the initial list of minimum provisions of animal health equipment were made by reviewing the key industry resources to identify items that were recommended and not included in the initial list.

4.3.2. Other sources of information

Personal experience and direct communication with experienced AAVs were used to consider other animal health equipment for inclusion or exclusion in the proposed minimum provisions of animal health equipment. Redundancy of equipment was considered throughout the process.

Validation of shipboard animal health equipment was sought formally during industry validation process as part of second stage of this project. Input was sought from experienced AAVs and stockpersons through the industry bodies.

5. Results

5.1 Literature review - limitations

Before reporting results from this literature review, some discussion is warranted on the major issues that currently limit the ability to conduct reviews or research in the livestock export industry. These issues cause major limitations when attempting to analyse any animal health data currently reported under regulatory requirements or when trying to compare industry research results. Operationally these issues have a widespread effect and limit the regulations, exporter planning, animal health decision making, and the adoption of findings from industry research.

It has been considered appropriate to present these issues as results rather than mentioned in the methodology as this work considers the relevant wider regulatory framework and makes recommendations to allow the ASEL requirements for shipboard provisions to be effective in ensuring good animal welfare outcomes.

Specifically, the issues causing major limitations are the reporting of disease diagnosis, and the definitions used to group animals in livestock exports. It is important for the reader to understand these specific issues; they provide important context about the ability to gain insights into the expected major syndromes or diseases that occur on board livestock export vessels and make recommendations for shipboard provisions.

5.1.1 Data limitations - diagnosis of disease or identification of syndrome

Diagnosis of disease, within Australia, is generally an act of veterinary science under the regulation of the Veterinary Registration Board of that state or territory. This is for good reason, as reaching a definitive diagnosis requires assessment of many pieces of information.

> *"Clinicians and pathologists devote substantial time to arriving at the "correct" diagnosis when investigating disease. The diagnosis is usually reached through a process of clinical examination and assessment and the application of various diagnostic tests. Competent investigators use good judgement, a thorough knowledge of the literature, past experience, diagnostic tests and intuition to organise their observations and reach a diagnosis." (Sergeant and Perkins, 2015)*

There are limited diagnostic facilities on board a vessel and relatively few diseases that can be diagnosed definitively without diagnostic procedures. On vessels, Australian Accredited Veterinarians (AAVs) are the only people that have the education and applicable registrations to determine a differential or definitive diagnosis. A review of the AAV job description is available in the report *Identifying the causes of mortality in cattle exported to the Middle East appendices document* (Perkins et al., 2015b). Around 20% of voyages have an AAV on-board (Australian government, 2020d); this means a definitive diagnosis cannot be determined on approximately 80% of voyages.

The difficulty in definitively diagnosing disease on board a vessel is demonstrated well in the industry funded research report, associated PhD thesis, and published papers from the project: *Identifying the causes of mortality in cattle exported to the Middle East (Perkins et al., 2015a) & (Moore et al., 2014).*

Where a definitive diagnosis is not able to be made, the syndrome should be reported; a syndrome is a common set of signs that can be easily recognised. When animals present with a syndrome, the animal could be suffering from one or more specific conditions associated with that syndrome.

In 1999, RT Norris and JH Creeper (Norris and Norman, 2003) recommend there is a need for a standardised method aimed at recording objective measurements where possible, so that a performance history can be built up over time. This will allow comparison with other voyages as appropriate and will allow the effects of changes in management to be assessed objectively.

In 2000, the Independent Reference Group review (Farmer, 2011) recommended that industry and government review the livestock export industry data requirements, acquisition and maintenance systems, and public availability of performance information, with a view to both improved efficiency and transparency. Additionally, they recommended that industry and government adopt and communicate a clear definition of animal welfare for the purposes of the livestock export trade and use this definition as a benchmark for future considerations and operation.

In 2008, *Respiratory disease of export cattle* (Perkins, 2008) was investigated. Within this report, it states that there appears to be little standardisation for disease diagnosis and recording of disease events on vessels. Different people (veterinarians and stockpersons) may classify disease occurrence and severity using varying criteria. The major impact of these reporting issues is that voyage reports do not offer a source of valid data on which conclusions may be drawn concerning the importance of specific causes of death. There are genuine risks to industry from reports that contain subjective and unverified observations that are made with the best of intentions but are misleading.

Also in 2008, the difficulties using existing data to assess mortality, clinical disease incidence, and weight changes, were further described in the project *Stocking density in cattle shipments and animal health and performance – an assessment of existing data* (Morton and Phillips, 2008). The authors concluded that case definitions for common syndromes do not appear to have been defined, and the sensitivity of monitoring systems for detecting and reporting clinical disease is uncertain.

The recently published article *Animal Based Measures to Assess the Welfare of Extensively Managed Ewes* (Munoz et al., 2018) gives an example of how definition based observations can be assessed for their usefulness when the observations are made by different people. Understanding how useful and robust definitions are, is crucial to being able to analyse and interpret the resultant data and help make good evidence-based decisions.

In 2020 the same recommendations can be made - clearly defined syndrome definitions should exist. These definitions are needed so:

- AAVs can record a syndrome where a definitive diagnosis cannot be made
- on vessels without an AAV, the stockperson can record the syndrome they observe in a sick animal, and/or record their post-mortem syndrome observations
- animal health data reported under regulatory requirements can be more effectively collated and analysed to provide better industry information on risks to animal health and welfare

5.1.2 Data limitations - definitions to define groups of animals

The terms used to describe groups of similar livestock are inconsistently used within government documents and within industry; these terms include *species, class, type, line*, kind, and *category.* These are described in Table 1.

Clear definitions of terms used to group animals are needed to allow effective regulation, collection, and analysis of data to identify animal welfare risks. Without clear definitions routinely collected data cannot be collated, analysed, and compared without the risk of error or bias.

Table 1: List of terms that are used in the regulatory documents to describe groups of animals

Terms	Approved Arrangement (AA) (Australian government, 2018a) Approved Export Program (AEP) (Australian government, 2018b)	Australian Standards for the Export of Livestock (ASEL) version 2.3 (Australian government, 2011)	Working Draft – Reformatted Standard (Technical Advisory Committee, 2018)	ASEL 3.0 (Australian government, 2020a)
Class	Defined as: the end purpose of the livestock, where it may be breeder, feeder or slaughter	Undefined but used to describe common characteristic to a species such as: S3.9 … classes of sheep for export … (i) For livestock held in paddocks: pastoral and station sheep lambs (less than 34 kg and no permanent incisors); and sheep and goats that have been held on trucks for more than 14 hours. (ii) For livestock held in paddocks or sheds: full-mouth wethers with a body condition score greater than 4 broken-mouth sheep; and pregnant ewes. Table A4.2.2 Feed specifications for cattle and buffalo - Class of cattle and buffalo Cattle and buffalo weighing less than 250 kg	Defined as: A group of livestock of the same species that share a common characteristic such as age, size or sex, or some other physiological characteristic such as pregnancy.	Defined as: means the export grouping of animals based on their end use, be it feeder, slaughter, or breeder. The term breeder includes any subsets of this class such as productive heifers. However, it is used inconsistently with this definition within the text e.g. 3.7.8 For export to or through the Middle East by sea between 1 May and 31 October (inclusive), the operator of the registered premises must not prepare these classes of sheep: a) for sheep held in paddocks at the registered premises: b) for sheep held in paddocks or sheds at the registered premises

Terms	Approved Arrangement (AA) (Australian government, 2018a) Approved Export Program (AEP) (Australian government, 2018b)	Australian Standards for the Export of Livestock (ASEL) version 2.3 (Australian government, 2011)	Working Draft – Reformatted Standard (Technical Advisory Committee, 2018)	ASEL 3.0 (Australian government, 2020a)
		Breeding heifers with six or fewer permanent incisor teeth (regardless of pregnancy status) Pregnant cows Other classes of cattle and buffalo		Table 13 Feed requirements for cattle Class of cattle Cattle weighing less than 250kg Breeding heifers with six or fewer permanent incisor teeth (regardless of pregnancy status) Pregnant cows Other classes of cattle
Type	Undefined but used in the AA guidelines without the ability to clearly interpret meaning such as: Appendix 2 Veterinary Kit - 0020Additional veterinary therapeutics (over and above ASEL minimum) in light of the extended voyage length, type of livestock and route	Undefined but used within the document without ability to clearly interpret meaning such as: 3.2 Required outcomes (1) Facilities at registered premises are appropriate for the type and species of livestock to be held.	Undefined but used interchangeably with species and class. Appendix H—Fodder and water requirements for export by sea: Table 16 - Type of livestock Cattle and buffalo that are: Less than 250kg Pregnant Breeding heifers with ≤6 permanent incisor teeth For all other cattle and buffalo	Undefined but used in document: Appendix C, b, v) be supplied with bedding material that: (ii) is replaced if soiled, as necessary, subject to type and species Fat-tailed sheep means a general type of domestic sheep known for their distinctive large tails and hindquarters.

Terms	Approved Arrangement (AA) (Australian government, 2018a) Approved Export Program (AEP) (Australian government, 2018b)	Australian Standards for the Export of Livestock (ASEL) version 2.3 (Australian government, 2011)	Working Draft – Reformatted Standard (Technical Advisory Committee, 2018)	ASEL 3.0 (Australian government, 2020a)
Line	Not used	Undefined but used to describe groups of livestock such as: S4.11 Livestock for export must be presented for loading, and penned on the vessel, in lines segregated by species, class, age, weight, criteria in S2.10(e)(i) to (iii), and any other relevant characteristic (and, where relevant, port of destination), in accordance with the approved loading plan.	Undefined but used in the definition of Appropriately segregated: Livestock of the following types must be segregated in different lines or pens: animals of different species animals of the same species sourced for different end purposes, i.e. feeder animals must be segregated from breeder animals of the same species young animals from older animals animals of a dissimilar size any animals covered by an ASEL management plan from those that aren't covered by an ASEL management plan camels of different sexes. Also used in Daily report – sea voyages template: 9 - Animal health and welfare by deck/tier, based on an assessment	Undefined 5.1.7 Livestock for export must be presented for loading, and penned on the vessel, in lines segregated according to the loading plan.

Terms	Approved Arrangement (AA) (Australian government, 2018a) Approved Export Program (AEP) (Australian government, 2018b)	Australian Standards for the Export of Livestock (ASEL) version 2.3 (Australian government, 2011)	Working Draft – Reformatted Standard (Technical Advisory Committee, 2018)	ASEL 3.0 (Australian government, 2020a)
			of at least 2 representative pens of each species, representative of the class or line, per deck. 10 - Respiratory type, by class and line and by deck, per day.	
Kind	Not used in AA Used and not defined in AEP EAN 2018-07 type, kind, or classes of livestock to be exported	Not used	Not defined but used in definition Livestock As defined under 'live-stock' in the Export Control (Animals) Order 2004, livestock (live-stock) means cattle, sheep, goats, deer, buffalo, and camelids (that is, camels, llamas, and alpacas) and includes the young of an animal of any of those kinds	Not used

Category is not used in terms of defining groups of animal in the documents listed above. However, it is used within industry and in research. Again, this is a term that is poorly defined and inconsistently applied.

5.2 Literature review - Expected major syndromes or disease

For each livestock species, what are the expected syndromes or diseases that occur on vessels that are treatable with medications?

To keep the body of this report concise, a summary of findings is presented in 6.1 Literature review conclusions and the in-depth description of the assessed literature is presented in Appendix 1 - Literature review.

5.2.1 Publicly available Australian government data summary

Again, to keep the body of this report concise the results of the full data analysis, which provides valuable context, are presented in Appendix 2 – Livestock export data analysis. The main results relevant to this review are presented in this section.

5.2.1.1 Data limitations - shipment outcomes or consignment outcomes

Reports to Parliament provide information obtained from Australian Maritime Safety Authority (AMSA) and document mortality outcomes at the shipment level; this is the overall result for that vessel for that voyage.

A vessel on a single voyage may have multiple consignments on board; different consignments on a vessel may be exported by the same exporter, or by different exporters. Mortality performance is used by the department to regulate the industry; this is applied to the consignment level rather than at the voyage level. The differences between datasets in reporting consignment level or voyage level data creates complexity when trying to assess trends from the publicly available data.

Additionally, the department nominates the consignment notifiable incident level for mortalities using a simple percentage; this is calculated for each consignment by dividing the number of mortalities by the total of the species loaded. A major disadvantage of this approach is the time component of the voyage is not considered; this means fair comparisons between voyages of different lengths cannot be made. As a result, within the same voyage length category (fewer than 10 days and greater than 10 days), longer voyages need to manage animals to a lower risk per day at sea, than shorter voyages. Furthermore, regulating at the consignment level by a simple percentage means that smaller consignments are at a greater risk of becoming a notifiable mortality incident.

5.2.1.2 Live export data 2013-2019

As previously discussed, there are significant limitations in analysing the available public data due to the lack of case definitions and the ability of non-veterinarians to report definitive diagnoses.
There are a number of publicly available information and data sources from the department; these are:

- Mortality investigation reports (Australian government, 2020b)
- Reports to parliament (Australian government, 2020e)
- Live animal export statistics (Australian government, 2020c)

Table 2 displays summary information from these data sources.

Variation exists between these different data sources. This is demonstrated by the yearly number of animals exported differing by data source; for example, in 2019 total cattle exports varied by 48,793 between the smallest and largest numbers reported by government data sources; considering the median number of cattle loaded in 2019 was 2772 head, this could equate to a difference of 17 voyages depending on which departmental data source is used. During 2019 Independent Observers were present on many voyages to provide more government oversight, yet the resultant increase in available data from IO reports seems to produce more variability in the department's numbers.

This variation in official regulatory data introduces inaccuracies when calculating statistics or performance measures due to the uncertainty around the denominator in these calculations.

Table 2: Summary of publically available Australian government livestock export data

		2013	2014	2015	2016	2017	2018	2019
Number of voyages (ship) [A]		233	347	350	314	275	324	357
Number of consignments [C]		-	-	604	537	499	453	274
Buffalo	Number exported [A]	798	4,068	5,122	4,230	7,214	7,147	9,704
	Number exported [B]				4,230	7,214	7,321	9,530
	Number exported [C]	-	-	5,907	5,792	9,710	8,872	9,923
	Notifiable incident investigations published [E]	0	1	0	1	3	2	1
	AAV on-board notifiable incident		0		0	0	0	0
	Voyage duration (min-max)		10		-	8-13	12	11
Cattle	Number exported [A]	776,583	1,307,579	1,325,527	1,109,513	889,525	1,118,102	1,290,515
	Number exported [B]				1,141,769	862,226	1,116,938	1,243,740
	Number exported [C]	-	-	1,301,361	1,136,352	857,795	1,114,733	1,292,533
	Number exported [D]					857,765	1,115,844	
	Notifiable incident	3	5[F]	2	4	1	4	3

		2013	2014	2015	2016	2017	2018	2019
	investigations published [E]							
	AAV on-board notifiable incident [E]	0	2	0	1	1	2	2
	Voyage duration (min-max) [E]	14-18	8-36	12 & 19	9-23	8	8-17	9-17
Goats	Number exported [A]	1,080	850	1,000	0	0	0	0
	Number exported [B]	-	-	1,000	0	0	0	0
	Number exported [C]			1,000				
	Notifiable incident investigations published [E]	0	0	0	0	0	0	0
Sheep	Number exported [A]	1,897,270	2,249,643	2,007,549	1,759,340	1,741,314	1,259,860	1,047,080
	Number exported [B]				1,705,575	1,845,272	1,143,498	969,513
	Number exported [C]	-	-	2,014,516	1,775,321	1,845,272	1,114,508	1,076,994
	Number exported [D]					1,845,268	1,143,437	
	Notifiable incident investigations published [E]	1	1[F]	0	2	1	0	0
	AAV on-board notifiable incident [E]	1	1		2	1		
	Voyage duration (min-max) [E]	32	36		23 & 25	21		

[A] - Reports to Parliament data summary table on department website

[B] - Reports to Parliament datasets

[C] - Live animal export statistics – department website excel sheet – export to permit and HC numbers

[D] - National livestock export industry sheep, cattle, and goat transport performance report 2018

[E] - Mortality investigation reports

[F] combined notifiable incident investigation was conducted into both cattle and sheep consignments on the voyage – data not available from department's website

Different departmental sources of data result in significant variations in total animals exported within a calendar year. For cattle, the discrepancy is equivalent of 17 median voyages. This highlights there is no clear denominator to use in analysis; as such, a level of caution should be taken when assessing the complete analysis presented in Appendix 2 – Livestock export data analysis.

Another analysis consideration is the distribution of variables; within export datasets variables are generally not normally distributed. Significant errors arise when variables that are not normally distributed are described using the mean as measure of central tendency. In datasets associated with livestock exports, the error of describing the measure of central tendency using the mean will usually cause the measure to be overestimated. Using the median to describe the measure of central tendency in these situations is more appropriate and results in a more accurate estimate.

5.2.1.3 Have things changed over the last 5 years?

The visual trend over the last 5 years suggests for each species there are more animals per consignment and fewer consignments per year. This trend holds true when considering departure ports. Overall, for the period 2015 - 2019:

- the number of buffalo exported has doubled
- since 2016 each year has seen more cattle exported than the previous year
- total sheep numbers exported has declined every year
- there have been no specific major changes in importing countries, where the trend is a decline in total numbers (e.g. sheep) then this trend is reflected across all importing countries.

5.2.1.4 What insights does the data give?

Assessment of the likelihood of making ongoing significant improvements in mortality performance can be made using information from the *Livestock export industry performance report* (Norman, 2019), Reports to Parliament 2019 data, and land-based livestock industry estimates. Table 3 provides a summary of this information.

Performance data from 2018, and the total animals exported for 2018 by species were used as the standard exported animal population; this was done to provide clear comparisons across the estimates. Mortality percentages from other reference sources are used to calculate an equivalent number of mortalities based on the 2018 exported animal population. Median number of days exposed were sourced from the references used to calculate the animal days at risk; where this was an annual mortality rate - 365 days was used as the number of days exposed.

Finally, 2019 industry mortality data from the Reports to Parliament department's website summary table (animals exported and animal deaths) was used along with median voyage lengths identified in the analysis to further understand and compare the most recent reported year's performance.

Care needs to be taken when interpreting the Reports to Parliament voyage length data, as loading and discharge times may not have been consistently included or excluded in the voyage length. Prior to 2019, information which included voyage length was provided by the Ships Master under the Marine Orders Part 43 subsection 425(1AA); however, this document does not define voyage length. Since November 2019, voyage duration has been defined to include loading and unloading times under Marine Order 43 (Cargo and cargo

handling — livestock) 2018, Division 15 - Reports and investigations 85 S4 - 1); this order voyage duration to be reported with the Masters Report Carriage of Livestock.

The calculated mortality incidence rates (Table 3) can be directly compared to understand how the livestock export industry compares to the background level of mortality on Australian farms. Whilst this method of drawing comparisons is not perfect, it does serve as a broad indicator of the likelihood of future significant improvements in mortality performance.

An analysis that is further stratified would be more insightful; for example, comparisons between Bos indicus and Bos taurus, or pregnant sheep and rams, were not possible due to the limitations of available data.

Table 3: 2018 annual livestock export data (Norman, 2019) and Australian livestock industry estimates

Species	Measure	Total Voyage	Total animals	Animal deaths	Mortality (%)	Average number of days [A]	Animals at risk	Animal days	Mortality incidence rate (1000 animal days)
Cattle	Exported 2018	323	1,115,844	1,339	0.12 %	12.1	1,115,174	13,449,004	0.099
	Farm estimate [B]		1,115,844	33,475	3.00 %	365.0	1,099,106	401,173,814	0.083
	Export-farm equivalent		1,115,844	1,116	0.10 %	12.1	1,115,286	13,450,350	0.083
	2019 [D]	341	1,290,515	1,296	0.10 %	10.0 [E] (12.1) [F]	1,289,867	15,555,796	0.100 (0. 083) [E]
Sheep	Exported 2018	27	1,143437	5,202	0.46 %	22.0	1,140,836	25,144,025	0.207
	Farm estimate [C]		1,143,437	53,742	4.70 %	365.0	1,116,566	407,546,674	0.132
	Export-farm equivalent		1,143,437	3,430	0.30 %	22.0	1,141,722	25,163,549	0.136
	2019 [D]	20	1,047,080	2,701	0.26 %	21.0	1,045,730	21,960,320	0.123

[A] Average number of days from Norman et al. includes the duration of the sea voyage and the duration of discharge (time to unload animals from the vessel after arrival at the destination port)

[B] The cattle industry assumed general background mortality rate of 3% mortality a year

[C] *Assessing and addressing on-farm sheep welfare* (Doyle, 2018) reports an estimated average annual ewe mortality rate of 4.7%

[D] Reports to Parliament 2019 summary table

[E] Data presented in Table 21, it was unable to be determined if duration of loading is included in the voyage duration reported and this raises the possibility the voyage duration being an underestimate.

[F] Norman 2018 duration applied for comparison

To help interpret the data presented, we will use an example of comparing 2018 and 2019 cattle estimates (Table 2, Table 3 and Table 23) – In this example, there was increase in the total number of cattle exported in 2019, yet fewer consignments occurred; the number of cattle on each voyage in 2019 was generally larger than 2018; the decrease in voyage duration (average number of days) in 2019 could be explained by a shift towards the more frequent use of vessels with a larger carrying capacity on shorter voyages and/or faster vessels than those used in 2018. Considering other information presented in Appendix 2, the predominate importing country, by volume, in 2019 was Indonesia; there was an increase in the total cattle exported to Indonesia with fewer total consignments and an increase in cattle per consignment. Voyages to this destination are generally of a short duration therefore resulting in a lower median voyage duration for 2019.

The voyage duration estimates for 2018, from the National livestock industry export report (Norman, 2019), confusingly may be an under-over estimate. To explain this there are three issues to consider; first, the voyage definition in the report is described as:

> *"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". 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 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."*

It becomes difficult to understand this effect on the dataset and voyage length as it might cause more shorter voyages or more longer voyages depending on how close the final destination ports are to each other.

The second issue, as mentioned above, the voyage duration was not defined for ships' masters prior to 2019 and this may have led to under-reporting of voyage duration.

The third issue, Norman describes the measure of central tendency as an average, there is no explanation of methodology and the assumption is made that this references the mean. From the data presented in Table 3 calculating the mean values for cattle voyage duration in 2018 and 2019 results in 12.0 days and 11.3 days respectively, while the median results in 11 days and 10 days.

Considering the recent trends described, a decline in the number of consignments and increase in animals per consignment, indicates there are probably fewer "*split-load voyages*" occurring and more dedicated shipments to fewer ports. If the impact of "*split-loads*" was to over-estimate voyage duration, then fewer "*split-loads*" would see a reduction in voyage duration. This assessment aligns well with the changes in regulations and analysis results of departmental export data.

Moving on from voyage length, cattle exports during 2018 observed a mortality incidence rate higher than the background industry rate of mortalities on farm, 0.099 versus 0.083 mortalities per 1000 animal days. To compare the recent 2019 results for cattle, using data from the Reports to Parliament, the mortality incidence rate is 0.100 mortalities per 1000 animal days using the median voyage length of 10 days, or 0.083 mortalities

per 1000 animal days using the *average* voyage length for 2018. For interest, the 2019 mean voyage length of 11.3 days results in 0.089 mortalities per 1000 animal days.

5.2.1.5 Performance indicators limitations

Understanding data sources, reporting biases, and the methodology of analysis is important when drawing conclusions from performance indicators. Simple percentage-based performance indicators do not account for time-at-risk.

In the previous section, examples of analytical results and interpretations hopefully illustrate how simple percentage-based performance measures are insufficient to allow comparisons across voyages, years, or industries.

As described in section 4.1.4, animal-days-at-risk should be used when calculating performance indicators.

5.2.1.6 Cattle data summary

Cattle on Australian farms broadly experience an estimated 3% overall background mortality; this equates to 0.083 mortalities per 1000 animal days. Cattle exported from Australia in 2018 and 2019 experienced 0.099 and 0.100 mortalities per 1000 animal days, respectively. Considering the described possible errors in the available data, the mortality incidence rate for cattle exports during 2018 and 2019 is remarkably close or equivalent to the mortality incidence rates on farms in Australia.

From Table 23, the median cattle mortality incidence rates for cattle shipments in 2018 and 2019 are 0.059 and 0.053 mortalities per 1000 animal days, respectively. This means that cattle mortalities on board livestock export vessels are no more frequent (probably less frequent) than mortalities on farms in Australia.

Finally, these figures indicate that preventative animal diseases currently have a small impact on cattle exports, especially considering that musculoskeletal injuries of cattle are the second most common treatable syndrome with clustering of these injuries around when cattle are trucked, loaded and unloaded onto vessels, reside in a yarded environment, and are exposed to sea conditions.

5.2.1.7 Sheep data summary

Sheep on Australian farms broadly experience an estimated 5% background mortality; this equates to 0.132 mortalities per 1000 animal days. Sheep exported from Australia in 2018 and 2019 experienced 0.207 and 0.123 mortalities per 1000 animal days, respectively. Considering the described possible errors in the available data, the mortality incidence rate for sheep exports during 2018 was above the Australian on-farm mortality incidence rate. In 2019, the mortality incidence rate for sheep exports was below the Australian on-farm mortality incidence rate.
From Table 23, the median mortality incidence rates for sheep shipments in 2018 and 2019 are 0.168 and 0.112 mortalities per 1000 animal days, respectively. This means that sheep mortalities on board livestock export vessels are no more frequent (probably less frequent) than mortalities on farms in Australia.

Finally, as for cattle, these figures indicate that preventative animal diseases currently have a small impact on sheep exports, especially when considering that musculoskeletal injuries of sheep are currently the most common treatable syndrome with clustering of these injuries around when sheep are trucked, shorn, loaded and unloaded onto vessels, reside in a yarded environment, and are exposed to sea conditions.

5.3 Medications

The following four sections were used to develop recommendations for the minimum provisions of medications to be required on vessels exporting livestock by sea.

5.3.1 Operational constraints

For each livestock species, what are the general operational constraints, including antimicrobial stewardship, to providing shipboard medication treatments?

5.3.1.1 Shipboard environment

The livestock vessel is unique in its operating environment and the challenges it presents; it is mostly an isolated environment that is a remote workplace out at sea, with a finite limit of resources, and no supply lines or direct support available. While mostly isolated in physical means, vessels can also be isolated through challenges with communication services; these services are improving but with vast distances covered, there are often times when services are unavailable or unreliable.
Another set of challenges can present on arrival in the importing country, through the complex international environment of working with foreign country officials, under different legal systems, and while meeting customs requirements.

Table 4 identifies the major operational constraints on board livestock vessels that impact the effective treatment of animals and use of medications. Resources are defined as staff (including the ship's crew), medication, and equipment. It is important to note that at times on-board resources can become the limiting factor, and resource allocation can be challenging when there are competing interests. Additionally, the ship's crew who work with the animals also have other responsibility relating to the operation of the ship; the crew may not always be available as a resource for animal issues when they are performing important maritime tasks.

Table 4: major operational constraints impacting treatment of animals on board livestock vessels at sea

Area of risk	Constraint	Mitigation through medication selection	Mitigation through resource allocation
Occupational health and safety	Ability to safely examine and/or treat an individual animal		Staff and equipment allow safe handling and/or restrain animals
	Medication exposure poses a danger to human health	Provision of medications with a low impact on human health if accidental exposure occurs	Provision of appropriate equipment to medicate animals safely
Animal welfare	Diagnostic capacity is limited on vessels with no laboratory support available		Provision of educated, trained, and experienced staff in syndrome recognition
	Availability of suitable medications for effective treatment	Provision of medication for the treatment of major syndromes categories identified in the standards Provision of medications for diseases that are identified through an exporter animal health assessment process	Provision of appropriate amount of medication for the assessed risk loaded on board the vessel
	Ability to effectively medicate an animal for dose and duration required	Provision of medications with appropriate duration of action Provision of medications with appropriate volume that can be administer with equipment on-board	Provision of equipment which can administer the required dose volume of medications selected with the minimal number of injections
Business and international trade	Availability of suitable medications to minimise risk of antimicrobial resistance and residues in meat after slaughter in importing country	Provision of medications with appropriate withhold period for the destination market and purpose of the livestock	Provision of educated, trained, and experienced staff Record management system for treatment of animals allowing identification of potential residue issues and communication to the importer

5.3.1.2 *Antimicrobial stewardship*

On a global level, the mitigation of antimicrobial resistance is crucial for the protection of human, animal, plant and environmental health (World Organisation for Animal Health (OIE), 2020). Of particular consideration is the development of antimicrobial resistance to antibiotics critical for human use. 'Critical' antibiotics are those used to treat serious or life-threatening infections in humans for which there are either very limited or no alternative antibiotics that can be used if antibiotic resistance develops. (Australian government, 2018c)

The second objective in Australia's First National Antimicrobial Resistance Strategy 2015-19 (Australian Strategic and Technical Advisory Group on Antimicrobial Resistance, 2015) is:

> *To implement effective antimicrobial stewardship practices across human health and animal care settings to ensure the appropriate and judicious prescribing, dispensing, and administering of antimicrobials.*

The Australian veterinary profession in partnership with the livestock industries has a long history of addressing antimicrobial resistance. This work has resulted in relatively low levels of antimicrobial resistance in Australian food animals (Cutler. R et al., 2019).

Antimicrobial stewardship describes practices designed to reduce the need for antimicrobial use and to ensure when antimicrobials are used it is in a way that maximises efficacy while minimising adverse effects. (Australian Lot Feeders' Association, 2018). 'Good Stewardship Practice' describes the development, implementation and continual improvement of an antimicrobial stewardship plan, the collaborative process between those responsible for the livestock and those responsible for supporting the health and welfare of the livestock. This includes tailoring approaches at the farm, business, and enterprise levels (Hewson, 2018).

The Australian Veterinary Association (AVA) is currently developing antimicrobial prescribing guidelines for all species. This body of work was to be completed in 2018; however, only the prescribing guidelines for pigs and sheep are available. The prescribing guideline for pigs is a useful resource for the livestock export industry as the principles of antimicrobial stewardship are well discussed; these principles are being used by the AVA as the basis to develop guidelines for the other species. This document provides a practical approach to antimicrobial stewardship and frames objectives simply, such as:

> One of *the key objectives of any antimicrobial stewardship program is to reduce the use of antimicrobials. Eliminating the unnecessary use of antimicrobials is an essential part of this equation. While other objectives include ensuring appropriate prescribing practice and ensuring optimal infection prevention and control, the best way to secure the use of antimicrobials for the future and to reduce selection pressures favouring resistant organisms is to reduce the overall amounts used. (Cutler. R et al., 2019)*

5.3.1.2.1 Exporter antimicrobial stewardship

Exporters should have an antimicrobial stewardship plan; this could be incorporated in a broader document – an export supply chain medications plan.

The antimicrobial stewardship guidelines provided in section 4 of *Antimicrobial stewardship guidelines for the Australian cattle feedlot industry* (Australian Lot Feeders' Association, 2018) is a good starting point for the industry. Briefly, when exporters develop their antimicrobial stewardship plan, they should engage a veterinarian who has expertise in the livestock export industry for advice. This plan should incorporate the 5 Rs approach (Page et al., 2014).

> ***Responsibility*** *of all stakeholders (from development to use) to uphold the principles of antimicrobial stewardship*
> ***Review*** *of compliance with stewardship practices with continuous improvement to reflect contemporary best practice*
> ***Reduce*** *the need to use antimicrobials wherever possible without compromising animal health and welfare*
> ***Refine*** *the use of antibiotics to ensure that the right antibiotic is used, at an appropriate dose, for the right duration and by the most appropriate route of administration to maximise clinical efficacy*
> ***Replace*** *antibiotics that are medically important in human health when there is evidence to support the efficacy and safety of an alternative and without compromising animal health and welfare*

5.3.1.2.2 Shipboard antimicrobial stewardship

Antimicrobial stewardship is presented with additional challenges on livestock vessels; as described previously - the on-board environment has its unique operating constraints and the majority (80%) of voyages do not having a veterinarian on board (Australian government, 2020d) to prescribe the animals' treatment. Prescription and use of antimicrobials are restricted within Australia under legislation.

Since non-veterinarians are using antimicrobials on vessels, and in some instances with little veterinary oversight, it is important that the industry has up-to-date training and competency requirements for accredited stockpersons to ensure antimicrobials are used appropriately. This training needs to cover what the current best practices and evidence-based prescribing guidelines are for livestock.

To ensure antimicrobials are used appropriately on board, it is also important that exporters have an antimicrobial stewardship plan that clearly documents 'treatment protocols' (as described in the feedlot recommendations). Additionally, when the need arises, stockpersons on vessels must be able to directly communicate with a veterinarian regarding treatments.

Other challenges to antimicrobial stewardship include the availability of registered medicines. Currently, there are no medicines registered in Australia for use in buffalo; as such all medications used in buffalo are off label and further veterinary oversight is required.

To guide appropriate usage of antimicrobials on vessels, staff should:

- only use antimicrobials when there is a strong clinical suspicion of a bacterial disease
- base the choice of antimicrobial on the assessment of the susceptibility of the bacteria believed to be implicated in the clinical disease
- consider withholding periods when selecting antimicrobials
- consider the specificity and spectrum of antimicrobials, using the narrowest appropriate spectrum of activity
- consider the antimicrobial activity - bactericidal versus bacteriostatic activity
- consider inter-current disease such as kidney or liver disease and its influence on efficacy and the risk of toxicity
- consider pregnancy, age and other physiological states that may influence drug action.

Expanding further on these minimum considerations for shipboard antimicrobial stewardship, the following principles taken from the 22 elements identified in Antimicrobial prescribing guidelines for pigs (Cutler. R et al., 2019) are relevant to the shipboard environment and provide important considerations when determining which antimicrobials are most appropriate to load onto a vessel.

PRE-TREATMENT PRINCIPLES

Disease prevention

Preventative measures help reduce infectious disease incidence and the need for antimicrobial use. Preventative measures can include an exporter's livestock procurement policy, pre-export preparation, vaccination, animal husbandry, parasite control, precise nutrition, cattle handling, and better diagnosis.

Apply appropriate biosecurity, husbandry, hygiene, health monitoring, vaccination, nutrition, housing, and environmental controls.

THERAPEUTIC OBJECTIVE AND PLAN

Develop outcome objectives (for example clinical or microbiological cure) and an implementation plan (including consideration of therapeutic choices, supportive therapy, host, environment, infectious agent, and other factors).

DRUG SELECTION

Justification of antimicrobial use

Consider other options first; antimicrobials should not be used to compensate for, or mask poor farm or veterinary practices. Use informed professional judgment balancing the risks (especially the risk of antimicrobial resistance selection and dissemination) and benefits to humans, animals and the environment.

Guidelines for antimicrobial use

Consult disease- and species-specific guidelines to inform antimicrobial selection and use.

Critically important antimicrobial agents

Only use all antimicrobial agents, after careful review and reasonable justification. Avoid using those considered important in treating refractory infections in human or veterinary medicine.

Spectrum of activity

Use narrow-spectrum in preference to broad-spectrum antimicrobials whenever appropriate.

Extra-label (off-label) antimicrobial therapy

Must be prescribed only in accordance with the applicable laws and regulations along with consideration for the importing country requirements.

Confine use to situations where:

- medications used according to label instructions have been ineffective or are unavailable
- there is scientific evidence, including residue data if appropriate, which supports the off-label use pattern and the veterinarian's recommendation for a suitable withholding period and, if necessary, export slaughter interval (ESI).

ANTIMICROBIAL USE

Dosage regimens

Where possible, optimise regimens for therapeutic antimicrobial use following current pharmacokinetic and pharmacodynamic (PK/PD) guidance.

Duration of treatment

Minimise therapeutic exposure to antimicrobials by treating only for as long as needed to meet the therapeutic objective.

Labelling and instructions

Ensure that written instructions on drug use are given to the end user by the veterinarian, with clear details of method of administration, dose rate, frequency and duration of treatment, precautions, and withholding period.

Target animals

Wherever possible, limit therapeutic antimicrobial treatment to ill or at-risk animals, treating the fewest animals possible.

Record keeping

Keep accurate records of diagnosis (indication), treatment and outcomes to allow therapeutic regimens to be evaluated by the prescriber and permit benchmarking as a guide to continuous improvement.

Compliance

Encourage and ensure that instructions for drug use are implemented appropriately.

Monitor response to treatment

Report to appropriate authorities any reasonable suspicion of an adverse reaction to the medicine in either treated animals, or farm staff having contact with the medicine, including any unexpected failure to respond to the medication. Thoroughly investigate every treated case that fails to respond as expected.

5.3.2 Available registered medications – Australian Pesticides and Veterinary Medicines Authority review

For each livestock species, what are the medications registered for use in Australia in the drug classes recognised to treat expected syndromes or disease that occur on vessels?

Before reporting the findings of the available registered medications, discussion is needed on withholding periods and export slaughter intervals.

5.3.2.1 Withholding period (WHP) or Export Slaughter Interval (ESI)

Scattered through the key industry resources are references to both withholding periods (WHP) and export slaughter intervals (ESI).

Considering animals, the Agricultural and Veterinary Chemicals Code Act defines the withholding period as:

> *In relation to the use of a chemical product, means the minimum period that needs to elapse between:*
> *(a) the last use of the product on relation to a crop, pasture, or animal; and*
> *(b) the grazing of animals on the crop or pasture, (or the) slaughtering of the animal for human consumption:*
> *in order to ensure that the product's residues fall to or below the maximum limit that the Australian Pesticides and Veterinary Medicine Authority (APVMA) registration permits*

The purpose of AVPMA withholding periods is to ensure consumer safety is not adversely affected by residues of agriculture and veterinary (AgVet) chemicals in products. The international trade assessment process for residues is detailed in the APVMA Risk assessment manual - Residues and trade (Australian government, 2019a)

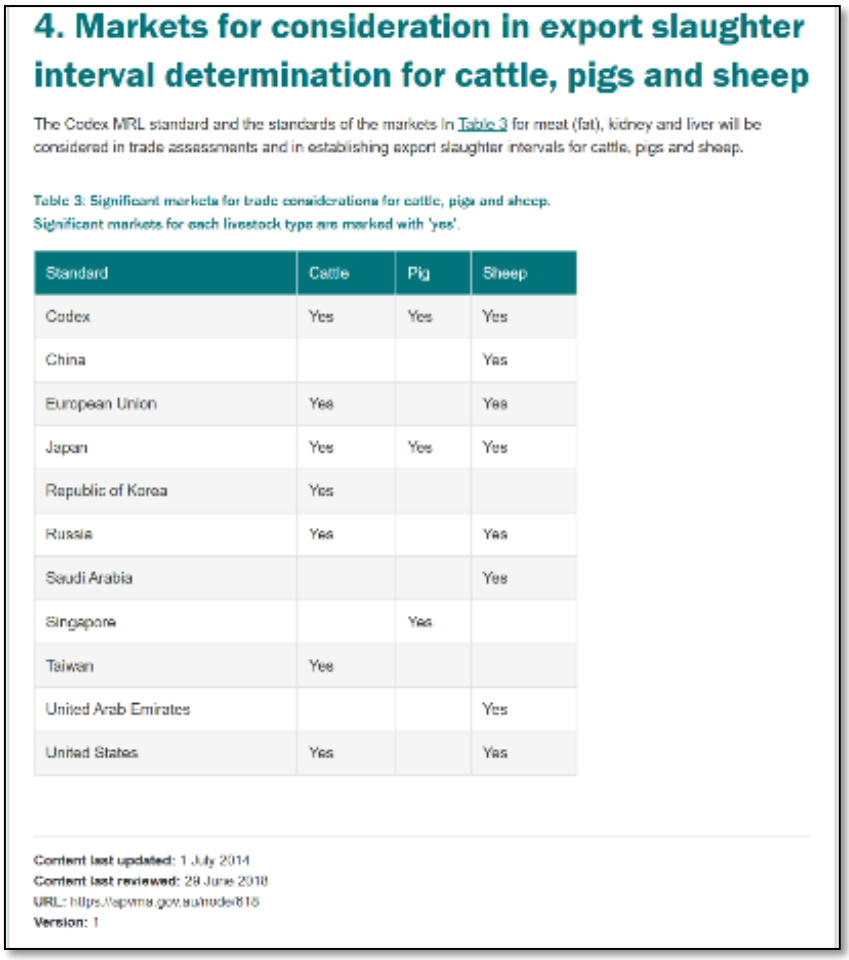
> *The APVMA must be satisfied that the proposed use of AgVet chemicals does not unduly prejudice trade or commerce between Australia and places outside Australia.*
> *Countries set MRLs in food and other commodities (such as livestock feed) to control and minimise exposure of people and animals to residues of AgVet chemicals. If a country does not have an MRL set for a chemical, its laws may not allow any quantifiable residue in a commodity.*
> *This means that Australian MRLs for AgVet chemicals in food and other commodities may differ from those of our trading partners. This can result in potential risk, or prejudice, to trade.*

The ESI is explained in a recent report *Examination of Export Slaughter Intervals* (Ernst and Young, 2018) as the period that must elapse between chemical application or exposure through feed to livestock, and their slaughter for export purposes; ESIs manage the differences between MRLs in animal meat commodities

allowed from uses of chemical products in Australia, and the MRLs set by its trading partners. The report identifies:

> *Australia is the only country which has a separate slaughter interval for exports compared to its key competitors (US, New Zealand, and Brazil). The 'ESI endpoint' for each tissue in Australia is usually:*
>
> - *the lowest relevant MRL of a significant export market*
>
> *or*
>
> - *is a reasonable level of quantification (LOQ) in situations where no relevant MRL has been established by a significant export market*
>
> *Once the assessment of a product is finalised, the APVMA sets Australian ESIs for a given commodity/chemical, based on the MRLs of the most significant market(s). In practice, the ESI then applies to all international markets for that commodity/chemical.*
>
> *The current application of trade partner consideration should be clarified. In addition, the trade partner list should be updated in line with changes in major markets. The frequency of the updates should reflect a balance between providing industry with certainty, and consistency, and providing up-to-date market information.*
> *Transparency in the process is required to provide a consistent understanding of the application of the APVMA's methods and factors the APVMA actually considers when setting an ESI. The list of trading partners considered, for instance, has left many registrants with the impression that the requirements of all trading partners within the list will be determining factors for each product, when in practical terms this is not the case and can vary on a product-by-product basis.*

The current significant markets (countries) which are considered during the APVMA trade assessment process to determine ESI are shown in Fig. 1 (Australian government, 2018d)



4. Markets for consideration in export slaughter interval determination for cattle, pigs and sheep

The Codex MRL standard and the standards of the markets in Table 3 for meat (fat), kidney and liver will be considered in trade assessments and in establishing export slaughter intervals for cattle, pigs and sheep.

Table 3: Significant markets for trade considerations for cattle, pigs and sheep.
Significant markets for each livestock type are marked with 'yes'.

Standard	Cattle	Pig	Sheep
Codex	Yes	Yes	Yes
China			Yes
European Union	Yes		Yes
Japan	Yes	Yes	Yes
Republic of Korea	Yes		
Russia	Yes		Yes
Saudi Arabia			Yes
Singapore		Yes	
Taiwan	Yes		
United Arab Emirates			Yes
United States	Yes		Yes

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Fig. 1: Current significant markets that are considered when ESI are determined

In conclusion, veterinary medicines registered for use within Australia have a WHP that is approved by the APVMA. ESI are determined for meat exports and are appropriate for use when exporting meat to our significant trading partners. It is unclear, due to poor transparency, which country and its MRL are used to determine an ESI. This inability to determine which country's requirements were used to determine an ESI, along with difficulty in understanding how this ESI might relate to livestock exports to other importing countries that have their own MRL limits, leaves ESI with little value for use in livestock exports. ESI are not appropriate for use or consideration within the livestock export industry when making choices on which medication to load onto vessels or use in an animal. MRLs are currently more applicable to livestock exports; they apply to all registered products in Australia and provide reasonable information to help select the most appropriate medications to use within the livestock export process.

During an animal health assessment to identify appropriate medication to load onto vessels and provide voyage instruction to the on-board staff, exporters should consider each consignment and the importing country's MRL requirements. Part of the animal health assessment should identify if the animal products will be consumed within the importing country soon after arrival; is there a risk of the importing country's MRL being exceeded due to treatment with selected medications during the export process? When this is the case exporters should consult with the importer on this issue and inform the importers which animals have had treatments during the export process.

5.3.2.2 *Public Chemical Registration Information System review*

The Australian Pesticides and Veterinary Medicines Authority (APVMA) Public Chemical Registration Information System (PubCRIS) was used to review the veterinary medications currently registered for use in livestock.

In Australia, there are 900, 630 and 130 products registered for cattle, sheep, and goats, respectively. There are no products registered for use in buffalo. When duplicates are removed, a total of 1279 products are registered for use in cattle, sheep or goats. Goats are not considered further in this review as no sea exports have occurred in the last 5 years.

Products from the 'product types' field in the PubCRIS database which were deemed irrelevant for treatment of major syndromes or diseases on board livestock export vessels were removed. The removed product types were:

- Alimentary system
- Anti-histamine
- Branding substance
- Dermal and equipment disinfection
- Disinfectant
- Euthanisiates
- Fungicide
- Genitourinary system
- Immunotherapy
- Miscellaneous veterinary
- Parasiticides
- Parasitic and nutritional
- Respiratory system (adjunctive treatments)

The list of products relevant to treatment of major syndromes or diseases was grouped by active ingredient and product type into the following 6 categories:

- Antimicrobial
- Analgesics and anti-inflammatories
- Corticosteroids
- Sedatives
- Topical wound treatment
- Supportive products

5.3.2.2.1 Cattle

There are 521 cattle products registered relevant to shipboard use in livestock export. When products with the same active ingredients are grouped together, there are 253 relevant active ingredients; these are classified into the following PubCRIS product types (Table 5).

Table 5: Registered cattle products of product types relevant to shipboard medicine

Product type	Number of active ingredients
Anaesthetics/Analgesics	10
Analgesic and musculoskeletal	2
Antibiotic and related	51
Antibiotic and nutritional	2
Antidotes	3
Central nervous system	6
Dermatological preparations	41
Endocrine system	25
Insecticide	4
Musculoskeletal system	7
Nutrition and metabolism	99
Ophthalmic preparations	3

Cattle - Antimicrobials

This category includes products listed under the product types 'Antibiotic and related' and 'Antibiotic and nutritional'. There are 53 antimicrobial active ingredients registered for use in cattle.

There are 21 active ingredient groups identified when duplicates are consolidated (e.g. an active ingredient is listed under two product types), related active ingredients are grouped together (e.g. Ceftiofur hydrochloride and Ceftiofur sodium are grouped as Ceftiofur), and active ingredients that are not antimicrobials are removed (e.g. Prilocaine and Imidocarb).

Removal of active ingredient groups that are only used in intermammary preparations and/or food additives resulted in 13 active ingredient groups. Table 6 displays these 13 groups along with relevant information for on-board management.

In relation to antimicrobial stewardship, Ceftiofur is a third-generation cephalosporin that is rated by ASTAG as having 'High Importance', a rating assigned to:

> *"… essential antibacterial for the treatment or prevention of infections in humans where there are few or no treatment alternatives for infections. These have also been termed "last resort" or "last line" antibacterial."*

Within the antimicrobial stewardship framework, the use of Ceftiofur in cattle should be reserved for rare and exceptional circumstances in individual cows where culture and susceptibility testing of clinical samples indicates there is no suitable alternative. The need for Ceftiofur should be considered an alert to closely examine management practices and to develop and implement a health plan to prevent infection and improve animal health without the need for use of an antibacterial of 'High Importance'.

Table 6: Active ingredient groups with antimicrobial action registered for use in cattle

Antimicrobial category	Active ingredient group	Required drug volume* (mL/100 kg)	Withholding period (meat, days) †	Spectrum	Frequency	Route‡	ASTAG rating §
B lactams	Amoxycillin	5-10	14-30	Broad	Daily	SC/IM	Low
	Ceftiofur	2-4	1-14	Broad	Single/repeat every 24 hours	SC/IM	High
	Penethamate	3	5	Narrow	Repeat in 1-5 days	IM	Low
	Procaine Penicillin (with benzathine penicillin)	4-6	5-30	Narrow	Daily	IM/SC	Low
Macrolides	Erythromycin	1-2	14	Broad	Once daily	IM	Low
	Tulathromycin	2.5	35	Broad	Single	SC	Low
	Tylosin	2.5	21	Broad	Daily. Up to 5 days	IM/IV	Low
	Tilmicosin	3	28-35	Narrow	Preliminary dose then re-evaluate after 48 hours	SC	Low
Phenicols	Florfenicol (+/- flunixin)	7-14	28-49	Broad	Single	SC/IM	Low
Aminoglycosides	Neomycin (+/- oleandomycin)	1-5	10-35	Broad	Every 8-12 hours	IV/IM	Low
Tetracyclines	Oxytetracycline	3-10	11- 42	Broad	One dose/daily for 3-5 days	IM/IV/SC	Low
Iodides	Sodium Iodide	13	28	Narrow	Twice at 10 day intervals	IV/SC	Not evaluated
Sulphonamides	Trimethoprim (+/- sulfa-)	3-6	14-28	Broad	Once off +/- repeat treatments daily	IM/IV/SC	Low

* Exact figure depends on the product/preparation used
† Exact figure depends on the product/preparation used
‡Route of administration - SC = Subcutaneous injection, IM = Intramuscular injection, IV = Intravenous infection. Note that there are several antimicrobial intramammary preparations and food additives/oral preparations. These are not included here as they are considered inappropriate for shipboard use.
§ Based on Australian Strategic and Technical Advisory Group on Antimicrobial Resistance 2018. Importance Ratings and Summary of Antibacterial uses in Human and Animal Health in Australia. In: Office of Health Protection (ed).

5.3.2.3 *Cattle - Analgesics and anti-inflammatories*

This category includes products listed under the product types 'Anaesthetics/analgesics', 'analgesic and musculoskeletal' and 'musculoskeletal system'. There are 19 active ingredient groups registered for use in cattle under these three product types.

There are 6 active ingredient groups identified when duplicates are consolidated (e.g. an active ingredient is listed under two product types), related or identical ingredients are grouped together (e.g. 'Flunixin as meglumine' and 'Flunixin meglumine' are grouped into 'Flunixin'), and active ingredients that are not analgesics are removed (e.g. anaesthetics such as Ketamine and Lignocaine).

Removal of active ingredient groups only used in ointments (inappropriate for use shipboard) resulted in 5 active ingredient groups. In addition to these, there are 2 active ingredient groups listed in antimicrobial categories ('Antibiotic and related') that combine analgesic active ingredient with an antimicrobial active ingredient.

Table 7 displays these 7 groups along with relevant information for on-board management.

Cattle - Corticosteroids

This category includes products listed under the product type 'Endocrine system'. There are 25 active ingredient groups registered for use in cattle under this product type.

There are 13 active ingredient groups identified when related or identical ingredients are grouped together (e.g. 'Dexamethasone' and 'Dexamethasone as sodium phosphate' are grouped into 'Dexamethasone'). Of these, 12 groups are for treating reproductive disorders and are therefore not relevant for shipboard use, leaving only 1 active ingredient group – Dexamethasone.

Table 7 displays this group along with relevant information for on-board management.

Cattle - Sedatives

This category includes products listed under the product type 'Central nervous system'. There are 8 active ingredient groups registered for use in cattle under this product type.

There are 2 active ingredient groups when related or identical ingredients are grouped together (e.g. 'Acepromazine' and 'Acepromazine as Acepromazine maleate' are grouped into 'Acepromazine').

Table 7 displays these 2 group along with relevant information for on-board management.

Table 7: Active ingredient groups registered for use in cattle

Medication category	Active ingredient group	Required drug volume * (mL/100kg)	Withholding period (for meat, days) †	Frequency	Route of administration ‡
Analgesics and anti-inflammatories	Flunixin	2-4	7-28	Daily	IV/IM
	Ketoprofen	3	4	Daily	IV/IM
	Lignocaine (+/- adrenalin)	-	0	As required	Locally
	Meloxicam	1-10	8-15	Single §	SC/IV
	Tolfenamic Acid	5-10	10	Two 48 hours apart	IM/IV
	Florfenicol and flunixin	14	48	Once only **	IM
	Oxytetracycline and flunixin	10	28	Blood levels persist for 5-6 days	IM
Corticosteroids	Dexamethasone	5-10	7-28	24-48 intervals	IM/IV
Sedatives	Acepromazine (+/- atropine)	0.5 - 2	2	-	SC/IM/IV
	Xylazine	0.1-1.8	3-28	-	IM
	Yohimbine (reversal agent for Xylazine)	6.25	28	-	IV

* Exact figure depends on the product/preparation used
† Exact figure depends on the product/preparation used
‡ SC = Subcutaneous injection, IM = Intramuscular injection, IV = Intravenous infection.
§ Recommended by subcutaneous or intravenous administration only. Intramuscular administration may result in residues for the withholding periods listed.
** Registered for subcutaneous use only

Cattle - Topical wound treatment

This category includes products listed under the product type 'Dermatological preps'. There are 41 active ingredient groups registered for use in cattle under this product type.

There are 11 active ingredient groups when related or identical ingredient are grouped together (e.g. 'Iodine and 'Iodine glycerine' are grouped into 'Iodine-based'), and products that are only registered for use for treating teat conditions or disinfecting housing are removed.

Table 8 displays these 11 group along with relevant information for on-board management.

Table 8: Active ingredient groups with topical wound treatments registered for use in cattle

Treatment type category	Active ingredient group	Preparation type	Condition for which they are registered
Antiseptic/Antibiotic	Iodine-based	Topical cream, ointment, paste, gel, lotion	Cracks, sores, wounds, infections of the skin.
	Lanolin oil-based	Ointment	Cracking and chapping of teat
	Bacitracin Zinc (+ other actives)	Ointment	Ear and eye infections
	Benzoic/Boric acid (+ other actives)	Ointment	Crack, sores, wounds, cracking and chapping of teat, cut or wound dipping
	Centrimides/Chlorhexidines	Sprays and ointments	Crack, sores, wounds, cracking and chapping of teat
	Chloramine	Powder	Cut or wound disinfection
	Malic acid-based	Cream, spray	Clean wounds of necrotic tissues and debris, cracks, sores, and wounds, keratolytic or cleaning agent
	Triclosan	Ointment	Antibiotic, anti-infective
Antibacterial and insecticide	Cresol	Medicated oil	Cracks, sores, and wounds
Antibacterial and fungicide	Dichlorophen	Ointment	Ringworm and skin irritation
Wound healing	Trypsin	Spray	Cracks, sores, wounds

Supportive products

There are 186 products registered under 'Nutrition and metabolism'.

5.3.2.4 Sheep

There are 200 sheep products registered relevant to shipboard use in livestock export. When products with the same active ingredient are grouped together, there are 75 relevant active ingredients. These are classified into the following PubCRIS product types (Table 9).

Table 9: Registered sheep products of product types relevant to shipboard medicine

Product type	Number of active ingredients
Anaesthetics/Analgesics	8
Analgesic and musculoskeletal	16
Antibiotic and related	16
Antibiotic and genitourinary	1
Antidotes	1
Central nervous system	4
Dermatological preparations	18
Endocrine system	11
Musculoskeletal system	2
Nutrition and metabolism	62
Ophthalmic preparations	2

Sheep - Antimicrobials

This category includes products listed under the product types 'Antibiotic and related' and 'Antibiotic and genitourinary'. There are 38 antimicrobial active ingredient groups registered for use in sheep.

There are 7 active ingredient groups when duplicates are consolidated (e.g. an active ingredient is listed under two product types) and related ingredients are grouped together (e.g. Neomycin sulfate and Neomycin base as the sulphate are grouped into Neomycin).

Table 10 displays these 13 group along with relevant information for on-board management.

Table 10: Active ingredient groups with antimicrobial action registered for use in sheep

Antimicrobial category	Active ingredient group	Required drug volume [15] (mL/50kg)	Withholding period (for meat, days) [16]	Spectrum	Frequency	Route of administration [17]	ASTAG rating [18]
B lactams	Amoxycillin	2-5	14-30	Broad	24-48 hours	IM	Low
	Penethamate	5-10	5	Narrow	Every 1-5 days	IM	Low
	Procaine Penicillin (with benzathine penicillin)	2-2.5	5-30	Narrow	Daily-every 3 days	IM	Low
Macrolides	Erythromycin	0.5	14	Broad	Daily	IM	Low
Aminoglycosides	Neomycin (+/- oleandomycin)	0.5-2	10-35	Broad	8-24 hours	IM/IV	Low
Tetracyclines	Oxytetracycline	2-10	10-42	Broad	Daily – every 5 days	IM/IV/SC	Low
Sulphonamides	Trimethoprim (+/- sulfa-)	1.5-5	14-28	Broad	Daily	IM/IV/SC	Low

Sheep - Analgesics and anti-inflammatories

This category includes products listed under the product types 'Anaesthetics/analgesics' and 'musculoskeletal system'. There are 17 active ingredient groups registered for use in sheep under these product types.

There is one active ingredient group (Meloxicam) when duplicates are consolidated (e.g. an active ingredient is listed under two product types) and active ingredients that are not analgesics are removed (e.g. anaesthetics such as Ketamine and Lignocaine).

Table 11 displays this group along with relevant information for on-board management.

Sheep - Corticosteroids

This category includes products listed under the product type 'Endocrine system'. There are 19 active ingredient groups registered for use in sheep under this product type.

There are 10 active ingredient groups when related or identical active ingredients are grouped together (e.g. 'Dexamethasone' and 'Dexamethasone as sodium phosphate' are grouped into 'Dexamethasone'). Of these, 9 of the groups are for treating reproductive disorders and are therefore not relevant for shipboard use, leaving 1 active ingredient group - Dexamethasone.

[15] Exact figure depends on the product/preparation used
[16] Exact figure depends on the product/preparation used
[17] SC = Subcutaneous injection, IM = Intramuscular injection, IV = Intravenous infection. Note that there are several antimicrobial intramammary preparations and food additives/oral preparations. These are not included here as they are considered inappropriate for shipboard use.
[18] Based on Australian Strategic and Technical Advisory Group on Antimicrobial Resistance 2018. Importance Ratings and Summary of Antibacterial uses in Human and Animal Health in Australia. In: Office of Health Protection (ed).

Table 11 displays this group along with relevant information for on-board management.

Sheep - Sedatives

This category includes products listed under the product type 'Central nervous system'. There are 4 active ingredients or groups registered for use in sheep under this product type.

There are 2 active ingredient groups when related or identical ingredients are grouped together (e.g., 'Acepromazine' and 'Acepromazine as Acepromazine maleate' are grouped into 'Acepromazine').

Table 11 displays this group along with relevant information for on-board management.

Table 11: Active ingredient groups registered for use in sheep

Medication category	Active ingredient group	Required drug volume [19] (mL/50kg)	Withholding period (for meat, days) [20]	Frequency	Route of administration [21]
Analgesics and anti-inflammatories	Meloxicam	1-10	10-11	Single	SC/orally
	Lignocaine (+/- adrenalin)	-	0	As required	Locally
Corticosteroids	Dexamethasone	1-3	7-28	24-48hr interval	IM/IV
Sedatives	Acepromazine (+/-atropine)	0.25-0.5	2	-	IM/SC/IV
	Xylazine	0.025-.055	28	-	IM

Sheep - Topical wound treatment

This category includes products listed under the product type 'Dermatological preps'. There are 21 active ingredients (or groups of active ingredients) registered for use in sheep under this product type.

There are 12 active ingredient groups when related or identical ingredients are grouped together and pessary preparations are removed

Table 12 displays these 12 group along with relevant information for on-board management

[19] Exact figure depends on the product/preparation used
[20] Exact figure depends on the product/preparation used
[21] SC = Subcutaneous injection, IM = Intramuscular injection, IV = Intravenous infection.

Table 12: Active ingredient groups with topical wound treatments registered for use in sheep

Treatment type category	Active ingredient/group of	Preparation type	Condition for which they are registered
Antiseptic/Antibiotic	Iodine-based	Spray	Bacterial infection, fungal infection
	Bacitracin Zinc (+ other actives)	Ointment	Ear and eye infections
	Benzoic/Boric acid (+ other actives)	Ointment	Crack, sores, wounds, cracking and chapping of teat, cut or wound dipping
	Centrimides/Chlorhexidines	Creams and ointments	Crack, sores, wounds, bacterial prevention, cracked teats
	Chloramine	Powder	Cut or wound disinfection
	Copper-based product	Concentrate	Footrot
	Oxytetracycline	Spray	Dermatitis, footrot
	Other Zinc-based products	Creams and concentrates	Antibiotic, footrot, and bacterial prevention
	Cresol	Medicated oil	Cracks, sores, and wounds
	Formaldehyde-based	Concentrates	Footrot, cracks, sores, and wounds
Insecticide and Antiseptic	Di-N-Propyl Isocinchomeronate-based	Spray	Insect repellent, bacterial skin infections and open wounds
Wound healing	Trypsin	Spray	Cracks, sores, wounds

Sheep supportive products

There are 95 products registered under 'Nutrition and metabolism'.

5.4 Animal health equipment

Animal health equipment requirements from ASEL 2.3, ASEL 3.0, and equipment identified from the key resources were used to develop the initial table of required equipment. Additional equipment recommendations were identified through on-board experience and consultation with exporters, AAVs, and stockpersons.

5.4.1 Redundancy

Redundancy requirements consider the possibility of equipment breakage or loss, where equipment is vital to enabling the provision of animal treatments health. Where it is appropriate that equipment is required as a redundancy this has been specified in**Error! Reference source not found.**.

5.4.2 Diagnostic equipment

There is a limit to the capacity of diagnostic equipment routinely available on vessels. Due to these general limits, obtaining diagnostic results generally relies on the samples reaching laboratories within a country. Diagnostic results provide important information about what disease processes are occurring; this understanding allows identification of appropriate treatments or management changes to reduce the risk to animal health. Understanding this diagnostic information is also valuable for future voyages as it allows assessment of potential preventative measures that can be applied during the livestock export process.

During this project, the department's Live Animal Export branch was contacted to see if advice existed for exporters, AAVs and stockpersons on how to bring diagnostic samples back to Australia for testing. At present

there is no specific advice available for the importation of samples taken from Australian animals on board a livestock export vessel.

To collect samples for diagnostic laboratory testing, a full post-mortem kit (including storage containers and fixatives) should be carried on all livestock vessels. This is only a recommendation if the department provides clear guidelines to the industry on how to meet Australia's importing requirements for diagnostic samples obtained from Australian livestock during sea transport to the importing country. While it may be possible to get samples to a laboratory in the importing country for diagnostic testing this must be considered on a case-by-case basis and is considered unreliable at this time.

5.4.3 Equipment requirements

Animal health equipment requirements should be assessed during pre-export consignment planning for each class and other descriptors that group animals (type/line/group/category) into similar risk categories. The exporter should consider the stockperson and AAV's equipment preferences at this stage.

5.4.3.1 Buffalo

Previously, ASEL equipment requirements for buffalo and cattle have been combined together due to the perceived similarity of these species. Specific equipment requirements for buffalo should reflect the animal health risks posed by the voyage.

5.4.3.2 Goats

Previously, ASEL equipment requirements for goats and sheep have been combined together due to the perceived similarity of these species. Specific equipment requirements for goats should reflect the animal health risks posed by the voyage.

5.4.3.3 Other species

Specific equipment requirements for other species should reflect the animal health risks posed by the voyage.

Cattle and sheepError! Reference source not found.Table 16 displays the recommendations for the minimum animal health equipment to be provided on livestock export voyages carrying cattle or sheep. Specific equipment requirements for cattle and sheep should reflect the animal health risks posed by the voyage.

Quantity of equipment per 1000 animal days

Quantities of needles, syringes, and cartridges for euthanasia have been calculated as number required per 1000 animal days; this ensures the minimum amount required is consistent across voyages with different sea day duration. The estimated "days at sea" (the voyage length minus the loading and discharge days) should be used to calculate the number of animal days used in determining the quantities to load.

The rationale for using "days at sea" and not the ASEL 3.0 voyage length definition is: unfit animals should not be loaded; during loading days shore-based supplies can be used or supplies can be restocked before departure; during discharge days there are an ever decreasing number of animals on board and shore-based supplies are likely to be available. This rationale for using "days at sea" will avoid general oversupply of equipment which does not further reduce the risks to animal health and leads to unnecessary cost and potential waste issues.

The number required per 1000 animal days was calculated using the ASEL 2.3 nominated amounts for a voyage fewer than 10 days. Quantities of syringes and needles have also been standardised with the number of doses of medication required to be loaded. This was to provide a minimum of 1 piece of equipment (needle or syringe) per 20 medication doses.

Further consideration is needed to decide if the quantity of equipment recommendations are applicable to voyages with greater than 20 days at sea. Considerations is needed as the notifiable mortality levels in ASEL 3.0 (Australian government, 2020a) recognise the decrease risk per day to livestock on voyages with longer durations. This is recognised through the average daily mortality rate being required to decrease every day after 20 days for these longer voyages to comply with the voyage mortality rate limit. Acknowledging the regulator's recognition that risk per day decreases with voyages over 20 days, applying the equipment provisions recommended in**Error! Reference source not found.**to these longer voyages could result in a general oversupply of equipment without additional benefits, leading to increased cost and wastage.

Other identified equipment

A loading platform is the platform between the end of the vessel's loading ramp and livestock transport trucks; this includes gates to stop livestock or divert them towards a different truck. Consideration should be given to the practicalities of introducing a requirement for vessels to carry their own loading platform suitable for the ship's loading ramp. This could resolve some of the issues that occur in importing countries where the loading platforms are of poor design or in poor condition (KPMG, 2018). This could be included as either an ASEL, AMSA or ESCAS requirement.

6 Conclusions

6.1 Literature review conclusions

For each livestock species, what are the expected syndromes or diseases that occur on vessels that are treatable with medications?

6.1.1 Diagnosis of disease or identification of syndrome

The difficulty in definitively diagnosing disease on board a vessel is demonstrated well in the research. Development of clear syndrome definitions has been recommended in various reports for more than 20 years; none have been defined and implemented for use by the regulator or industry.

Clear syndrome definitions are needed so:

- Australian Accredited Veterinarians (AAVs) can record a syndrome where a definitive diagnosis cannot be made
- on vessels without an AAV, the stockperson can record the syndrome they observe in a sick animal, and/or record their post-mortem syndrome observations
- animal health data reported under regulatory requirements can be more effectively collated and analysed to provide better industry information on risks to animal health and welfare.

This issue has limited the conclusions that can be drawn from the literature review and industry data analysis conducted in this project.

6.1.2 Definitions to define groups of animals

The terms used to describe groups of similar livestock are inconsistently used within government documents and within industry; these terms include *species, class, type, line*, *kind*, and *category.*

Clear definitions of terms to use to group animals are needed to allow effective regulation, collection, and analysis of data to identify animal welfare risks. Without clear definitions, routinely collected data cannot be collated, analysed, and compared without the risk or error or bias. This issue has limited the conclusions that can be drawn from the literature review and industry data analysis conducted in this project.

Without definitions of terms to use to group animals, insights into the risks to animal health on vessels will remain difficult to obtain.

6.1.3 Shipment outcomes or consignment outcomes

A vessel on a single voyage may have multiple consignments on board. The different consignments on a vessel may be being exported by the same exporter or by different exporters. Mortality performance is used by the department to regulate the industry; this is applied to the consignment level rather than at the voyage level. This difference that occurs between datasets reporting consignment level and voyage level data creates complexity when assessing trends from the publicly available data.

6.1.4 Performance indicators

Understanding data sources, reporting biases, and the methodology of analysis is important when drawing conclusions from performance indicators. Simple percentage-based performance measures do not account for time-at-risk and are insufficient to allow animal health and welfare comparisons across voyages, years, or industries.

Animal-days-at-risk should be used by industry and government when calculating animal health and welfare performance indicators to monitor or regulate the livestock export industry.

6.1.5 Cattle expected major syndromes and diseases

Cattle on Australian farms broadly experience an estimated 3% overall background mortality. This equates to 0.083 mortalities per 1000 animal days. Cattle exported from Australia in 2018 and 2019 experienced 0.099 and 0.100 mortalities per 1000 animal days, respectively. Considering the described possible errors in the available data, the mortality incidence rate for cattle exports during 2018 and 2019 is remarkably close or equivalent to the estimated mortality incidence rates on farms in Australia.

6.1.5.1 Cattle literature review summary

The literature review, presented in Appendix 1 (Cattle expected major syndromes or disease), aimed to identify of the major expected syndromes or disease and focused on those conditions which are treatable with medications.

Table 13 has been created from the information assessed in the literature review; it shows syndromes that are clinically recognisable and the relation these have to results from further diagnostic tests. This intends to illustrate the current uncertainty in the data due to lack of syndrome definitions.

Table 13 is not intended to be a table of recommended syndromes; further determination of appropriate syndromes and definitions for use within the industry is needed.

Table 13: Cattle Clinical observable syndromes and further clarification of syndrome from further diagnostic procedure i.e. gross post-mortem

Clinically observable syndrome		Syndrome after further diagnostic procedure							
	Other terms	Bloat	Pneumonia BRD[22]	Hyperthermia	Ketosis	IBK[23]	Mastitis	Musculoskeletal injury	Infectious diarrhoea
Downer			X	X	X			X	
Enteric disease	Diarrhoea Bloat Scours	X							X
Eye Disease	Pinkeye					X			
Heat stress			X	X					
Illthrift	Inappetence Shy feeder		X						
Lameness	Swollen legs Knuckling		X		X			X	
Premature lactation							X		
Respiratory Disease	Nasal discharge Respiratory distress		X	X	X				
Sudden Death			X	X				X	
Trauma			X					X	

[22] Bovine respiratory disease
[23] Infectious bovine keratoconjunctivitis

The major syndromes or diseases identified through the literature review for cattle are:

Respiratory disease

Respiratory disease is likely the most frequently encountered disease related to mortality on livestock export sea voyages. This has been identified through multiple research reports.

The frequency of mortalities associated with respiratory disease during livestock export voyages correlates well with what is known to occur in the Australian feedlot industry. We can extrapolate from this that the morbidity estimates from Australian feedlots could reasonably be applied to livestock export voyages.

In Australian feedlots, the timing of morbidities and mortalities after mixing of animals peaks around 37 days; this may explain an underlying driver for heat stress mortality events on livestock export voyages that occur within this time frame. Depending on the length of pre-export preparation required, 37 days after mixing may occur in the equatorial zone or other areas with high ambient temperature and/or high relative humidity.

The industry would benefit from further investigation of the possible underlying disease risk factors for individual animals recorded as dying from heat stress during export voyages.

Musculoskeletal conditions and injuries

Musculoskeletal conditions and injuries are frequent on board livestock export vessels; treatment is important for pain relief or subsequent infection. It is important to consider that musculoskeletal conditions or injuries are often a precursor to other conditions that cause poor animal health outcomes. An example of this mechanism is stress caused by an injury predisposes the animal through lowering the immune system's functionality to other illnesses.

Other syndromes or diseases

The following minor conditions or diseases are discussed due to their consideration for medication requirements or perception within the industry.

Eye disease

Eye disease is often described in the livestock export industry using the term "pinkeye"; this is also used as general term to describe Infectious Bovine Keratoconjunctivitis (IBK). There are multiple underlying causes that can lead to outbreaks of eye disease; for example, viruses such Bovine Herpesvirus can cause a respiratory disease Infectious Bovine Rhinotracheitis as well as outbreaks of eye disease. Following injuries to the eye or infections with viruses, the eye can become secondarily infected with bacteria that can cause further disease of the eye. Corneal ulceration, temperature, and presence of nasal plaques can help to differentiate between the viral and bacterial causes; antimicrobial treatment is indicated if a bacterial infection is present.

Heat stress

Heat stress has received a large amount of attention in recent years due to media exposure of events occurring on sheep export voyages. There are no constant or specific histopathological changes associated with heat stroke (Radostits et al., 2000) and ruling out pneumonia or other underlying causes is complex, as concerns exist with the historical data where heat stress has been recorded as a diagnosis or cause of death.

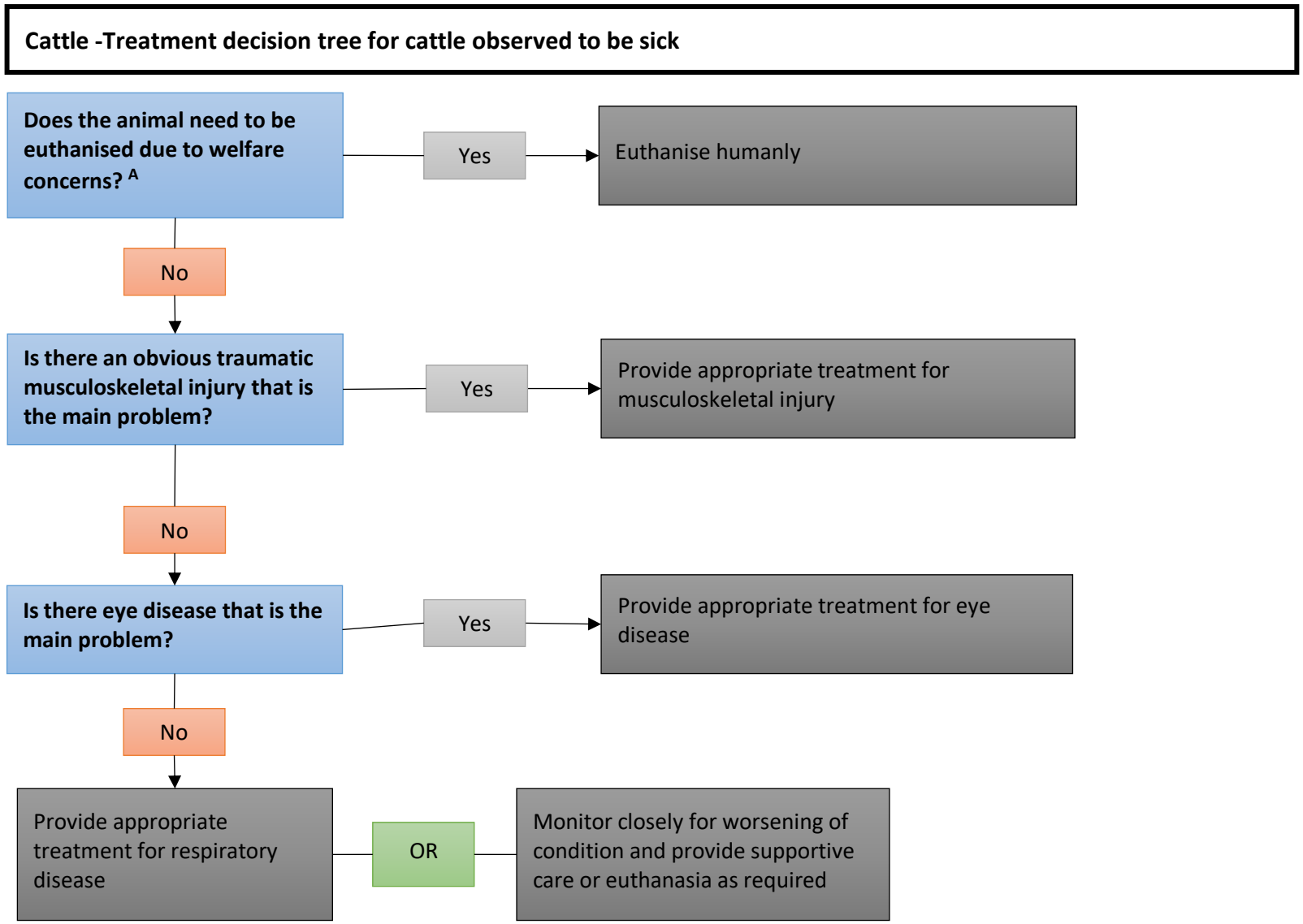
Mastitis

A possible increased risk of mastitis occurrence has been associated with premature lactation in pregnant heifers during the export voyage. Conventional mastitis treatment is recommended where required and no specific prevention or treatment has been identified for premature lactations.

6.1.5.2 Cattle Treatment

The literature provides good evidence that identifying respiratory disease from pen side observations of cattle during export voyages is an extremely poor test. Pen side observations alone are not useful for detecting cattle with respiratory disease to determine which animals require treatment. Respiratory disease in cattle on board vessels has been shown to present with a large range of non-respiratory related clinical signs. Improvement in diagnostic accuracy can be achieved by animal restraint and from a thorough clinical exam.

The following evidence-based (Appendix 1 - Literature review) treatment decision tree (Fig. 2) can be applied for cattle on board livestock vessels. This uses the following approach: first – consider animal welfare needs; second - if the observer detects an easily identifiable syndrome then treatment for this syndrome is commenced; third – if easily identifiable syndromes are not present treatment for the most likely syndrome is commenced or the animal is further monitored. Fig. 2: Cattle treatment decision tree



A The Veterinary Handbook for Cattle, Sheep & Goats (Jubb. T et al., 2019) has a section on considerations and management options for sick or injured livestock to aid decision making

Fig. 2: Cattle treatment decision tree

6.1.6 Sheep expected major syndromes and diseases

Sheep on Australian farms broadly experience an estimated 5% background morality. This equates to 0.132 mortalities per 1000 animal days. Sheep exported from Australia in 2018 and 2019 experienced 0.207 and 0.123 mortalities per 1000 animal days, respectively. Considering the described possible errors in the available data, the mortality incidence rate for sheep exports during 2018 was above the Australian on-farm mortality incidence rate. In 2019, the mortality incidence rate for sheep exports was below the estimated Australian on-farm mortality incidence rate.

6.1.6.1 Sheep summary

The literature review, presented in Appendix 1 (Sheep expected major syndromes or disease), aimed to identify the major expected syndromes or disease and focused on those conditions which are treatable with medications.

Table 14 has been created from the information assessed in the literature review; it shows syndromes that are clinically recognisable and the relation these have to results from further diagnostic tests. This intends to illustrate the current uncertainty in the data due to lack of syndrome definitions.

Table 14 is not intended to be a table of recommended syndromes; further determination of appropriate syndromes and definitions for use within the industry is needed.

Table 14: Sheep Clinical observable syndromes and further clarification of syndrome from further diagnostic procedure i.e. gross post- mortem

Clinically observable syndrome		Syndrome after further diagnostic procedure							
	Other terms	Bloat	Pneumonia	Hyperthermia	Ketosis	IOK*	Mastitis	Musculoskeletal injury	Infectious diarrhoea
Downer			X	X	X			X	X
Enteric disease	Diarrhoea Bloat Scours	X							X
Eye Disease	Pinkeye					X			
Heat stress			X	X					
Illthrift	Inappetence Inanition Shy feeder		X	X	X				
Lameness	Swollen legs Knuckling Shearing injuries		X					X	
Respiratory Disease	Nasal discharge Respiratory distress		X	X	X				
Sudden Death			X	X				X	
Trauma								X	

* Infectious ovine keratoconjunctivitis (IOK)

The available literature that describes the frequency of syndromes or diseases that affect sheep during export voyages by sea is limited and somewhat outdated.

Since 2018 there have been many changes implemented by industry and many regulatory changes. Generally, these changes have resulted in different selection criteria for animals to be prepared for export, different industry approach to pre-export preparation, an increase in space allowance for sheep on board voyages, and restricting voyages from departing Australia during the northern summer. Due to these changes we have seen the average mortality decline to 0.25% (Australian government, 2020e); whilst this is not a complete measure of animal risk, it is acknowledging that these industry changes have resulted in fewer sheep being exported with fewer overall mortalities.

Anecdotally, these industry and regulatory changes may have resolved some of the key underlying risk factors for the inanition/enteritis complex. The reporting of morbidity and mortalities due to the inanition/enteritis complex has declined significantly. Current mortality rates around 0.25% (Norman, 2019) indicate that the previous major diseases are now occurring at low frequency and it is possible they are now not the diseases of interest. Anecdotal reports indicate very few medication treatments are now being conducted on vessels as there are very few animals requiring treatment. The current mortality performance incident rates go some way to supporting this.

In sheep it continues to remain unclear what predisposes some animals to have a lower tolerance to heat and becoming more likely to die during heat stress events. If there are underlying causes which predispose sheep to poorer outcomes during heat stress events, risk mitigation for heat stress should include prevention and treatment for these underlying causes. Additionally, having good information on these likely underlying causes is important to be able to provide the most appropriate medications for on-board use.

Currently the major syndromes in sheep and their underlying causes are poorly understood. There are a few reasons for this; the frequency of sheep voyages is generally low and high mortality incidents are rare events; lack of syndrome definitions, changes in the regulations over time, and inconsistencies in data collection and recording techniques constrain informative data analysis. Moreover, the current low mortality incidence rates and reported low morbidity level during sea voyages indicate that any perceived high-risk activity is currently being managed well.

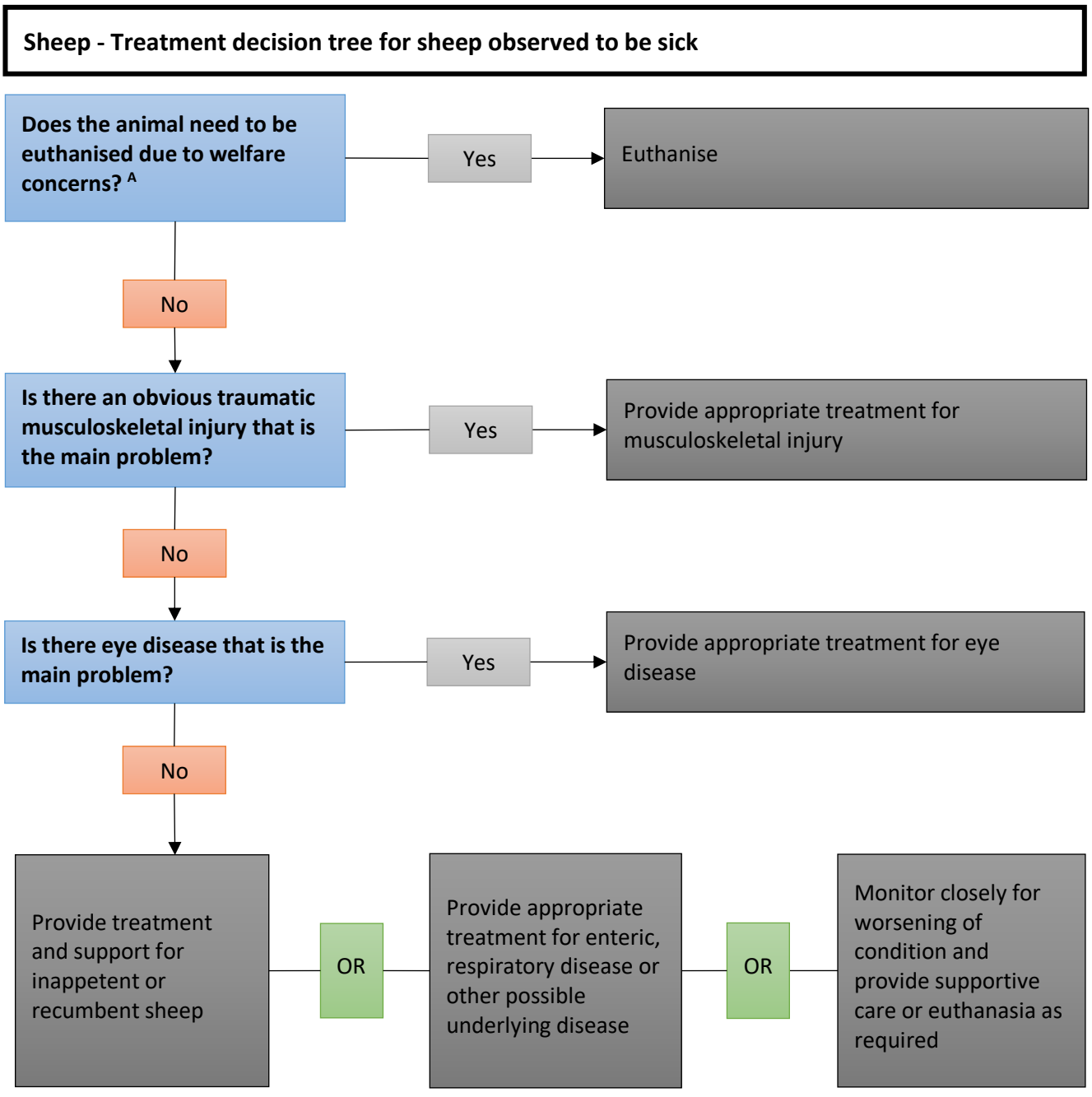
The major syndromes or diseases identified through this review for sheep are:

Musculoskeletal conditions and injuries

Musculoskeletal conditions and injuries are frequent on board livestock export vessels; treatment is important for pain relief or subsequent infection. It is important to consider that musculoskeletal conditions or injuries are often a precursor to other conditions that cause poor animal health outcomes. An example of this mechanism is stress caused by an injury predisposes the animal through lowering the immune system's functionality to other illnesses.

6.1.6.2 Sheep Treatment

The following evidence-based (Appendix 1 - Literature review) treatment decision tree (Fig. 3) can be applied for sheep on board livestock vessels. This uses the following approach: first – consider animal welfare needs; second - if the observer detects an easily identifiable syndrome then treatment for this syndrome is commenced; third – if easily identifiable syndromes are not present treatment options for range of the most likely syndromes are commenced or the animal is further monitored.



A The Veterinary Handbook for Cattle, Sheep & Goats (Jubb. T et al., 2019) has a section on considerations and management options for sick or injured livestock to aid decision making

Fig. 3: Sheep treatment decision tree

6.1.7 Prevention of disease or syndromes

Prevention of diseases and syndromes are preferable to treating or managing sick animals for many reasons. The major syndromes that occur on cattle and sheep voyages are respiratory disease and eye disease; these can often have both bacterial and/or viral components. Preventative vaccinations against some of these organisms on the farm or during pre-export preparation can reduce the prevalence of these syndromes within the later parts of the livestock export supply chain. Animal management can also help reduce prevalence and severity of these disease; the timing of mixing groups of animals from different origins before stress events has been shown to reduce the incidence of these diseases.

Reduction of musculoskeletal injuries seen on board the vessel will be reduced by good animal management, handling, and facility management during pre-export preparation and especially during shearing for sheep.

Pre-export planning for prevention of disease through identification of risks to animal health from the sea voyage (port of loading, destination, ship, etc.) for each class and identified sub-groups of animals (type, lines, etc) allows consignment-level animal health risk mitigation measures to be developed and implemented. Understanding the major animal health risks to each consignment will allow appropriate selection of medications and equipment to be loaded.

6.1.8 Continual performance improvement

Animal health issues for cattle and sheep that result in mortalities during livestock export voyages appear to be at a low level which is similar to what is seen or predicted to occur in land-based operations. This indicates the animal selection processes and preventative measures currently undertaken by exporters are mitigating risks equally or more effectively than on-farm management in Australia.

A continuation of this argument provides some indication that there are most likely no major infectious disease risks regularly occurring that require specific medications to be provided.

In the future, data using clear definitions for groups of animals, syndromes, etc., and a standardised data collection format will allow stratification of industry data to identify areas posing a higher risk to animal welfare. This in turn will increase the likelihood of animal welfare performance improvements through specific targeted changes in the export supply chain or the governing regulations. However, identifying significant additional risks may remain challenging due to the current low level of occurrence and low overall impact.

6.2 Medications - operational constraints conclusions

For each livestock species, what are the general operational constraints, including antimicrobial stewardship, to providing shipboard medication treatments?

The operational constraints that are unique to the shipboard environment require a higher level of planning than other land-based production systems for treatment and care of sick livestock. Considering the broader issues of operational constraints and antimicrobial stewardship, an integrated approach within export companies between overarching company policies, antimicrobial stewardship, pre-export consignment planning, pre-export preparation of livestock, and operational instructions for on-board staff covering medication requirements and treatment protocols is important. Operational constraints need to be considered when selecting the shipboard provision of medications and also during shipboard use of medications.

Overarching company policies are important to outline the company's approach to certain issues and would describe the standard at which the company aims to conduct its business; an example of a relevant overarching company policy is an export supply chain medications plan that incorporates an antimicrobial stewardship plan. Development of these overarching company policy documents should occur in consultation with veterinary advice where the policy relates to animal health and welfare. The approaches outlined in such company documents need to be considered at both the pre-export planning stage and at an operational level.

A pre-export consignment planning process of assessing the likely animal health risk to individual consignments should occur to identify the major risks to animal health for each consignment and allow appropriate mitigation measures to be developed. These measures may be preventative such as in the pre-export phase or may be treatment orientated such as loading specific shipboard medications.

6.2.1 Shipboard provision of medications

Shipboard provision of medications is about having the right medications on board that are suitable for shipboard use. Relevant overarching company policies, pre-export animal health assessment, and health outcomes from the pre-export preparation process would inform selection of appropriate medications and their amounts to load. The AAV responsible for pre-export preparation of the livestock should provide written advice to the on-board AAV or stockperson informing them of any prior health issues that affected the livestock during pre-export preparation.

For medications to be considered suitable for use on vessels they should meet the following operational constraint considerations:

- have a low impact on human health if accidental exposure occurs
- be suitable for treatment of major syndrome categories identified in the standards
- be suitable for treatment of diseases identified through an exporter animal health assessment process
- have an appropriate duration of action
- the required volume for a treatment can be administered using the animal health equipment carried on board with a minimum number of injections
- have an appropriate withholding period for the destination market and purpose of the livestock

- oral medications should only be considered if the vessel has the appropriate infrastructure and equipment to provide accurate dosing.

For medications to be considered suitable for use on vessels they should meet the following current antimicrobial stewardship and prescribing guideline recommendations:

- have a low ASTAG importance rating
- be narrow spectrum in preference to broad-spectrum antimicrobials where appropriate.

There are many reasons why treatments on board may occur with minimal restraint of the animal. Where these treatments occur, the major functional consideration for selecting medications is the volume that can be administered in a single injection using the animal health equipment on board. Considering the maximum volume that can be injected and the required dose for each medication is important to ensure animal treatments are effective and efficient.

For example, pole injectors are commonly used to treat cattle on export voyages; the Westergun and MasterJect pole injectors have a 10ml and 20ml maximum delivery volume, respectively. To treat a 500kg cow using Oxytetracycline (10ml/100kg) would require 5 injections with the Westergun or 3 injections with the MasterJect; whereas, using Tulathromycin (2.5ml/100kg) would require 2 injections with Westergun or 1 injection with the MasterJect. Anti-inflammatories providing pain relief are often administered when antimicrobial treatment occurs; therefore, combination antimicrobial and anti-inflammatory products can further reduce the number of injections required. Consideration should also be given to maximum volume injected at any one injection site.

6.2.2 Shipboard use of medications

Shipboard use of medications is about how the medications that are on board are used. AAVs and/or stockpersons are responsible for the treatment and care of sick or injured livestock on vessels. Shipboard instructions to AAVs or stockpersons should outline the use of medications that have been provided for the voyage.

Developing shipboard instructions for treatment and care of sick or injured livestock would encompass parts of an exporter's relevant overarching company policies, such as an export supply chain medications plan, as well as health outcomes from the pre-export preparation processes.

Section 8 of the Veterinary Handbook discusses operational constraints on vessels to consider when making decisions if to treat, monitor, or euthanise seriously sick or injured animals. If a choice to treat an animal is made by the on-board staff, then the shipboard instructions and animal health risks identified in the export planning process would provide helpful information or guidance for them when choosing which of the medications on board to use.

6.3 Medication review conclusions

For each livestock species, what medications are registered for use in Australia and are the drug classes appropriate to treat expected syndromes or disease that occur on vessels?

6.3.1 Available registered medications

Table 5 - Table 12 display the currently registered active ingredient groups that are relevant to treatment of livestock on export vessels. These tables display additional information that allows the reader to consider the recommendations made in 6.2.1 *Shipboard provision of medications* to help identify the most appropriate medications for use.

6.3.2 Water medication

Previously, key industry resources have recommended that oral (in-water or in-feed) antibiotics only be used if there are no reasonable alternatives and if specific equipment is on board to allow accurate medication such as header tanks designed for water medication. This recommendation has been made for a number of reasons including the major problem of individual livestock not receiving the required treatment dose along with the risk of creating harm through disruption of rumen microflora and increasing the chance of enteric disease in healthy animals.

Situations where treatment of a large number of animals is required present logistical difficulties; in these instances, antimicrobial treatment may increase survival rates of at-risk livestock. During scenarios such as large outbreaks of pneumonia in cattle/sheep or coccidiosis in goats, water medication could be considered with appropriate shipboard equipment. However, over the last 10 years the export industry has seen major changes in the selection and preparation of animals, the decrease in frequency of mortality events, and low overall industry mortality incidence rates to suggest that risks of large disease outbreaks are well controlled.

6.3.3 Treatment of eye disease

The literature review identified there is no clear preferred mode of treatment (parental, oral, or topical) and it is not clear if any particular antimicrobial is more effective for eye disease that occur in livestock. In addition, the researchers of the current MLA project B.AHE.0319, “Risk factors, treatment and prevention options for pinkeye disease in cattle” were consulted and their more extensive literature review also identified that treatment indications and advice remain unclear.

ASEL 2.3 required all voyages to load topical pink eye treatment. Generally, the topical antibiotic eye ointment preparations available in Australia have a short in-date period; this has resulted in a large amount of medication wastage across the industry through disposal of out-of-date products. Additional consideration needs to be given for ability to effectively restrain animals for application of topical eye treatments and the occupational health and safety of the on-board staff to deliver effective treatment of topical products.

As it is not clear if topical treatments are more effective than other forms of treatment for eye disease, administration of topical treatment have a higher occupational health and safety risk, and they are currently a

cause of a large amount of medication wastage, the ASEL 2.3 requirement for topical pink eye treatment should be removed.

It is recommended antimicrobials for the treatment of eye disease be included within the requirement for minimum injectable antimicrobials.

6.3.4 Exporter medications planning

The shipboard environment poses unique operational constraints to the livestock export industry requiring a higher level of planning than other land-based production systems.

To provide effective antimicrobial stewardship an exporter would need an antimicrobial stewardship plan in place. This plan essentially outlines how antimicrobials are used in their supply chain. The planning idea could be extended to include all medications - an exporter supply chain medications plan. Such an overarching company policy document gives the company direction when selecting medications to load and would help to inform shipboard use of the chosen medications. The exporter should develop the plan in consultation with the relevant experienced veterinarians. Additionally, during each individual consignment planning process the risks to animal health need to be determined by considering: the type of animals loaded, their background history, the destination market, the vessel, etc. For example, the risks to animal health for pregnant Bos indicus breeder cattle departing Australia in winter for Israel would be different to slaughter Bos Taurus cattle departing Australia in summer to China. Additional medication requirements for class of livestock/ type/line, etc. should also be determined during this consignment planning process. This allows other risks such as tick fever to be considered and relevant medications, such as Imidocarb, could be loaded if the assessed risk is considerable and requires mitigation.

All extended long-haul voyages and voyages with pregnant livestock are required to have an AAV accompany a voyage (ASEL 3.0 s 4.1.9 b). Additional medications to load, for these consignments, should be determined during a pre-export planning process in consultation with the pre-export AAV and shipboard AAV for the consignment. Exporters may apply for an alternative arrangement under s4.1.10; if this is approved by the department appropriate medications to load should be determined in consultation with the pre-export veterinarian.

6.4 Medication requirements

6.4.1 Shipboard provision of medications

Table 4 outlined the major operational constraints impacting treatment of animals on livestock vessels at sea. As described in section 6.2.1 medications suitable for shipboard use should meet the following requirements:

- have a low impact on human health if accidental exposure occurs
- be suitable for treatment of major syndromes categories identified in the standards
- be suitable for treatment of diseases identified through an exporter animal health assessment process
- have a low ASTAG impact rating
- be narrow spectrum in preference to broad-spectrum antimicrobials if appropriate
- have an appropriate duration of action
- the required volume for a treatment can be administered with the animal health equipment carried on board
- have an appropriate withholding period for the destination market and purpose of the livestock
- oral medications should only be considered if the vessel has the appropriate infrastructure and equipment to provide accurate dosing

Table 5 - Table 12 display the currently registered active ingredient groups that are relevant to treatment of livestock on export vessels. These tables display additional information that allows the reader to consider the above requirements for medications to be suitable for use on livestock vessels.

Table 6 identifies Ceftiofur as the only antimicrobial registered in Australia for use in cattle that does not have a low ASTAG importance rating. While Ceftiofur is not used in humans, it has a high importance rating as it has potential to select for cross resistance to antibacterials used in humans. Medications with a 'High Importance' ASTAG rating are essential antibacterials for the treatment or prevention of infections in humans where there are few or no treatment alternatives for these infections. These antibiotics have also been termed "last resort" or "last line" antibacterials. As such, the use of Ceftiofur should only occur in livestock export under exceptional circumstances and cannot be recommended for consideration as a general medication.

6.4.2 Buffalo medication summary

Previously, ASEL medication requirements for buffalo and cattle have been made together due to the perceived similarity of these species. There were no products registered in Australia for use in buffalo; off-label use of cattle medication seems the most appropriate solution. Exporters should work with their consulting veterinarian to develop an export supply chain medications plan. The department should ensure this document is in existence when approving exports of buffalo under the exporter's Approved Arrangement.

6.4.3 Cattle and sheep medication summary

Table 13 presents the recommendations for shipboard provisions of medications for cattle and sheep by product type and the major syndromes or disease that are required to treat.
The provisions required are displayed as the number of doses per 1000 animal days at sea; this was calculated using the ASEL 2.3 (Australian government, 2011) requirements for a voyage duration of 10 days. There have been no reports of this medication loading amount for a 10-day voyage being insufficient by the regulator or industry. By calculating this loading requirement as a number of doses per 1000 animal days at sea it can be applied to voyages of any length.

Estimated days at sea, excluding loading and discharge days, should be used to calculate required provisions. This is different to the ASEL 3.0 definitions for voyage length, which clearly include loading and discharge days. The rationale for using estimated days at sea includes: unfit animals should not be loaded; during loading days shore-based supplies can be used, or supplies can be restocked before departure; during discharge days there are an ever-decreasing number of animals on board and shore-based supplies are likely to be available if needed. Using estimated days at sea to calculate the amount of provisions required will avoid a general oversupply of medications, which leads to unnecessary cost to the exporter and potential waste issues, without delivering additional risk reduction for the livestock.

It is generally accepted that the requirements presented in ASEL 2.3 have been sufficient and there was no evidence from the departmental mortality investigation reports that the requirements resulted in insufficient available medications. Exporters can load greater amounts of medications than the minimum ASEL requirement. There was no data available to determine how often this occurs, but this provides an alternative reason why medication supply issues are not identified during mortality events. Information was requested from the department about the number of voyages where medication supply was an issue or the number of occasions the department has placed a condition on an exporter to load increased amounts of medication. No information from the department was received.

Further consideration is required when applying the recommendations to voyages where days a sea are greater than 20 days. ASEL 3.0 (Australian government, 2020a) notifiable mortality levels recognise the decrease risk per day to livestock on longer voyages. The average daily mortality rate is required to decrease every day after 20 days, so the voyage keeps within the required mortality rate per voyage. Recognising this and applying the provisions recommended in Table 13, for voyages greater than 20 days, could also result in a general oversupply of medications leading to unnecessary cost to the exporter and potential waste issues without delivering additional risk reduction for the livestock.

Anecdotal reports on the current low incidence of disease are supported by analysis of the publicly available data; section 5.1.2 provides evidence that cattle and sheep exported experience a low incidence of diseases resulting in death and the risk of mortality is similar to land-based operations.

6.4.4 Goat medication summary

Previously, ASEL medication requirements for sheep and goat have been made together due to the similarity of these species and as registered medications for goats are also normally registered for use in sheep. There was a lack of published information on the major conditions or diseases affecting goats during sea voyages. It is possible that medications required to mitigate these risks may not be registered in Australia for use in goats. Off-label use of sheep medication maybe an appropriate solution; exporters should work with their consulting veterinarian to develop an export supply chain medications plan. The department should ensure this document is in existence when approving exports of goats under the exporter's Approved Arrangement.

6.4.5 Other species summary

There was a lack of published information on the major conditions or disease affecting other species during sea voyages. Medications registered for use in Australia for these species or off-label use of other medication maybe required to manage the risks to animal health for these species. Exporters should work with their consulting veterinarian to develop an export supply chain medications plan. The department should ensure

this document is in existence when approving exports of each of these species under the exporter's Approved Arrangement.

6.5 Animal health equipment requirements

For each livestock species, what minimum equipment is required for treatment of expected syndromes or diseases?

Animal health equipment requirements should be assessed during pre-export consignment planning for each class and other descriptors that group animals (type/line/group/category) into similar risk categories. The exporter should consider the stockperson and AAV's equipment preferences at this stage.

6.5.1 Buffalo, goats, and other species equipment summary

Specific equipment requirements for these individual species should reflect the risks to animal health as assessed during the consignment planning process.

Cattle and sheep equipment summaryError! Reference source not found.displays the recommendations for the minimum provisions of shipboard animal health equipment for export vessels carrying cattle or sheep. Specific equipment requirements for cattle and sheep should reflect the risks to animal health as identified during the pre-export consignment planning process.

For the same reasons given for medications requirements, amounts of equipment required were determined per 1000 animal days at sea and further consideration is required when applying the recommendations to voyages where days at sea are greater than 20 days.

6.6 Loading the most appropriate medications and equipment to meet requirements

This report follows the format proposed in the ASEL 2013 review and makes recommendations in mandatory standards and complementary guidelines format.

Standards recommendations are to the level of detail that provides relative stability of the requirements over time and are applicable to all exporters regardless of class of livestock or destination.

Complementary guidelines are needed to allow flexibility where a prescriptive or mandatory approach presents barriers to improving animal welfare outcomes. This occurs due to the large variation within the export industry – class of animals being exported, animal backgrounds, operational constraints of the voyage, importing country residue limits, etc. – this results in the need to supply provisions for different situations. Flexibility is also needed for items prone to frequent change or supply; complementary guidelines can easily allow for changes in treatment recommendations, or availability of registered medications.

Following an update of ASEL requirements, complementary guidelines should be developed to help exporters in meeting these requirements, by assisting them in determining the most appropriate shipboard equipment and medications to load based on the assessed animal health risks for each voyage.

6.6.1 Consignment animal health assessment

A pre-export planning process to assess risks to animal health during the sea voyage for each consignment is needed to improve animal welfare outcomes. A process such as a Consignment Animal Health Assessment (CAHA) provides the framework to allow the mandatory standards and complementary guidelines format to be implemented for animal health equipment and medication.

The CAHA process should be conducted at the time the exporter is developing the Standard Export Plan (SEP) into a Consignment Specific Export Plan (CSEP) and should involve the pre-export AAV and shipboard AAV.

A CAHA process would need to consider each individual consignment including the groups of animals (type, lines, etc.) being loaded, their background history, the vessel and operational constraints, the port of loading, the destination port and market requirements. This would allow group-level animal health risk mitigation measures to be implemented.

An example where the CAHA process would identify significantly different risks to animal health is clear when comparing a consignment of pregnant Bos indicus breeder cattle departing southern Australia in winter for Israel to a consignment of Bos Taurus slaughter cattle departing Australia in summer to China.

These mitigation measures may be preventative, such as those that occur in the pre-export phase, or treatment orientated, such as choosing the most appropriate selection of medications and equipment to meet ASEL requirements for loading onto the vessel.

Any additional medication and equipment requirements not covered by the minimum ASEL requirements would also be identified by the outcomes of a CAHA process. This allows other risks such as tick fever to be considered and relevant medications such as Imidocarb loaded if the assessed risk is high enough to warrant

mitigation. Shipboard AAV and stockpersons' equipment and medication preferences should be considered at the time of conducting the CAHA process.

6.6.2 Complementary animal health equipment and medication guidelines

Complementary guidelines should be developed to assist the exporter in determining the most appropriate equipment and medications to load onto the vessel that:

- meet the operational constraints of voyage
- mitigate the animal health risks identified in a CAHA process
- are registered medications for the species or have off-label prescriptions
- meet the ASEL equipment and medication requirements.

The guidelines would provide the exporter with a structured approach to determining the most appropriate medications to load. Much of this approach has been provided within this report by identifying the major operational constraints on livestock vessels and determining what attributes make medication suitable for shipboard use. These attributes are:

- have a low impact on human health if accidental exposure occurs
- be suitable for treatment of major syndromes or diseases identified in the standards
- be suitable for treatment of diseases identified through an exporter animal health assessment process
- have a low Australian Strategic and Technical Advisory Group on Antimicrobial Resistance impact rating
- where practical, be narrow spectrum in preference to broad-spectrum antimicrobials
- have an appropriate duration of action
- have an appropriate volume that can be administered using the animal health equipment carried on board with a minimum number of injections
- have an appropriate withholding period for the destination market and purpose of the livestock
- oral medications are only considered if the vessel has the appropriate infrastructure and equipment to provide accurate dosing of livestock.

Table 5 through to Table 12 provides information to assess the above attributes on the currently registered medications by active ingredient groups. Information similar to what is provided in these tables should be included in the guidelines.

Development of the guidelines relies on further information; this is mostly related to recommendations from antimicrobial prescribing guidelines or assessment of the evidence-base for treatments of different syndromes or disease experienced on livestock vessels.

7 Recommendations

This body of work developed a set of recommendations for the livestock export industry, the Australian government Department of Agriculture, Water and the Environment (the department), and the Australian Standards for the Export of Livestock (ASEL) technical committee to consider when updating the ASEL standards for shipboard provisions of animal health equipment and medications.

The effectiveness of ASEL requirements to ensure animal welfare outcomes is inherently linked to the regulation framework; this work additionally considers the relevant wider regulatory framework and makes general recommendations to allow the ASEL requirements for shipboard provisions to be effective in ensuring good animal welfare outcomes.

The recommendations within this report follow the format proposed in the ASEL 2013 review, of mandatory standards and complementary guidelines. In this, the standards recommendations in this report are to the level of detail that provides relative stability of the requirement over time and is applicable to all exporters regardless of class of livestock or destination.

Complementary guidelines are needed to allow flexibility where a prescriptive or mandatory approach presents barriers to improving animal welfare outcomes. This occurs due to the large variation within the export industry resulting in the need to supply provisions for different situations. Flexibility is also needed for items prone to frequent change or supply; complementary guidelines can easily allow for changes in treatment recommendations, or availability of registered medications. Following an update of ASEL requirements, guidelines should be developed to help exporters in meeting these requirements, by assisting them in determining the most appropriate shipboard equipment and medications to load based on the assessed animal health risks for each voyage.

7.1 General recommendations

The wider regulatory framework was considered and the following general recommendations to allow the ASEL requirements for shipboard provisions to be effective in ensuring good animal welfare outcomes are presented for the Australian government and the livestock export industry's consideration.

7.1.1 Definitions to define syndromes

Development of clear syndrome definitions have been recommended in various reports for more than 20 years; none have been defined and implemented for use by the regulator or industry.

Clear syndrome definitions are needed so:

- Australian Accredited Veterinarians (AAVs) can record a syndrome where a definitive diagnosis cannot be made
- on vessels without an AAV, the stockperson can record the syndrome they observe in a sick animal, and/or record their post-mortem syndrome observations
- animal health data reported under regulatory requirements can be more effectively collated and analysed to provide better industry information on risks to animal health and welfare.

Recommendation 1: Defining syndromes
The syndromes which are used to describe and report animal health issues during the livestock export process have clear definitions that are agreed upon by government and industry.

7.1.2 Definitions to define groups of animals

The terms used to describe groups of similar livestock are inconsistently used within government documents and within industry. Clear definitions of terms to use to group animals are needed to allow effective regulation, collection, and analysis of data to identify and mitigate animal welfare risks.

Recommendation 2: Defining groups of animals
The terms used to describe groups of animals in the livestock export process have clear definitions that are agreed upon by government and industry.

7.1.3 Performance indicators

Simple percentage-based performance measures do not account for time-at-risk and are insufficient to allow comparisons across voyages, years, or industries.

Recommendation 3: Performance indicators
Animal-days-at-risk should be used by industry and government when calculating animal health and welfare performance indicators to monitor or regulate the livestock export industry.

7.1.4 Systematic risks to animal health

Analysis of the publicly available data provides evidence that cattle and sheep during export from Australia experience a risk of mortality similar to land-based operations in Australia and support the current anecdotal reports that incidence of diseases on vessels is low. Additionally, during sea voyages the low frequency of high mortality events, the low mortality incidence rates, and the reported low morbidity rates indicate that the systematic risks to animal health in livestock export are low and are being managed.

Recommendation 4: Systematic risks
Areas of greater systematic risk in the livestock export process should be determined, by government and/or industry, through comparing the prevalence of specific animal health issues within the livestock export industry with other Australian land-based production systems.

7.1.5 Governance improvements

The following governance recommendations are made to enable animal health risks to be further reduced and to allow a standards and guidelines approach to be applied to the ASEL requirements for shipboard provisions of equipment and medications.

7.1.5.1 Export supply chain medication plan

Broadly, an export supply chain medication plan is to manage a standard approach to medications across the exporter's operations. Specifically, it should contain an antimicrobial stewardship plan that outlines how and when antimicrobials are used in the supply chain, provide directions for selecting the most appropriate medications to load on vessels, and provide information for shipboard use of medications. The plan should be developed by each exporter in conjunction with their consulting veterinarian.

Recommendation 5: Export supply chain medication plan

An export supply chain medication plan should be incorporated into the exporter's business process. This should contain information on antimicrobial stewardship, provide directions for selecting the most appropriate medications, and information on the use of medications within their export supply chain.

7.1.5.2 Consignment animal health assessment

A pre-export planning process to assess risks to animal health during the sea voyage for each consignment is needed to improve animal welfare outcomes. A process such as a Consignment Animal Health Assessment (CAHA) provides the framework to allow the mandatory standards and complementary guidelines format to be implemented for animal health equipment and medication.

The CAHA process should be conducted at the time the exporter is developing the Standard Export Plan (SEP) into a Consignment Specific Export Plan (CSEP) and should involve the pre-export AAV and shipboard AAV.

A CAHA process would need to consider each individual consignment including the groups of animals (type, lines, etc.) being loaded, their background history, the vessel and operational constraints, the port of loading, the destination port and market requirements, etc. This would allow group-level animal health risk mitigation measures to be implemented. These measures include selecting the most appropriate medications for the consignment to meet the ASEL requirements, and the loading of other shipboard provisions of animal health equipment or medications in addition to the ASEL requirements where needed.

Recommendation 6: Consignment animal health assessment

A Consignment Animal Health Assessment process (CAHA) should be conducted for each consignment at the time the exporter is developing the Standard Export Plan (SEP) into a Consignment Specific Export Plan (CSEP).

A CAHA process identifies animal health risks through considering each individual consignment specifics including the groups of animals (type, lines, etc.) being loaded, their background history, the vessel and operational constraints, the port of loading, the destination port, market requirements, etc. This allows group-level animal health risks mitigation measures to be developed and implemented.

7.2 ASEL medication recommendations

Recommendation 7: Minimum provisions of medications for sea export voyages with cattle and sheep

The following table is recommended as the standards for the provision of animal health medications to the Australian Standards for the Export of Livestock Technical Advisory Committee.

The following table is recommended as the standards for the provision of animal health medications to the Australian Standards for the Export of Livestock Technical Advisory Committee.

Table 15: Recommendations for the minimum provisions of medications for sea export voyages with cattle and sheep

Product type	Specific items	Species	Provisions required per 1000 animal days [A] [C]	Medication must be included to treat major syndromes or diseases
Analgesics/anti-inflammatories including corticosteroids	Injectable anti-inflammatories	Cattle	4.5 doses [B]	-
		Sheep	0.1 doses [B]	-
	Local anaesthetic	Cattle	1ml (minimum 50ml)	-
		Sheep	0.1ml	-
Injectable antimicrobials		Cattle	4.5 doses [B]	1 - Respiratory disease
				2 - Musculoskeletal conditions and injuries
				3 - Eye disease
		Sheep	0.1 doses [B]	1 - Musculoskeletal conditions and injuries
				2 - Enteric disease
Sedatives		Cattle	0.5 doses [B]	-
		Sheep	0.1 doses [B]	-
Topical wound treatment		Cattle	1 treatment	Musculoskeletal conditions and injuries
		Sheep	0.1 treatment	Musculoskeletal conditions and injuries Flystrike
Supportive products	Metabolic solutions	Cattle	1 treatment	-

[A] 1000 animal days at sea is the number of animals multiplied by the number of days at sea divided by 1000
[B] Required drug volume for average weight of the animals loaded
* Further consideration is required when applying the recommendations to voyages with days at sea greater than 20

7.3 ASEL equipment recommendations

Recommendation 8: Minimum provisions of equipment for sea export voyages with cattle and sheep

The following table is recommended as the standards for the provision of animal health equipment to the Australian Standards for the Export of Livestock Technical Advisory Committee.

Table 16: Recommendations for the minimum provisions of equipment for sea export voyages with cattle and sheep

Equipment	Item	Consignment type	Detail	Number per vessel	Equipment per on-board staff[A]	Redundancy
Personal Protective Equipment[B]	Examination gloves	All	More than 50	-	1	-
	Obstetrical gloves	All	More than 50	1	-	-
	Eye protection	All	For use with drug administration and euthanasia	-	1	1
	Ear protection	All	For use with euthanasia	-	1	1
Handling equipment	Portable head bale	Cattle	Light weight, able to be moved around the ship and secured as needed	1	-	-
	Rope halter	Cattle	-	1	-	-
	Nose grips	Cattle	-	1	-	1
	Ropes for handling	Cattle	-	2	-	1
	Cattle talker/slapper	Cattle	Appropriate for low stress stock handling	4	1	1
Identification	Marker	Sheep	Stock identification marker		1	1
Diagnostic equipment	Thermometers	All	-	2	-	1
	Meat temperature gauge	All	To determine post-mortem muscle carcase temperature	1	-	-
	Multi-test dipstick	All	More than 50	1	-	-
	Small post-mortem	All	2 post-mortem knives plus steel and sharpening stone	2	-	-
Site preparation	Antiseptic	All	1 litre of chlorhexidine, iodine or equivalent	1	-	-
	Isopropanol, methylated spirits, or equivalent	All	1 litre of methylated spirits or equivalent	1	-	-
Surgical equipment	Small suture kit	All	Scalpel blades, scalpel handle, needle drivers, forceps, needles, and suture material	1	-	-
Treatment equipment	Pole syringe devices or equivalent	Cattle	Examples: MasterJect or Westergun		1	2 plus parts[D]
	Sheep bottle mount injection	Sheep	Examples: NJ Phillips Automatic BMV Injector	-	1	1 plus parts[D]
	Syringes	Cattle	Syringes suitable for pole syringe device	0.5 per 1000 animal days[C]		10
		Cattle	20 ml or above	2 per 1000	-	-

Equipment	Item	Consignment type	Detail	Number per vessel	Equipment per on-board staff[A]	Redundancy
				animal days[C]		
			10ml or below	2 per 1000 animal days[C]	-	
		Sheep	10 ml and above	0.05 per 1000 animal days[C]	-	-
			5 ml or below	0.01 per 1000 animal days[C]	-	-
	Needles	Cattle	Suitable for pole syringe device and loaded medications	1 per 1000 animal days[C]		20
		Cattle	Needles suitable for manual injection	2 per 1000 animal days[C]	-	-
		Sheep	Needles for bottle mount injection device	0.02 per 1000 animal days[C]		20
		Sheep	Needles suitable for manual injection	0.05 per 1000 animal days[C]	-	-
	GIT equipment	All	Stomach tube	1	-	-
		Cattle	Bloat trocar/cannula	1	-	-
	Hoof equipment	Cattle	Hoof knife or pincers	1	-	-
		Cattle	Hoof blocks and glue	10	-	-
		Sheep	Foot secateurs	1	-	
	Obstetrical equipment	All pregnant breeder consignments	Mechanical assistance device	1	-	-
			Obstetrical chains/ropes	1	-	-
			Prolapse needle & prolapse tape	1	-	-
			Obstetrical lubricant	5 litres	-	-
	Wound equipment	All	Cotton wool	2 rolls	-	-
		All	Vetwrap or equivalent	2 rolls	-	-
		All	Elastoplast, PVC duct tape, or equivalent	2 rolls	-	-
Euthanasia equipment	Captive-bolt device	All	-	1	-	1 plus parts D
	Cartridges	Cattle	Suitable for weight/type of livestock	4 per 1000 animal days	-	-
		Sheep	Suitable for weight/type of livestock	1 per 1000 animal days	-	-

[A] On-board staff refers to AAVs and stockpersons

[B] This is not inclusive of all OH&S equipment that might be required for the exporter to provide a safe work environment
[C] 1000 animal days at sea is the number of animals multiplied by the number of days at sea divided by 1000
[D] 1 complete spare device plus spare parts to rebuild the minimum number of device required on board
* Further consideration is required when applying the recommendations to voyages with days at sea greater than 20

7.3.1 Diagnostic equipment

A full post-mortem kit along with required storage containers and fixatives to collect samples for laboratory testing and histopathology should be carried on all livestock vessels if clear guidelines are available from the department on how to bring samples back to Australia for diagnostic testing.

Recommendation 9: Diagnostic equipment
The department provides clear guidelines to the industry on how to meet Australia's importing requirements for diagnostic samples obtained from Australian livestock during sea transport to the importing country.

7.3.2 Animal health equipment and medication guidelines

Complementary guidelines should be developed to assist the exporter in determining the most appropriate equipment and medications to load onto the vessel that:

- meet the operational constraints of the voyage
- mitigate the animal health risks identified in a CAHA process
- are registered medications for the species or have off-label prescriptions
- meet the ASEL equipment and medication requirements.

The guidelines would provide the exporter with a structured approach to determining the most appropriate medications to load considering the operational constraints and the animal health risks identified in a consignment animal health assessment (CAHA). Much of this approach has been provided in this report and development of the guidelines relies on further information related to recommendations from antimicrobial prescribing guidelines or assessment of the evidence-base for treatments of different syndromes or disease experienced on livestock vessels.

Recommendation 10: Animal health equipment and medication guidelines
Following an update of ASEL requirements, complementary guidelines should be developed to help exporters in meeting these requirements by assisting them in determining the most appropriate shipboard equipment and medications to load based on the assessed animal health risks for each voyage.

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9 Appendix 1 - Literature review

9.1 Cattle - expected major syndromes or disease

9.1.1 Key industry resources

Veterinary Handbook for Cattle, Sheep, & Goats (Jubb. T et al., 2019) and associated report Live Export Veterinary Disease Handbook (Perkins and Jubb, 2012)

The Veterinary Handbook outlines a large number of diseases and conditions including some that are rarely seen. Less common conditions were included for completeness because they are differential diagnoses for syndromes that have other, more common causes. It also states inclusion of less common diseases is to help users make accurate diagnoses for insurance, disease reporting and exotic disease exclusion purposes. The Handbook identifies 16 syndromes for cattle.

The major conditions that can cause increased mortality and that have triggered disease investigations in the past are identified in the handbook with an *. It can be seen from these major conditions along with their syndromes in Table 15, that diseases can have multiple syndromes and most syndromes have multiple disease. The frequency of syndromes or diseases in cattle exported by sea is not described in the Veterinary Handbook.

Table 17: Specific cattle diseases and associated syndromes identified in the Veterinary Handbook that can cause an increase in mortality

Cattle - Specific Diseases in Handbook	Syndrome
Heat stress	Respiratory distress
	Sudden death
Inappetence/ inanition	Illthrift
Pneumonia	Nasal discharge
	Respiratory distress
Pneumonic – emboli	Sudden death
Salmonellosis	Diarrhoea
	Illthrift
	Sudden death
Traumatic injury	Downer
	Knuckling
	Lameness

Section 11.4 of the Veterinary handbook describes necropsy findings for specific conditions. These are Bovine Respiratory Disease (BRD), Heat Stress, Musculoskeletal injury, Ketosis, and Septicaemia.

It is noted that heat stress and pneumonia may be difficult to differentiate while the animal is alive, and it is important to measure core temperature soon after death to avoid erroneously attributing post-mortem elevation of body temperature to heat stress.

Live export - Best practice us of veterinary drugs (Rolls and Campbell, 2008)

This resource does not identify syndromes or diseases, or their frequency of occurrence.

Stockman's Handbook Transport of Cattle by Sea Short & Long Haul Voyages (Ainsworth, 2008)

This resource identifies the following syndromes or diseases that are encountered during voyages. Frequency of these main syndromes is not described.

- pneumonia is mentioned as one of the more common and serious disease conditions seen on long haul cattle voyages. The disease can present in a wide range of forms from sudden death with no other signs, to chronic poor doers with low-grade lung infections and abscesses
- treatment of wounds or injuries is always indicated on long haul voyages, as even if the injury is not likely to become infected, the stress of the injury will predispose the animal to pneumonia and other illnesses
- if an animal is found dead and heat stress is a possibility, then it is important to try to determine if it was indeed the primary cause or if there are other complicating factors such as pneumonia.

9.1.2 Industry funded research reports

Mortality and Morbidity Risk Factors for Livestock During Sea Transport from Australia (Norris and Norman, 2003, Norris et al., 2003)

This report identified the major conditions relating to mortalities that were experienced on voyages in the study as:

- enteric disease
- heat stress
- respiratory disease
- septicaemia
- trauma

It is not possible to identify from the report the proportion of mortalities on which post-mortem were conducted. This limits further interpretation and consideration with more recent research results. Frequency of these major conditions is not described.

Other conditions identified in this project relating to morbidity are:

- bloat
- hyperthermia
- lameness/swollen legs or feet
- pinkeye
- pneumonia
- scours
- shy feeder
- snotty nose

These syndromes are similar to those identified in a report from 1999 attached to this study - heat stress, inanition, lameness/trauma, pneumonia, and rumenitis.

Identifying the causes of mortality in cattle exported to the Middle East (Perkins et al., 2015a) and associated PhD thesis - Investigating causes of mortality in live export cattle (Moore et al., 2014) and Mortality of live export cattle on long-haul voyages: pathological changes and pathogens. (Moore et al., 2014)

These related research documents provide the most recent information and informative insights into clinical signs, gross post-mortem results, and definitive diagnosis.

In Moore's PhD thesis, a recent literature review was provided into heat stress, trauma/lameness, and respiratory disease as causes of mortality. Moore recognises some respiratory viruses can have lifelong latency and recrudescent shedding with potential transmission to in-contact cattle. This gives rise to the possibility that stress events may lead to outbreaks of respiratory disease in groups of animals which have previously been clinically normal.

From the research report: a total of 194,216 cattle on 21 voyages were studied. Where a definitive diagnosis was made:

- respiratory disease accounted for 59% of deaths
- musculoskeletal and injury-related conditions accounted for 15% of deaths
- other causes of death were responsible for 1% to 6% of mortalities, representing relatively minor contributions to overall mortality counts.

Since 2006, respiratory disease appears to have taken the place of heat stress as the most important cause of death in live export cattle, particularly for cattle on long-haul voyages. The epidemiology of Bovine Respiratory Disease (BRD) in live export cattle appears to be similar to feedlot cattle, so mortality reduction practices used in land-based feedlots in Australia and overseas could be used to reduce the risk of mortality due to BRD during voyages; these practices include yard weaning, backgrounding, vaccination, and metaphylactic antibiotic treatment.

In the study, respiratory disease accounted for 107/215 (49.8%) of deaths overall, and 107/181 (59.1%) of deaths for which a diagnosis could be made. This is higher than that previously reported for cattle exported by sea but is broadly similar to that reported in beef feedlots in Canada (46–65%) and the U.S. (55–75%). Additionally, pneumonia was also identified in 33% of animals for which respiratory disease was not considered the primary cause of death, indicating that respiratory disease plays a role on both morbidity and mortality during voyages.

Pathology results from lung samples that were collected during the study were:

- 130/195 had histological changes and/or positive qPCR results suggestive of infectious lung disease
- 93/130 had evidence of primary bacterial infection
- 4/130 with primary viral infection
- 2/130 with concurrent bacterial and viral infections
- 4/130 the causative organism could not be identified.

The pathology testing identified all major viral and bacterial pathogens of interest in BRD were present in cattle during the study. These findings reinforce the view that BRD epidemiology in export cattle is the same disease process seen in land-based feedlot cattle. Mortality percentages in Australian feedlot cattle are about 0.27% per month on feed (deaths from all causes) and about 0.14% per month on feed for deaths from respiratory disease alone.

Daily mortality risk on long-haul voyages peaks at 3-4 weeks post-departure. The timing of the peak mortality period appears to be similar to that observed in land-based feedlots in both Australia and North America which suggests that mortality control measures used in feedlot cattle may also be effective in live export cattle.

BRD morbidities are likely to involve a much higher percentage of cattle loaded – as many as 1 to 2% of cattle loaded, depending on assumptions about morbidity.

9.1.2.1 Application of research findings

The future clinical application of the diagnostic test results is discussed in depth in W.LIV0252 report under section 7.10 - Diagnostic test assessment for causes of death.

Moore et al, concluded the diagnosis of BRD as a cause of death is very unreliable if based on clinical observation alone. At a minimum it requires a gross necropsy. In contrast, musculoskeletal conditions and injuries can be effectively diagnosed as a cause of death using clinical observations. A brief summary of this discussion is given below.

Respiratory disease

The project findings can be used to improve the way stockpersons and AAVs manage animal health. Those responsible for animal health on vessels are expected to use their observational skills to monitor animal health and also to use appropriate procedures (clinical observations and necropsies) to identify causes of death.

The project shows on export voyages, clinical observations alone are not useful for gaining any reasonable understanding of the extent respiratory disease causes death. Considering the clinical observations as a diagnostic test; the sensitivity is low (0.08), indicating that clinical information is particularly poor at detecting those animals that truly have died from respiratory disease. This would also hold true for detecting animals with respiratory disease to provide appropriate treatment. Even during voyages with a significant prevalence of respiratory disease, the predictive values of the clinical observation (positive predictive value (PPV) 0.6 and negative predictive value (NPV) 0.51) are little better than tossing a coin to determine the probability of the disease outcome given the findings of the clinical information. The apparent prevalence estimate (proportion of all deaths that are due to respiratory disease) when based on clinical information is seriously inaccurate and an under-representation of the true prevalence.
Gross necropsy performs much better as a diagnostic test in detecting respiratory disease (PPV of 0.9 and a NPV of 0.85). This means, if the gross necropsy diagnosis is respiratory disease then the animal has a 90% chance of truly having respiratory disease as the cause of death. Conversely, if the gross necropsy diagnosis is not respiratory disease, then that animal has an 85% probability of having died from a cause other than respiratory disease.

The results confirm that clinical observations alone are insufficient to provide a reasonable understanding how respiratory disease is contributing to export voyage mortalities, and gross necropsy diagnosis is essential to achieve a good understanding of the contribution respiratory disease is playing in voyage mortalities.

Musculoskeletal conditions and injury

Clinical detection of musculoskeletal conditions and injury performs as well as gross necropsy as a test for detection of musculoskeletal conditions and injury as a cause of death.

The findings support that musculoskeletal conditions and injury cases are more likely to have been observed and recorded in clinical observation records. Musculoskeletal conditions and injury are more obvious and noticeable both in ante-mortem and post-mortem inspections.

Clinical detection of musculoskeletal conditions and injury has a moderate PPV of 0.79; this means once a clinical diagnosis of musculoskeletal conditions and injury is made as a cause of death, there is a 79% probability that musculoskeletal conditions and injury were the true cause of death. This does not mean that the musculoskeletal conditions and injury observation was not accurate and likely reflects the fact that lame or injured animals become increasingly susceptible to other serious diseases that may ultimately cause the animal's death. The role of musculoskeletal conditions and injury as a cause of death has some relatively complex causal pathways.

Epidemiology and management of bovine respiratory disease in feedlot cattle Part A: Epidemiology study Feedlot (Barnes et al., 2015)

The study looked at 35,160 cattle in 170 cohorts at 14 feedlots in Australia. There was considerable variation in the incidence of Bovine Respiratory Disease (BRD) between cohorts and feedlots.

The overall results of the study found:

- 18.2% of cattle were treated for BRD
- 0.7% of cattle died from BRD
- the peak incidence of disease occurred between 15 and 30 days after induction
- approximately 97% of all BRD cases occurred within 50 days of induction
- of the cattle that died from BRD, 18.6% had not received any treatment.

Of the BRD cases identified:

- 3.4 % died within 50 days of onset of BRD
- 64% of these deaths were attributed to BRD
- approximately 50% of deaths occurred within the first ten days after initial treatment
- the numbers of fatalities from clinical observed BRD cases peaked around 37 days after the start of time at risk (mixing or induction).

Other relevant results for the livestock export industry were:

- Herefords were at a greater risk than all other breeds
- Bos indicus and cross breeds were a lesser risk than other breeds
- weight of cattle at induction was identified as a risk factor
- lighter cattle at induction were at a greater risk than heavier cattle.
- This study identified mixing of cattle in the time period leading up to induction is an important risk factor in BRD:
- cattle mixed with four or more other groups in the time period (12 days prior to induction until the cohort is formed) are at increased risk compared to those mixed with only two or three groups during this period
- cattle mixed at least one month prior to induction are at reduced risk of BRD compared to those that had not been mixed before one month prior to induction
- cattle transferred through saleyards at least 27 days before induction were at reduced risk of BRD, while those with a saleyard transfer from 27 to 12 days before induction were at increased risk
- no conclusion could be reached about mixing in the time period from two to four weeks before induction as very few of the study cattle were mixed during this time.

They concluded that none of the viruses appeared substantially more important in increasing the animals' risk of BRD.

Review of diagnostic technologies for monitoring feedlot animal health (Al-Alawneh et al., 2015)

The authors discuss how there is no gold standard diagnostic method for respiratory disease detection in cattle and they compare the presence or absence of post-mortem pulmonary lesions with the ante-mortem diagnoses of clinical respiratory disease. Results from the study show a low correlation between diagnosis of clinical illness and post-mortem lung scores.

BRD is noted to be the most important and most common reason for illness and death in Australian feedlot cattle. BRD was noted to usually occur in the first four weeks after entry to the feedlot and is the result of a combination of stress and exposure to viruses and bacteria associated with the BRD complex.

A number of surveys have been conducted in Australia between 1991 and 2013 to estimate the impact of BRD and other infectious diseases in feedlot operations. Depending on the survey and year BRD is broadly responsible for:

- an average annual mortality of 2.7 - 7.8 animals per 1000 head turnoff, accounting for between 40% and 64% of all mortalities
- an average annual morbidity of 26 - 190 animals per 1000 head turnoff, accounting for between 44% and 84% of all morbidities.

Impact of subclinical bovine respiratory disease (Campbell et al., 2018)

The authors report up to 50% of slaughtered cattle with post-mortem lung abnormalities exhibit no clinical signs of BRD during the feeding period.

A lung scoring system was used to understand post-mortem carcase variation through sub-clinical and clinical disease. Findings from the research indicate that vaccination of cattle prior to feedlot entry reduced disease outcome in the carcase but it was not significant (p=0.056).

Physiology of heat stress in cattle and sheep (Barnes et al., 2004)

Assessment of electrolyte supplementation for supportive care in cattle with heat stress was conducted in the study. This research project had a small sample size and occurred under experimental conditions and not on board a livestock vessel. The on-board research part of the project yielded data that was unable to be analysed.

The results determined there may be a difference in need and usefulness of electrolyte supplementation between *Bos taurus* and *Bos indicus* cattle. They concluded the current methods of electrolyte supplementation should be reviewed and recommendations developed for accurate supply.

Investigating premature lactation in pregnant dairy females (Bovine Research Australasia, 2003)

This report provides a general discussion about mastitis in heifers. Relevant information for the livestock export includes:

- heifers showing mammary distension should be:
- teat dipped with an iodine-based teat dip
- placed in cleaner pens
- fed on a diet higher in chaff
- heifers should be treated for mastitis with systemic therapies rather than intramammary therapies
- the reported incidence of udder distention in pregnant heifers during a voyage was 17% (129/766)
- 3 out of 10 heifers inspected had mastitis
- preventative strategies for pre-export preparation were recommended.

Premature Lactation in Exported Dairy Cattle (P.D. et al., 2012)

This report does not provide estimates for frequency of premature lactation in livestock export. No specific treatments were identified for animals with premature lactation, but it was determined these animals were at risk of mastitis.

Eye disease in cattle on long-haul voyages (Laurence, 2019a) and Mitigating eye disease in sheep and cattle destined for live export (Laurence, 2019b)

This report provides a good literature review into eye disease of cattle and the possible extent of the problem in the livestock export industry.

In defining the problem at the start of the report a single exporter's experience is given:

- serious on-board outbreaks of ocular disease that resemble infectious bovine kerato-conjunctivitis (IBK) have occurred on long-haul and extra long-haul voyages
- up to 20% of Bos taurus cattle have been affected with ocular disease which presented as a more severe syndrome than traditional IBK
- anecdotally, 5% of animals were recorded as becoming bilaterally blind and approximately 1% suffered perforated globes
- the syndrome often occurs despite prior vaccination with Piliguard, which has seemingly little effect
- there is anecdotal evidence that consignments vaccinated with live IBR vaccine are less affected.
- Clinical presentation was summarised:
- foreign bodies generally affect a single globe on a single animal
- Bovine Rhinotracheitis (IBR) caused by Bovine Herpesvirus 1, can result in a conjunctivitis outbreaks similar to Infectious Bovine Keratoconjunctivitis (IBK) or "Pinkeye"
- corneal ulceration is the major differentiating feature on clinical presentation and does not occur with IBR
- animals affected with IBR may have increased temperatures and nasal plaques maybe be present.

It was concluded that eye disease in export cattle is a multifactorial disease process with different possible causative agents and several risk factors. Recommendations from the project suggest that wherever practical, exporters should aim to access cattle at least four weeks before quarantine such that full courses of appropriate vaccines can be given to minimise eye disease outbreaks.

Unfortunately, this research did not have conclusive results; the author comments that one problem with this type of research is the difficulty in gaining positive association with treatments when disease outbreaks are rare.

9.1.3 Peer-reviewed and other published scientific literature

9.1.3.1 Peer-reviewed published scientific literature

The search results yielded 41 publications; four of these were identified for possible inclusion in addition to those peer-reviewed published papers that had been identified through the industry funded research review. On further assessment of these publications, the four papers were determined not to have relevant information on treatable syndromes or diseases that livestock face during sea voyages.

9.1.3.2 Other published scientific literature

Literature review of scientific research relating to livestock exports (Collins. T et al., 2018)

The recent literature review of the scientific research relating to animal health and welfare in livestock exports assesses the available published evidence of animal health issues.

> *This review found 184 literature items in total; including 105 peer-reviewed studies pertaining to animal health and welfare and the Australian live export industry, 6 theses, 9 conference papers, 3 book chapters, 2 books, 59 non-peer-reviewed industry reports and 3 procedural documents. The majority (84%) of literature was published since 2000. The review summarised the findings and appraised the quality of the evidence; each piece of literature was subjectively classified by quality of evidence, ranked as high (presents original data and peer-reviewed), moderate (presents original data but not peer-reviewed or does not present original data but is peer-reviewed) or low (does not present original data and is not peer-reviewed).*

Caution must be taken when reading this document. The literature appraisal was conducted in a non-standard way and placed much emphasis on the peer-review publishing process for providing validation of the results.

Additionally, this resource considers and describes all aspects of livestock exports not just sea voyages. The section on animal health and welfare during the sea voyage is brief and does not represent the full body of knowledge that exists within the literature. This paper also fails to recognise the changes that have occurred in the industry over time which have resulted in historical research not being representative of the industry today.

Frequency of major conditions or diseases that occur on vessels was not described.

The authors conclude: infectious diseases affecting cattle on ships are similar to, and carried on from, those in pre-export feedlots. Briefly, respiratory diseases are by far the greatest infectious mortality risk for export cattle on long sea voyages.

9.1.4 Cattle summary

This literature review into cattle expected major syndromes or disease aimed to identify the major expected syndromes or disease and focus on those conditions that are treatable with medications.

9.1.4.1 Cattle major expected syndrome or disease that are treatable with medications

Table 18 has been created from the information assessed in this literature review. It shows syndromes that are clinically recognisable and the relation to conclusions available from further diagnostic tests.

This is not intended to be a table of recommended syndromes and is intended to illustrate the current issues with syndrome definitions. Further determination of appropriate syndromes and definitions for use within the industry is needed.

Table 18: Cattle Clinical observable syndromes and further clarification of syndrome from further diagnostic procedure i.e. gross post-mortem

Clinically observable syndrome		**Syndrome after further diagnostic procedure**							
	Other terms	Bloat	Pneumonia BRD[25]	Hyperthermia	Ketosis	IBK[26]	Mastitis	Musculoskeletal injury	Infectious diarrhoea
Downer			X	X	X			X	
Enteric disease	Diarrhoea Bloat Scours	X							X
Eye Disease	Pinkeye					X			
Heat stress			X	X					
Illthrift	Inappetence Shy feeder		X						
Lameness	Swollen legs Knuckling		X		X			X	
Premature lactation							X		
Respiratory Disease	Nasal discharge Respiratory distress		X	X	X				
Sudden Death			X	X				X	
Trauma			X					X	

The major syndromes or diseases identified through this review for cattle are:

[25] Bovine respiratory disease
[26] Infectious bovine keratoconjunctivitis

9.1.5 Respiratory disease

Respiratory disease is likely the most frequently encountered disease related to mortality on livestock export sea voyages. This has been identified through multiple research reports.

The respiratory disease mortality frequency results from livestock exports correlate well with what is known in the Australian feedlot industry. We can extrapolate from this correlation that the morbidity estimates from Australian feedlots can reasonably be applied to livestock export sea voyages.

The timing of morbidities and mortalities in feedlots, after mixing of animals commenced, peak round 37 days; this may explain an underlying driver for heat stress mortality events that occur within this timeframe. Depending on the length of pre-export preparation required, 37 days after mixing may occur in the equatorial zone or other areas with high ambient temperature and/or high relative humidity.

The industry would benefit from further investigation of the possible underlying disease risk factors for individual animals recorded as dying from heat stress.

9.1.5.1 Musculoskeletal conditions and injuries

Musculoskeletal conditions and injuries are frequent on livestock export vessels. Treatment is important as pain or infection are often associated. It is important to consider that musculoskeletal conditions or injuries are often a precursor to other conditions that ultimately cause poor animal health outcomes. An example of this mechanism is the stress caused by the injury predisposes cattle to other illnesses through lowering the immune system's functionality.

9.1.6 Other syndromes or diseases

The following minor conditions or diseases are discussed due to their consideration for medication requirements or perception within the industry.

9.1.6.1 Eye disease

In livestock export this is often termed "pinkeye" as a general term for Infectious Bovine Keratoconjunctivitis (IBK). However, there are multiple underlying causes that can lead to outbreaks of eye disease including different viruses such Bovine Herpesvirus which can also cause Infectious Bovine Rhinotracheitis (IBR). Secondary bacterial infections can also occur and cause further disease of the eye. Corneal ulceration, temperature, and presence of nasal plaques can help to differentiate between the viral and bacterial causes. Antimicrobial treatment is indicated if a bacterial infection is present.

9.1.6.2 Heat stress

Heat stress has received a large amount of attention in recent years due to media exposure of events occurring with live sheep exports. Concerns exist with the historical recording of heat stress as there are no constant or specific histopathological changes associated with heat stroke (Radostits et al., 2000) and ruling out pneumonia or other underlying causes is complex.

9.1.6.3 Mastitis

The export of pregnant heifers has been associated with premature lactation and possible increase risk of mastitis. No specific treatment has been identified for premature lactations and conventional mastitis treatment is recommended where required and possible.

9.2 Sheep - expected major syndromes or disease

9.2.1 Key industry resources

Veterinary Handbook for Cattle, Sheep, & Goats (Jubb. T et al., 2019) and associated report Live Export Veterinary Disease Handbook (Perkins and Jubb, 2012)

The Veterinary Handbook outlines a large number of diseases and conditions including some that are rarely seen. Less common conditions were included for completeness because they are differential diagnoses for syndromes that have other, more common causes. It also states inclusion of less common diseases is to help users make accurate diagnoses for insurance, disease reporting and exotic disease exclusion purposes.

The major conditions that can cause increased mortality and that have triggered disease investigations in the past are identified in Table 4.2 of the handbook with an *. It can be seen from these major conditions along with their syndromes in Table 19, that diseases can have multiple syndromes and most syndromes have multiple disease. The frequency of syndromes or diseases in sheep exported by sea is not described in the Veterinary Handbook.

Table 19: Specific sheep and goat diseases and associated syndromes identified in the Veterinary Handbook that can cause an increase in mortality

Sheep/Goat - Specific Diseases in Handbook	Syndrome
Heat stress	Respiratory distress
	Sudden death
Inappetence/ inanition	Illthrift
Pneumonia	Respiratory distress
Pneumonic – emboli	Sudden death
Salmonellosis	Diarrhoea
	Illthrift
	Sudden death
Traumatic injury	Downer
	Knuckling
	Lameness

Live export - Best practice us of veterinary drugs (Rolls and Campbell, 2008)

This resource does not identify syndromes or diseases and frequency of occurrence.

LiveCorp Handbook for shipboard stockmen and veterinarians - Sheep and goats (Lightfoot, 2008)

Inanition and salmonellosis are identified as the two main causes of sheep and goat deaths at sea. Anecdotally, these two syndromes account for about 75% of shipboard mortalities. Other syndromes or disease identified in the text are pinkeye, pneumonia, foot abscess, and trauma.

9.2.2 Industry funded research reports

Investigating mortality in sheep and lambs exported through Adelaide and Portland (Makin et al., 2010)

This project provides information on the causes of death in live export sheep, the factors contributing to the risk of death, and it discusses if the risks of mortality for pastoral sheep and lambs during the May to October period are higher than for other classes of sheep.

This project collected 39 datasets from the pre-export preparation of sheep between September 2005 and June 2008. Shipboard mortality data was collected from 27 voyages during the same period.

It was found for mortalities with a diagnosis:

- enteritis and inanition accounted for over 76%
- enteritis 34.4%
- inanition 23.9%
- enteritis/inanition 18.2%
- heat stress accounted for 9.5%
- heat stress deaths were largely confined to two voyages that had heat stress events
- pneumonia accounted for 7.9%
- other causes accounted for 3.9%
- these included diseases such as cancer, intestinal catastrophes, liver and kidney disease, and systemic infections which are often pre-existing conditions unrelated to live export
- trauma, urinary and clostridial disease account for less than 2.5%.

It was discussed that pneumonia occurred sporadically and tended to occur towards the end of the voyage and was typically bacterial in appearance. The authors note: generic investigation of risk factors for mortality is difficult due to the low and variable incidence of mortality.

The finding that sheep from specific locations were more likely to die provides an opportunity for targeted investigation of disease risk factors and a means to evaluate the effectiveness of potential interventions. The results shown in Fig. 4 demonstrate the variation between the groups of animals and the syndrome or disease diagnosed as the cause of mortality.

Mortality in exported sheep and lambs from Adelaide and Portland

Figure 9.6 shows post-mortem diagnosis results by class. Included are post-mortems where a diagnosis was made.

Key - AW/BW/CW = A/B/C class weather, E = Ewe, L = Lamb, W = Wether (no class), PR = Pastoral Ram, PW = Pastoral Wether, R = Ram, YW = Young Wether

Figure 9-6 Post-mortem diagnosis by class. For each class the relative contribution (%) to diagnosed mortality of each of the major 6 diagnoses are shown

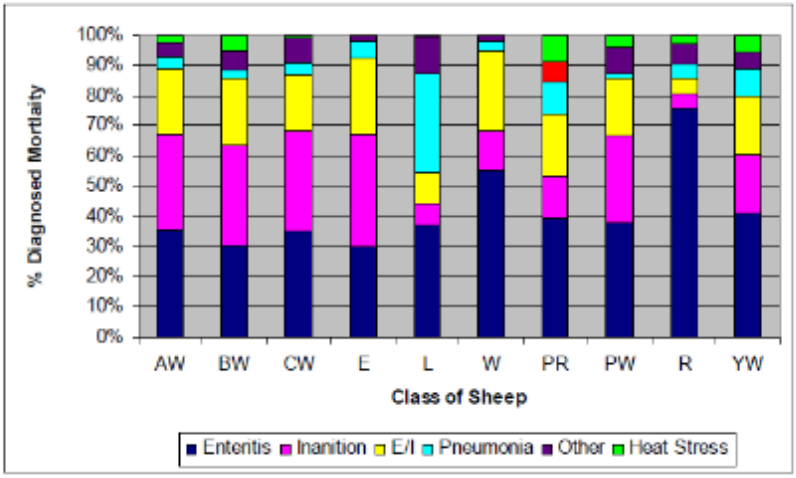

Fig. 4: Results showing syndromes or disease varies by the grouping of animals (Makin et al., 2010)

Another observation reported was that, during the 2000s, the demographic of the exported flock changed with more young sheep entering the trade than older heavy wethers. Because of this, inappetence and negative energy balance may no longer be the primary drivers of disease and mortality.

Factors identified as important drivers of disease in sheep exported by sea were the level of salmonella exposure and the animals' immunity. It is difficult to determine which disease process is occurring first, as the biological pathways are complex and the factors that affect the development of disease are continually fluctuating. Animals experimentally challenged with salmonella developed a fever, went off their feed, and developed diarrhoea within 36 – 48 hours. The interval following challenge to the onset of clinical signs is influenced by the salmonella serotype and challenge dose. Generally, the larger the challenge dose the shorter the interval; clinical signs peak between 3 – 7 days following the challenge and it is uncommon for animals to die after day 14.

The project experimentally challenged sheep with salmonella; from the results a greater understanding of the clinical course of the disease was obtained, and they concluded:

- with a 3-day pre-export period, the amount of disease observed at the registered premises will be minimal if the sheep were exposed to the organisms for the first time on arrival
- in these instances, the majority of the disease will be observed during the first 7 – 10 days of the voyage. However, exposure to salmonella will occur over a more prolonged period of time so the onset and duration of disease on the vessel will be more prolonged.

Temporal distributions from the start of the voyage for different syndromes can be seen in Fig. 5 (an extract from the research report).

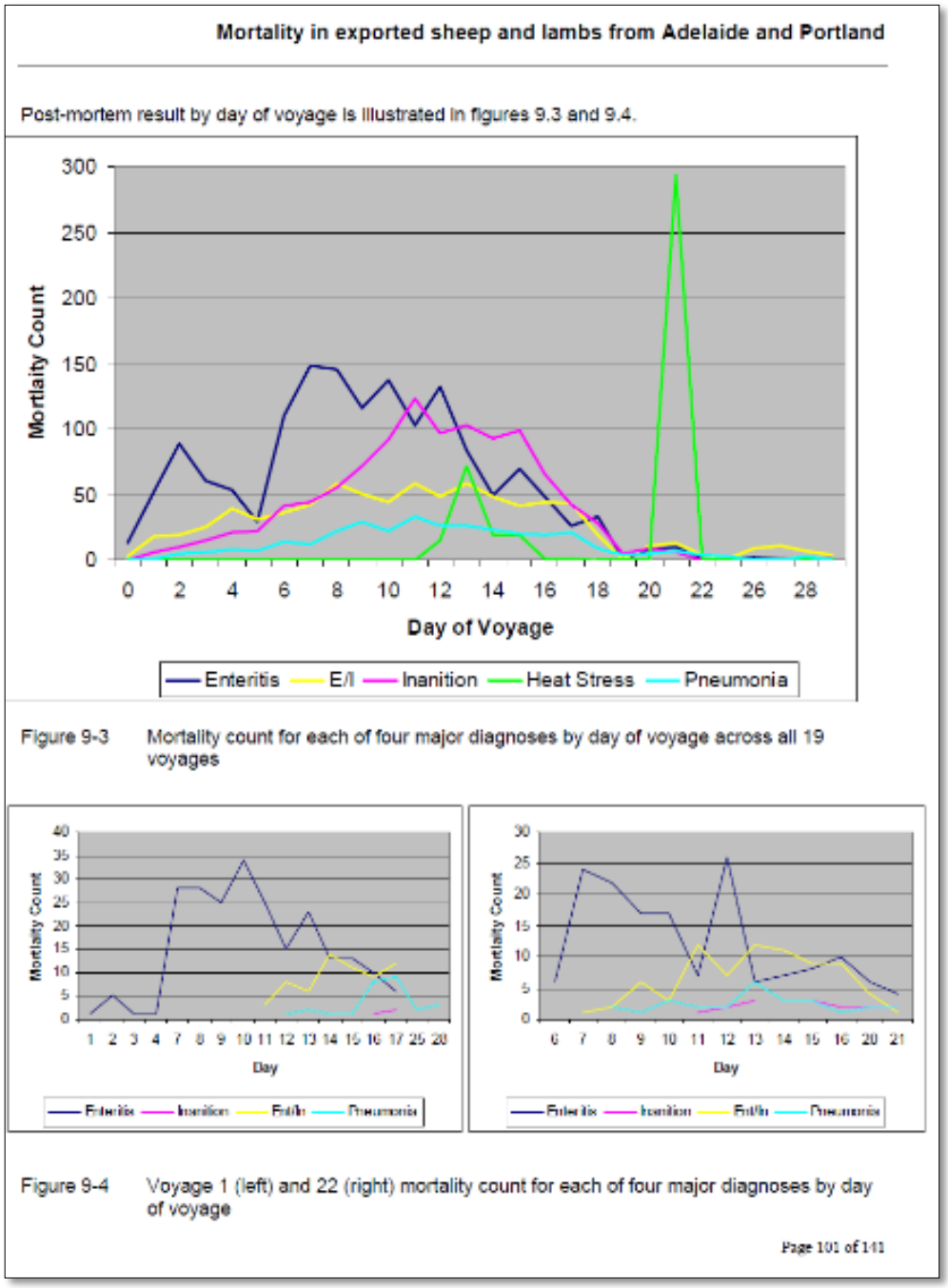

Fig. 5: Results showing temporal distributions of shipboard mortalities due to different syndromes (Makin et al., 2010)

A treatment trial for salmonella was conducted on one voyage; there was no statistical difference observed between the different treatment groups. The authors concluded that antibiotics in some form reduce the mortality rate of sheep with clinical signs of salmonella, recognised these results were from a limited trial, and suggested further shipboard investigation of therapeutic options is warranted for lines with clinical salmonellosis and high mortality.

Case definitions

The authors further discuss the importance and impact of *Case definitions.* The results of this study concluded mortality was primarily attributed to enteritis if a sheep was found to have reduced rumen fill (pellets) accompanied by signs of acute inflammation of the gastrointestinal tract. Discussions with Dr Tony Higgs (Department of Agriculture and Food, WA) suggest that in previous studies a similar sheep would have been classified as a primary case of inanition. The relative difference in the proportion of mortality attributed to salmonellosis and enteritis may in part reflect a difference in case definition.

In the appendices the author provides details along with images about mortality classification based on post-mortem examinations:

- The majority of enteritis diagnoses are associated with salmonella infection; infrequently, clostridial enteritis is also seen. Clostridial enteritis has similar gross changes to salmonella enteritis.
- Enteritis in sheep can be caused by a number of infectious agents including.
    - Salmonellosis
    - Clostridial disease
    - Yersiniosis
    - Johne's disease
    - Campylobacter
    - parasitic infections
- Inanition is characterised by low or absent rumen contents, poor body condition, and absence of other significant pathology (i.e., gross enteritis or pneumonia). The condition is characterised by a reduction in rumen solids (often the rumen contents are predominantly liquid), enlargement of the gall bladder is common and in fatter sheep, and it is not uncommon to see evidence of fat mobilisation and accumulation of fat in the liver.
- Enteritis/inanition: In this category a combination of the gross changes described under the enteritis and inanition categories is seen. Enteritis lesions may not be as severe and are often chronic. Rumen solids are typically low to moderate (rather than absent) and depletion of body stores is less severe. It is hypothesised in these cases, enteritis was the initiating disease which lead to inappetence and later inanition.
- Review of ASEL Scoping Study - Export of sheep from southern ports to the Middle East in winter months (Shiell et al., 2013)

Analysis within the report on major conditions or disease focused on information from reportable mortality events.

In summary: There were 13 reportable mortality investigations involving sheep voyages between 2006 and 2012. These reports involved voyages that included sheep loaded from all three major ports (Fremantle, Portland, and Adelaide). There were two major drivers of mortality identified in the investigations: enteritis or more broadly salmonella-inanition, and heat stress.

Salmonellosis control and best-practice in live sheep export feedlots – final report (Moore, 2002) - Salmonella

This report does not identify the frequency of occurrence. This report provides much information about the management of Salmonellosis in registered premises: however, treatments were not identified in the report.

The authors made recommendations that “antimicrobial agents should only be used during feedlotting under veterinary supervision.”

Sheep inanition (Barnes et al., 2008)

This report does not identify frequency of occurrence. This report provides much information about the management of inanition; the use of electrolytes and treatment with sea water were discussed but no firm conclusions are made. There were no medications identified for use.

Physiology of heat stress in cattle and sheep (Barnes et al., 2004)

The researchers concluded that, even if sheep are subject to high heat and humidity there is no indication for electrolyte supplementation to sheep that are eating and drinking. The usefulness of supplements for sheep subject to other stressors, and in situations where they are not eating, should be investigated.

Antibiotic medication for the treatment of Infectious Ovine Keratoconjunctivitis (IOK) in pre-export feedlots. The pharmacology and clinical efficacy of in-water and in-feed oxytetracycline. (Murdoch and Laurence, 2014) & (Murdoch, 2016)

From this study, eye disease is estimated to be the cause of 0.5% of rejections at a sheep pre-export feedlot in Western Australia.

There were limited treatments trialled during the research; the only antibiotics considered were various forms of oxytetracycline and topical cloxacillin.

The report concludes the greatest clinical improvement was obtained when sheep with clinical signs of IOK were treated:

- with long-acting oxytetracycline injected into the neck muscle at a dose of 20mg/kg bodyweight
- with a second injection at the same dose rate if clinical signs were still present after 4 days.

9.2.3 Peer-reviewed and other published scientific literature

9.2.3.1 Peer-reviewed published scientific literature

The search results yielded 41 publications. Four of these were identified for possible inclusion in addition to those peer-reviewed published papers that had been identified through the industry funded research review. On further assessment of these four papers were determined not to have relevant information on treatable syndromes or diseases that livestock face during sea voyages.

9.2.3.2 Other published scientific literature

Literature review of scientific research relating to livestock exports (Collins. T et al., 2018)

The section on animal health and welfare during the sea voyage is brief and does not represent the full body of knowledge that exists in the literature and the changes that have occurred within the industry over time. These changes have resulted with some diseases decreasing in prevalence and becoming less important within the industry.

Caution must be taken when reading this document. The literature appraisal was conducted in a non-standard way and placed much emphasis on the peer-review publishing process for providing validation of the results.

Additionally, this resource considers and describes all aspects of livestock exports not just sea voyages. The section on animal health and welfare during the sea voyage is brief and does not represent the full body of knowledge that exists within the literature. This paper also fails to recognise the changes that have occurred in the industry over time which have resulted in historical research not being representative of the industry today.

Frequency of major conditions or diseases that occur on vessels was not described.

The authors conclude: infectious diseases affecting sheep on export vessels are similar to, and carried on from, those in pre-export feedlots. Briefly, the combination of inappetence and Salmonella infection ('inanition') is the greatest infectious risk for sheep on sea voyages.

Inappetence in sheep can lead to animal mortalities on livestock export vessels through the syndrome of inanition (see section 3.4.2 of their report). A variety of approaches have been trialled to mitigate this effect, but it remains problematic (Barnes et al. 2008b). For example, preferential feeding management of inappetent sheep on ships (Norris et al. 1990) has been shown to be ineffective at stimulating feed intake in persistently inappetent sheep.

9.2.4 Sheep summary

This literature review aimed to identify the major expected syndromes or diseases and focus on those conditions that are treatable with medications.

9.2.4.1 Sheep major expected syndrome or disease that are treatable with medications

Table 18 has been created from the information assessed in this literature review. It shows syndromes that are clinically recognisable and the relation to conclusions available from further diagnostic tests.

This is not intended to be a table of recommended syndromes and is intended to illustrate the current issues with syndrome definitions. Further determination of appropriate syndromes and definitions for use within the industry is needed.

Table 20: Sheep -Clinical observable syndromes and further clarification of syndrome from further diagnostic procedure i.e. gross post-mortem

Clinically observable syndrome		Syndrome after further diagnostic procedure							
	Other terms	Bloat	Pneumonia	Hyperthermia	Ketosis	IOK*	Mastitis	Musculoskeletal injury	Infectious diarrhoea
Downer			X	X	X			X	X
Enteric disease	Diarrhoea Bloat Scours	X							X
Eye Disease	Pinkeye					X			
Heat stress			X	X					
Illthrift	Inappetence Inanition Shy feeder		X	X	X				
Lameness	Swollen legs Knuckling Shearing injuries		X					X	
Respiratory Disease	Nasal discharge Respiratory distress		X	X	X				
Sudden Death			X	X				X	
Trauma								X	

The available literature which describes the frequency of syndromes or diseases for sheep exported by sea is limited and somewhat outdated.

There have also been many changes by industry along with many regulatory changes by government since mid-2018. Generally, these changes have resulted in an increase in space allowance for sheep and restricted voyages from departing Australia during the northern summer. These changes have seen the average mortality decline to 0.25% (Australian government, 2020e); while this is not a complete measure of animal risk, it is acknowledged that the industry changes have resulted in fewer sheep being exported and fewer overall mortalities.

Anecdotally, these regulatory changes along with industry changes in the selection of animals and pre-export preparation may have resolved some of the key underlying risk factors for the inanition/enteritis complex. The reporting of morbidity or mortalities due this complex have declined significantly; current mortality rates

* Infectious ovine keratoconjunctivitis (IOK)

around 0.25% (Norman, 2019) indicate that the previous major diseases are now occurring at low frequency and it is possible they are now not the diseases of interest.

Anecdotal reports also indicate very few medication treatments are being conducted on board as there are very few animals requiring treatment. The mortality percentages go some way to supporting this.

It remains unclear what predisposes some sheep to having a lower tolerance to heat stress and therefore are more likely to die during heat stress events. If there are underlying causes which predispose sheep to poorer outcomes during heat stress events, risk mitigation for heat stress should include prevention and treatment of these causes. Additionally, having good information on these likely underlying causes is important to ensuring appropriate medication is selected.

Identifying the major expected syndromes or diseases of sheep during sea voyages is difficult due to the current low rates of mortalities, reported low morbidity rates, the lack of knowledge about possible underlying causes of heat stress, and the lack of good case definition. The major syndromes or diseases identified through this review for sheep are:

9.2.4.2 Musculoskeletal conditions and injuries

Musculoskeletal conditions and injuries are frequent on livestock export vessels. Treatment is important as pain or infection are often associated. It is important to consider that musculoskeletal conditions or injuries are often a precursor to other conditions that ultimately cause poor animal health outcomes. An example of this mechanism is the stress caused by the injury predisposes sheep to other illnesses through lowering the immune system's functionality.

9.3 Mortality summaries literature review

9.3.1 Industry funded research reports

National livestock export industry sheep, cattle and goat transport performance report 2018 (Norman, 2019)

This report considers voyages that involved loading at multiple Australian ports (split-load voyages) and discharge at multiple destination ports, as separate "voyages" although they might be on the same ship. As mentioned previously, the difference in reporting of voyage and consignment data along with the different definition of a voyage (split-load) makes it difficult to understand what is occurring at a ship level.

Although simple percentage mortality rates are limited in usage, this report provides some context through presenting historical information. From the report, Fig. 6, shows the percentage of cattle, goats, and sheep delivered to the destination from those loaded in Australia. While this figure does not demonstrate the change in volume of animals exported over time, it can be seen as a crude measure that demonstrates continual improvement in the delivery percentage.

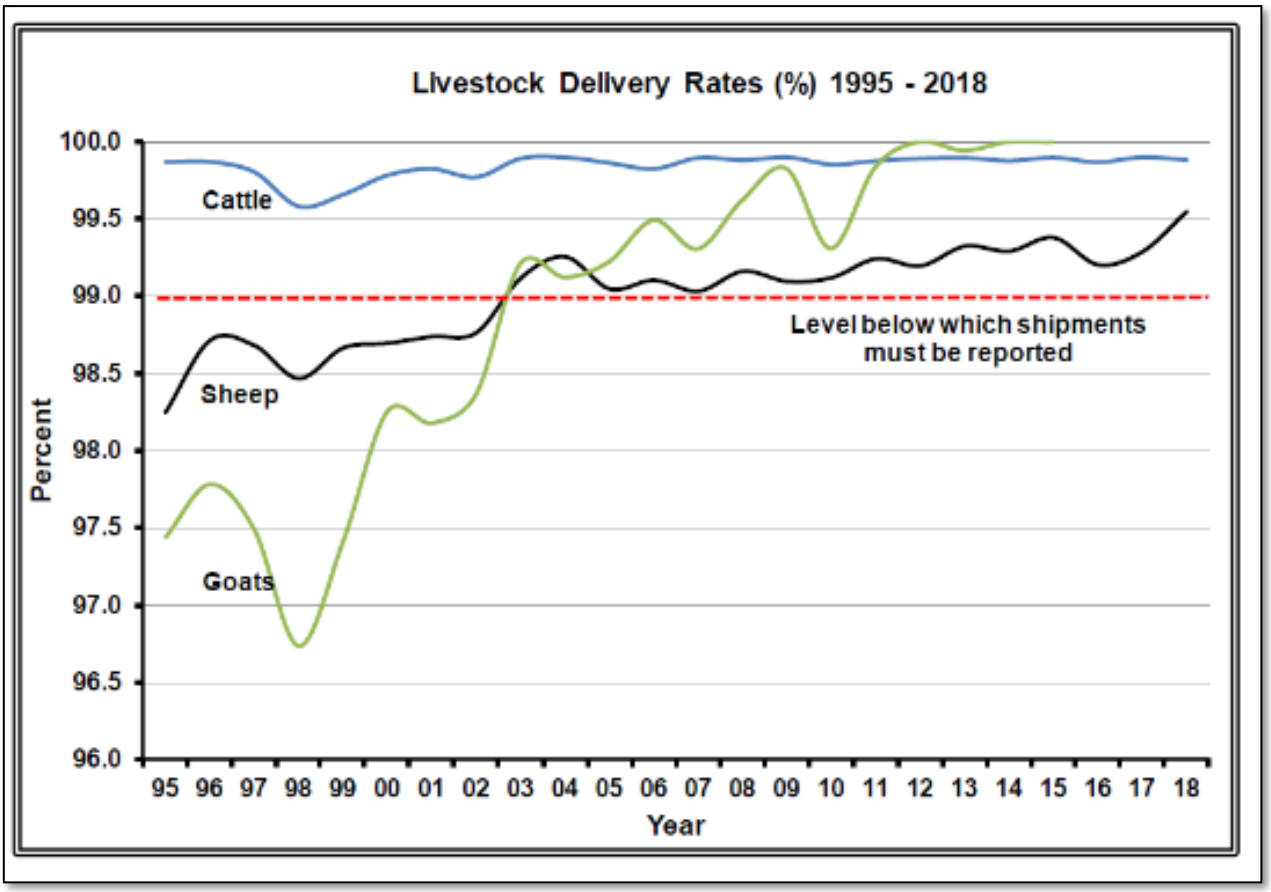

Fig. 6: Livestock delivery percentage by year (Norman, 2019)

Relevant summary information provided for 2018:

- cattle exported by sea transport recorded 1,327 mortalities from 1,120,000 cattle exported
- sheep exported by sea transport recorded 5,202 mortalities from 1,140,000 sheep exported.

A major limitation to understanding this data is that different voyage lengths are not accounted for in simple mortality percentages. A mortality incident risk should be calculated to further understand which voyages pose a higher risk to animal health; mitigation strategies can be then be focussed on these situations.

In summary for 2018:

- there were 34 sheep voyages with an average voyage length of 18 days and a sheep mortality percentage of 0.46%
- there were 365 cattle voyages, including 83 (23%) voyages with no mortalities, an average voyage length of 10.6 days and a cattle mortality percentage of 0.12%.

9.3.2 Cattle mortality summaries

Review of ASEL - Appendix B Analysis of cattle export data (Shiell et al., 2014)

Within the Review of ASEL the authors summarised the previous six years of mortality data and reportable mortality event investigations. Of the 20 voyages that had a reportable mortality event involving cattle between 2006 and 2011, the major findings were:

- pneumonia or other respiratory disease was the identified cause in 6/20 (30%) events
- injuries and downer animals, perhaps exacerbated by rough weather, was the identified cause in 6/20 (30%).
- heat stress was the identified cause in 3/20 (15%) - 2 long haul voyages and 1 short haul voyage
- 10/20 (50%) events involved trips to Indonesia and 10/20 (50%) events occurred on voyages fewer than 10 days in duration.

A number of recommendations were identified from the department's mortality investigation reports and related to:

- understanding causal factors for respiratory disease and improving
    - prevention - vaccination and animal selection
    - treatment - antibiotic and other treatments
    - care on board - having veterinarians accompany more shipments
    - collection of better records of morbidity and mortalities.
- Analysis of mortality data from Reports to Parliament for voyages from 2006 to 2012 found:
- there was little difference in the mortality rate between voyages to South East Asia and other destinations
- the lowest mortality rates were seen on ships carrying mid-level numbers of cattle (1,000 to 5,000 cattle. Of these, shipments that carried mixed species had higher mortality rates than those ships that carried cattle only
- higher mortality rates with either fewer than 1000 or greater than 5000 cattle
- southern ports had a higher mortality rate than northern ports in Australia
- voyages loading cattle from southern ports and travelling to SE Asia had a higher likelihood of experiencing a mortality event compared to voyages loading cattle from the north and travelling to SE Asia
- there was little evidence for a seasonal pattern in mortality rates in voyages to the Middle East
- there was some evidence for a seasonal pattern in mortalities for voyages travelling to SE Asia.

Investigating causes of mortality in live export cattle - PhD thesis (Moore et al., 2014)

In this PhD thesis associated with MLA project *Identifying the causes of mortality in cattle exported to the Middle East* (Perkins et al., 2015a) a retrospective data analysis for sea voyages was conducted. Data for the period between January 1995 and December 2012 was obtained from the Shipboard Mortality Database (SMDB) which is funded by Meat & Livestock Australia and administered by the Department of Agriculture and Food, Western Australia.

Conclusion from the analysis included the following relevant points:

- the overall voyage mortality percentage across the 13 million cattle exported on 6,447 voyages was 0.17%
- 46.2% of cattle voyages had no mortalities
- cattle mortality rates decreased significantly after 2000 and stabilised at low levels from 2003
- cattle mortality rates on voyages to the Middle East and North Africa (0.44%) were significantly higher than for South East Europe (0.28%), North East Asia (0.12%) and South East Asia (0.09%)
- cattle exported from ports in southern Australia carry a higher mortality risk than those exported from northern ports for both long- and short-haul voyages
- the daily mortality rate peaks at 3-4 weeks post departure.

Fig. 7 shows the historical changes that have occurred within the industry and the general reduction in incident risk of mortalities per 1000 animal days at an annual level.

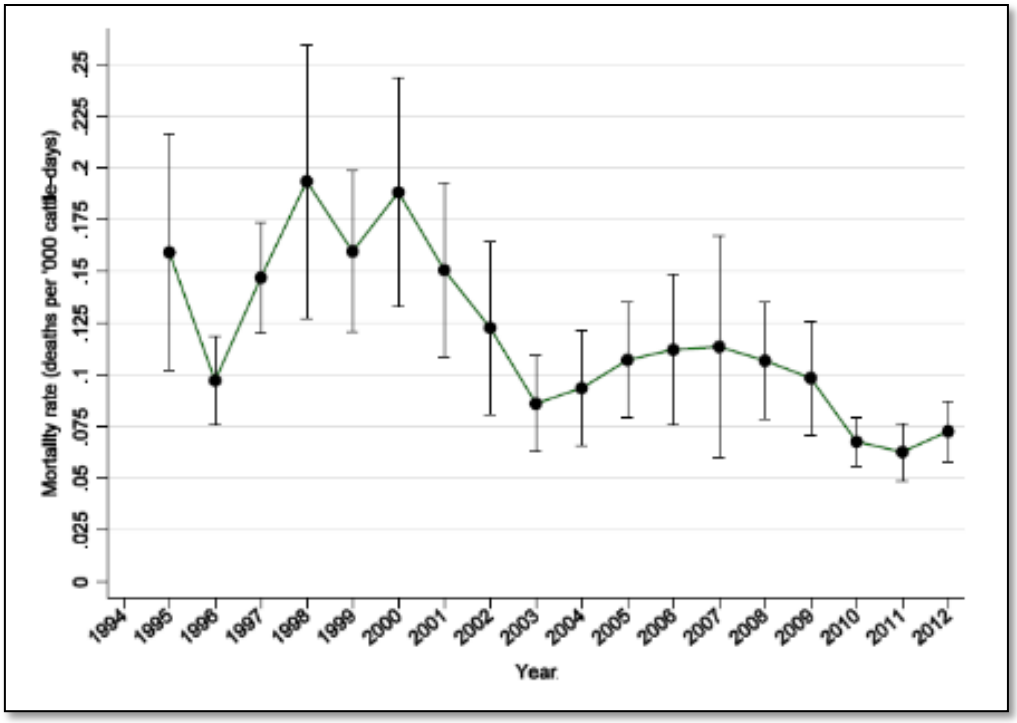

Fig. 7: Average annual voyage mortality incident rate for live export cattle voyages from Australia between 1995 and 2012 by year. Bars represent 95% confidence intervals. [Figure 6.2] (Moore, 2014)

Fig. 8 shows the mortality incident risk by month and periods of years together again showing the continual reduction in incident risk of mortalities.

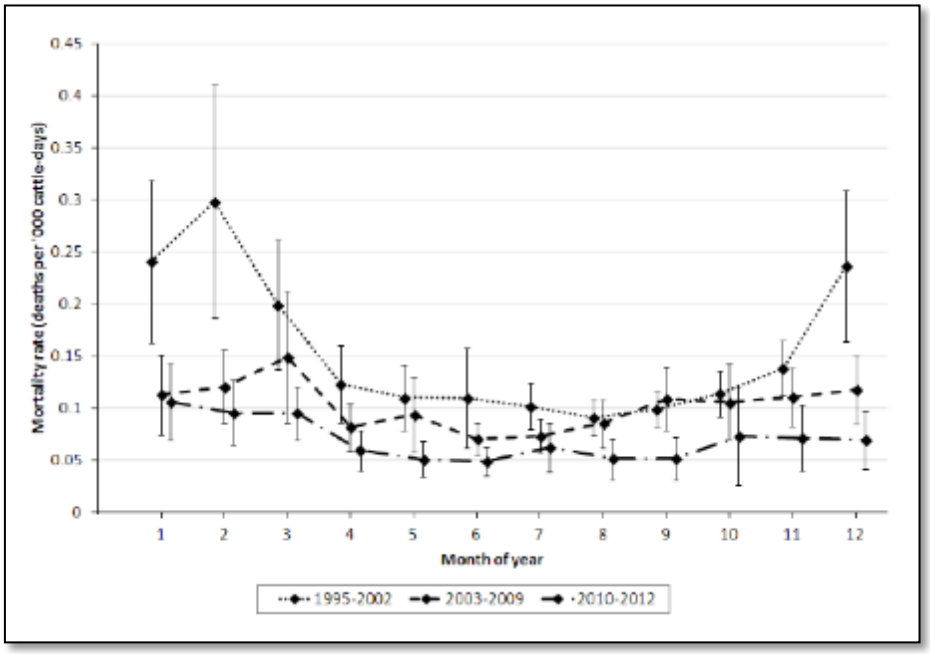

Fig. 8: Average monthly voyage incident mortality rate for live export cattle voyages from Australia between 1995 and 2012 by year period. Bars represent 95% confidence intervals [Figure 6.3] (Moore, 2014)

9.3.3 Sheep mortality summaries

Review of ASEL Scoping Study - Export of sheep from southern ports to the Middle East in winter months (Shiell et al., 2013)

Within this scoping study the authors summarised the previous five years of mortality data and reportable mortality event investigations. There were 13 investigation reports involving deaths in sheep exported by sea from southern ports between 2006 and 2011.

The major findings were:

- investigation reports did not contain the same level of detail
- the major causes of deaths were heat stress and enteritis
    - in most cases where enteritis occurred it was associated with deaths that were attributed to enteritis alone, enteritis in combination with inanition, and inanition alone
    - in some cases, the voyage reports indicated that those decks and pens where deaths had occurred from enteritis were then hard hit by heat stress. However, there were instances where deaths due to heat stress were not preceded by any evidence of prior illness or deaths from other causes
- deaths due to heat stress appeared to follow cumulative exposure to hot conditions (often several days in a row), around the period when vessels are in the Gulf region and in some cases associated with unloading.

A number of recommendations were identified from the department's mortality investigation reports and related to:

- for infectious diseases such as enteritis (likely caused by Salmonella organisms), the measures included:
    - prompt removal of dead animals from pens
    - isolation of sick animals by moving them to hospital pens
    - regular cleaning of feed and water troughs
    - clinically affected animals were provided with chaff to promote feed and water consumption
    - administration of antibiotic (oxytetracycline) to affected animals either in the water or by injection
- heat stress, reports indicated that on-board management may include moving sheep to utilise as much space as possible on the ship
    - in several cases and most notably when heat stress was considered to be a cause of mortalities, the actions included requiring the exporter to assign additional space to sheep on the next consignment
- additional antibiotics were required to be loaded.
- Analysis of mortality data from Reports to Parliament for voyages from 2006-2012 found:
- An overall pattern displayed by the average line which suggests a low mortality rate in the first four months of the year, followed by a gradual rise to a peak in August, and then a gradual decline between August and December
- Overall monthly voyage mortalities remain above 1% until after October.
- The authors provide a long discussion on gaps in the current standards, the main points are:
- additional value to national summary statistics would be provided by
- improved reporting of mortalities at the consignment level
- improved reporting of mortalities by key categories of cause of death
- a review of options is needed for identification and management of sheep that may be clinically affected with salmonellosis or posing exposure risk to other sheep while on the ship, in order to minimise adverse welfare outcomes in both the affected and unaffected sheep
- it should be possible to use existing resources to develop a brief manual on how to differentiate the major causes of death in export livestock by gross post mortem so that on-board veterinarians and stockpersons can better diagnose major conditions without having to meet import requirements to bring samples back into Australia for pathology examination.

9.4 Medications - Operational constraints

9.4.1 Key industry resources

Veterinary Handbook for Cattle, Sheep, & Goats (Jubb. T et al., 2019) and associated report Live *Export Veterinary Disease Handbook (Perkins and Jubb, 2012)*

The handbook has information on many syndromes and diseases that can occur in livestock export process. Treatments are identified within most disease sections. Operational constraints that impact the treatment of animals are not specifically discussed within this resource.

However, section 8 - Decision making for seriously sick or injured livestock, gives a good discussion on the broad considerations that are needed when managing sick or injured animals. These include:

- animal welfare and risk to other animals
- accuracy of diagnosis
- stage of disease
- ability to treat and nurse effectively and safely
- likelihood of recovery
- time for recovery before discharge
- withholding periods
- rejection by importing country
- value of diagnostic information obtained from post-mortem
- opportunity cost of treatment
- insurance
- risk to other animals
- risk to human

The options available for on-board staff include monitor, treat and monitor, or euthanise.

Live export - Best practice use of veterinary drugs (Rolls and Campbell, 2008)

Operational constraints that impact the treatment of animals are not specifically discussed within this resource. However, aspects of these can be found within some sections.

For example, ease of treatment is considered when assessing what course of action to take with a sick animal that needs parenteral treatment.

- if the animal is quiet and the facilities allow repeat handling that is safe and without undue stress, a short-acting antibiotic is generally preferred. However, if the animal is not quiet, or the facilities do not allow daily treatment that is safe and involves minimal stress, a long-acting preparation is generally recommended

This resource discusses different aspects of what is needs to be considered when using medications within the livestock export industry, such as:

- responsible drug use
- Australian registered veterinary medicines
- storage of medicines
- authority of use
- withholding periods and export slaughter intervals
- off-label use
- human use of veterinary medicines
- inventory control
- record keeping
- disposal of medicines

Some of the principles of Antimicrobial Stewardship are covered in the treatment check list. Further specific discussion can be found on the use of injectable antibiotics versus oral (in-water or in-feed) antibiotics.

The authors summarise:

- if antibiotics are required, they should be given by injection rather than orally in the feed or drinking water. There are good reasons for not using oral antibiotics:
    - oral antibiotics disrupt the bacterial flora in the rumen
    - apart from disrupting digestion, oral antibiotics can increase the risk of disease. For example, many strains of salmonella bacteria are resistant to oxytetracycline. Putting oxytetracycline in the feed or water increases the risk of salmonellosis by knocking out competing bacteria and allowing salmonella to grow more freely.
    - animals that are sick and in need of antibiotics often have a depressed appetite and may not drink much, so they do not get an effective dose of antibiotic when administered via feed or drinking water. By contrast, the animal is certain to get a full dose of any antibiotic given by injection.
    - unless there is a header tank system designed for drug administration, putting antibiotics in the drinking water is very hit and miss. If an antibiotic powder or pre-mixed concentrate is added to individual troughs, the first livestock to drink may get many times the recommended dose, with the concentration of antibiotic getting progressively less with dilution as the trough re-fills with water.
- There are only two circumstances where mass oral medication with antibiotics is the treatment of choice:
    - outbreak of pneumonia, where antibiotic treatment can make the difference between death and survival, but individual treatment of a large number of animals presents logistical difficulties and may be stressful for the animals involved. Mass medication should not be undertaken unless a firm diagnosis of pneumonia has been established and the affected group has been clearly defined. Oxytetracycline is the drug of choice. Treatment should be limited to the sheep and goats at risk
    - outbreak of coccidiosis in goats, where sulphonamides in the water can be used to good effect.

Stockman's Handbook Transport of Cattle by Sea Short & Long Haul Voyages (Ainsworth, 2008)

This resource gives much more insight and information on the practical operations issues that occur on ships. However, operational constraints that impact the treatment of animals are not specifically discussed.

LiveCorp Handbook for shipboard stockmen and veterinarians - Sheep and goats (Lightfoot, 2008)

Operational constraints that impact the treatment of animals are not specifically discussed. However, aspects of these can be found within some sections. The main constraints that are raised are the difficulties in treating a large number of sheep or goats if an outbreak of disease occurs. These include:

- impractical to catch large numbers of sheep for individual treatment and attempting to do so can be quite stressful on the pen as a whole
- treatment of clinical cases requires intensive fluid therapy, which is not practical on a large scale and has a low success rate
- antibiotics are sometimes put in the drinking water of affected pens as a preventive measure. This makes the crew feel that they are doing something. There is little evidence that blanket antibiotic treatment is of benefit, and there is compelling evidence that oral antibiotics disrupt the rumen flora in otherwise healthy sheep or goats in the pen.

Some related advice is given on medication such as

- availability of drugs
- storage of drugs
- do not use suspect drugs
- directions of use.

Some of the principles of Antimicrobial Stewardship are covered in the advice: Before administering a treatment, consider the following:

- Is treatment really necessary?
- Are there likely to be any adverse side effects?
- Will treated animals get an effective dose?
- Is there a shorter-acting alternative?

10 Appendix 2 – Livestock export data analysis

Different departmental sources of data result in quite different totals for animals exported within a calendar year. A level of caution should be taken when assessing the complete analysis presented below as there is no clear denominator to use when determining performance measures.

10.1 Departmental mortality investigation reports

As identified in 2013 (Shiell et al., 2013), the department mortality investigation reports do not all contain the same level of detail. Between December 2013 and 2019 there were 35 notifiable mortality investigation reports published by the department. Table 21 provides a summary of destination country, species, and presence of an AAV on the vessel.

Table 21: Summary information of notifiable mortality investigation reports for destination and species

Country	Buffalo		Cattle		Sheep	
	Consignments	AAV on board	Consignments	AAV on board	Consignments	AAV on board
Brunei			1	1		
China			4	4		
Indonesia	1		1			
Japan			4			
Malaysia	1					
Middle East North Africa			1*	1	5*	5
Mexico			1	1		
Philippines			2			
Thailand			1			
Vietnam	5		7	1		
Total	8	0	22	8	5	5

*- combined notifiable incident investigation was conducted into both cattle and sheep consignments on the voyage

Buffalo mortality investigation reports were reviewed but there was little information available relevant to this review for medications.

Table 22 provides a summary of the conditions described or mentioned in the notifiable mortality investigation reports by species and for cattle if an AAV was present on board.

Table 22: Conditions reported or mentioned in the investigation report

Reported syndromes during mortality event	Cattle		Sheep
	AAV (8 voyages)	Stockperson (14 voyages)	AAV (5 voyages)
Downer		1	
Enteric disease	2	1	4
Eye Disease	1	4	1
Heat stress	3	2	3
Illthrift			1
Lameness	1	3	
Premature lactation			
Respiratory Disease	5	11	3
Sudden Death			
Injury/Trauma	2	6	2

There was no treatment information provided for any sheep voyages.

There was some level of animal treatment information included in the notifiable mortality investigation reports for cattle. In summary for cattle:

- antibiotics information was available in 11/22 (50%) notifiable investigations reports
    - 5 out of 8 cattle voyages when an AAV was present
    - 6 out of 14 cattle voyages when only stockpersons were on board
- median percentage of animals treated with antibiotics on voyages with information was 3.3% (minimum of 0.4% and maximum of 12.4%)
- anti-inflammatories antibiotics information was available in 4/22 (18%) notifiable investigations reports
    - 2 out of 8 cattle voyages when an AAV was present
    - 2 out of 14 cattle voyages when only stockpersons were on board
- percentage of animals treated with anti-inflammatories was 0.1, 0.4, 0.7 and 3%
- the department only required an increase in medication to be loaded after one mortality investigation; the notifiable voyage did not have an AAV on board.

AAVs were on 13/35 (37%) voyages that underwent a mortality investigation. It seems the departmental purpose of requiring AAVs on higher risk voyages to mitigate animal welfare risk has been successful. This can be concluded because AAV's are estimated to be on-board 20% of voyages, whereas AAV's were on-board 37% of the voyages which had a mortality investigation report conducted. AAV's were more likely to be on voyages which had a mortality investigation than on voyages which did not.

10.2 Reports to Parliament

Data for 2016 to 2019 (8 datasets) was downloaded from the department's website. Standardisation of data, such as ensuring consistently named header rows, was conducted in Excel for each dataset. Stata was used to amended datasets and perform calculations for measures such as mortality incidence rate.

This dataset provides data at shipment level; more than one consignment can be on a ship's voyage. This data was used to help identify if there have been changes in recent years that indicate previous research may no longer be relevant. The following measures were determined:

- changes over time in the number of shipments
- changes over time in the duration of voyages
- changes over time in the mortality incidence risk by species and departure date
- differences between voyages that have had a mortality investigation conducted and voyages that were not investigated.

The destination information in this dataset is not immediately useful as it lists destination by the port name only and all destination ports for a voyage are listed together in one variable.

None of the distributions for voyage duration (Fig. 9), animals loaded per voyage (Fig. 10), or mortality incidence rate (Fig. 11) are close to being normally distributed. In these situations, using the mean as a measure of central tendency cannot be justified. Use of the median to describe the central tendency will be a better measure as it will provide a more representative measure of the dataset. Another solution to deal with non-normally distributed data is to transform the data but understanding and communicating the results become more difficult. For these reasons, the report will focus on medians to describe central tendency of the data.

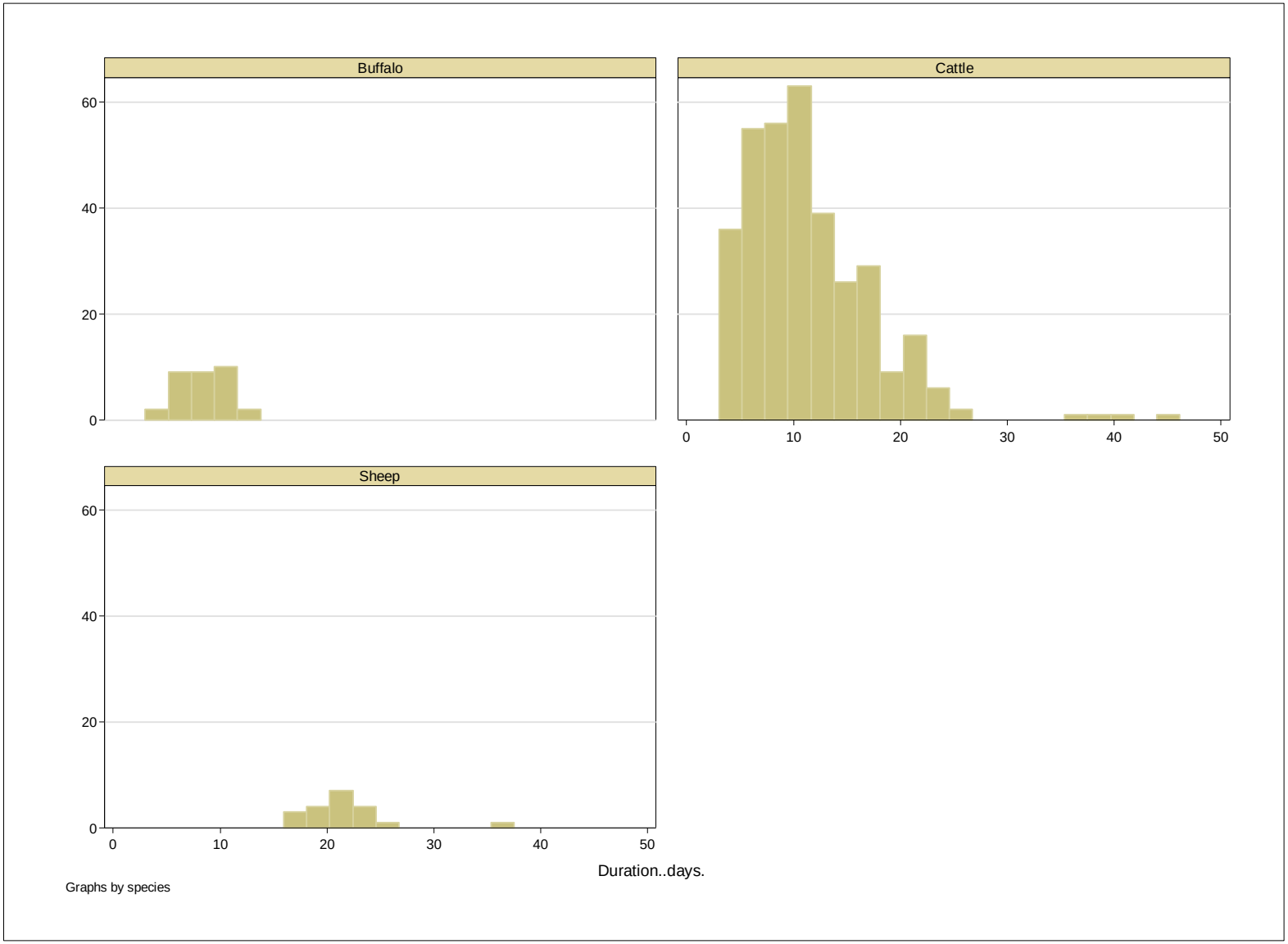

Fig. 9: Duration of voyages in 2019 by species

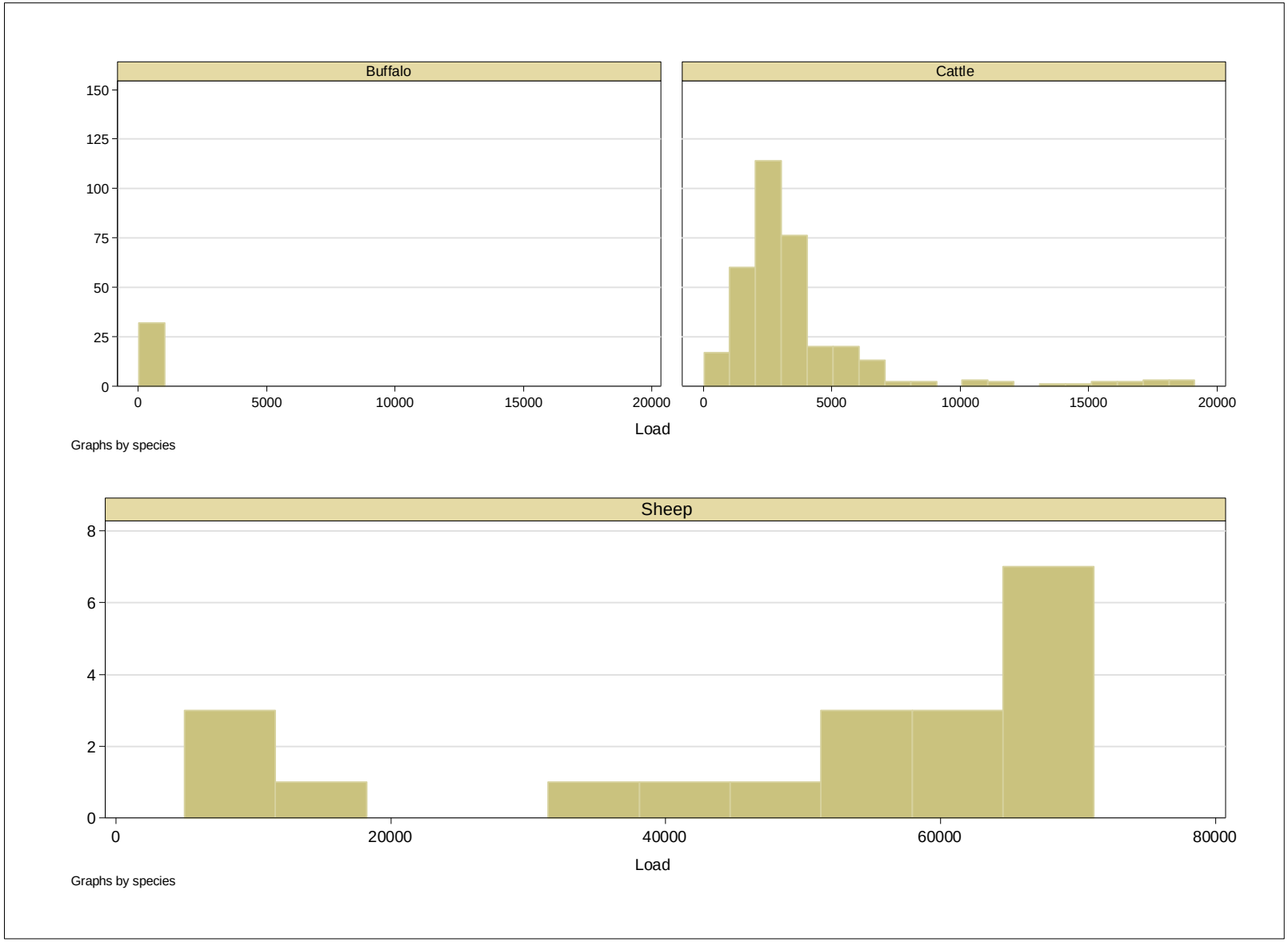

Fig. 10: Distribution of animals loaded per ship in 2019 by species

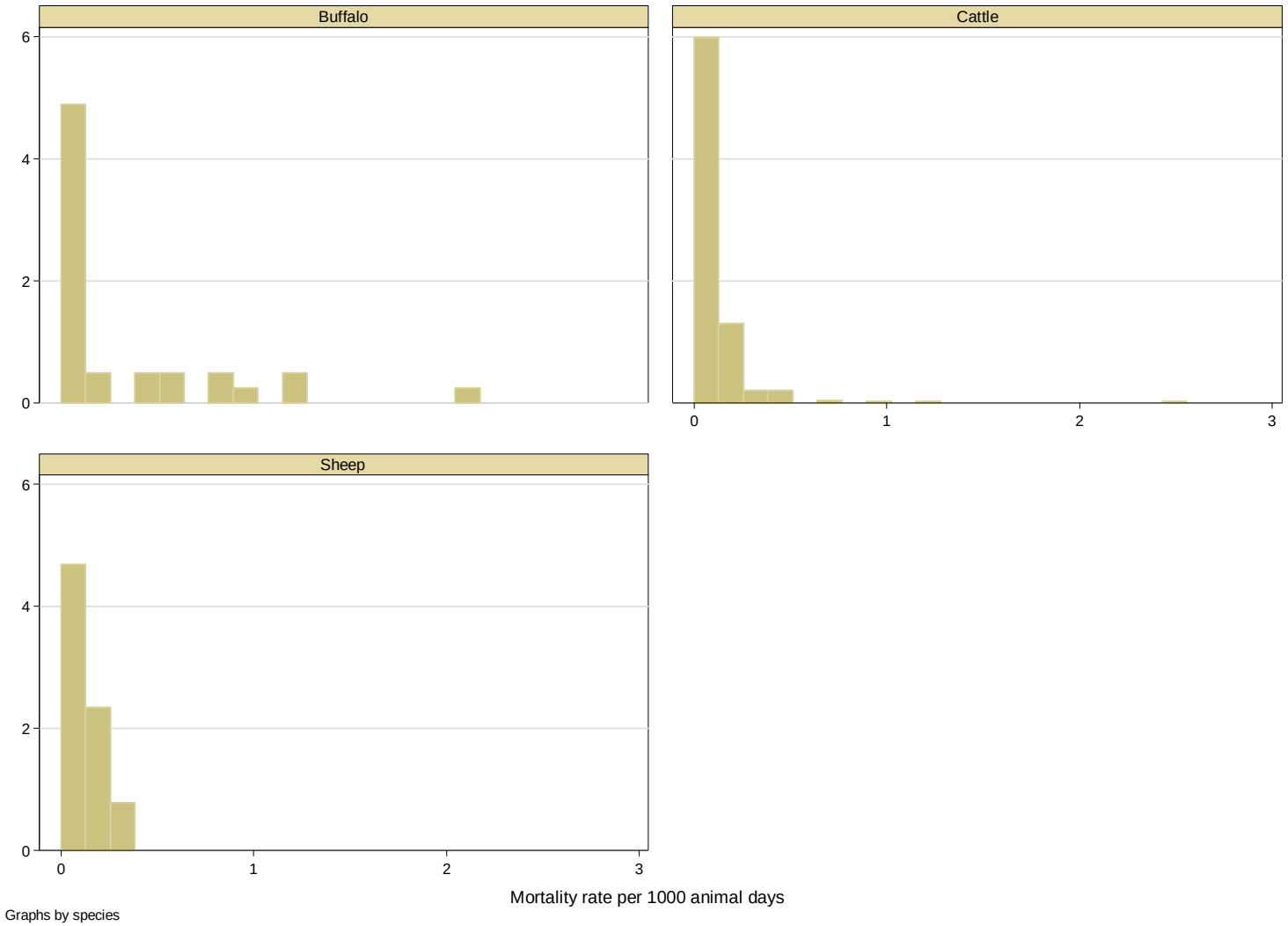

Fig. 11: Mortality incidence rate (1000 animal days) for 2019 by species

Box plots are a useful way to visualise non-normally distributed data. Fig. 12 describes the attributes that are associated with box plots to help understand the box plot graphs used further within this report.

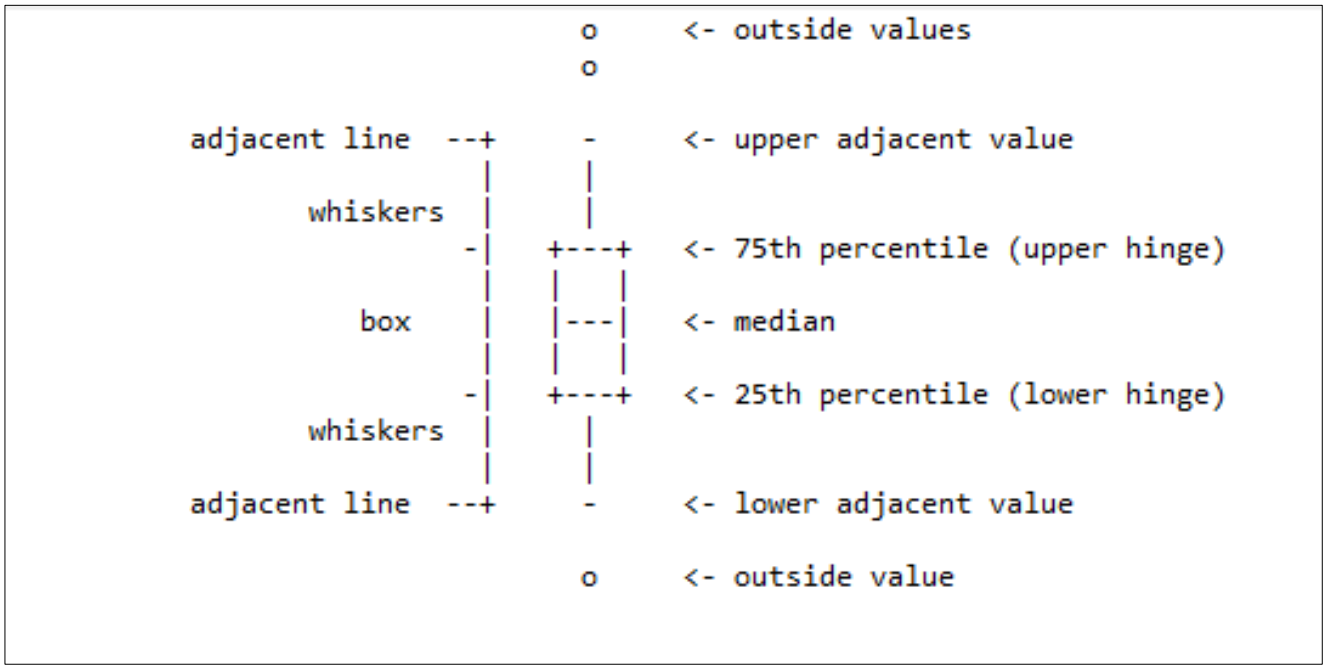

Fig. 12: Box plot explanation

Fig. 13 shows the distribution of the mortality incidence rate for each year, species, and by mortality investigation using box plots. It can be seen that cattle have consistently had a low mortality incidence rate across all years. Sheep exports have seen a consistent decline each year in the mortality incidence rate from 2016 to 2019.

Voyages that had a mortality investigation report generally had a much higher mortality incidence rate yet some voyages that had an investigation mortality report had an incidence rate similar or below voyages that did not have an investigation report.

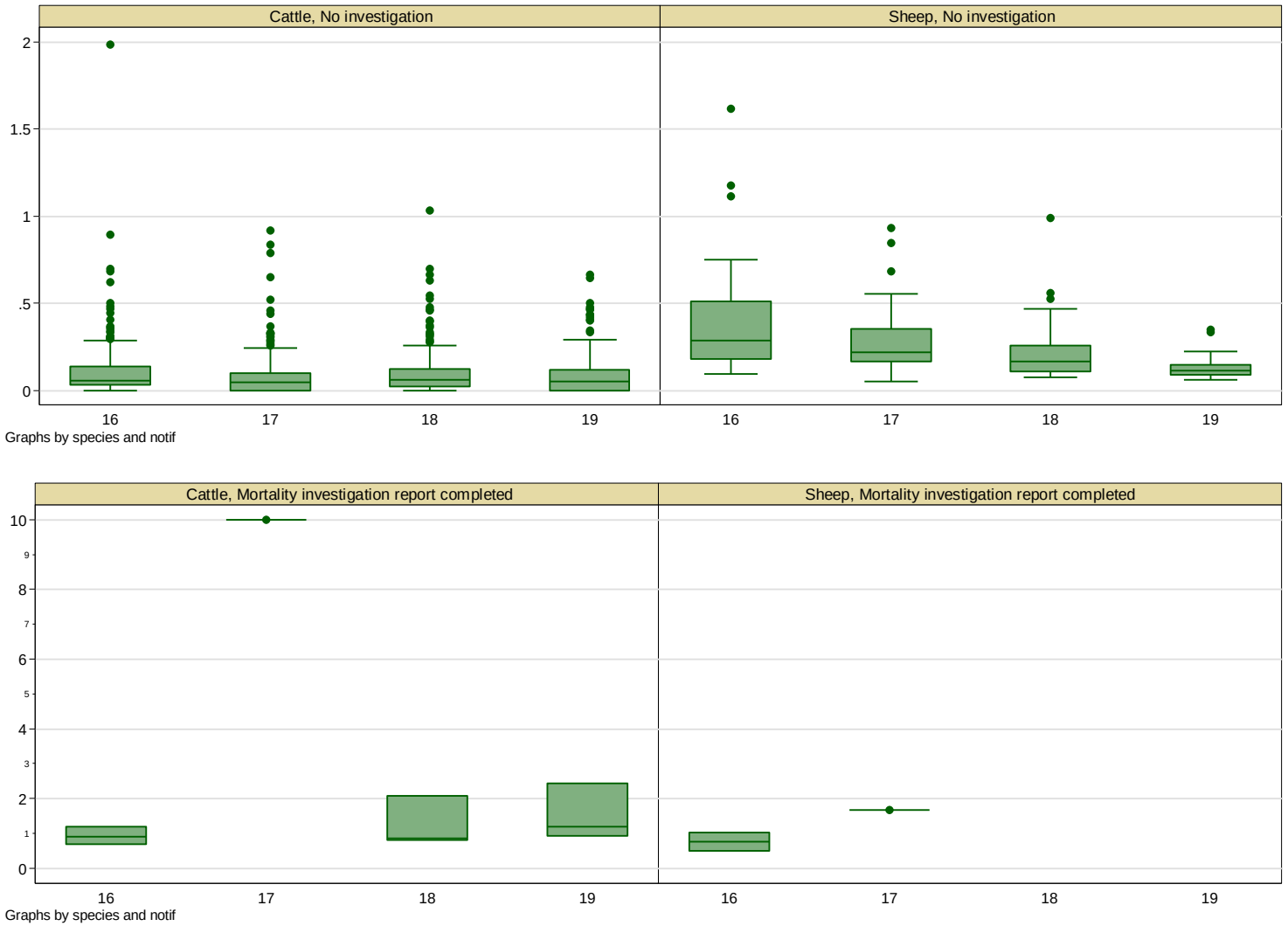

Fig. 13: Box plots for mortality incidence rate for voyages that had no mortality investigation and those that did by species

Fig. 14 shows the number of animals exported, number of shipments, and median mortality incidence rate by month of departure and species. The number of mortality investigation reports is also marked. It is hard to determine if a seasonal trends exists at a national level over this 4-year period for voyages with a mortality investigation report.

Acknowledging that the median is most likely an over-estimate of the central tendency of the mortality incidence rate distribution, Fig. 14 shows:

- there are large changes in the mortality incidence rate for buffalo; this variation is most likely due to the small number of animals exported in each shipment
- the number of shipments of cattle per month is closely related to the total number of cattle exported per month. The number of shipments per month is the main driver for total number of cattle exported rather than the size of the ship
- the number of shipments of sheep per month is not related to the total number of sheep exported per month. The size of the ship is the main driver of total sheep exported per month rather than the number of shipments per month as is the driver for cattle
- it appears an inverse relationship may exist between sheep median mortality incidence rate per month and total sheep exported per month. This could be due to the individual ships used or type of sheep loaded during times when the total number of sheep exported is low. This relationship needs further analysis to understand the drivers.

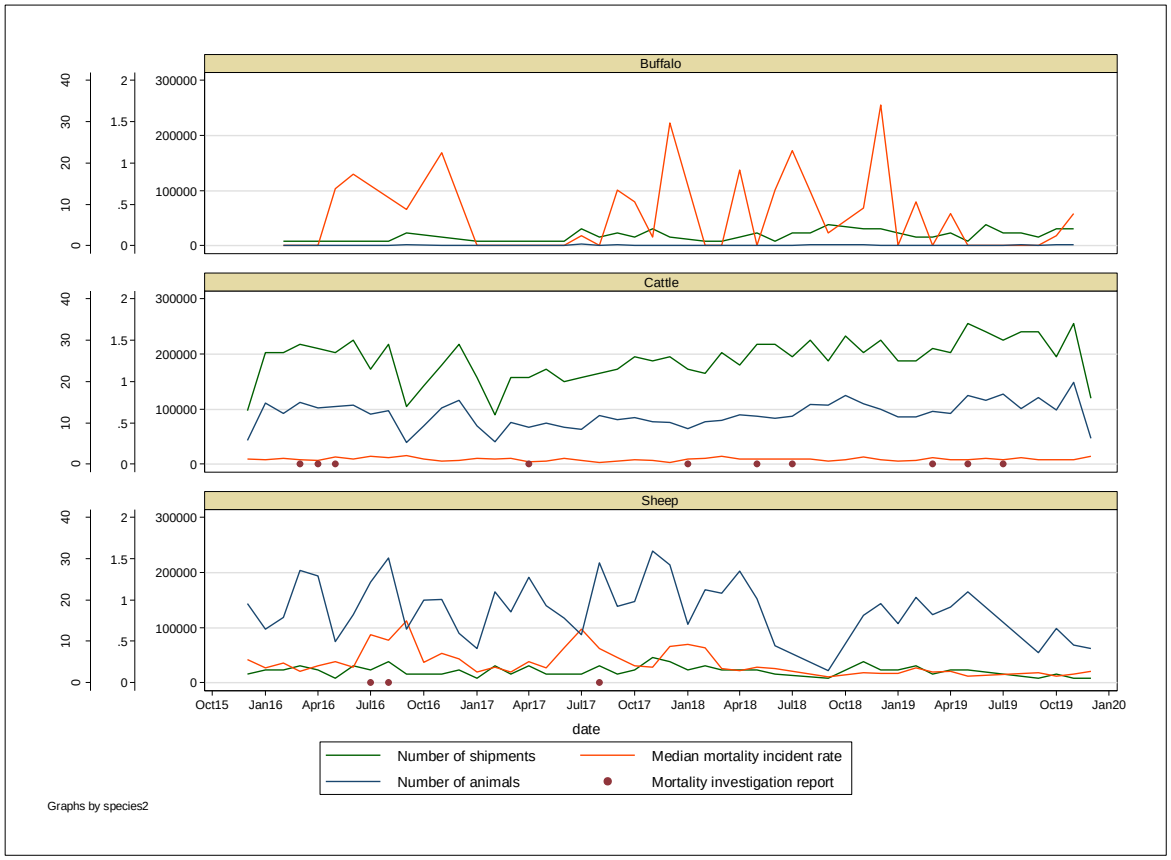

Fig. 14: Total animals exported per month and the median mortality incidence rate for that month

Table 23 gives a summary of the Reports to Parliament dataset providing median values. The number of voyages with no mortalities within a year is also reported.

Table 23: Summary table for Reports to Parliament dataset (2016 – 2019)

Species	Year	Shipments	Median duration	Median number of animals	Median mortality rate per 1000 animal days	Voyage with no mortalities	Number of mortality investigation reports	Mortality reports range of mortality rate per 1000 animal days
Buffalo	16	11	9	300	0.6017	2	1	-
	17	21	8	200	0*	11	2	-
	18	27	9	254	0.3567	10	2	-
	19	32	8	231	0*	20	1	-
Cattle	16	306	9	3015	0.0584	49	3	0.682 – 1.189
	17	261	9	3035	0.0454	86	1	9.992
	18	323	11	2661	0.0589	68	3	0.789 - 2.071
	19	341	10	2772	0.0529	89	3	0.916 – 2.428
Sheep	16	35	24	62,028	0.3156	0	2	0.500 - 0.759
	17	37	23	60,360	0.2186	0	1	1.667
	18	27	22	57,428	0.1675	0	0	-
	19	20	21	57,741	0.1123	0	0	-

* Buffalo median values are 0 because where there are more than half the voyages within this year with 0 mortalities then the median across all voyages is 0

10.3 Live animal export statistic report

The live export statistic data is at the consignment level for number of animals, class of animals, departure data, and destination country. Data is available for 2015 to 2019 and was downloaded from the department's website. Stata was used to provide visual representation of the data. This dataset is useful for identifying the following changes to help inform if there have been changes in recent years that indicate previous research may no longer be relevant.

This dataset's consignment information is useful for:

- changes over time in the number of consignments
- changes over time in the number of animals and class of livestock in consignments
- changes over time in the importing countries and class of livestock exported.

Destination data within this dataset is useful as it is reported at the consignment level and not at the shipment level. It can be used to understand what classes of Australian livestock are being imported to what countries. This is helpful to assess if there have been any significant changes in the type of livestock being exported from Australia during the last five years and if the historical research is still relevant to assessing major conditions or diseases and medications to load.

Fig. 15, Fig. 16, and Fig. 17 display buffalo, cattle and sheep results, respectively, for the class of livestock with the number of consignments and the number of animals loaded for each state and year.

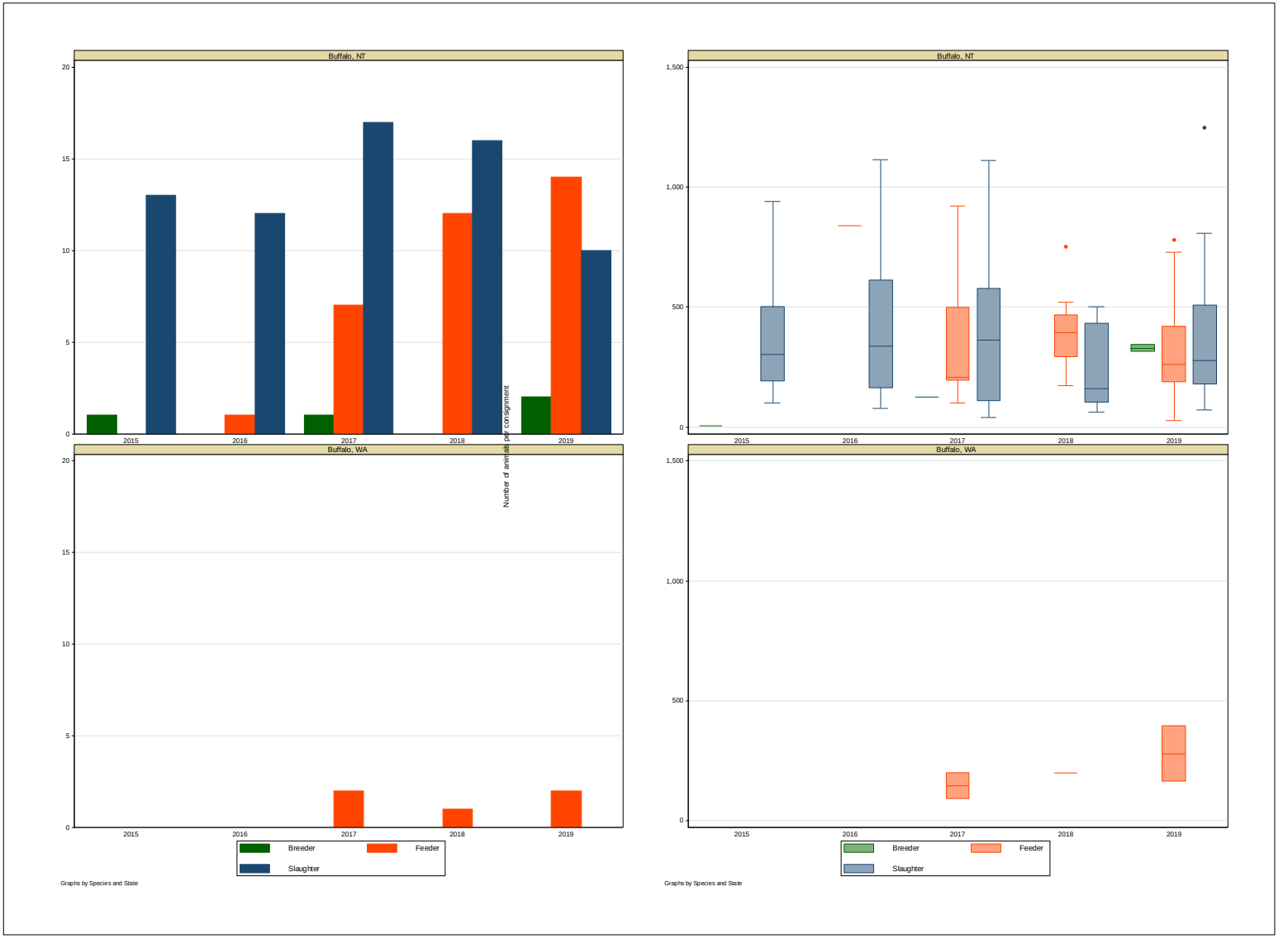

Fig. 15: Buffalo- number of consignments and number of animals in a consignment by year, Australian state of loading, and class of livestock

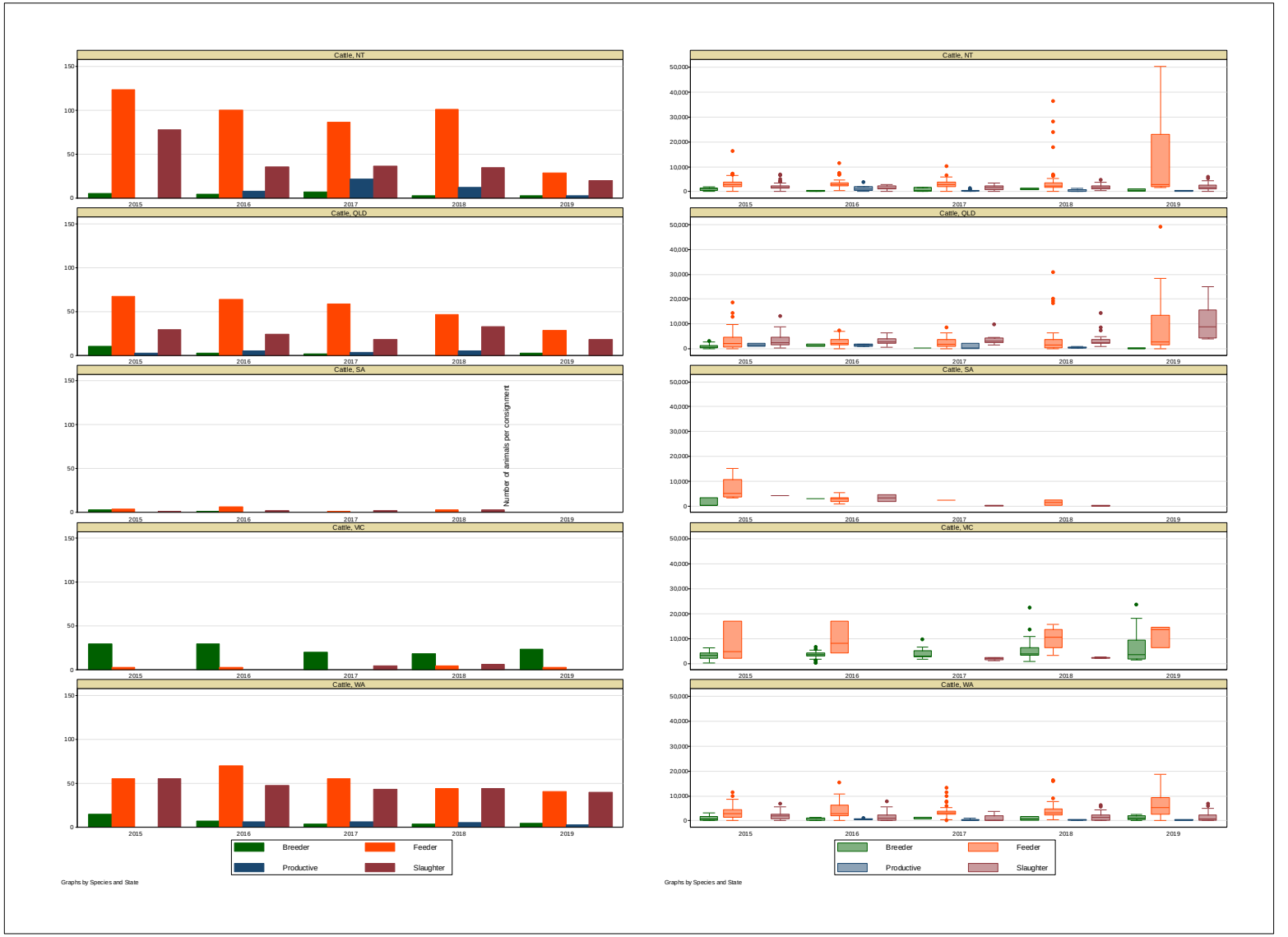

Fig. 16: Cattle - number of consignments and number of animals in a consignment by year, Australian state of loading, and class of livestock

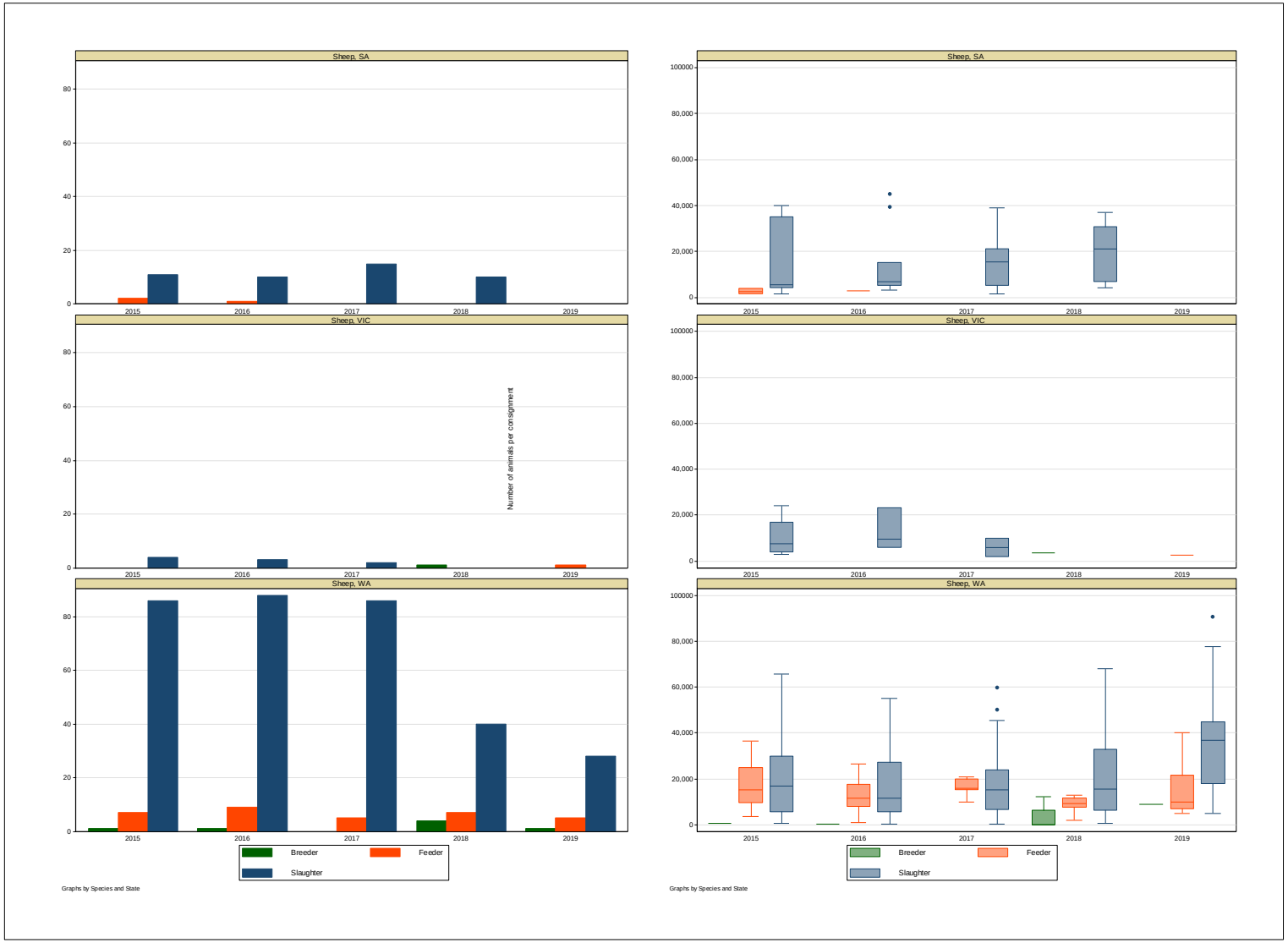

Fig. 17: Sheep - number of consignments and number of animals in a consignment by year, Australian state of loading, and class of livestock

To help interpret the above graphs the following points are made:

- for buffalo:
    - there has been an increase in feeder buffalo exported in 2018 and 2019
- for cattle:
    - the number of consignments across all classes and states has generally declined year on year
    - an increase in the variation and the median size of each consignment can be seen in all states that exported cattle in 2019. This means in 2019 there were fewer overall consignments and these consignments in general had more animals per consignment than previous years
- for sheep
    - overall, there has been a general decline in the number of sheep consignments from all states during this period
    - there has been an increase in the size of consignments, especially slaughter sheep, during 2018 and 2019.

The graphs for each species (Fig. 18 - Fig. 23) display the number of consignments and the total number animals to each country by year. This allows an understanding of the changes that have occurred during this time period.

Table 22 provides a broad summary table of this dataset allowing us to quantify the changes we can see graphically.

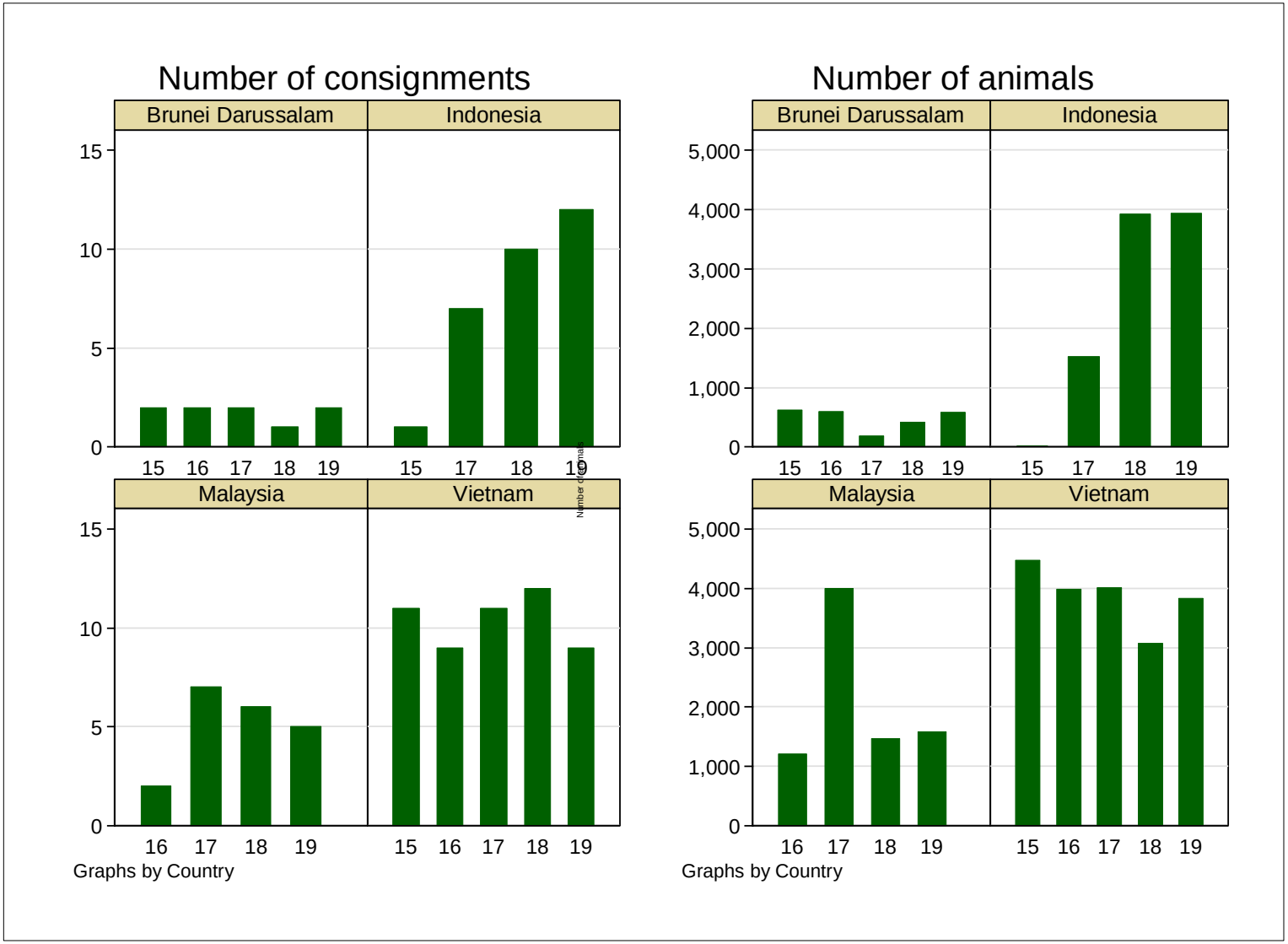

Fig. 18: Buffalo -importing countries and the number of consignments and number of animals exported by year (2015-2019)

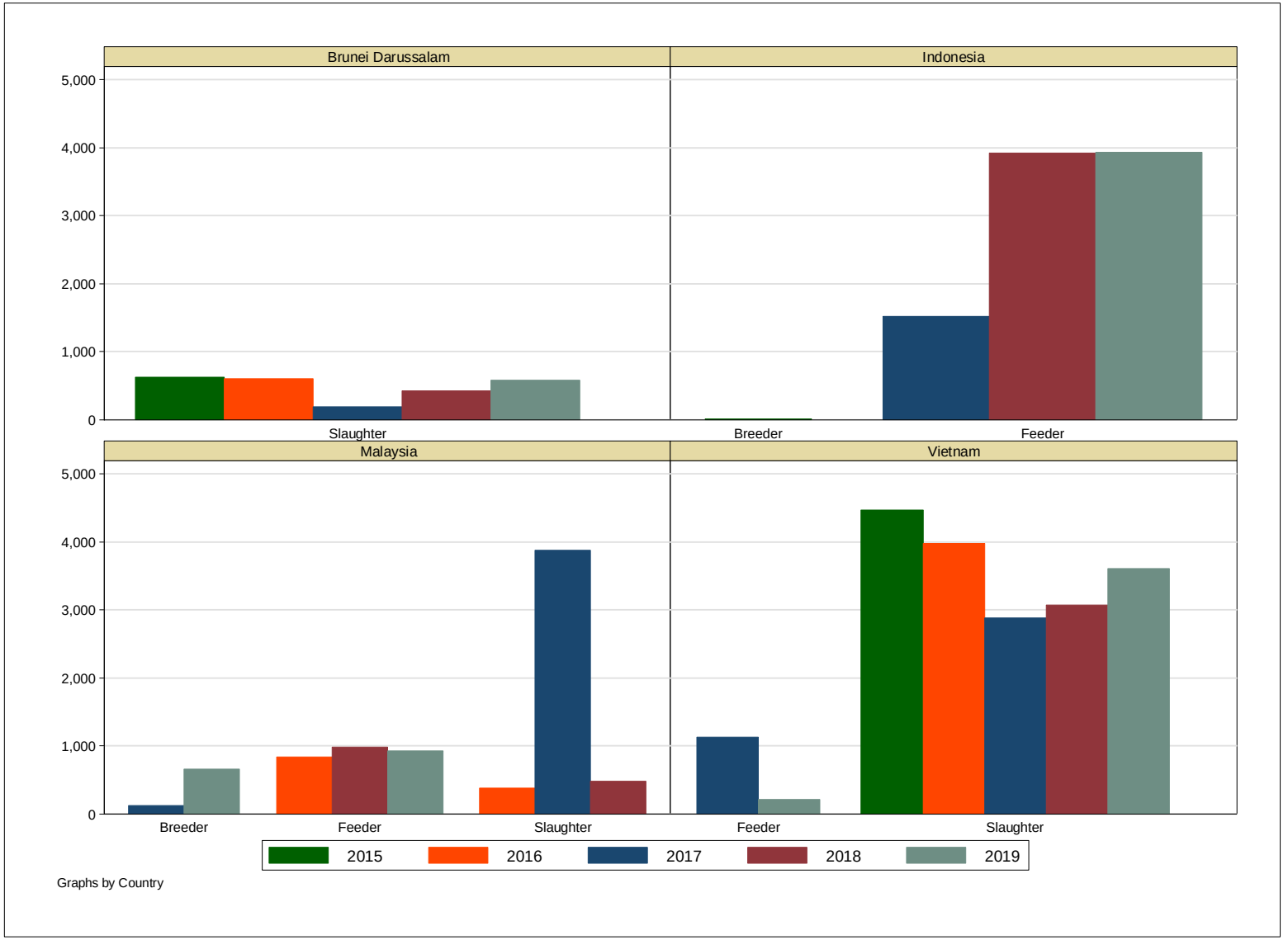

Fig. 19: Buffalo - number of animals exported in the last 5 years by importing country, class, and year

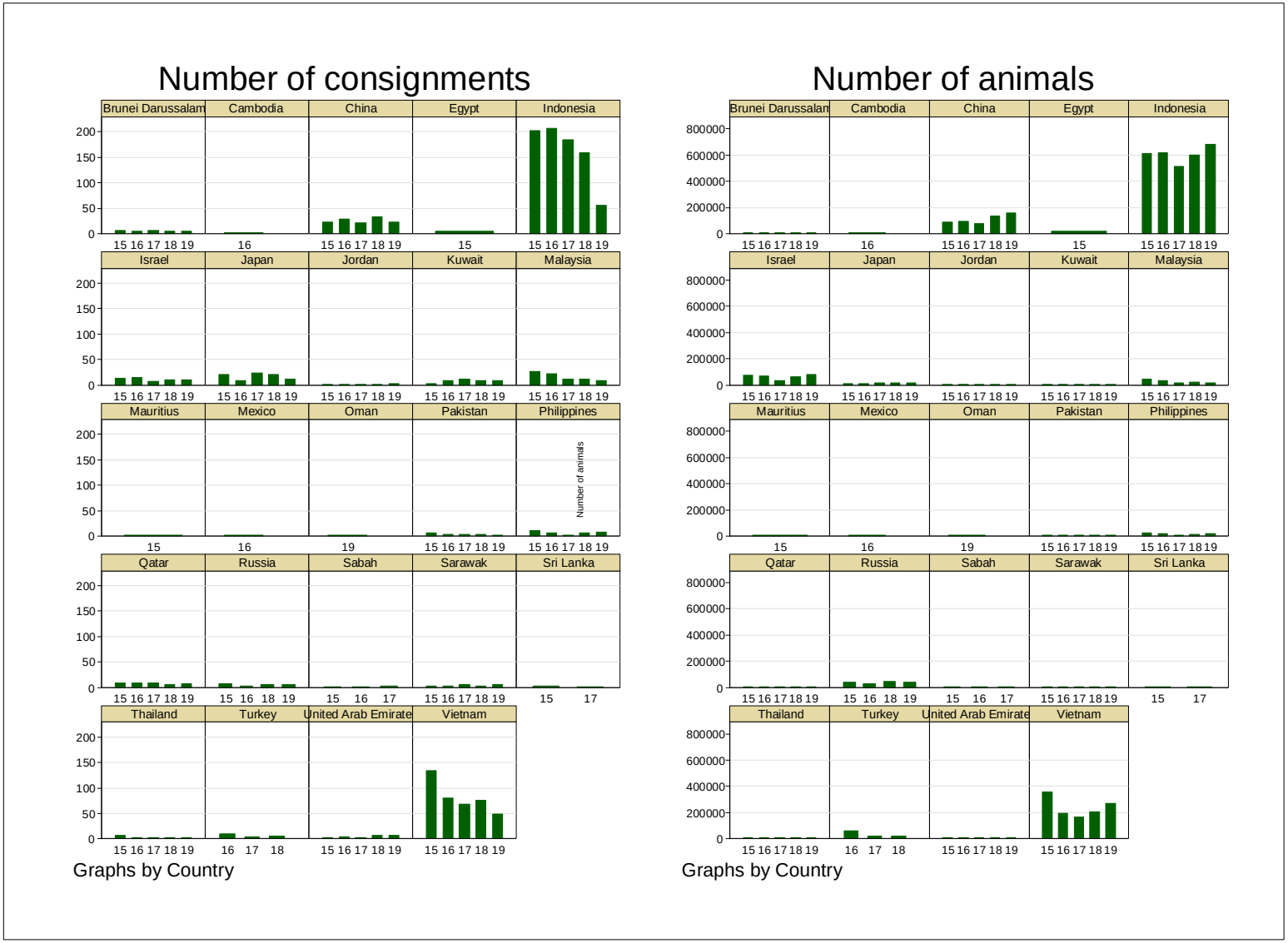

Fig. 20: Cattle -importing countries and the number of consignments and number of animals exported by year (2015-2019)

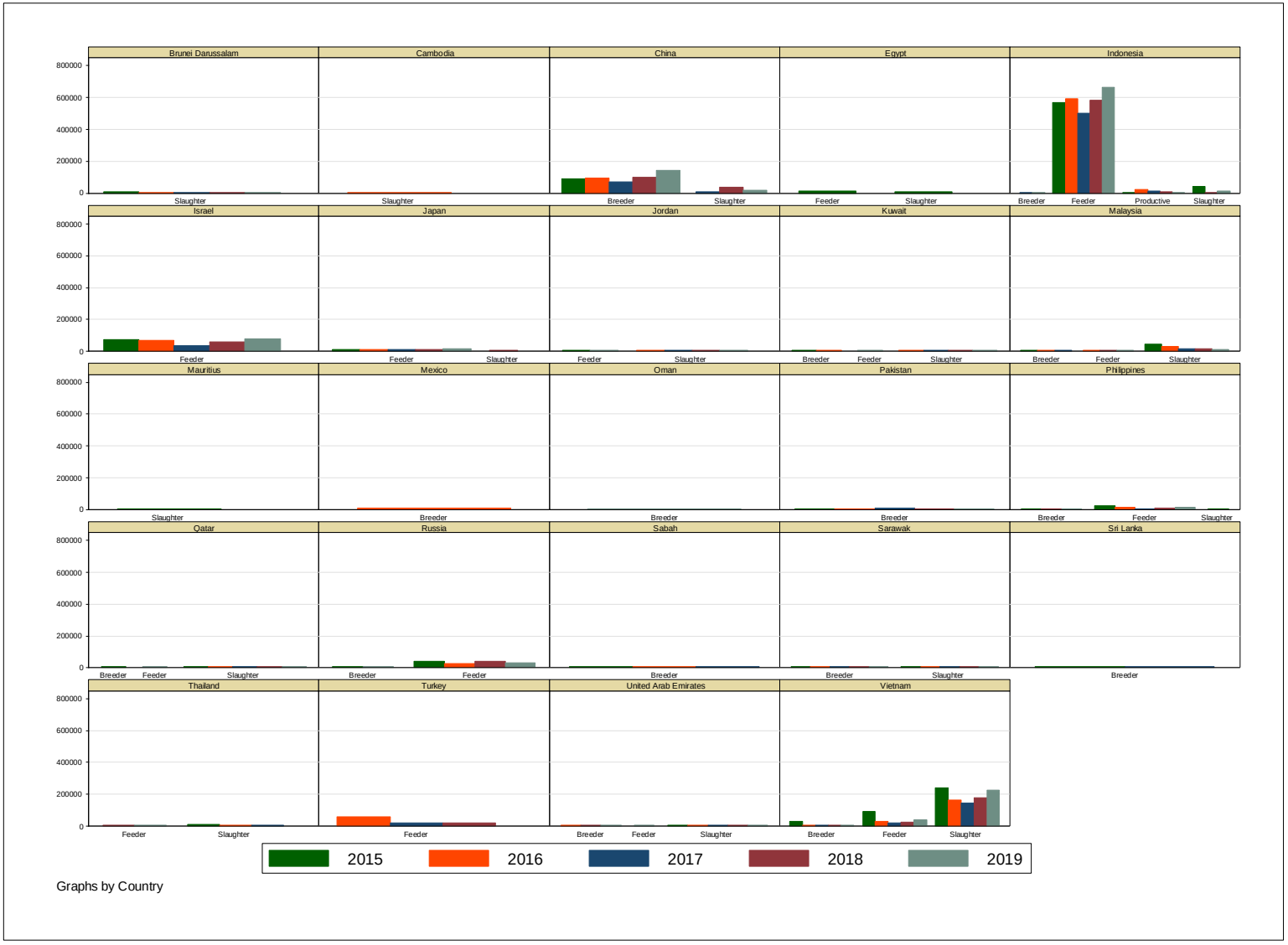

Fig. 21: Cattle- number of animals exported in the last 5 years by importing country, class, and year

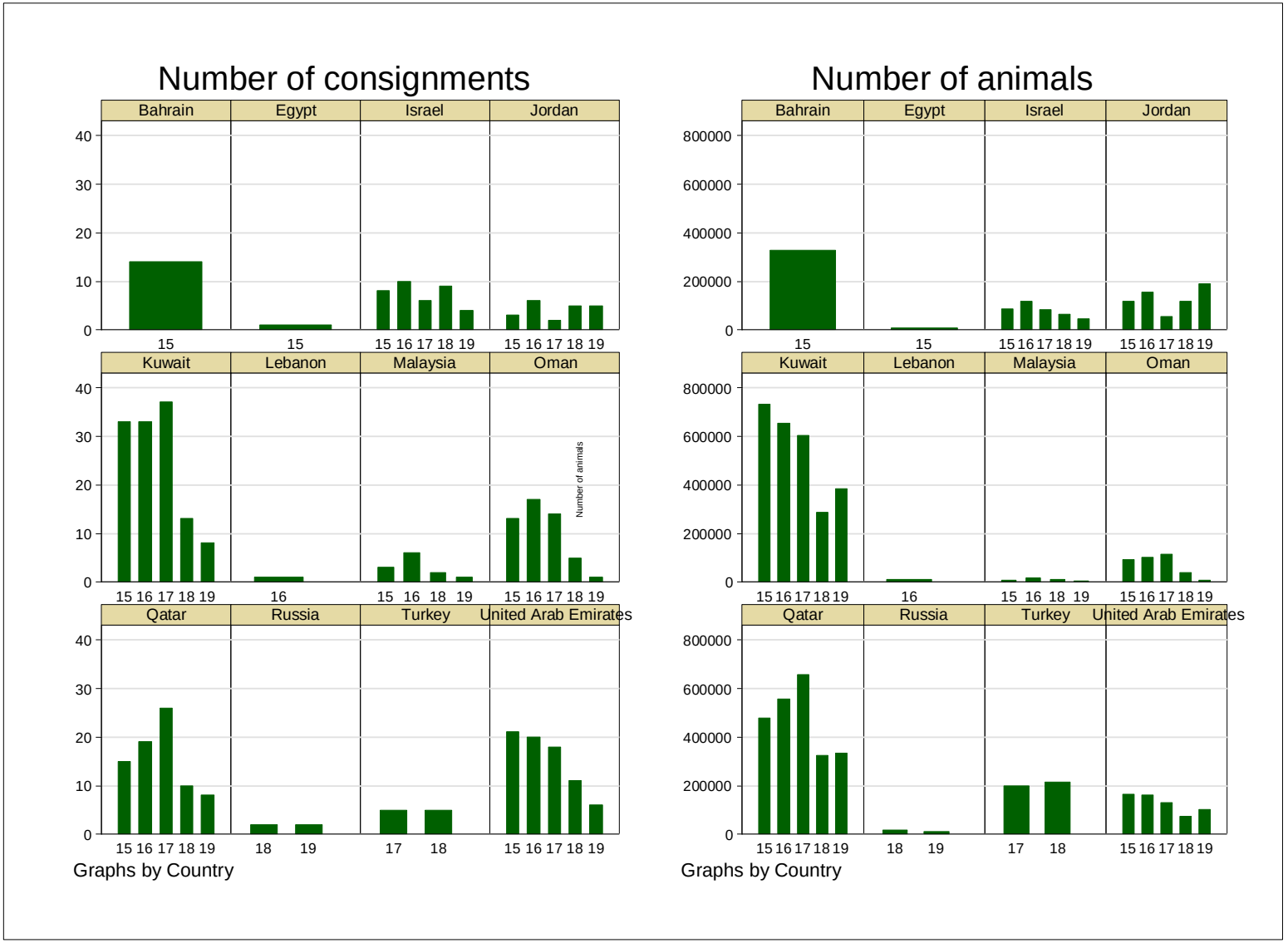

Fig. 22: Sheep -importing countries and the number of consignments and number of animals exported by year (2015-2019)

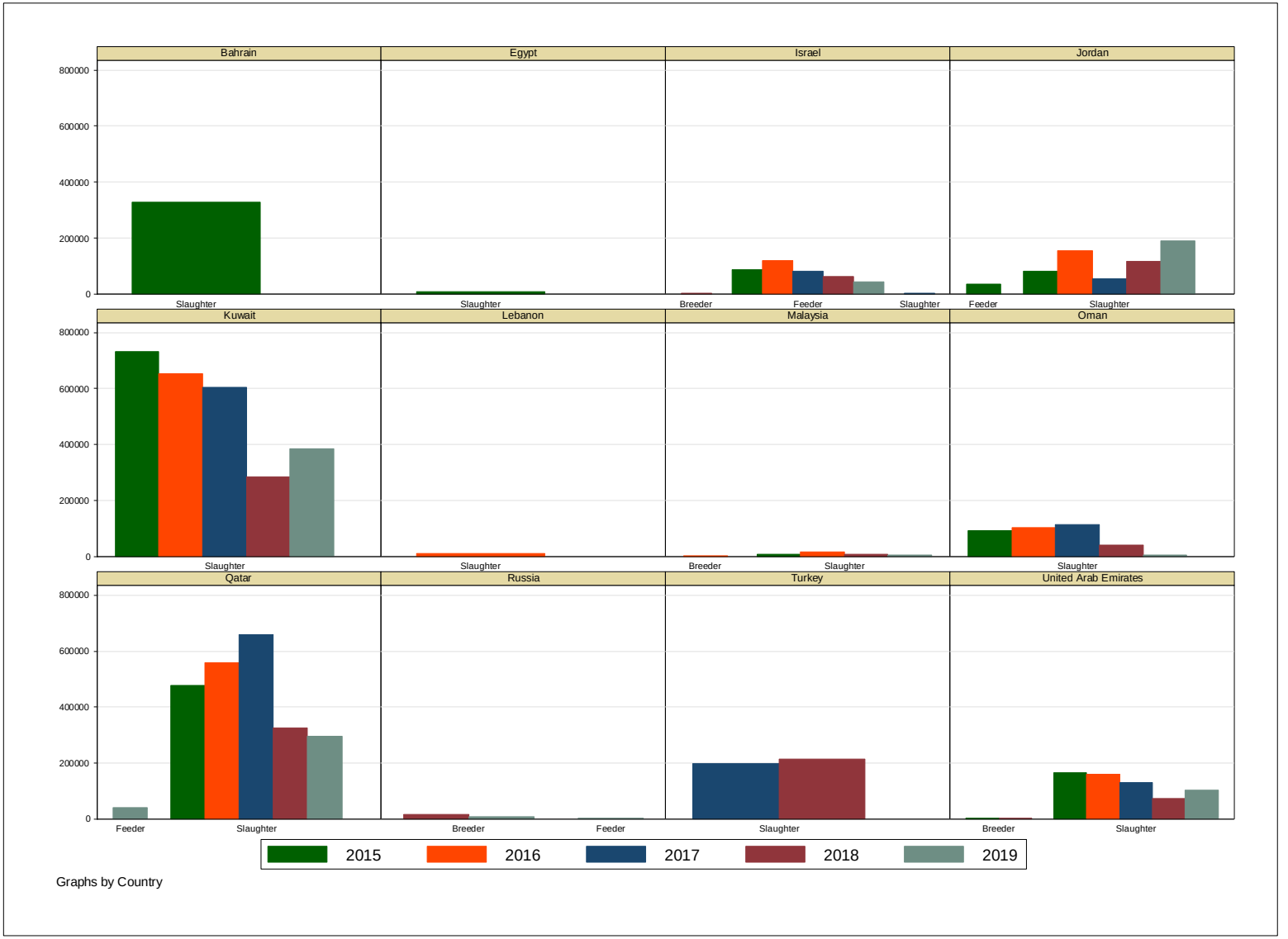

Fig. 23: Sheep - percentage of animals exported in the last 5 years by importing country, class, and year

Table 24: Summary table of live animal export statistics data for species, state, number of consignments and median number of animals per consignment by year of export

Species	Year	NT		QLD		SA		VIC		WA	
		Consignments	Median number of animals	Consignments	Median number of animals	Consignments	Median number of animals	Consignments	Median number of animals	Consignments	Median number of animals
Buffalo	15	14	297	0	-	0	-	0	-	0	-
	16	13	372	0	-	0	-	0	-	0	-
	17	25	207	0	-	0	-	0	--	2	145
	18	28	298	0	-	0	-	0	-	1	199
	19	26	300	0	-	0	-	-0	-	2	280
Cattle	15	205	2,268	108	2,076	8	3,663	32	3,438	123	2,002
	16	147	2,739	94	2,424	9	2,890	32	3890	130	2,099
	17	150	1,952	80	2,363	3	199	24	2,892	107	2,097
	18	149	1,986	83	2,199	6	279	28	3,642	98	2,193
	19	52	2,383	48	4,599	0	-	26	5,114	85	2,170
Sheep	15	0	-	0	-	13	5,089	4	7,459	94	16,501
	16	0	-	0	-	11	6,451	3	9,523	98	11,300
	17	0	-	0	-	15	15,440	2	5,912	91	15,595
	18	0	-	0	-	10	21,124	1	3,721	51	13,000
	19	0	-	0	-	0	-	1	2,650	34	27,628

In summary:

- for buffalo
    - there has been an increase in feeder buffalo exported which has driven the increase in the number of consignments
    - buffalo are only exported from the Northern Territory and Western Australia
- for cattle
    - a general decline in consignment numbers to all countries has occurred during the 5-year period; this was driven by a large decrease in the number of consignments to Indonesia and Vietnam
    - while the number of consignments has decreased the total number of animals exported to Indonesia and Vietnam has increased from 2018
    - exports of feeder cattle predominately go to Indonesia while slaughter cattle are predominantly exported to Vietnam
    - a recent increase in the export of cattle to Indonesia and Vietnam is the main reason why total cattle export numbers have increased in 2018 and 2019
    - the trend of fewer consignments with more animals per consignment can be seen across all States and Territories
- for sheep
    - there has been a large decline in consignment numbers and an increase in the number of animals per consignment over the 5-year period; this is most likely due to the vessels currently in use having a larger capacity
    - overall, the total number of sheep exported has declined during this 5-year period.