live export

LIVE.102 & SBMR.003

Best practice standards for the preparation & husbandry of cattle for transport from Australia

Final Report prepared for MLA and Livecorp by:

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FOREWARD

The following document is an exposure draft written in two parts. Part A consists of best practice recommendations. Part B comprises the links to established scientific knowledge.

A summary of how the best practice recommendations are supported by the scientific literature is shown in Table 1 within Part A.

Best practice operates by surveying the ranges of practices carried out in a particular area and selecting what seems to be the best. This document summarises well considered observations from the trade, supplemented by material that currently exists in the body of scientific knowledge.

Adequate support from science was deemed if the best practice recommendations could be reconciled with established scientific principles. In many cases, additional support was obtained from specific experimental studies. In some cases, commonsense was adequate justification.

These best practice recommendations are designed to be integrated with the existing Live Export Accreditation Program (LEAP) standards.

A significant level of the best practice recommendations dwell on what happens prior to the cattle being loaded on ship, i.e. the sourcing of cattle and pre-shipment preparation.

We commend this document to you for your consideration and participation as part of the industry's aspirations to establish a culture of continual improvement in industry standards and operating practices.

Signed: Signed:

For LiveCorp: For MLA:

Date: Date:

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1. PREFACE

M.L.A. has contracted Australasian Livestock Services Pty Ltd to identify the best practice standards for the preparation and husbandry of cattle transported by sea on long haul voyages from Australia.

These draft recommendations are designed to be read in conjunction with both the latest issue of the LEAP Rules and Standards (version December 1999) and the Shipboard Management Program Stockman's Handbook.

The LEAP standards contain a set of minimum mandatory requirements for the export of cattle, sheep and goats from Australia. The best practice recommendations are above these mandatory requirements. It is considered, however, that adoption of these recommendations will deliver further improvements to the health and welfare of animals.

These best practice recommendations are primarily concerned with factors that influence health and welfare and the recommendations are specifically targeted at the export of live cattle on long haul voyages.

Whilst the Standards have formed the basis of the exporter's quality assurance programs under the LEAP, it is envisaged that many of these best practice recommendations will be incorporated into exporter's quality assurance programs. Exporting companies would then be in a position to translate these recommendations into operating procedures.

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The Best Practice Recommendations represent an important part of the livestock export industry framework and are being extensively circulated to industry members for feedback and comment. Apart from industry members, organisations including LIVECORP, ALEC, AFFA and AQIS are being included in the consultative process. Once comment is receive from these interested parties and incorporated into the document as appropriate, a final draft of the recommendations will be presented to MLA. The outcome of the project will be the incorporation of the recommendations into the LEAP standards document for general industry use. In addition, the project involves a review of the associated LEAP standards with recommendations for modification as appropriate.

This draft has been produced from numerous sources including a literature review, a request to exporters for their personal input and company manuals and the consensus opinion of over 40 stockmen and veterinarians, who have sailed on or had experience with long haul voyages. It is estimated that the combined total of long haul voyages for these participants add up to a figure in the order of 300 individual trips.

All of this information has been continually refined during the delivery of four separate training courses / workshops conducted over the last 12 months and using the experience obtained from the close monitoring of active commercial trade.

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Each section is structured to provide : -

(i) An brief outline of the particular issue.

(ii) A comment on the perceived current industry practices.

(iii) A note of the relationship of the issue to the current LEAP standards (December 1999).

(iv) A statement – bold and enclosed in a text box – of the suggested best practice recommendation.

(v) An indication of the justification level for the best practice recommendation.

In addition, MLA has appointed Associate Professor Dr. David Adams to assess the level of scientific support (or otherwise) for each of the best practice recommendations presented in this draft. A table summarising his findings are attached as Table 1. The full text of his review accompanies this report.

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2. JUSTIFICATION.

For the purposes of this document the justification levels for each best practice recommendation have been broken into four general categories:-

(a) A proven fact. There is a basis in established scientific principles and support from documented specific scientific evidence.

(b) A generally accepted proposition as a result of industry experience. There is a basis in established scientific principles and support from industry experience rather than specific scientific evidence.

(c) A disputed issue needing further clarification by scientific examination. The scientific basis is plausible rather than established and documented scientific evidence is not available.

(d) A proposition based on common sense and the collective experience of veterinarians and stockmen who have completed multiple long haul voyages. Minimal or nil supporting scientific evidence. This collective experience provides a sound basis for scientific advances through structured observations of cattle during the transport process.

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3. BEST PRACTICE RECOMMENDATIONS

3.1 SOURCING OF CATTLE

The type, breed, geographical location and pre-export history have the capacity to affect the ability of cattle to cope with the stress of ocean transport. The following issues should be considered when sourcing cattle for long haul voyages.

3.1.1 Source cattle breeds best suited to travel conditions.

(i) Temperature and humidity stress to cattle shipped during the Northern Hemisphere summer is one of the most significant threats to health and welfare on long haul voyages. Bos Indicus breeds are physiologically better suited to cope with heat stress than Bos Taurus breeds.

(ii) While animals have been sourced from northern Australia in the past there has not been an aggressive, industry wide push to ensure that only Bos Indicus infused stock are sourced during the northern summer.

(iii) This matter is not mentioned in the LEAP standards.

(iv) Source Bos Indicus infused cattle for export during the most stressful period. In the case of the Northern Hemisphere this is from the beginning of May through till the end of October.

Where known heat sensitive Bos Taurus animals are sourced south of the 26th parallel during the northern summer they should be provided with a reduced loading density in the order of 10% than that described in the current LEAP standards.

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(v) Justification level (a), (c) for specific cut off points.

3.1.2 Source cattle acclimatized to expected weather conditions.

(i) Regardless of breed, cattle that originate from hot and humid environments will be better placed to cope with high temperature and humidity stress on board ship.

(ii) While this is regarded as important by industry it does not have a high priority.

(iii) This matter is not mentioned in the LEAP standards.

(iv) Select animals that have been acclimatised to warm weather conditions if they are to be transported to or through climatic zones of high temperature and humidity.

(v) Justification level (a).

3.1.3 Avoid the export of cattle which have a history of stressful incidents prior to export.

(i) Animals, which have suffered some form of stress during the period immediately prior to export, will be much less able to cope with the normal stresses of ocean travel. Examples of such stresses include long distance truck travel, excessive handling, boggy yard conditions, severe weather conditions. These cattle will be more susceptible to injury and illness than similar, non-stressed animals.

(ii) This is a well recognised problem within the industry with exporters generally making every effort to avoid pre export stress.

(iii) Mentioned indirectly in LEAP standards 5.1.

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(iv) Animals that have not fully recovered from a stressful incident prior to shipment should not be exported.

(v) Justification level. (a)

3.1.4 Make allowances for stock with special characteristics.

Avoid exporting very large and or very fat animals.

(i) As the mature weight of adult cattle increases, their agility declines and there is an increase in the probability of physical injury. Over fat animals are more susceptible to heat stress and less athletic than lean animals of the same body weight.

(ii) Current industry practice is to avoid these heavy and fat animals at present but commercial pressures have resulted in this type of stock being exported in the past. The key areas for disagreement on this issue are the cut off points rather than the principle involved.

(iii) 5.8.5 of the LEAP standards addresses the issue of heavy weight cattle for Category A exports only. It makes no mention of fat levels.

(iv) Animals over 500 kg live weight or with fat cover of 20mm at the P8 site should not be selected for export. Cattle with CALM fat scores 4H, 5 and 6 all have fat measurements of greater than 20 mm of fat at the P8 site. If very fat animals are exported they should be provided with reduced densities in the order of 10%.

(v) Justification level (a) for the general principle and (c) in the case of the specific cut off points.

Avoid exporting pregnant cows

(i) While pregnant cows are not suited to long ocean voyages, there may be circumstances when this form of transport is the most appropriate.

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(ii) This proposition is well understood by the industry although commercial pressure has meant that in some cases that additional space or other measures to improve the comfort and safety of stock have not been implemented prior to the introduction of the new LEAP standards.

(iii) The LEAP standards already exclude a range of unsuitable stock from export (5.1.2, 5.1.6 and 5.1.7) with the December 1999 standards providing specific density requirements for pregnant stock. Additional bedding for pregnant cattle is not mentioned.

(iv) In the case of pregnant cows (first two trimesters) the provision of adequate bedding to last for the entire voyage is essential. A minimum of 15% additional space should be provided.

If the export of pregnant animals during the third trimester of pregnancy is unavoidable then adequate soft bedding such as saw dust or straw to last for the entire trip should be loaded and the animals should be accompanied by a veterinarian or suitably experienced Accredited Stockman.

Cows pregnant in the third trimester should be provided with 100% additional space. This recommendation was present in the first draft of this document but has since been incorporated into the LEAP standards.

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(v) Justification level (a) with (c) for the cut off point.

3.2 PRESHIPMENT PREPARATION

Adequate planning for the preparation of the stock for delivery to the vessel is one of the most critical steps in ensuring the health and welfare of the cattle throughout the voyage.

3.2.1 Introduce cattle to the shipboard ration while on the farm or in the assembly depot.

(i) Even in the very best shipboard environment, cattle will be stressed by the new and unusual surroundings. The introduction of a new feed at this time will represent an additional stress factor. Animals will adapt to their new shipboard ration much more quickly if it is gradually introduced on the farm or assembly depot prior to loading.

Three to four days appears to be adequate but even a one day exposure to the new feed will improve consumption onboard during the first few days of the voyage. "Shy feeders" represent a significant proportion of the health problems identified during long haul voyages. Shy feeders result in general poor performance and occasionally death on long haul voyages. Introduction to shipboard rations on land may reduce the level of shy feeders during long haul voyages.

(ii) Current industry practice is largely driven by the logistics of the particular exporting environment. In southern Australia, where animals are generally sourced from a very large number of farms,

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they are transported directly from the farm to the ship. Feeding a very large number of small groups of cattle on farms of origin would be impractical. In northern Australia where larger mobs are usually available and large export assembly depots are common, the pre-feeding of export cattle in depots is more frequently practiced.

(iii) Briefly mentioned in 5.4.1 of the LEAP standards in relation to assembly depot management.

(iv) Introduce the cattle to the shipboard diet prior to loading onto the vessel.

(v) Justification level. (a) and (b)

3.2.2 Feed and water curfews prior to loading cattle onto trucks or vessels.

(i) Cattle will generally travel better if they have had a feed and water curfew. This benefit results from the improved agility of a relatively empty animal and a reduction in the amount of urine and faeces on the floor of the truck or ship. Exceptions include consideration of long road transport or extremely hot weather conditions.

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(ii) Current industry practice varies considerably. The number of compounding factors which contribute to the exporters decision to curfew or otherwise are too numerous to consider here. While curfew does play an important role in the welfare travelling stock, the associated rest periods are probably more critical.

(iii) Best Practice in this area is detailed in the LEAP standards. The statement below is slightly modified but still in general agreement with the standards. Some of the wording is seen to be more appropriate in the section on transport and rest periods.

(iv) Cattle should be held off feed and water for at least 6 hours before transportation from the property of origin or assembly depot. The feed and water curfew may be reduced or waived if :

a) Transportation time is expected to be more than 24 hours (including loading, trucking, waiting time on the truck and unloading); or

b) the environmental temperature and humidity are very high.

(v) Justification level. (a) and (b)

3.2.3 Ensure that cattle have had adequate rest prior to loading after long road journeys.

(i) Animals that are very tired from extended periods on trucks will be more susceptible to injury and illness if they are loaded directly onto a vessel. Injuries and illness associated with the loading process are one of the most important health issues encountered on long haul voyages. Where assembly depots in convenient locations are not available in southern Australia, long road journeys from the farm to the ship may present problems. Best practice is difficult to capture in a simple statement since there are so

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many possibilities in respect to the sourcing and delivery of cattle to the ship. The general principle involved is that cattle should not be transported or loaded onto a vessel until they have had adequate rest following mustering, processing or road transport.

(ii) *Current practice can be driven more by logistics than by welfare considerations. Where animals are trucked from distant farms direct to the ship in locations where suitable yards for resting stock are not available then practical reality may over-ride considerations for the welfare of the stock.*

(iii) *The LEAP standards contain some contradictions in this case for the reasons of complexity as outlined above. They include a Best Practice statement in the current standards which follows section 5.6.3. This states that "The time between mustering on-farm and delivery to the assembly depot, wharf or airport should be kept to a minimum." This may be true in some cases but is certainly not the case where animals will need to be given significant rest periods after extended periods of mustering, processing or on road transport. We believe this Best Practice statement should be deleted or reworded. We also suggest the rest period after very long transport periods be extended as below.*

(iv) ***Cattle should be provided with rest periods prior to loading aboard the export vessel with free access to feed and water following extended road journeys in line with the following:***

a) ***For journeys of between 1000 and 1500 km, or for periods between 12 and 36 hours, a rest period of 24 hrs should be provided.***

b) ***For journeys exceeding 1500 km or 36 hours, a minimum rest period of 48 hrs should be provided.***

c) ***Additional rest periods should be provided in more extreme climatic conditions.***

d) ***In some unusual circumstances, the welfare of the animals may be best served by immediate loading aboard the vessel. These arrangements should be discussed and agreed between the exporter, third party veterinarian and the AQIS certifying officer.***

(v) *Justification level. (a) and (b) and (c) for the specific cut off points.*

3.3 LOADING

3.3.1 Loading of the vessel.

(i) *The loading process has considerable potential for injury and stress to stock if not managed properly. Great care should be taken in planning and execution of the load plan. The overall aim of the process is a smooth flow of stock into their allocated locations with a minimum of stress.*

(ii) *Current industry practice could generally be regarded as consistent with this aim.*

(iii) *Section 5.8 in the LEAP standards outlines some issues relating to the loading of the vessel. They could be expanded as described below.*

(iv) The following represent the key elements of best practice for a successful cattle vessel loading. The

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finer details relating to the individual tasks are contained in the Stockman's Handbook, which should be read in conjunction with this document.

- **Take great care with the preparation of the load plan.**
- **Confirm the appropriate loading density and other regulations relating the destination, load port and season.**
- **Consider the type, source and history of the stock.**
- **Maintain lot integrity where possible and ensure animals are penned with cattle of the same sex, weight range and breed.**
- **Establish clear lines of responsibility and communications.**
- **Constantly monitor the loading process.**
- **Have contingency plans to deal with problems as they arise.**
- **Be prepared to deal with injured animals promptly and in a way that does not interfere with the welfare of the other animals in the shipment.**
- **Examine the check lists for veterinary chemicals, equipment, fodder, bedding and other essential supplies prior to sailing.**

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(v) Justification level : (d)

3.4 ON BOARD MANAGEMENT

Attempting to describe Best Practice once the animals are onboard is much more difficult than the pre loading and discharge activities which tend to be fairly similar regardless of the vessel or the season.

Once on board, these and many other minor factors have such a large influence on the outcome of the voyage that making general statements about best practices will mean that invariably, under certain conditions, some of the following recommendations will not be appropriate.

Notwithstanding, the best practice issues outlined below are likely to be accurate in most circumstances during most voyages.

3.4.1 Priority activities 24 - 48 hours after loading.

(i) The activities of the first one to two days after sailing are always a compromise between leaving the animals alone to rest and settle into their new environment and observing the stock closely with feeding, watering and the management of any welfare issues such as loading injuries or density readjustments.

(ii) Activities in the past have varied considerably according to the instructions from the exporter or the individual opinion of the stockman or crew. With only Accredited stockmen travelling at

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the present time, the activities will tend to be more consistent with the principles of management as described in the Stockman's Handbook.

(iii) The LEAP standards do not include a great deal of detail in relation to the management requirements of cattle on board.

(iv)

- **Prior to loading, drinking water should be medicated with electrolytes.**

- **Inspect all stock for injuries or illness as soon after loading as is practical. In conjunction with the Master and crew, take appropriate action to address any problems which are identified.**

- **Assess pen densities and take appropriate action if any pens are overstocked. Ensure that these transfers are well organised and performed with adequate support from the crew to minimize risk of injury to animals and man.**

(iv) Justification level : (d)

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3.4.2 Temperature, Humidity and Ventilation.

(i) These three factors are so closely interrelated that they are dealt with here as a single issue. Of all the factors influencing the welfare of the cattle on board ships, this group generally has the single most significant impact. Ironically, it also tends to be one of the matters over which the stockman and crew have the least control.

(ii) The Exporter can only contribute to this aspect of the shipping process by chartering ships with a reputation for good ventilation and maintenance. The Stockman's Accreditation program has resulted in the training of stockmen to identify and deal with ventilation problems on board vessels as they arise.

(iii) This matter is not mentioned in the LEAP standards.

(iv) Constant vigilance is required by the stockman on board to identify hot spots as quickly as possible.

Once problem areas have been identified then action must be taken as a matter of priority. The range of options available to those on board the vessel are outlined in the Stockman's Handbook.

(v) Justification level : (d)

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3.4.3 Deck and Bedding.

(i) The management of bedding and the cleaning of the decks is a constant compromise between:

a) allowing a build up of soft, relatively dry faeces to provide a comfortable pad for the cattle to lay on and,

b) a need to remove loose, wet faeces and urine which discourage animals from laying down, produce ammonia, contribute to increased humidity and disease.

The general aim of bedding management is to clean the deck the least number of times during the voyage while maintaining animal comfort and preventing the buildup of ammonia.

(ii) Current practice is as per the training provided to Accredited Stockmen.

(iii) This issue is mentioned in the LEAP standards 5.8.15 where it specifies the volumes to be loaded and notes the need for quality control of bedding materials. The information below is additional.

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(iv)

- **Load sufficient saw dust or equivalent material to allow for at least two complete changes of bedding during the voyage (one application already in place at loading).**

- **Monitor deck conditions constantly.**

- **When planning cleaning events consider the timing of the wash in relation to geographical hot spots. If at all possible, arrange for the low humidity period following wash down to coincide with passage through these areas of high temperature and humidity.**

- **Use mild acids such as 2% Acetic or Citric acid to spray down bedding in order to reduce ammonia release into the atmosphere of the cattle space. This method may allow periods between cleaning events to be extended by a number of days.**

- **Ensure that the crew are aware that hosing activities should be carried out in such a way as to cause least disturbance to the cattle. Wash down exercises have been noted to result in injuries to stock if carried out in a careless manner. Washdown management should aim to minimize the time cattle are off feed and water.**

- **Where sawdust has been laid on the deck, particular care should be taken to avoid the splashing of such bedding into the eyes of stock as this has been noted as a cause of pink eye problems.**

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(v) Justification level : (a), (b), (c) and (d)

3.4.4 Fodder and Feeding

(i) The aim of feeding on board is to maintain rather than gain body weight. Actual weight gain may be counterproductive during the hotter periods as animals consuming rations which will result in genuine weight gain (as opposed to recovery of gut fill) will generate significantly higher levels of surplus body heat than those on maintenance rations.

Budgeting of feed volumes is a particularly challenging task on long haul voyages as there is much greater scope on 14 -30+ day voyages for arrival and discharge delays to result in feed shortages towards the end of the journey.

(ii) The vast majority of the fodder available to exporters is of a consistently high standard. While storage of the fodder prior to loading is rarely a problem, storage of fodder on board vessels has frequently been inadequate. Ships with pellet silos have been observed to have a higher prevalence of fodder related health problems than other vessels. While it is not common for ships to run out of feed prior to discharge, this does happen often enough to propose a higher contingency volume of feed be loaded as a best practice measure.

(iii) The LEAP standards discuss the minimum standards for provision of feed (5.8.10, 11, 12 and 13) There appears to be some ambiguity

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in that the discretionary requirement for chaff in relation to Category A exports is noted in section 5.8.10 (d) while in section 5.8.12 (b) the minimum volume of chaff (and or hay) is fixed at 1%. The recommendations below are generally additional to these except that it is proposed that 5 days additional feed be carried rather than 3 days.

(iv)

- **Load 5 days additional feed as a reserve for contingencies.**

- **Repeat feed budget calculations at least once per day.**

- **Constantly monitor the storage arrangements of the remaining fodder to ensure it is protected from the weather and other means of spoilage.**

- **Minimize the wastage of feed by monitoring consumption carefully and feeding according to appetite and budget parameters.**

- **Constantly monitor the quality of the fodder presented to stock.**

- **Feed consumption is an excellent indicator of health and welfare of the stock. Whenever a reduction in intake is observed, immediately initiate an investigation into the possible cause.**

- **Where pellets are fed which have been delivered through silos, augers or blower systems they often contain higher levels of pellet**

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dust or "fines". When levels of fines are high, the incidence of bloat observed on board is elevated. In these circumstances, chaff or other roughage should be fed at higher levels.

- **Bloat is commonly noted to develop about the 8th to the 10th day of the voyage. Where the risk of bloat is high, roughage should be fed some days prior to this time to prevent the development of the problem.**

- **Where the risk of bloat is high, the volume of chaff or other roughage loaded on board should be adequate to treat all cattle with about 1 kg every 6 days. This will require the loading of about 2% of chaff by weight of feed required.**

- **Chaff or hay should be provided on all long haul voyages, not just Category A export shipments.**

(iv) Justification level : (a), (b), (c) and (d)

3.4.5 Water and Electrolytes.

(i) The issues relating to water provision and consumption are relatively straight forward. However, hard scientific evidence on appropriate electrolyte composition and use is lacking. What is known is that the physiological changes in cattle on board ships during periods of heat stress are quite different to those observed in

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land based cattle management systems. The most appropriate form of electrolytes and the best strategy for use require further research.

(ii) Current industry practice varies with most exporters using some electrolytes of varying compositions at some stage during the voyage.

(iii) The LEAP standards outline minimum volumes of water which must be carried or produced by the ship. The standards do not mention the use of electrolytes.

(iv)

- **Fresh water should be available to cattle at all times.**
- **Water troughs must be checked regularly during the day and night to identify and remove faecal contamination.**
- **Where automatic bowl drinking systems are in place, additional water can be provided in empty feed troughs during times of peak water consumption.**
- **Water consumption should be monitored daily to assist with assessment of the performance of the stock.**
- **Electrolytes will benefit cattle when they are under stress or recovering from stress. This is most important in the case of heat stress. It is recommended that they be provided to stock after**

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loading and at any time during the voyage when animals are placed under stress. During the Northern Hemisphere summer this may represent virtually the entire trip.

- **Provision of electrolytes may also be of use to alleviate stress during the discharge process.**

(iv) Justification level : some (a) and (d)

3.4.6 Animal Health.

(i) Despite the fact that there is still much to learn about the causes of ill health on board vessels, it appears that there are a relatively small range of common problems which are regularly recognised by stockmen and veterinarians accompanying cattle on long haul voyages.

Further research into the causes of ill health and mortalities during long haul voyages is being undertaken at the present time. These problems are discussed in the Stockman's Handbook. As research findings come to hand and experience is gradually built up by stockmen and veterinarians, the accurate recognition and appropriate response to problems is constantly being improved.

(ii) Current industry practice closely follows the guidelines for the veterinary kit and equipment as described in the Stockman’s Handbook.

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(iii) The LEAP standards state that a suitable supply of veterinary equipment by taken on board. The Handbook is much more specific in respect to the recommended chemicals and equipment including minimum quantities. The euthanasia section in the LEAP standards should be modified to include the use of sedatives in standing animals prior to the use of a captive bolt.

(iv)

- **Ensure that the ship is carrying a comprehensive and up to date veterinary kit prior to sailing. Details of the minimum requirements for the recommended kit can be found in the Stockman's Handbook.**

- **If health problems are encountered which are not able to be identified and which may endanger significant numbers of stock, the stockman should communicate with shore for further assistance and advice.**

- **If animals fail to respond to treatment then serious consideration should be given to humane destruction.**

- **Euthanasia of cattle should be carried out using a captive bolt as per the instructions in the Stockman's Handbook. If the animal is still standing or able to move its head freely then a large dose of sedative should be administered from the automatic syringe to render the animal unconscious and safe to destroy with the captive bolt.**

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(v) Justification level : part (a), (b) and (d)

3.4.7 Dispute Resolution.

(i) This matter is covered in the instructions to the Exporter, veterinarians, stockman and Masters in the Shipboard Management Program Pre Shipment Briefing notes.

(ii) Industry is following these SMP requirements.

(iii) The LEAP standards make no mention of this matter.

(iv) It is indisputable that the Master of the vessel has the final word on any decision on board the vessel.

In the event that the Accredited stockman and the Master are unable to agree on an issue in relation to the welfare of the stock, advice should be sought by communicating with the ship owner, the exporter and Livecorp.

A final decision on the appropriate resolution to the problem will be decided by these parties and communicated to the vessel.

(v) Justification level : (b)

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3.4.8 Shipboard Safety.

(i) Safety at sea, in respect to the Accredited stockmen is an area that has been neglected on some vessels in the past. It is an area that needs additional attention and resources to protect the health and welfare of the stockmen.

(ii) Some vessels provide full safety briefings and drills for stockmen while others completely neglect this aspect of their responsibilities.

(iii) Not mentioned in the LEAP standards

(iv)

- **Each stockman should undertake a training course in Maritime Safety and be provided with a manual on Survival at Sea.**
- **Each stockman should be thoroughly briefed by a member of the crew on the safety features of the vessel.**

(v) Justification level : (a)

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3.5 DISCHARGE

(i) Good planning and execution of the discharge of the cattle is vital to ensure that all the hard work to date caring for the livestock prior to and during the voyage is not undone at the last moment. Even small modifications and improvements to unloading arrangements can make a very significant difference to the smooth flow of the discharge process. Further details on specific measures to facilitate a smooth discharge are included in the Stockman's Handbook.

(ii) Current industry practice matches well with the following best practice suggestions as exporters and stockmen constantly strive to improve the efficiency of discharge.

(iii) The LEAP standards make no mention of the discharge process.

(iv)

- **The stockman, Master and Chief Officer should meet shortly before discharge to plan the strategy for unloading.**
- **Constantly review feed budgets and always have contingency plans for unexpected delays.**
- **Determine from the Exporter if any feed and or water curfew has been agreed with the Importer and make the appropriate arrangements according to this advice.**

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- **Prior to the discharge of the first cattle the stockman should walk along the alleyways and discharge ramps onto the trucking platform to ensure that there are no features which may endanger stock.**

- **The stockman (or exporter) should personally check at least a sample of the trucks presented for discharge for their suitability to carry the stock.**

- **It is vital that the stockman observe the first few truck loading events personally to ensure that the process is being completed in a safe and efficient manner.**

- **The stockman should review the trucks available and set maximum loads for each vehicle and make sure the agents or trucking contractors follow these instructions.**

- **If any of the requirements for safe discharge or truck loading are not being followed, the stockman should call a halt to the process until the problems are rectified.**

- **If the discharge is extended, the animals remaining on board may be redistributed to the empty pens to reduce stocking densities. The stockman must check with the Master before making any such movements to ensure that the stability of the vessel is not endangered.**

(v) Justification level : (b) and (d)

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Table summarising the best practice recommendations for live cattle export from project SBMR 003 and their support from the accompanying scientific review, *Links to Established Scientific Knowledge*.

	Best Practice Recommendations	Stressors and risk factors involved	Comment on best practice
3.1 Sourcing of cattle	***The type, breed, geographical derivation and pre-export history of can affect the ability of cattle to cope with the stress of ocean transport.***	All stressors considered • Physical stressors – thermal stress. • Nutritional stressors including water balance. • Behavioural stressors. • Disease stressors.	A general treatment of stress and stressors is given in section 3.3 of the scientific review.
3.1.1 Breeds	*3.1.1.iv Exporters should source Bos indicus infused cattle for export during the most stressful period. In the case of the Northern Hemisphere, this is from the beginning of May through till the end of October.* *Where Bos taurus animals are sourced south of the 26th parallel during the northern summer, they should be provided with a reduced loading density at least to the level of 15% as described in the current AQIS orders. Additional density reductions may be appropriate for known heat sensitive breeds during the peak of the northern summer*	Physical stressors, mainly heat, and the associated risk factors are the predominant consideration.	There is a basis for this best practice in established scientific principles and support from documented specific scientific evidence. See section 5.2.1 of the scientific review. *Justification level (a) for general issue and justification level (c) for cut-off points.*
3.1.2 Acclimatisation	*3.1.2.iv Select animals that have been acclimatised to warm weather conditions if they are to be transported to or through climatic zones of high temperature and humidity.*	Physical stressors, mainly heat, and the associated risk factors are the predominant consideration.	There is a basis in established scientific principles and support from documented specific scientific evidence. See section 5.2.2 of the scientific review.

	Best Practice Recommendations	Stressors and risk factors involved	Comment on best practice
			Justification level (a).
3.1.3 Cattle History	*3.1.3.iv Animals that have not fully recovered from a stressful incident prior to shipment should not be exported.*	Notes on recovery from stressful incidents are found in the discussion of each stressor class.	There is a basis in established scientific principles and support from documented specific scientific evidence. A background to stress is given in section 3.3 of the scientific review and is further developed in section 5.3 on physical stressors. *Justification level (a).*
3.1.4 Special Characteristics	*3.1.4. Avoid exporting very large or very fat animals. Animals over 500 kg liveweight or with fat cover of 20 mm at the P8 site should not be selected for transport.* *3.1.4. Pregnant animals. In the case of pregnant cows (first two trimester) the provision of adequate bedding to last for the whole voyage is essential. A minimum of 15% additional space should be provided.* *If the export of pregnant animals during the third trimester of pregnancy is unavoidable and there are no signs of impending parturition at the time of export then export can proceed as long as the animals are allocated 100% additional space.* *Pregnant cattle should also be provided with adequate soft bedding such as saw dust to last for the entire trip and be accompanied by an accredited stockman experience in the care of pregnant stock.* *3.1.4 Horned cattle Cattle exported as slaughter or feeder animals should not have horns because horns are a major cause of bruising and other injury.* *LIVECORP recognises, however, that a significant proportion of the Australian cattle herd is still horned and that dehorning grown cattle can be very stressful. The delay until 1 January 2000 before introducing the dehorning requirement is to allow time for cattle producers to change on-farm management practices.* *Animals with horns should be penned together with a reduction in*	• Agility declines and proneness to injury increases with size. • The best practice recommendation also refers to temperament and low condition score resulting from undernutrition. These are distinct issues. • Pregnancy and the physical states mentioned as special considerations are treated under a heading separate from the four classes of stressors.	There is a basis in established scientific principles and support from documented specific scientific evidence for these best practice recommendations. See sections 5.2.3 and 5.2.4 of the scientific review for discussion of body condition and pregnancy. Pregnancy is also treated in section 9.2. Horns are treated in section 8.2.3. *Justification level (a) for general issues and justification level (c) for specific cut-off points for body condition and pregnancy.*

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	Best Practice Recommendations	Stressors and risk factors involved	Comment on best practice
	stocking density of at least 10%. All horned cattle must at least be tipped as per the LEAP standards.		
• **Preshipment preparation**	***Adequate planning for the preparation of stock for delivery to the vessel is one of the most critical steps in ensuring the health and welfare of cattle throughout the voyage.***		
3.2.1 Pre-feeding	*3.2.1 Introduce the cattle to the shipboard diet prior to loading onto the vessel.*	The risk factors here relate to nutritional stressors.	There is a basis in established scientific principles for this best practice recommendation. See section 5.2.6 and 6.3.2 of the scientific review. *Justification level (c).*
3.2.2 Curfews	*3.2.2 Cattle should be held off feed and water for at least 6 hours before transportation from the property of origin or assembly depot. The feed and water curfew may be reduced or waived if:* • *Transportation time is expected to be more than 24 hours (including loading, trucking, waiting time on the truck and unloading); or* • *The environmental temperature and humidity are very high.*	The risk factors here relate to physical and nutritional stressors including water balance. Animals that have been held of feed and water for a short period travel better by truck because of improved agility and a reduction in the amount of urine and faeces on the transport floor.	There is a basis in established scientific principles for these best practice recommendations. See section 6.3.3 of the scientific review and background material in sections 6.1 and 6.2. *Justification levels (a) and (b).*
3.2.3 Rest Periods	*3,2,3 Following extended road journeys and prior to loading aboard the export vessel, cattle should be provided with rest periods with free access to feed and water in line with the following:* *(1) For journeys of between 1000 and 1500 km, or for periods between 12 and 36 hours, a rest period of 24 hours should be provided.* *(2) For journeys exceeding 1500 km or 36 hours, a minimum rest period of 48 hours should be provided.* *(3) Additional rest periods should be provided in more extreme climatic conditions. In some unusual circumstances, the welfare of the*	The risk factors here relate to all of the stressors. The concept of stress as the cost of adaptation is important as are the physiological states associated with fatigue. Rest periods are considered to more important that the time involved in the feed and water	There is a basis in established scientific principles for these recommendations. The actual figures must be regarded as the maximum. Information can be found in sections 5.4 (Risk factors and best practice for mechanical and other physical

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	Best Practice Recommendations	Stressors and risk factors involved	Comment on best practice
	animals may be best served by immediate loading aboard the vessel. These arrangements should be discussed and agreed between the exporter, third party veterinarian and AQIS certifying officer.	curfew.	stressors), 6.3.3 (feed and water curfews) and 6.3.8 (water and electrolytes) of the scientific review. *Justification levels (a) and (b) and justification level (c) for the cut-off points.*
3.3 Loading	<u>*3.3.1*</u> *The following represent the key elements of a successful cattle vessel loading. The finer details relating to the individual tasks are contained in the Stockman's Handbook, which should be read in conjunction with this document.* *(1) Take great care with the preparation of the load plan.* *(2) Confirm the appropriate loading density and other regulations relating to the destination, load port and season.* *(3) Consider the type, source and history of the stock.* *(4) Maintain lot integrity where possible and ensure that animals are penned with cattle of the same sex weight range and breed.* *(5) Establish clear lines of responsibility and communication.* *(6) Have contingency plans to deal with problems as they arise.* *(7) Be prepared to deal with injured animals promptly and in a way that does not interfere with the welfare of the other animals in the shipment.* *(8) Examine the checklists for veterinary chemicals, equipment, fodder, bedding and other essential supplies prior to sailing.*	The loading process has considerable potential for injury and stress to stock if not managed properly. Physical and behavioural stressors are involved.	These best practice recommendations are base d on commonsense and do not require support from science. *Justification level (d).*
3.4 On board management	***The LEAP Standards do not include the management requirements of cattle on board except to mention the fodder and water requirements and the need for an experienced stockman.***		
3.4.1 Initial period	*(1) Prior to loading, drinking water should be medicated with electrolytes.* *(2) Ensure all animals have free access to feed and water.*	The best practice recommendations here are a checklist of actions.	These best practices refer to commonsense operational procedures and do not require support from science.

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	Best Practice Recommendations	Stressors and risk factors involved	Comment on best practice
	(3) Inspect all stock for injuries or illness and relocate that which require treatment to sick pens. *(4) Assess pen densities to determine if any pens are overstocked.* *(5) Where pens are overstocked, make appropriate adjustments. Ensure that these transfers are well organised and performed with adequate support from the crew to minimise the risk of injury to animals and man.* *(6) Complete the above with the minimum amount of human presence in the cattle holds.*		*Justification level (d).*
3.4.2 Temperature, humidity and ventilation	*3.4.2 Constant vigilance is required by the stockman on board to identify hot spots as quickly as possible.* *Once problem areas have been identified, then action must be taken as a matter of priority. The range of options available to those on board the vessel are outlined in the Stockman's handbook.*	Heat stress, heat-related disorders and the associated risk factors are the issues here.	Temperature, humidity and ventilation is dealt with generally under the heading of heat in sections 5.1 and 5.2 of the scientific review and specifically in section 5.2.5. *Justification level (d).*
3.4.3 Deck and bedding	*3.4.3* *(1) Load sufficient saw dust or equivalent material to allow for at least two complete changes of bedding during the voyage (one application already in place at loading).* *(2) Monitor deck conditions constantly.* *(3) When planning cleaning events consider the timing of the wash in relation to geographical hotspots. If at all possible, arrange for the low humidity period following wash down to coincide with the passage through these places.* *(4) Use mild acids such as 2% acetic or citric acid to spray down bedding in order to reduce ammonia release into the atmosphere of the cattle space.* *(5) This method may allow periods between cleaning events to be extended by a number of days.* *(6) Ensure that the crew are aware that hosing activities should be carried out in such a way as to cause least disturbance to the cattle. Wash-down management should aim to minimise the time*	Physical and behavioural stressors are the issues here.	Much of this set of best practices is commonsense and does not require support from science. The state of arousal produced when cattle are disturbed is dealt with in section 7.1.3 of the scientific review report. Deck and bedding is discussed specifically in section 5.2.8. *Justification levels (a), (b), (c) and (d).*

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	Best Practice Recommendations	Stressors and risk factors involved	Comment on best practice
	cattle are off feed and water. *(7) Where sawdust has been laid on the deck, particular care should be taken to avoid the splashing of bedding into the eyes of stock as this has been noted as a cause of pink eye problems.*		
3.4.4 Fodder and feeding	*(1) Load 5 days additional feed as a reserve for contingencies.* *(2) Repeat feed budget calculations at least once per day.* *(3) Constantly monitor the storage arrangements of the remaining fodder to ensure it is protected from the weather and other means of spoilage.* *(4) Minimise the wastage of feed by monitoring consumption and feeding according to appetite and budget parameters.* *(5) Constantly monitor the quality of fodder presented to stock. During feeding, ensure that troughs are stirred to avoid compaction and settling of fines.* *(6) Feed consumption is an excellent indicator of health and welfare of stock. Whenever a reduction in intake is observed, immediately initiate an investigation into the possible cause.* *(7) Where pellets are fed which have been delivered through silos, augers or blower systems, they often contain higher levels of pellet dust or "fines".* *(8) When levels of fines are high, the incidence of bloat observed on board is elevated. In these circumstances, chaff or other roughage should be fed.* *(9) Bloat is commonly noted to develop about 8-10 days into the voyage.* *(10) Where pellet handling systems on board are likely to lead to the production of high levels of pellet dust, the volume of chaff or other roughage loaded on board should be adequate t o treat all cattle with a bout 1 kg every 6 days.* *(11) Shy feeders should be identified as early as possible and removed to a pen to receive appropriate treatment.* *(12) The volume of fodder contained in bulk tanks should be amenable t o accurate measurement.*	Nutritional stressors are the major issue here. There are interactions with heat stress and disease.	Much of the set of best practice recommendations on fodder and feeding is based on commonsense and does not require support from science. Those requiring support from science are fully supported by available knowledge. The application of science to specific issues is dealt with in sections 5.2.6 and 6.3 of the scientific review. *Justification levels (a), (b), (c) and (d).*

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	Best Practice Recommendations	Stressors and risk factors involved	Comment on best practice
3.4.5 Water and electrolytes	3.4.5 *(1) Fresh water should be available at all times.* *(2) Water troughs must be checked regularly during the day and night to identify and remove faecal contamination.* *(3) Where automatic bowl drinking systems are in place, additional water can be provided in empty feed troughs during times of peak water consumption.* *(4) Water consumption should be monitored daily to assist with the assessment of the performance of the stock.* *(5) Electrolytes will benefit cattle when they are under stress or recovering from stress. This is most important in the case of heat stress. It is recommended that electrolytes be provided to stock after loading and at any time during the voyage when animals are placed under stress. During the Northern Hemisphere summer, this may represent the entire trip.* *(6) Provision of electrolytes may also be of use to alleviate stress during the discharge process.* *(7) Delivery of electrolytes is best achieved by in-line dosing equipment. The next best option is to place the product in the ship's water tanks. Hand delivery to water troughs is useful but not the preferred option.*	The nutritional issue here is water balance, which is a major risk factor in heat stress.	The best practice recommendations here have is a basis in established scientific principles. In some cases there is further support from documented specific scientific evidence. Water and electrolytes are dealt with in 5.2.7 of the scientific review. However, the major treatment is found in section 6.2 (general background) and 6.3.8 (specific issues). *Justification levels (a) and (d).*
3.4.6 Animal health	3.4.6 *(1) Ensure that the ship is carrying a comprehensive and up to date veterinary equipment and chemicals kit prior t o sailing. Details of the recommended kit can be found in the Stockman's Handbook.* *(2) The Stockman should be trained in the recognition and treatment of health problems at least to the level provided in the Accredited Stockman's course.* *(3) If health problems are encountered which are not able to be identified and which may endanger significant numbers of stock, the stockman should communicate with shore for further assistance and advice.* *(4) If animals fail to respond to treatment then serious consideration*	Disease stressors and the associated risk factors are the issues here.	Infectious disease is dealt with in section 8.1 of the scientific review. Two issues are raised. First is that outbreaks of infectious disease can blow out mortality figures and have the potential for occurring on rare instances. An anticipatory risk assessment could help with emergency management. Second is the benefit sourcing of cattle

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	Best Practice Recommendations	Stressors and risk factors involved	Comment on best practice
	should be given to humane destruction. *(5) Euthanasia of cattle should be carried out using a captive bolt as per the instructions in the Stockman's Handbook. If the animal is still standing and able to move then a large dose of sedative should be administered from the automatic syringe to render the animal unconscious and safe to destroy with the captive bolt.*		from farms which have integrated control programs against endemic diseases such as the tick fevers. *Justification levels (a), (b) and (d).*
3.4.7 Dispute resolution	*3.4.7 It is indisputable that the Master of the vessel has the final word on any decision on board the vessel.* *In the event that the accredited stockman and the Master are unable to agree on an issue in relation to the welfare of the stock. Advice should be sought by communicating with the ship owner, the exporter and LiveCorp.*	This matter is not mentioned in LEAP Standards but is considered in the instructions to the Exporter, veterinarians, stockmen and Masters in the Pre Shipment Briefing Notes of the Shipboard Management Program.	This best practice recommendation is supported by commonsense and practical experience. *Justification level (b) and (d).*
3.4.8 Shipboard safety	*3.4.8 Each stockman should undertake a course in Maritime Safety and be provided with a manual on Survival at Sea.*	This is a consideration for occupational health and safety.	*Justification level (d).*
3.5 Discharge	*3.5.iv* • *The stockman, Master and Chief Officer should meet shortly before discharge to plan the strategy for unloading.* • *Constantly review feed budgets and always have contingency plans for unexpected delays.* • *Determine from the Exporter if any feed or water curfew has been agreed with the Importer and make the appropriate arrangements according to this advice.* • *Prior to discharge of the first cattle, the stockman should walk along the alleyways and discharge ramps and onto the trucking platform to ensure that there are no features which may endanger stock.* • *The stockman (or exporter) should personally check at least a sample of the trucks presented for discharge for their suitability to carry the stock.* • *It is vital that the stockman observe the first few truck loading events*	The major stressors are physical and behavioural relating to the risk of injury a state of stress.	No support from the body of scientific knowledge is necessary for the best practice recommendations related to discharge. *Justification level (d).*

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	Best Practice Recommendations	Stressors and risk factors involved	Comment on best practice
	personally to ensure that the process is being completed in a safe and efficient manner. • *The stockman should review t he trucks available and set maximum loads for each vehicle and make sure the agents or trucking contractors follow these instructions.* • *If any of the requirements for safe discharge or truck loading are not being followed, the stockman should call a halt to the process until the problems are rectified.* • *If the discharge is extended, the animals remaining on board may be redistributed to the empty pens to reduce stocking densities. The stockman must check with the Master before making any such movements to ensure that the stability of the vessel is not endangered.*		

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LIVE CATTLE EXPORT:

BEST PRACTICE

RECOMMENDATIONS

(LONG HAUL VOYAGES)

Links to established scientific knowledge

May 2000

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1. INTRODUCTION

Australia has long historical involvement in the international transport of all species of animals and has amassed a large body of experience and expertise in the care and management of animals during the process. For example, the foundation stocks of Australia's domestic livestock were transported over long distances to the island continent and animals with particular genetic merits have been imported to provide for populations of livestock suited to Australia's wide variety of environments. Australia is also a major exporter of livestock and livestock products. The export trade in live cattle is a significant component of Australia's cattle industry and earned $224M during 1998 from over half a million exported cattle. So, Australia has a major stake in the export trade in live cattle as a "total business" that will be "sustainable into the future", will satisfy customers' needs and have the confidence of the community regarding high standards of animal welfare.

Experience over a long period and throughout the world demonstrates that animals can travel from country to country by modern forms of transportation without harm to their welfare. Furthermore, if conditions of husbandry are appropriate, neither distance travelled nor time of travelling, are a burden on the wellbeing of animals. At the same time, however, all modes of international transport are potentially hazardous and can be associated with disease, stress and suffering. These two sides to international transport provide a challenge for animal husbandry. They set the scene for the present project, which seeks to assist the Australian livestock export industry in its aim of establishing and maintaining a culture of improvement in industry standards and operating procedures (see Foreword to the Australian Livestock Export Standards, ALES; April 1999).

It is significant that a recent book by an American author devoted to livestock handling and transport (Grandin, 1993) provides little information on the sea transport of cattle. Long-distance international transport of cattle is of special interest to Australia and Australia's unique experience will almost certainly provide international benchmarks for best practice.

2. AIMS AND SIGNIFICANCE OF PROJECT

Meat and Livestock Australia is supporting three projects related to the export trade in live cattle. One has surveyed the morbidity and mortality of cattle in the trade. Another will investigate aspects of ventilation on board ships. The third (SBMR.003, *Live Cattle Export: Best Practice Recommendations*) has examined best practice standards for the preparation and husbandry of cattle from Australia. The present proposal is designed to supplement this last project on best practice standards by providing a connection to the body of published scientific knowledge. The aim is to:

- ascertain the degree of existing scientific support for each of the recommendations put forward as best practice,
- identify where the scientific literature might suggest other recommendations,
- foreshadow where scientific knowledge might be pursued so that improvements to husbandry can be made in the future, and
- provide another resource for the continuous improvement to animal husbandry in the live export trade.

The object of SBMR 003, *Live Cattle Export: Best Practice Recommendations,* and thus the present project, is to assist the Livestock Export Accreditation Program (LEAP) in its quest to establish a culture of continual improvements in industry standards and operating procedures. In particular, SBMR 003 provides a discussion paper for the Accreditation and Standards Committee that monitors standards and recommends amendments or improvements to the Australian Livestock Export Standards (ALES).

Important background here is that Australian Livestock Export Standards (ALES) are the focal point for the self-regulated protection of animals by the livestock export industry. The Australian Livestock Export Corporation (LiveCorp), which owns LEAP and initiated the development of the ALES, is the standards body responsible for livestock export under the AMLI Act and Regulations. The AMLI Act and Regulations are the *Australian Meat and Livestock Industry Act 1997* and *Australian Meat* and the *Livestock Industry (Export Licensing) Regulations 1998* (the AMLI Regulations).

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LiveCorp administer the LEAP through a contracted service provider organisation, AUSMEAT, which is the standards body for meat export under the AMLI Regulations. Accreditation by the LEAP is a requirement for a livestock export licence under the AMLI Act.

2.1 The current welfare situation in the live cattle trade

Statistics of disease and mortalities are essential indicators of animal welfare but do not provide the whole picture. Mortality is, perhaps, the tip of a "welfare" iceberg, with death being the ultimate consequence of an animal's unsuccessful attempts to cope with its environment. The earlier consequences of failure to cope raise welfare concerns and animals that do not die may have had their welfare compromised. If these earlier welfare concerns are addressed, mortalities will be reduced. Similarly, if mortality is addressed these satellite welfare concerns will also be reduced. So, the qualifications about mortality as an indicator of welfare do not erode its importance

Livecorp, Agwest (Western Australian Department of Agriculture) and the National Office of Animal Health in the Commonwealth Department of Agriculture Fisheries and Forestry have all conducted analyses of mortality statistics associated with the live export of cattle over both short haul and long haul voyages.. Statistics were provided from the Master's reports of voyages required by the Australian Maritime Safety Authority. These three analyses have reached similar general conclusions. The National Office's analysis came up with the following picture of mortality:

- There is an overall pattern of low level of loss with an occasional eruption. One percent and 2.5 percent of the voyages accounted for 32% and 52% of the mortalities, respectively for the voyages during the period January 1997 to August 1998. The occasional eruptions distort statistics on the overall performance. Recent figures show an overall mortality of 0.2%.
- Factors such as the length of voyage should be evaluated with care. There are confounding influences such as destination which is linked to route and exposure to heat. If heat stress is a major element in the mortality of cattle, a concept of "total heat load or burden" may be important.

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- Analyses of the present mortality statistics are absolutely limited by the absence of important information in the available AMSA data about the animals themselves (breed, sex and age).

The key observation for present purposes is that many voyages of long duration and long distance are associated with negligible mortality or even no mortality. In other words, measurable performance standards or benchmarks have been achieved that can be regarded as reflecting best practice. This best practice can be used to lift welfare performance across the whole trade. In order to do so, best practice itself must be identified and then put to work and managed through quality assurance systems. Accordingly, a clarification of the terms, best practice, benchmarking, quality management, quality control and quality assurance, will be helpful in positioning both SBMR 003 and the present report.

2.2 Best practice and quality assurance

Best practice is not necessarily connected with quality management and is not mentioned in the *International Standard on Quality Management and Quality Assurance – Vocabulary* (ISO 8402) of the International Organisation for Standardisation. Nonetheless, best practice is a simple but effective concept. It operates by surveying the range of practices carried out in a particular area and selecting what seems to be the best. This process identifies standards or benchmarks and is known as benchmarking. Best practice can suggest what can be included in quality assurance systems and provide a basis for the evolution of these systems; hence, SBMR 003 and the present project which supports it.

ISO 8402 provides a common and internationally accepted starting point on concepts and terminology for the management of quality including that for animal welfare. It underpins both the ISO 9000 family of quality standards and guidelines, which aim at quality management systems, and the ISO 14000 family of international standards, which aim at environmental management.

As for terminology, "quality assurance" is more general than "quality control" and refers to all the "planned and systematic activities implemented within the quality system and demonstrated as needed to provide adequate confidence that an entity will

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fulfil requirements for quality". The purposes of quality assurance are internal, to provide confidence to the management, and external, to provide confidence to the customers. In the case of animal welfare, the external purpose of providing confidence can be extended to the general community. The phrase "demonstrated as needed" implies the application of "objective evidence" or "information which can be proved true, based on facts obtained through observation, test or other means". In the case of the live export trade, this could refer to properly considered observations from the trade itself supplemented by material already present in the body of scientific knowledge.

Quality control is a component of quality management. It is applicable to manufacturing production as statistical quality control (Britannica CD, Version 98c, 1994-1998) but contains some ideas that could be extended to the management of welfare in the live export trade. To explain, control charts or R-charts are used to determine whether a particular problem is due to randomly occurring variations, so-called "common causes" that are unconnected to the process is, or to extraordinary or "assignable" causes that can be attributed to the process. A similar distinction between "common causes" and "assignable causes" applies to animal welfare during transport. For the live export of cattle, heat stress would be an "assignable" cause of mortality. By contrast, the rupture of a pre-existing aortic aneurysm (for example), which could be neither predicted nor prevented, would be a "common cause". The current surveillance of mortality rates acts in the same manner as the control charts for manufacturing and can be used to signal concern when rates point beyond "common causes" to "assignable causes" that can be attributed to the process of transportation or to lapses in general husbandry. The task of quality management and best practice is to anticipate and prevent "assignable" causes of mortality.

To sum up, quality assurance (QA) schemes operate through sets of standards and the maintenance of production documentation to allow for the certification of the quality of a product produced, or activity pursued, under them. QA schemes are valuable for promoting and informing continual improvements in a given activity or product. In the present context, quality assurance refers to a demonstrable and comprehensive system for maintaining and improving desired levels of health and welfare in

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livestock during the whole process of live export through careful planning, the application of sound scientific knowledge, the use of proper equipment and procedures, continued inspection at critical points and corrective action where required. Demonstrability requires third party audit.

A common understanding of best practice and quality assurance is important if the LEAP standards are to drive the process of continual improvement and “best practice” is not to become a devalued concept or to be claimed without justification. Best practice implies a standard of excellence. The present purpose is to explore the support for best practice that resides in the body of published scientific knowledge.

2.3 The application of epidemiology to best practice and quality assurance

As stated previously, QA schemes are valuable for promoting and informing continual improvements in a given activity or product; for instance, the health and welfare of cattle during live export. Inputs to rational decisions for improving this health and welfare can come from:

(1) analysis of the current body of scientific knowledge,
(2) experiments to test hypotheses, and
(3) appropriately detailed observations made on cattle during the whole process of transportation.

The observations in (3) are critical for characterising best practice or identifying where current science might be applied or where more information and insight is required. Knowledge on the processes for observing the health status of populations of animals and people and making statistical inferences from these observations has been collated and codified as the scientific discipline of epidemiology.

Epidemiological methods can be tailored to animal welfare because this area of concern is intimately bound to disease and health. They have already been used effectively in the live sheep trade and underpin a current MLA project on mortality and morbidity in the live cattle trade. Furthermore, epidemiological methods can build from the practical experience and clinical observations that underlie the best practice recommendations made in SBMR 003. Science includes this latter sort of germinal knowledge as well as established knowledge in the scientific literature.

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Epidemiology is described as the study of health-related conditions or events and factors (risk factors) associated with the occurrence of these conditions or events in defined populations (Last, 1988). Cattle transported by sea are a defined population. Furthermore, the multi-factorial nature of the cause of disease and health problems is regarded as a centrepiece of modern epidemiology. Experience suggests that the impacts on the welfare of cattle at sea are also multi-factorial and result from a web of causes involving interactions between the genetic make-up of cattle, their past conditioning and the prevailing environment. As for health-related factors, epidemiological methods can describe how healthy cattle adapt to sea transport and, at the same time, elucidate the processes and events that lead to disease and poor welfare. The contrasting picture between healthy and unhealthy cattle will show when animals are in the process of coping. It will also identify the associated risk factors and their mitigation. The essence of epidemiology is to let the system under study speak for itself.

An epidemiological view of the causes of health-related conditions is useful for understanding the interacting web of factors that affect the welfare of cattle and determine best practice husbandry. Causes can be either necessary or sufficient or both. “Necessary” causes always precede an effect but this effect need not be the sole result of the one cause. “Sufficient” causes inevitably initiate or produce an effect. Causes include enabling factors, predisposing factors, precipitating factors and reinforcing factors. Predisposing factors create a state of susceptibility to a disease agent or environmental stressor; for example, obesity predisposes to heat stress. Enabling factors facilitate either the expression of a disorder or the recovery from a disorder. For example, aspects of housing may either facilitate thermal stress or act against it. Predisposing and enabling factors may be “necessary” but are rarely “sufficient” causes of a disorder. “Precipitating” factors are associated with the definitive onset of a disease or disorder. For example, exposure to environmental temperatures and humidity precipitates the disorders associated with heat stress and is a necessary cause. “Reinforcing” factors tend to perpetuate or aggravate the presence of a disease, disorder or health-related condition.

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"Risk factor" is another epidemiological concept with an application to the quality assurance systems for health and welfare of cattle during live export. The best practice recommendations in SBMR 003 are directed at the management of risk factors. The term, risk factor, covers:

(1) attributes or exposures that are associated with an increased probability of a specified outcome, such as the occurrence of a disease;

(2) attributes or exposures that increase the probability of occurrence of disease or other specified outcome; and

(3) determinants that can be modified by intervention, thereby reducing the probability of occurrence of disease or other specified outcomes (Last, 1988) – these are so-called modifiable risk factors.

3. BACKGROUND CONSIDERATIONS

Some other preliminary considerations of animal welfare and husbandry are important background for the present report. These include:

- an account of the nature of animal welfare,
- a history of the general aspects of animal welfare during transportation, and
- an updated view on stress and stressors.

3.1 The nature of animal welfare

Much has been written about what animal welfare is and there are abundant definitions that emphasise different aspects of the subject in a confusing manner. The result is misunderstandings and cross-purposes that handicap the development of policy on animal welfare. This unfortunate situation is critically important in the present context since public concern about the export of live cattle relates to animal welfare and the Australian Livestock Export Standards are directed at animal welfare. Accordingly, a contemporary view of the subject is provided in Appendix 1. For present purposes, animal welfare refers to the humane care and use of animals. It covers animal health and the absence of disease. The scientific definition favoured is that of Broom (1986) which sees animal welfare as "the state of an individual [animal] as regards its attempts to cope with its environment". This definition allows for a view of animal welfare that embraces matters such as "fitness to travel" and "freedom from clinical disease" that are the crux of both quality assurance and the

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AQIS Third Party Service Program for the Pre-Export Preparation of Livestock Species.

3.2 General aspects of animal welfare during transportation

The current approach to animal welfare in the live cattle trade is the result of evolving experience. A retrospective on the general aspects of animal welfare during transportation is provided in Appendix 2 for orientation. The most influential development has been the application of epidemiological methods to animal health and welfare in the live sheep trade. Examples are:

(1) analyses of ill-health and mortality during live sheep exports (Richards, Norris, and McQuade, 1986),

(2) studies on the epidemiology of salmonellosis in the live export industry (Higgs, Norris and Richards, 1993),

(3) studies on the effect of season and age and fatness of sheep on death rates of sheep exported by sea (Higgs, Norris and Richards, 1991),

(4) the analysis deaths in sheep exported by sea from Western Australia using ship Master's (Norris and Richards,1989),

(5) investigation by post mortem examination of the causes of death in sheep exported live by sea (Richards, Norris, Dunlop, and McQuade,1989),

(6) an epidemiological study of sheep deaths before and during export by sea from Western Australia (Norris, Richards, and Dunlop, 1989a),

(7) a study of pre-embarkation risk factors for sheep deaths during export by sea from Western Australia (Norris, Richards, and Dunlop, 1989b), and

(8) an analysis of the seasonal metabolic factors that may be contribute to deaths in sheep exported by sea (Richards, Hyder, Fry, Costa, Norris, and Higgs,1991).

Results of epidemiological analyses have framed a rational approach to experimental studies. Examples here are through simulated voyages in feedlots to investigate aspects of nutrition (Warren et al., 1990; Norris et al, 1990: Norris et al., 1992). In summary, the marriage between epidemiological and experimental studies is the result of evolving experience. It has been effective for investigating health and welfare of sheep during live export and could be equally effective for same purpose in the live cattle trade.

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A bibliography on the transport and handling of livestock and poultry up to 1994 is available from the National Agricultural Library of the US Department of Agriculture. Reviews on the transport of cattle have been made by Knowles (1999), Leach (1982), Tarrant (1990), Tarrant and Grandin (1993), and Warriss (1990). Differences in the genotypes of Australian cattle and their resulting phenotype in response to climatic and other environmental factors prevents the literal application of results from overseas studies.

3.3 Stress and stressors

Stress is an important systemic state for animal welfare and is described more fully in Appendix 3. It appears when the mechanisms in animals for coping with their environment become overextended and start to breakdown (Stratakis and Chrousos, 1995). The environmental factors that produce stress when they act excessively are termed stressors. The stressors on cattle during live export can be classified as

- physical,
- nutritional,
- behavioural and
- those related to infection (disease stressors).

Adaptive responses to them involve the action of the nervous, endocrine and immune systems.

The interactions between stressors and the persistence of their effects are likely to be important for cattle during live export. A recent depiction of stress as the cost of adaptation to stressors, or the so-called allostatic or homeostatic load (McEwen, 1998), provides a useful way of looking at the problem and facilitating the epidemiological approach. Allostasis is a more recent variation on the concept of homeostasis[1]. It refers to “stability through change” and is an essential means for maintaining the constant internal environment of animals. Allostatic or homeostatic systems may be overtaxed, leading to disease and the state commonly referred to as “stress”.

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[1] Homeostasis: The maintenance of a constant internal state in an animal.

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This recent view of stress as the cost of adaptation or the allostatic load provides helpful guidance for best practice. The cost of adaptation can be repaid, or the allostatic load can be shed, if animals are allowed to adapt or recover at particular points in the transport chain. Alternatively, the cost of adaptation can become a rising debt or the load can become larger. Heat stress differs from other forms of stress because it suppresses rather than stimulates the activity of the adrenal cortex. Its interaction with other stressors is unclear. Do the different stresses compound with one another in cattle and build up as a “load” during the process of transportation? Best practice suggests that cattle can adapt to ships as though they were relatively stress-neutral and floating animal houses.

4. METHOD

The best practice recommendations in SBMR 003 are designed to mitigate or cancel out the impact on cattle of the

- physical stressors,
- nutritional stressors,
- behavioural stressors and
- disease stressors

that may be encountered during the process of transport. Best practice is directed towards the risk factors that influence the responses by animals to stressors in these four categories and determine their “fitness to travel”. Accordingly, the practicalities of best practice relate to the preparation, assessment and selection of animals before transport, the provision of suitable environments, feed, water, comfort and rest during transport and arrangements for recovery and restoration after transport. Some key questions are:

(1) What are the biological risk factors related to thermal stress that can be listed in a scientifically defensible way?

(2) Are breeds that are not heat adapted fit to undertake a journey where relatively rapid transport into hot regions prevents the opportunity for acclimatisation?

(3) What physiological states make animals unfit to undertake the journey?

The approach taken in the present report is to review each of the four classes of stressors and the risk factors involved with them in order to ascertain the degree of existing scientific support for the recommendations put forward as best practice in

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SBMR 003. This approach allows for two secondary aims, which are to identify where the scientific literature might suggest other recommendations, and to foreshadow where scientific knowledge might be pursued so that improvements to husbandry can be made in the future. For guidance through the text, the Appendix at the end of SBMR 003 shows the connection between the best practice recommendations, the stressors and risk factors associated with them and the support they have from scientific knowledge. Some issues that do not fall readily under the heading of these stressors are treated separately. This appendix can be used as a summary of findings from the present exercise.

Physical, nutritional and behavioural stressors are considerations for designing the environment of farm animals (Solon, Lay and von Borell, 1998). As a consequence, the risk factors connected to each of the four classes of stressors can be managed by "best practice" design of the physical, dietary and social environment provided for cattle during live export. Design characteristics of an animal's environment will influence the burden of disease ("disease stressors") by acting against secondary causative factors; the predisposing and other factors described earlier.

5. RESPONSES BY CATTLE TO PHYSICAL STRESSORS CONNECTED WITH TRANSPORT

Heat stress and physical injury were recognised in early accounts as the usual causes of mortality and rejection in slaughter cattle transported by sea (Anonymous, 1988). No new information has come to light to indicate that the situation has changed. So, heat will be regarded as the main physical stressor. Other physical stressors could be different sorts of mechanical factors such as jolting, swaying, vibration and the motion of ships at sea, particularly during rough weather.

5.1 PHYSICAL STRESSORS – HEAT

The physiology of heat stress and the pathological aspects of heat stress provide background for considering the risk factors for heat-related disorders that are the object for best practice.

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5.1.1 The physiology of heat stress

The fundamental ideas about thermal physiology are well established and are based on long known principles derived from the physics of heat. Many accounts of the subject appear in monographs, textbooks and articles. Examples are Bligh (1973 and 1998), Eckert (1988), Hensel (1981), Ingram and Mount (1975), Mount (1979), Ruckebusch and others (1991), Whittow, 1970, Yousef (1985) and Webb (1995).

In health, the core body temperature of homeothermic mammals such as cattle is preserved within a narrow range by sensitive homeostatic mechanisms that regulate rates of heat production and heat loss. The core, about 66% of body mass, stays constant and is represented by the rectal temperature, which has a normal value of 38.5°C and a critical point of 39.5°C for cattle (Blood and Radostits, 1989). The remainder of the body, the outer shell including the skin, can be at a lower or higher temperature depending upon circumstances such as the external heat load or physical activity that generates heat.

Total body heat is the result of heat produced in the body and heat transferred between the body and the environment. Key aspects of the thermal environment here are ambient temperature, humidity, radiation and wind which determine the rate of heat exchange through conduction, convection, radiation and the vaporisation of water molecules from the surface of the animal. Conduction, convection and radiation lead to sensible heat losses since the flow of heat to the environment can be sensed as heat. Evaporative heat loss is referred to as insensible since the environmental change observed relates to humidity. Evaporative heat exchange occurs (1) across the large surface area at the interface between respired air and the circulatory system in the lungs, (2) through sweating or the secretion of water to the skin surface via sweat glands and (3), in some small mammals, via saliva spread on the hair coat.

Evaporative heat loss is highly effective considering the latent heat of water of vaporisation of water is 2260 Joules per gram. In other words, the evaporation of one litre of water can lead to the dissipation of 2.26 MegaJoules of heat. The loss of heat by evaporation within the thermoneutral zone exceeds the aggregate loss by conduction, convention and radiation, and accounts for the loss of 0.42 litres of water

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for each MJ of heat exchanged to the environment (Standing Committee on Agriculture, Ruminants Subcommittee, 1990). The key point is the evaporative heat loss will cool animals when the environmental temperature exceeds their own and where dissipation of heat by conduction, convection and radiation is physically impossible.

An environment that is neither too hot nor too cold and which imposes minimal homeostatic or allostatic load or minimal cost of adaptation on an animal is classed as thermoneutral. The thermoneutral zone or comfort zone is the optimum thermal environment for animal production (Yousef, 1985c) and is described in physiological terms as "the range of ambient temperatures within which the metabolic rate is at a minimum, and within which temperature regulation is achieved by non-evaporative means alone" (Bligh and Johnson, 1973). This is illustrated in Figure 1 along with the lower critical temperature where heat production mechanisms cut in under the control of the nervous and endocrine system (Yousef, 1985d) and the upper critical temperature where mechanisms for evaporative heat loss cut in.

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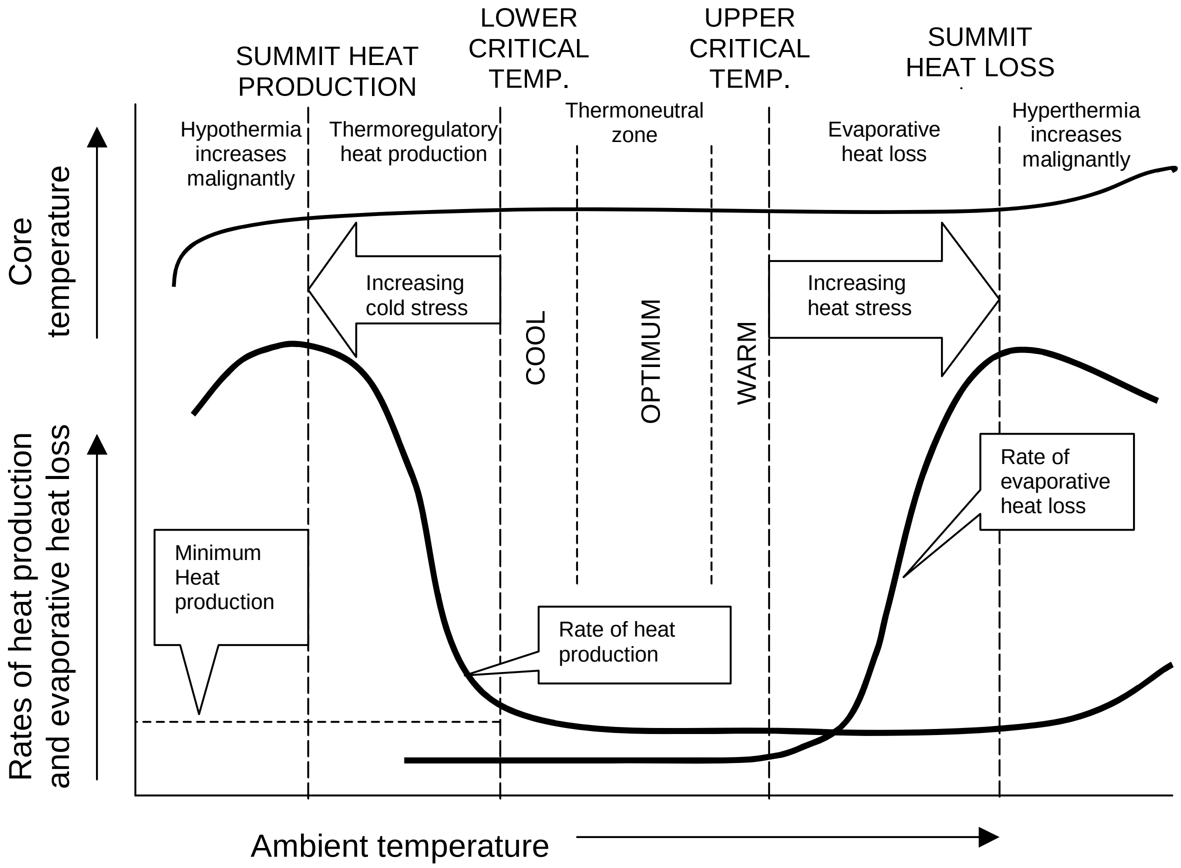

Figure 1. Thermoregulation in mammals such as cattle.

The diagram has been compiled from a variety of sources and ***shows the effect of environmental temperature on heat production*** *below the thermoneutral zone* ***and heat loss through evaporative cooling*** *above* ***the thermoneutral zone.***

Mechanisms for heat loss are the most relevant to present purposes. Heat loss from an animal to the environment is under the control of behavioural, autonomic and adaptive mechanisms but is ultimately governed by the laws of physics. Physical factors include (1) an animal's surface area, (2) the temperate difference between the animal and its environment and (3) the conductance of its surface. Surface area decreases with increasing liveweight and large animals have a relatively smaller surface area through which to lose heat. Small differences between the temperature of an animal and that of the environment require small flows of heat to maintain constant body temperatures. Insulation such as fat and a hair coat in the outer shell protect against heat loss and heat gain through convection, conduction and radiation and maintain core temperature within its limits.

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Behavioural mechanisms for heat loss include moving to a more favourable environment (shade-seeking, for example) and adjusting posture (for example, standing to expose the legs to the environment and take advantage of their large surface to volume ratio). Thermoregulatory behaviour is reviewed by Ingram and Dauncey (1985). Adaptive factors include longer term changes in the hair coat and fatty layer of the skin which appear through the process of acclimatisation or "the persisting spectrum of changes due to prolonged exposure to environmental conditions such as high or low temperatures" (Eckert, 1988). Adaptation here refers to the changes in behaviour of an organism during its life as a response to environmental stimuli. The word will be used later with a different shade of meaning in regard to the heat tolerance of different types, breeds and strains of cattle.

The autonomic mechanisms for maintaining core body temperature above the thermoneutral zone are directed towards heat loss through the vaporisation of water at the animal's surface. They come under the influence of the nervous, circulatory, respiratory, and endocrine systems. Mechanisms for maintaining the body's electrolyte and water balance are vital. Evaporative heat loss in cattle occurs through both panting and sweating but sweating predominates to make up 84% of heat loss at an air temperature of 40°C (McLean, 1963: quoted by Robertshaw, 1985). Respiratory evaporation and panting accounted for 32% of total heat loss from steers at 35°C (McLean and Calvert, 1972).

As for neural control of heat loss, a servomechanism appears to operate with feedback from heat loss and the possibility of feedforward from heat production (Webb, 1995). In this connection, there are heat receptors at the surface of the skin and neurones in the hypothalamus of the brain that respond to changes in the temperature of circulating blood (Ruckebusch et al., 1990). The apocrine sweat glands of cattle, which produce sweat and evaporative cooling, are controlled by alpha-adrenergic components of the autonomic nervous system (Findlay and Robertshaw, 1965). They differ from the eccrine sweat glands of people, cats and dogs which are controlled by cholinergic nerves. It was considered earlier that catecholamine hormones from the adrenal medulla or elsewhere did not influence sweating in cattle (Findlay and

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Roberstshaw, 1965). However, intravenous adrenaline or isoprenaline can induce sweating in live cattle and in isolated perfused skin from cattle (Johnson and Creed, 1982).

The circulatory system and the respiratory system together mediate a range of adaptive responses above the thermoneutral zone. For example, cattle have a network of small arteries at the base of the brain, the rete mirabilis, in which blood to the brain is cooled by countercurrent heat exchange with venous blood cooled in the nasal passages during the process of panting (Ruckebusch et al., 1990). However, the most important mechanism for thermoregulation provided by the circulatory system is to control rates of blood flow between the body core and body shell by shunting blood into or out of surface tissues (reviewed by Rübsamen and Hales, 1985).

Heat loss mechanisms are influenced by thyroid, adrenal and pituitary functions (reviewed for domestic animals by Yousef and Johnson, 1985). Heat acclimatisation in dairy cattle is accompanied by a decrease in activity of the thyroid gland (Thompson, 1973). Plasma cortisol concentrations in cattle rise on initial exposure to a hot environment and probably in response to heat as a non-specific stressor (Christison and Johnson, 1972). However, cortisol levels are reduced after acclimatisation (Yousef and Johnson, 1967; Alvarez and Johnson, 1973). This decreased is accompanied by the benefit of a reduced metabolic heat production. Heat stress is the only form of stress accompanied by decreased rather than increased production of cortisol. One of the most recent breed comparisons of heat tolerance showed that Brahmans had higher plasma cortisol concentrations than Herefords or Angus cattle (Hammond, 1996).

In view of the importance of evaporative cooling, it is not surprising that exposure to heat has an impact on the hormones involved in water and mineral metabolism in cattle. The first of these is aldosterone, an adrenal steroid, which promotes the retention of sodium and the secretion of potassium by the kidney and thus increases the volume of body water. Plasma concentrations of aldosterone decrease after about 24 hours exposure to heat stress (El Nouty et al., 1980). The second hormone is ADH, a pituitary hormone, which inhibits the thirst centre in the brain and produces a more

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concentrated urine by stimulating the reabsorption of water in the kidneys. ADH also reduces the secretion of sodium, magnesium, calcium, potassium and chloride by the kidneys. Plasma concentrations of ADH rise rapidly in cattle exposed to heat stress (El Nouty et al., 1980).

Hormones from the medulla of the adrenal gland are affected by heat stress. The content of noradrenaline and adrenaline increased in milk when dairy cows were exposed to heat stress for three days (Katti et al., 1987) suggesting these homones could be useful indicators of the cost of adaptation.

5.1.1a Temperature-humidity indexes

Indexes for measuring environmental warmth and have been developed for people and cattle (Yousef, 1985b). The index for people integrates wet bulb temperatures for humidity, dry bulb temperatures for ambient temperatures and Vernon globe (black body) temperatures for ambient radiant temperatures. Wind is measured by a thermoanemometer. An index developed for cattle is the temperature-humidity index which integrates wet and dry bulb temperatures for humidity and ambient temperate (Kibler, 1966, quoted by Yousef, 1985b). This temperature-humidity index is the basis of the heat alert table shown in the Stockman's Handbook. Relevant questions are whether a more suitable index of the thermal environment could or should be developed for routine application to the live export trade and whether the recording of the thermal environment of cattle during live export could be refined. A problem with the scientific literature examined for this report is that hot conditions are often described in terms of ambient temperature only, thus hindering comparisons between studies.

At the research level, evaporimeters are available for measuring rates of sweating of cattle in field conditions (Gatenby, 1980) and could be brought into line with more recent technology. Infra-red thermography is a possibility. Radiotelemetric methods have been used to measure core body temperatures in feedlot steers by the use of implanted transmitters (Lefcourt and Adams, 1996 and 1998).

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5.1.2 Pathological aspects of heat stress

The malfunctions, disorders and diseases that occur in cattle as a result of heat stress are not nearly as well known as the normal functions that help cattle adjust to their thermal environment. Malfunctions can appear (1) acutely as the result of a heat load that overwhelms an individual animal's capacity to respond or (2) chronically as part of the cost of adaptation to a heat load. Interactions with nutritional factors and water balance will be important in their causation – perhaps more important for the chronic effects of excessive heat. In this regard, heat loads can be either a necessary or sufficient causes of heat-related disorders (see section for a description of necessary and sufficient causes of disease). In some instances, heat load may act as a sufficient cause and both initiates and produces a heat-related disorder on its own. In other instances, heat load is a necessary cause and must always precede the disorder. However, the disorder will not appear unless other secondary causes associated with nutrition, water balance, genetic background or current physical status operate as risk factors.

Four interrelated disorders are associated with high environmental temperatures in people (Braunwald et al., 1988). They are mentioned here because the heat-related disorders of cattle are likely to show a similar range of variation and occur as a result of similar disruptions. A major proviso is that the ruminant digestive system and the accompanying adaptations in other systems will modify the responses observed. These are heat cramps, heat exhaustion, exertional heat injury and heat stroke. Their clinical characteristics merge with one another and they are considered to be variants in the range harm caused by environmental heat. They are most often seen during heat waves in the period before acclimatisation cuts in (about 4-7 days)[2]. Loss of water and electrolytes is an important consideration since it leads to increases in the viscosity of blood and its sluggish and ineffective passage through tissues, a drop in blood volume below that required for heart function and neurological disorders that accompany these two circulatory changes.

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[2] People, like cattle, can withstand remarkably high environmental temperatures with little change in core temperatures if sweating occurs and if water and salt lost through the process are replaced. Other changes during acclimatisation in people are dilatation of the peripheral blood vessels to help dissipate heat by convection and radiation, a decrease in total blood volume, a decrease in blood flow to the kidneys, an increase in antidiuretic hormone and aldosterone, a decrease in sodium in the urine and increases in respiratory and pulse rates.

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Heat cramps, painful spasms of the voluntary muscles after strenuous exercise, are the mildest of the disorders seen in people. They occur without a rise in body temperature and are treated by replacing depleted sodium chloride and water.

Heat exhaustion occurs when the circulatory system fails to adjust to a changing heat load. Since prostration occurs before exposure to heat is prolonged, the body temperature may be normal or below normal. The lesson from heat cramps and heat exhaustion for cattle during live export is that heat-related disorders need not be associated with raised body temperatures.

Exertional heat injury occurs with physical exertion in environmental heat (high temperatures and high humidity) and differs from heat stroke in that sweating occurs freely. The body temperatures observed are high but not as high as in heat stroke. Circulatory failure and electrolyte and water imbalances are seen. There can be severe complications such as kidney failure and breakdown of blood and muscle components.

Heat stroke is the most severe of the heat-related disorders seen in people. It usually occurs when there is pre-existing chronic disease and can appear without warning signs or profuse sweating. The body temperatures observed are extremely high. Death can occur quickly or can be delayed for several weeks and be related to heart damage, heart failure, kidney failure, pneumonia or bacterial infection. Liver damage is common. The lesson from exertional heat injury and heat stroke for cattle during live export is that heat-related disorders are associated with damage to a range of body systems, interact with other problems and have lingering effects.

A single heat-related disorder, hyperthermia (heat stroke), is described for cattle and other domestic animals in standard veterinary textbooks (Blood and Radostits, 1989;) but is unlikely to be the complete picture in view of the precedent from human medicine. Heat-related nutritional disorders will be discussed with the nutritional stressors.

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Hyperthermia in animals has the defining diagnostic feature of a raised body temperature. The possibility of extensive degenerative changes in most body tissues is pointed out. Post mortem findings are regarded as poorly defined and inconstant. Peripheral vasodilatation may be present. Blood coagulation may be slow and incomplete and rigor mortis and putrefaction may occur early. The key point is that post mortem findings are not diagnostic in themselves. Their lack of specificity cannot be used to refute the possibility of a heat-related disorder in the face of a history of exposure to a heat load and evidence of failing adaptive responses because risk factors have operated.

5.2 RISK FACTORS AND BEST PRACTICE FOR HEAT STRESS

5.2.1 Type, breed and strain of cattle

SBMR 003 (section 3.1.1) refers to the view that *Bos indicus* cattle are better able to cope with heat stress than *Bos taurus* cattle and are thus more suited to the conditions of travel encountered in the live export trade. It draws attention to the hazards associated with transporting *Bos taurus* cattle to the Northern Hemisphere from ports south of the 26th parallel during the period corresponding to the northern summer, from the beginning of May to the end of October. In doing so, it requires supporting evidence that there are differences in heat tolerance among the types, breeds and strains of cattle. There is ample evidence that the type, breed and strain of cattle are significant risk factors for the live export of cattle and require attention in quality assurance programs.

Primary evidence for these differences comes from the commonsense observation that cattle indigenous to tropical and sub-tropical regions are better adapted to the prevailing conditions of heat than cattle derived from temperate and cool regions that are, in turn, adapted to other conditions. Secondary evidence comes from studies of the physiological mechanisms involved in the response to heat stress and other studies where deliberate comparisons are made.

Differences between *Bos indicus* and *Bos taurus* cattle in their adaptation to hot conditions were recognised early in the development of Australia's northern cattle

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industry and were the subject of research and development programs that began in the 1930s. R. B. Kelley (1943) stated that “natural causes have operated so that domestic cattle can be divided into two great classes, those of tropical and sub-tropical countries and those of temperate and sub-arctic territories”. Epstein and Mason (1984) give a similar view in their treatment of the evolution of domestic cattle: “the hereditary physiological adaptation of Zebu cattle in tropical and sub-tropical environments must be attributed to their evolution in a warm climate”. The word adaptation is used here to refer to the “characteristics of a living organism evolved as a consequence of natural selection in its evolutionary past and which result in a close match with features of the environment and/or constrain the organism to life in a narrow range of environments” (Begon, Harper and Townsend, 1990). To avoid confusion, Yousef (1985a) suggests the use of the term genetic adaptation in this situation. Adaptation is used later in this report to refer to changes that occur during the life of cattle in response to environmental conditions.

Epstein and Mason (1984) divide *Bos indicus* into zebu-type cattle, which have thoracic humps and zeboid cattle, such as Sanga cattle, which have cervico-thoracic humps. Both derive from tropical regions. They also divide *Bos taurus* cattle (European cattle) into longhorn and shorthorn (brachyceros) types. Longhorn types are linked to hotter climates than shorthorn types and there is evidence that longhorn cattle are adapted to hot conditions. So, the general zoogeographical argument that animals indigenous to tropical and sub-tropical regions are better adapted to heat applies to *Bos taurus* as well as to *Bos indicus.* More recent work refers to “temperate” *Bos taurus* (for example the Hereford and Angus) and “tropical” *Bos taurus* cattle which have inferior and superior heat tolerance respectively (Hammond et al., 1996). The superior heat tolerance of *Bos indicus* cattle was a self-evident truth that drove the project to develop the Australian Milking Zebu, a tropically adapted dairy breed (Hayman, 1974).

As at 1985, no direct and deliberate comparisons of the heat tolerance of *Bos indicus* and *Bos taurus* cattle were said to be available (Robertshaw, 1985). However, Epstein and Mason (1984) make some suggestions about why zebu cattle are more resistant to high atmospheric temperatures and intense solar radiation than European cattle. They found no evidence that the hump dewlap and navel flap had any heat-dissipating

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function. By comparison with European cattle, zebus were stated to have a lower basal metabolic rate, a lower rate of water turnover, larger and more numerous sweat glands located closer to the skin surface and a better capacity for evaporative cooling.

A body of secondary evidence points to differences in the physiological mechanisms for heat tolerance among types, breeds and strains of cattle (reviewed in part by Finch, 1986). The general idea is sustained that *Bos indicus* cattle and their crosses with *Bos taurus* cattle have superior heat tolerance compared with *Bos taurus* cattle derived from temperate regions. In addition, “tropical” *Bos taurus* cattle are also better adapted to heat than “temperate” *Bos taurus* cattle. Differences are recorded in autonomic heat control mechanisms such as fasting metabolic rate, non-evaporative or sensible heat exchange (convection, conduction and radiation) and evaporative or insensible heat loss. There are differences of hair coat between *Bos taurus* and *Bos indicus* which influence both non-evaporative and evaporative cooling. Characteristics of the skin and hair coat are vital for protection against solar radiation. They were discussed in a report on heat strain in feedlot beef cattle (Blackshaw and Blackshaw, 1991). They will also be important for exported cattle because solar radiation will have an impact at some points along the transport chain.

Fasting metabolic rate, which reflects resting heat production, is lower in Brahmans compared with Hereford x Shorthorn crosses and Africander cattle (Vercoe, 1970). A figure of 80-85% lower when adjusted for metabolic weight[3] was quoted in Blackshaw and Blackshaw (1994). This translates to daily heat production of 30 MJ for a *Bos indicus* individual of 300 kg and contrasts with the 39 MJ suggested for a *Bos taurus* individual of the same weight (Anonymous, 1990). The difference could be significant for the design of shipboard environments.

Differences in non-evaporative heat exchange occur between *Bos indicus* and *Bos taurus* cattle. Finch (1985) exposed Brahman, Shorthorn and Brahman half-bred cattle to air temperatures ranging from 25ºC to 45ºC and examined the transfer of metabolic heat from the core to the shell of the animal body and the sensible or non-evaporative component of heat loss from the skin to the environment. Non-

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[3] Metabolic weight is liveweight$^{0.75}$

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evaporative heat transfer during heat stress in this study was 20% and 34% poorer in Shorthorns compared with that for Brahman halfbreds and pure Brahmans. The thicker haircoat of *Bos taurus* cattle impedes non-evaporative forms of heat loss (Finch et al, 1984). In this connection, the commonsense observation that clipping of the coat helps animals cope with heat stress has been demonstrated formally in cattle (Yeates, 1955).

Several studies point to the superiority of evaporative heat loss mechanisms in *Bos indicus* compared with *Bos taurus* cattle and “tropical” *Bos taurus* breeds compared with “temperate” *Bos taurus* breeds. In hot room studies, Jersey cattle started to sweat earlier than Zebus and had a higher respiratory rate (Allen, 1962). The sweating response, which integrated sweating rates and rectal temperatures, was a good indicator of the differences in thermoregulatory ability of Brahman, Brahman x Hereford-Shorthorn cross and Shorthorn steers exposed to a radiant heat environment (Finch et al, 1982). Sweating responses reached their limit during the study in the Shorthorns but not in the Brahmans or Brahman crosses. Heat resistance was evaluated in the F1 progeny of Boran, Tuli and Brahman bulls and Hereford dams in an environmentally controlled chamber (Gaughan et al, 1997). Sweating rates were highest in the Brahman x Hereford and Boran x Hereford crossbreds. Sweating rates in the “tropical” *Bos taurus* breeds of cattle, White Fulani and N'Dama, were similar, but were significantly higher than for N'Dama-German Brown crosses, the “temperate” *Bos taurus* breeds, German Browns and Friesians (Amakiri and Onwuka, 1980).

Finally, other studies emphasise the generally superior heat tolerance of *Bos indicus* cattle and their crosses. Allen and Donegan (1974) compared *Bos indicus* and *Bos taurus* crossbred dairy cattle for heat tolerance with a test integrating sweating rate, respiratory rate, rectal temperature and feed and water consumption. Half-bred *Bos indicus* were superior to quarter-bred *Bos indicus* and the test selected animals from dams derived from hot compared with temperate environments. Rectal temperatures, respiration rates, cutaneous evaporation rates, and skin temperatures were measured in Brahman cross, water buffalo (*Bubalus bubalis*), Banteng (*Bos javanicus)*, and Shorthorn steers exposed heat and exercise stress in the sun (Moran, 1973). The

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buffaloes were least heat tolerant followed by the Shorthorns with Brahman crossbreds and Bantengs being most heat tolerant. One direct comparison between breeds was made by Seif et al (1979) on Zebu and Scottish Highland cattle after seven days of acclimatisation at 31ºC. These observations are useful for because they suggest simple indicators of failing adaptation in the West Highland cattle. For example, water consumption increased by 190% in these animals, compared with 58% in zebu cattle, and did not prevent increases in core temperature.

Hammond et al (1996) investigated heat tolerance in heifers of "temperate" *Bos taurus* breeds (Angus and Hereford), "tropical" *Bos taurus* breeds (Senepol and Romosinuano), *Bos indicus* (Brahman), and reciprocal crosses of the Hereford and Senepol. Senepol and Romosinuano heifers were substantially heat tolerant, as were the crosses between the Senepol and the two "temperate" breeds. The heat tolerance of the Senepol and Brahman heifers was similar. In Brazil, Carvalho et al (1995) examined a set of physiological responses to heat and exercise stress in imported *Bos taurus* and native *Bos taurus* of the Simmental breed, and native *Bos indicus* cattle. The imported Simmentals could not complete the exercise test. The native Simmentals could but with severe respiratory stress. The native *Bos indicus* were well adapted and completed the test without obvious signs of stress.

As for the properties of skin and hair coat important in thermoregulation, short, glossy and sleek hair coats are superior to rough, thick coats for survival against heat stress in cattle and coat scores were developed to test the difference (Yeates, 1955). The importance of sleek coats for heat tolerance is corroborated by Turner and Schleger (1960) and Schleger and Bean (1971). Short sleek hair coats are characteristic of *Bos indicus* cattle (Epstein and Mason, 1984). Sweat gland are larger and more abundant in the skin of *Bos indicus* cattle and are located closer to the skin surface (Ferguson and Dowling, 1955; Nay, 1959; Allen et al., 1962).

In summary, there is strong argument from the body of scientific knowledge to support the reduced loading densities mentioned in SBMR 003 (section 3.1.1) and described in the current orders of AQIS where *Bos taurus* cattle are derived south of the 26th parallel during the Northern Hemisphere summer. There is also justification

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for additional reductions in loading density for known heat sensitive breeds during the peak of the northern summer.

5.2.2 Acclimatisation, geographical derivation and pre-export history

SBMR 003 (section 3.1.2) refers to importance of selecting animals that have been acclimatised to warm weather conditions if they are to be transported to or through climatic zones of high temperature and humidity. Scientific support for this best practice is associated with the concepts of acclimation and acclimatisation which refer either to the persisting change in a specific fuction (acclimation) or the persisting spectrum of changes (acclimatisation) brought about by prolonged exposure to environmental conditions such as hot temperatures. The two concepts are combined for present considerations. Acclimatisation involves adaptations that can occur within an animal's pre-existing genetic capacity for change. In other words, *Bos taurus* cattle can acclimatise to some hot conditions but the ceiling in this capacity will be lower than that for *Bos indicus.*

Blackshaw and Blackshaw (1994) state that acclimatisation to heat in cattle begins within two weeks of exposure to hot conditions and is complete within four to seven weeks. Accordingly, satisfactory acclimatisation will not occur during the process of transport and acclimatisation should be in place before the transport commences.

The time estimate of four to seven weeks for heat acclimatisation is built from several sources. Bianca (1959a and 1959b) showed that exposure to either a hot-dry or hot-humid environment for various daily periods over three weeks resulted in acclimatisation accompanied by increased rates of sweating and a lower metabolic heat production. Other support for the time estimate comes from the work of McDowell et al (1981) and Robinson et al (1986) who compared heat production during heat stress in cattle acclimatised to cold, thermoneutral and hot conditions. Senft and Rittenhouse (1985) explored a mathematical model for the heat acclimatisation of cattle in feedlots.

It is likely that different processes associated with acclimatisation adjust at different rates and are affected by season. For example, the long and dense winter hair coat of *Bos taurus* is an impediment to heat loss (Yeates, 1955; Finch, 1985) and

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acclimatisation depends upon the rate at which it can change. Sweat glands may have an enhanced capacity to respond to heat stress during the hotter periods of the year (Schleger and Turner, 1965).

5.2.3 Very large or very fat animals, thin animals and animals with undesirable temperaments

Section 3.1.4 of SBMR 003 looks to livestock with special characteristics and the need to avoid the export of very large or very fat animals. Best practice here is that, "as a general guide, animals over 500 kg liveweight or with fat cover of 20 mm at the P8 site should not be selected for export". SBMR 003 states that there is agreement in principle on this point but that the cut-off points are at issue and are being investigated. Concern is also raised about the export of thin animals with condition score 1 and animals with an undesirable temperament. The presentation for export of cattle with condition score 1 infringes the requirements of AQIS. Large size, obesity, thinness and undesirable temperament can be regarded as risk factors in relation to heat and mechanical stressors; that is, for heat stress and injury. Heat stress is treated here. Mechanical stressors and physical injury are dealt with later.

Scientific support for large size, obesity, thinness and undesirable temperament as risk factors for heat-related disorders and thus for the principles underlying the best practices around these characteristics of animals comes from general knowledge about the response of mammals to hot conditions rather than from the results of specific investigations. Experience of the live export trade has already prepared an indicative case and prompted the best practice recommendations. A complete case can be made through this general scientific knowledge. Further investigation, perhaps through systematic observations on cattle during live transport, will help to identify limits but may not refute the limits already suggested in SBMR 003 which are based on clinical judgement.

The argument for not exporting animals over 500 kg liveweight flows from the idea that heat loss occurs through evaporative and non-evaporative pathways as described earlier. Non-evaporative pathways operate completely through the skin and thus depend upon an animal's surface area. In cattle, approximately 70% of evaporative cooling occur through the skin and also depend upon an animal's surface area. The

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problem is that surface area decreases in relative terms as animals become heavier. Consequently, larger animals have a reduced capacity and smaller animals have an increased capacity for heat flow from the body (see Eckert, 1988). The mathematics on this point is that the surface area of a body of given density and isometric shape increases with the square of its linear dimensions whereas the volume, and hence mass, increases with the cube of its linear dimensions. So, large animals have an inherent problem for heat loss.

Scientific support for obesity as a risk factor for heat-related disorders comes from the ideas about size just described plus a particular phenomenon associated with obesity. Obesity increases the insulating capacity of the shell of an animal because fat has a lower thermal conductivity than water, which is the main component of non-fatty tissue (Eckert, 1988). In addition, fatty tissue has a lower blood supply than non-fatty tissue and a large layer of subcutaneous fat will impede the action of arteriovenous anastomoses which divert blood flow to or away from the skin (Rübsamen and Hales, 1984). So, heat loss from the core is impeded when cattle are fat. A point of information is that the condition scores described for cattle by the National Research Council of the USA (1996) relate scores of 5 (moderate), 6 (good), 7 (very good), 8 (fat) and 9 (very fat) to body fat percentages of 18.9, 22.6, 26.4, 30.2 and 33.9.

Scientific support for thinness as a risk factor for heat-related disorders differs from that applying to large size or obesity. AQIS requirements put the question of poor body condition outside the scope of best practice. It is basically unacceptable to transport thin animals.

Conditions score 1 refers to the scoring system of AUSMEAT and the presence of other scoring systems could be a source of confusion. At condition score 1 for beef cattle as described by the Ruminants Subcommittee of the Standing Committee of Agriculture (1990) and attributed to Lowman et al (1976), the spinous processes are still sharp to the touch and animals are very thin. This description tallies with condition score 2 of the National research Council of the USA which is associated with a body fat percentage of 7.5.

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Two factors compromise thin cattle exposed to hot conditions. Firstly, the high core temperatures that can accompany heat stress lead to increased metabolic rates which are difficult for thin cattle to cope with from their diminished energy reserves. Secondly, feed intakes are reduced by heat stress (Vercoe, Frisch and Moran, 1972; NRC, 1981; Conrad, 1985) which means that thin cattle may only have the option of fuelling their higher metabolic rate from body reserves of energy. An additional problem is that heat stress can lead to the catabolism of body protein (Vercoe, 1969; Vercoe and Frisch, 1970), which thin animals are also unlikely to be able to sustain.

Undesirable temperament, particularly when expressed as flightiness, is a risk factor for heat-related disorders in exported cattle. Flightiness refers to the tendency of cattle to display the alarm reaction more prominently and with lower stimulation that expected of the species (Beaver, 1994). The alarm reaction, the fight-or-flight response, is associated with an increased metabolism and heat production (Ruckebusch et al., 1991). The added heat from this source will be damaging if the heat load is already high. Heart rate increases in animals during the alarm reaction and persistent displays of alarm raise the resting heart rate. In this regard, heart rate can be used to gauge energy expenditure and thus heat production of cattle (Brosh et al, 1998). Accordingly, heart rate measurements could be useful in shipboard studies to clarify the physiological response of cattle to live transport. Finally, flighty behaviour in one animal can influence the general behaviour of in-contact animals and escalate heat production in groups of animals. Put simply, cattle must keep their cool.

5.2.4 Pregnant animals and heat stress

Pregnancy is a risk factor for heat stress because pregnant animals have a reduced heat tolerance and a greater susceptibility to heat-related disorders. Reduced heat tolerance in pregnancy is supported from basic scientific ideas. The developing foetus adds further tissue mass for heat production without adding sufficient surface area to dissipate the extra heat. A full account of the implications of pregnant animals for live export, including a greater susceptibility to heat-related disorders and their behavioural needs, is given in the section on physiological states. Heat stress can lead to loss of embryos and early foetal mortality in the initial stages of pregnancy (Ball, 1997). Heat stress in the last third of pregnancy can precipitate ketosis (“pregnancy

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toxaemia") if it perturbs water balance or decreases feed intake (Caple et al, 1977). The best practice recommendations of 15% more space during the first two trimesters of pregnancy and 100% more space in the last trimester is for behavioural reasons as well as for managing heat stress. The figures are recommended as reasonable minimum estimates.

5.2.5 Temperature, Humidity and Ventilation

SBMR 003 refers to temperature, humidity and ventilation as a set of closely interrelated factors with the single most significant impact on the welfare of cattle (section 3.4.2). However, control of these factors can be difficult for the stockman and crew because weather can change, the decision on risk related to voyages resides with the exporter and elsewhere, and the capacity of the ventilation is foreordained by its design characteristics.

Best practice refers to constant vigilance by the stockman on board to identify hot spots as quickly as possible and to take action according to the options in the Stockman's Handbook (3.4.2 iv). In many cases, the hotspots will be the result of design problems and will require clear reporting to those responsible for correction. Such reporting and recording could be part of best practice. It would be helped by the availability to stockmen of portable instrumentation for measuring temperature, humidity and airflows.

The effectiveness of ventilation depends on the heat generated by cattle that has to be dissipated, mainly by evaporative heat loss from the respiratory system (about 30%) and sweating (about 70%), against gradients of temperature and humidity in the prevailing environment. As the temperature and humidity in the environment increase, evaporative cooling becomes more difficult. Ventilating air flows must also increase if ventilation is to be effective in maintaining the health and wellbeing of cattle.

At some combinations of ambient temperature and humidity, ventilation without refrigeration and dehumidification will become ineffective. There are implications here for the chartering of ships "with a reputation for good ventilation and maintenance"; that is, those with design characteristics that can cope with the

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hardships of voyages to particular destinations at particular times of the year. Satisfactory practice in this connection will be clarified by the ventilation study being executed under the auspices of MLA. An informed choice of ships based on proper knowledge of the design characteristics of ventilation systems will be a major component.

Since the effectiveness of ventilation is related to the heat load that must be dissipated, the stocking density of cattle is highly significant. Overstocking of pens is mentioned in SBMR 003 in sections 3.3.1.iv ("confirm appropriate loading densities and other regulations relating to the destination, load port and season") and 3.4.1.iv (assess pen densities to determine overstocking and make appropriate adjustments).

Recommended stocking densities are based on liveweights of cattle and these can vary markedly depending upon water intake and the consequent state of hydration. Weight losses of cattle associated with transport are highly relevant here and have been reviewed comprehensively by Wythes (1994). Their relevance is that the heat production estimates used in feeding standards are based on animals whose state of hydration has not been perturbed. Weight estimates, and hence stocking densities, based on dehydrated cattle at the end of the road transport stage of the export process will underestimate the heat load that must be met by ventilation systems on board ship.

The provision of water is critical for weight loss during road transport (Wythes et al, 1980, 1981 and 1985) and is influenced by the additional provision of hay or salt (Bailey et al, 1985). This loss is more closely related to the total transit time than to the distance travelled (Wythes et al, 1981; Jones et al, 1988) and the loss of liveweight exceeds that for carcase weight because of the losses in gut fill (Holmes et al, 1982). Transit times reflect the total time off feed and water and the period of water deprivation, not transit time nor distance travelled, is the determinant employed in the *Australian Model code for the Welfare of Animals – Land Transport of Cattle.* However, the state of arousal of cattle with its impact on metabolic rate and heat production is an additional factor in water loss during road transport.

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Average liveweight losses in cattle deprived of feed and water for 6, 12, 24, 48 and 72 hours are about 2.5, 4, 6, 10 and 12% of initial liveweight (Wythes, 1994). If water deprived animals weigh in at say, 300 or 400 kg, after up to 48 hours of water deprivation, their normal hydrated liveweight could be 330 or 440 kg which means that pens could be overloaded. If the generalised prediction equation in the Australian feeding standards are applied (Ruminants Subcommittee, 1990), differences in resting heat production between 300 and 330 kg animals and 400 and 440 kg animals may amount to 2 MJ per day.

Best practice should include the requirement that liveweight estimates of cattle for determining stocking rates on ships are those for properly hydrated animals. A suggestion is that if animals are weighed at the completion of the road transportation stage, the appropriate upward adjustment could be 2.5, 4, 6 or 10% of the measured liveweight for times off water up to 6, 12, 24 or 48 hours.

5.2.6 Fodder and Feeding

Fodder and feeding in relation to heat stress are mentioned in section 3.4.1 of SBMR 003 as the need to "ensure animals have free access to feed and water". Section 3.4.5 refers to the problem of feeding for weight gain, which will generate more body heat than those on maintenance rations.

The feeding regime will affect heat production in cattle and have an impact on heat stress. Animals fed for weight gain will indeed generate more heat than animals fed for maintenance because the heat increment from feed will be larger as a result of the larger consumption. To explain, about 65-70% of the total heat generated by food is used for metabolism. Confined cattle generate about 880 kcal per day through the processes of eating such as chewing and regurgitating cud (Ruckebusch et al, 1991). The work of digestion mainly through fermentation processes in the rumen comprises about 10% of daily heat production. This percentage may vary significantly according to the nature of the ration. The heat produced by the processes of eating and digestion is known as the heat of increment.

Roughages containing a high proportion of cellulose have a high heat of fermentation and should be considered as a source of heat during live export. So, the nutritional

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strategy for cattle to cope with heat stress is to limit the heat of fermentation in rations without reducing their metabolisable energy. This can be achieved by reductions in the intake of fibre (see section 6.1.2 for further explanation). The reduction in fibre intake seems to run against common knolwedge. However, the approach is supported by the feeding strategies to sustain production in the face of hot conditions for dairy cattle (Beede and Collier, 1986; Conrad, 1985; Fuquay, 1981; Hall et al, 1997; Morrison, 1983) and beef cattle in feedlots (Young and Farrell, 1993). There appears to be no specific consideration in the scientific literature of the nutritional strategy for heat stress in cattle during live export by sea. #

5.2.7 Water and Electrolytes

Best practice aims at ensuring animals are properly hydrated and able to sustain evaporative cooling over long periods without entering water deficits that continue to escalate. Sections 3.4.1 and 3.4.5.(iv) of SBMR 003 refer to the medication of drinking water before loading and the methods for ensuring that water is available to cattle at all times. Water is discussed more fully under the heading of nutritional stressors and again with the behavioural stressors. However, as a guide to water requirements, sweating cattle can lose 600 ml of water per square metre of skin per hour (Ferguson and Dowling, 1955). The draft *Australian Model Code of Practice for the Welfare of Animals: Cattle* gives an approximate water consumption of 25-35 litres per day for an animal of 350 kg liveweight and states that this requirement can double in hot conditions.

5.2.8 Deck and Bedding

The connection between “deck and bedding” and heat stress is made in section 3.4.4.iv of SBMR 003 which raises the timing of deck wash downs as a factor to consider in relation to geographical hotspots. “If at all possible, arrange for the low humidity period following wash down to coincide with passage through these places”. It is not necessary to support for this best practice with references from the scientific literature. The local humidity created during wash downs will impede evaporative heat loss by cattle.

No reference was found in the scientific literature on the use of mild acids, such as 2% acetic or citric acid, to reduce ammonia production in bedding and to extend the

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period between pen cleaning. This procedure is likely to have worked in practice and is worthwhile accrediting by a study on ships, perhaps as part of the Stockman Program. The rationale in science is likely to be either an interference with the formation of ammonia from the urea in urine or the acid-base neutralisation of ammonia by a non-toxic organic acid.

5.3 PHYSICAL STRESSORS – MECHANICAL

Mechanical stressors are a concern for the husbandry of cattle during live export because they are responsible for physical injury and lead to various degrees of fatigue or exhaustion as a result of sustained physical effort. Different mechanical stressors operate at different stages of the transport chain and require standard operating procedures for their control and best practice recommendations to drive continual improvement. Examples of mechanical stressors are the jolting, swaying and vibration of road transporters and the motion of ships at sea, particularly during rough weather. The design of loading and unloading facilities, road transporters and ships, together with competent stock handling, are important for preventing physical injury. Proper periods of rest and recovery are required between stages of the transport chain to counteract exhaustion and repay the "cost of adaptation". Physical stressors are addressed by various best practice recommendations in SBMR 003.

5.3.1 Motion sickness

Motion sickness is mentioned since it is the result of mechanical factors and has been suggested but not demonstrated for cattle and sheep during live export. The disorder has been confirmed in monogastric animals such as pigs and rats and is accompanied by retching and vomiting and the subtle sign of sniffing at the air (Bradshaw and Hall, 1996). The disorder is associated with low frequency motion oscillations of between 0.05 and 0.5 Hertz (Randall and Bradshaw, 1998). In a comparative study, both pigs and sheep had increased blood levels of the stress hormone, cortisol, after a rough but not smooth trip on a road transporter. However, pigs and not sheep showed signs of motion sickness (Bradshaw et al, 1996). If sheep are taken as an example and combined with experience from cattle during live export, motion sickness may not occur in ruminants at all. Experience from the export of live cattle is that interruptions to feed intake on board ship result from mechanical rather than physiological interferences.

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5.4 RISK FACTORS AND BEST PRACTICE FOR MECHANICAL AND OTHER PHYSICAL STRESSORS

5.4.1 Physical injury

SBMR 003 refers to the raised probability of injury in very large or overfat animals which tend to be poorly agile (section 3.1.4) and animals that are fatigued as a result of exposure to stressors such as long distance truck travel. Section 3.1.4 also points out the injuries inflicted by horns. The issue of horns in cattle goes beyond injury and is considered later under the heading of physical attributes and physiological states.

The possibility of physical injury is raised in section 3.3.1 in connection with loading of cattle onto the export vessel. It is raised again in section 3.5 on discharge from the export vessel where best practice requires stockmen to walk along the alleyways and discharge ramps onto the trucking platform to ensure that there are no features that may endanger stock. This commonsense requirement requires no support from the body of scientific knowledge. However, a body of information on the design and construction of facilities for handling cattle to prevent injury is available in the scientific literature; for example, in a report from the Australian Standing Committee on Agriculture (Anonymous, 1991), Grandin (1990, 1993 and 1997) and Lapworth (1990). Best practice for environmental design could be based on this information.

Support from the scientific literature about the injury-proneness of large and overfat cattle comes from the US National Research Council which recognises that that mobility of fat animals at NRC condition score 9 is impaired (NRC, 1996). Poorly mobile animals are more likely to lose footing and fall. In addition, fat tissue continues to increase after the bone structure of an animal has reached its mature size (Hammond, 1960). Thus, the bony framework of a fat animal is under a heavier load and has a greater risk of injury than that of an animal in moderate to good condition. Very large animals are in the same situation as regards a poor bone strength to liveweight ratio (Hammond, 1960).

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Fatigue leads to injury proneness since fatigued animals are poorly agile and are unable to make rapid muscular responses to avoid injury. The physical exertion entailed in road transport damages the integrity of muscle fibres (Kenny and Tarrant, 1987; Warriss et al, 1995) as shown by increases in the plasma concentration of the enzyme, creatine phosphokinase, and depletes energy resources in muscles (Warriss, 1990). Fast twitch fibres, which engage in the proprioceptive muscular responses related to balance, are especially affected by stress (Lacourt and Tarrant, 1985).

5.4.2 Fatigue from physical effort

SBMR 003 refers to stressful incidents requiring physical exertion in section 3.1.3. Examples of stressors with mechanical elements at their forefront and producing fatigue are long distance truck transport, excessive handling, boggy yard conditions and severe weather conditions. The notion is that export of cattle with a history of stressful incidents should be avoided. Best practice here is “animals that have not fully recovered from as stressful incident prior to shipment should not be exported”.

The issue of fatigue and rest in between stages of the transport chain is also considered in section 3.2.3 which seeks to “ensure that cattle have had adequate rest prior to loading after long road journeys to the load port”. The total impact on animals from road transport includes the mustering and processing time. Best practice concerns the time for rest periods with free access to feed and water following extended road journeys and before loading on the export vessel. So, the nominated best practice is that a rest period of 24 hours should be provided following road journeys of between 1000 and 1500 kilometres or which take between 24 and 36 hours. In addition, a minimum rest period of 48 hours should be provided for journeys exceeding 1500 km or 36 hours. SBMR 003 points out some contradictions in the current LEAP standards which state (section 5.1.3(d)) that “the time cattle spend in the export system from farm to loading on the vessel…..should be kept to a minimum”.

The current *Australian Model Code of Practice for the Welfare of Animals, Land Transport of Cattle* refers to maximum water deprivation times rather than times for travel or distances travelled. Water deprivation times include the mustering and holding period prior to actual transport and the time after unloading before cattle have

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access to water. For mature cattle, this maximum water deprivation time is 36 hours with an extension to 48 hours permissible (1) if animals are not showing signs of fatigue, thirst or distress, (2) if adverse weather conditions are neither prevailing nor predicted, and (3) if the whole journey can be completed within the 48 hours, and animals are rested for at least 18 hours immediately upon arrival.

Fatigue is recognised as a general systemic state which can arise in a variety of circumstances and affect different body systems and parts of body systems to different extents (Blood and Radostits, 1989). Fatigue is associated with physical effort and is accompanied by loss of muscle strength, damage to muscle fibres, depletion of tissue resources of energy, reduced capacity of energy mobilising systems, depleted resources of physiologically important substances such as hormones and enzymes, and perturbed salt-water balance. Exhaustion is seen as the final stage in the general adaptation or stress syndrome (Selye, 1976).

Physical exertion by cattle in the road transport phase of live export results from standing for long periods in a truck and maintaining balance when the truck sways, jolts or vibrates. Further physical effort is involved in the social interactions in unfamiliar surroundings and with perhaps unfamiliar animals. Added to this, long periods of travel disrupt daily cycles of activity, rest and sleep. Similar problems can confront cattle during the sea transport phase of live export and is addressed, in part, by best practice concerning bedding.

An additional problem is that the usual time budget of activity, rest and sleep is disrupted during transportation. Animals such as cattle have biological rhythms of activity that represent adaptations to cyclical events in the physical environment (Ruckebusch et al, 1991). These can be arranged, for example, around days (circadian rhythms) or years (circannual rhythms). Cattle spend about 52% of their day in alert wakefulness, 45% in slow wave sleep and drowsiness and 3% in deeper rapid eye movement sleep (Ruckebusch et al, 1974). Sleep is important in maintaining function in a range of body systems, particularly the immune system (Born et al, 1997), and the sleep-wake cycle has been suggested as an index of an animal’s adaptation to its environment (Ruckebusch, 1975). Cattle may spend a considerable time at

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rumination to complete the 9000 to 25,000 chewing movements that are made each day and this important digestive activity is likely to be interrupted during transport

A range of physiological changes occur in cattle during transportation. The review by Leach (1981) points to increases in cortisol and lactic acid in plasma in cattle after road transport. Increases were also seen in enzymes associated with muscle damage. Transport interferes with function of lymphocytes (Blecha et al, 1984) and by implication with the competence of the immune system. A battery of other studies also point to impacts on the immune system. More recent investigations cattle during transportation for various times and various distances have also highlighted changes in various blood cells and enzymes, stress hormones and other substances in blood (reviewed in Knowles, 1999 and Schaefer et al., 1997). All indicate disturbances to cattle brought about in the main by relatively short periods of transportation.

The longest transportation time found was that in work by Cole et al (1988) who compared cattle transported for 12 and 24 hours and looked at a range of haematological and biochemical markers indicative of stress and muscle damage. Warriss et al (1995) investigated cattle given "doses" of 5, 10 and 15 hours travel and the accompanying responses in a range of biochemical markers in blood. This study is relatively rare in that it also examined recovery after transport. Many other studies were constrained in this respect by being directed at meat quality.

Most responses seen by Warriss et al (1995) increased progressively ("titrated") with time of travel. For example, the 15 hour group lost more weight than the 10 or 5 hour group (4.6, 6.4 and 7.0% of liveweight). Significantly, recovery to pre-transport values took five days. Creatine phosphokinase , an enzyme that indicates muscle damage when it appears in blood, increased with increasing travel times. Blood concentrations of this enzyme took longer to recover after the longer journeys. So did blood concentrations of urea which reflected disturbances in digestive activities. The conclusion from this study based on physiological measurements and observations of behaviour is that "a 15-hour transport period under good conditions is not unacceptable from the viewpoint of animal welfare". However, such a period could

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be unacceptable if another long period of transport were to follow without proper rest and recovery for the cattle involved.

The only other work found on recovery after road transport is that of Warriss (1990). Glycogen levels in muscle appear to take at least two days to recover following their depletion during road transport and even when animals have free and undisturbed access to feed and water.

To sum up, there are no studies to show that rest periods of 24 or 36 hours after transport times of 24 and 48 hours are exactly right. The two studies found on recovery suggest that these “best practice” times are too short rather than too long. It would be helpful if more direct tests of fitness could be applied to cattle to determine whether recovery has occurred. These could be based on behaviour and need not be invasive. Experience from the live export of cattle indicates that the handling of animals up to the stage of loading on to trucks is vitally important to their subsequent performance and wellbeing.

6. NUTRITIONAL STRESSORS INCLUDING WATER BALANCE

The major considerations for nutrition for cattle during live export are the protein-energy content of rations fed to cattle and the intake of water and minerals required for maintaining salt-water balance. Energy and water requirements can be placed under pressure when environmental temperatures are higher or lower than the “comfort” or thermoneutral zone (Conrad, 1985).

6.1 PROTEIN AND ENERGY

Energy from food or body reserves of glycogen, fat and muscle is required for driving all the processes that maintain life. Protein is required to maintain the structural components of the body and the enzymes that undertake metabolic processes. Ruminants can, in part, synthesise their protein from dietary sources of non-protein nitrogen. Protein and energy deficiencies usually occur concurrently. For practical purposes, these two major nutrients cannot be separated and will be considered together for their implications in nutritional stress during the export of live cattle.

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Demand for protein and energy by cattle will differ at different stages of the transport chain. Demand will also vary with states of arousal and come under the influence of temperament, handling, climatic conditions and exposure to new and unusual circumstances. In this regard, the connection between arousal, heart rate, metabolic rate and the consumption of energy is well established (Brosh et al, 1998; Holmes et al, 1976; Richards and Lawrence, 1984). The interplay between adequate nutrition, good environmental design and competent stockmanship is a rudimentary theme for the welfare of cattle during live export.

6.1.1 Metabolic disorders

High demand for energy may not always be met by the intake of metabolisable energy in feed and body reserves must be called upon. For example, the fasting that results from feed and water curfews and during the road transport phase of live export may coincide with periods of high energy expenditure. Two problems may arise. Firstly, body stores of energy will be inadequate in animals with low condition scores (see section 5.2.3 of this report which deals with best practice recommendation 3.4.1 that animals with condition scores of 1 or less are not candidates for export). Secondly, the rate of mobilisation of stored energy may be compromised and, in some instances, insufficient. The result will be a collapse of physiological processes and the activation of the clinical complex of ketosis and fatty infiltration of the liver seen in cattle during live export.

Ketosis is a disturbance of energy homeostasis characterised ketone bodies in the blood and urine, low blood glucose levels and low levels of glycogen in liver (Lean et al, 1991a). It has a classic association with the period around calving but can occur more generally when the acute demand for energy outstrips supply; for example, when there is an interruption to voluntary feed intake. The following risk factors for ketosis are taken from Lean et al (1991b). (1) Cattle with high condition scores may be at higher risk of ketosis. This observation has support from experience with large fat bullocks in the live export trade. It is treated in section 5.2.3 of this report which links to best practice recommendation 3.1.4 – “avoid transporting very large or very fat animals), (2) Diets that deliver propionic acid precursors and which will generate glucose will forestall ketosis. As a result, high roughage diets are a risk factor and high ratios of concentrate to forage are recommended for dairy cattle; for example, 45

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to 35 or higher in early lactation. High concentrate levels in rations may also prevent ketosis during live export. (3) High protein intakes can be related to ketosis and protein concentrations less than 16-18% of the ration are recommended for dairy cattle. (4) Vitamins and minerals should be provided in the diet in amounts recommended in feeding standards. A case in point is sodium deficiency, which is associated with loss of appetite.

Fatty infiltration of the liver is the central feature of a disorder that occurs when excessive quantities of fat are mobilised from body stores and enter blood as free fatty acids in order to meet peak demands for energy. The liver is highly active in removing free fatty acids from blood and reconstituting them into fat (Ruckebusch et al, 1991). Accordingly, it is prone to overload and consequent dysfunction. The following risk factors for fatty infiltration of the liver are taken from Blood and Radostits (1989). (1) Obese animals with high conditions scores are prone to fatty infiltration of the liver. (2) The circumstances for fatty infiltration of the liver occur when energy demands outstrip the supply of metabolisable energy in feed and when body stores of energy must be mobilised to meet the deficit. The circumstances under which cattle may be prone to fatty infiltration of the liver are pregnancy and obesity. These are covered by best practice recommendation 3.4.1 and are dealt with in sections 5.2.4 and 9.2 for pregnancy and 5.2.3 for obesity.

6.1.2 Feeding practices

Hot conditions are a particular challenge for the nutrition of cattle during live export They raise questions about the nature of the ration on offer, the amount to be fed and pre-shipment feeding.

Heat increment is the major consideration for the choice of rations for cattle under hot conditions. It has been mentioned earlier in section 5.2.6 which deals with best practice recommendation 3.4.4. Heat increment is the increase in heat production following consumption of food by an animal in a thermoneutral environment (Conrad, 1985). It includes the heat produced by fermentation processes in the rumen, the energy expended for digestion and the heat produced as a result of nutrient processing. Heat increment is considered “non-useful” energy. It can warm animals in cold conditions but adds to heat load in hot conditions. Energy loss by heat increment

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can vary from 33% to 70% of the intake of metabolisable energy in ruminants. Fats have the lowest heat increment, followed by soluble carbohydrates then protein. Soluble carbohydrates have a lower heat increment that cellulose, the acid detergent fibre (ADF) fraction of feed (Conrad, 1985). The proposition arising runs counter to the commonly held idea that rations rich in roughage are best in hot conditions. The reality is that rations high in concentrates and low in roughage are better in hot conditions (Beede and Collier, 1986; Conrad, 1985; Fuquay, 1981; Hall et al, 1997; Morrison, 1983; NRC, 1981; Young and Farrell, 1993).

The question of how much to feed depends upon the energy requirements for maintaining the health and welfare of cattle during live export and whether animals should be fed for gain. Voluntary feed intake is fairly stable at ambient temperatures between 15°C and 27°C (NRC, 1981; Conrad, 1985). It increases at temperatures below 15°C and decreases at temperatures above 27°C. A 3%-10% reduction in intake relative to maintenance requirements occurs at temperatures between 25°C and 35°C and a 10%-35% reduction relative to full feeding occurs at temperatures above 35°C (Conrad, 1985). The relationship between ambient temperatures and feed intake has given rise to the thermostatic theory of appetite regulation (Ruckebusch et al, 1991).

Curiously enough, hot conditions will increase the maintenance energy requirements of cattle (NRC, 1981). Causes are the energy requirements for panting and the Q_{10} law of chemistry. Oxygen consumption and energy expenditure increase by 7% with rapid shallow breathing and by 11-25% when there is open mouth panting. The Q_{10} law refers to the fact chemical reactions and thus metabolic activities proceed more rapidly at higher temperatures. The catabolism of body protein observed in cattle during heat stress (Vercoe, 1969; Vercoe and Frisch, 1970) is probably driven by the Q_{10} law.

Limited information is available on the value of pre-shipment feeding. In a particular situation where *Bos indicus* steers were being transported to South East Asia, Wilkes (1996) showed some benefit from the pre-shipment feeding of bundy centro hay together with a commercial electrolyte preparation.

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6.2 WATER AND ELECTROLYTES

Water and electrolytes can be considered jointly for their role in nutritional stress of cattle during live export. Together with soluble protein, they are the major components of liquid compartments of the body, which are intracellular fluid, extracellular or interstitial fluid, blood and lymph. A brief account of the function of water and electrolytes in the body, their requirement by cattle as nutrients and their behaviour in response to heat sets the scene for discussing risk factors and best practice.

Life depends absolutely upon maintaining a relatively constant composition of the interstitial fluid that bathes cells. The processes of homeostasis are entailed and are undertaken by the blood, urinary system and digestive system. They involve the ingestion and distribution of nutrients such as water and electrolytes, the removal of waste products and concomitant retention of valuable substances by the kidney and exchange of substances between blood and interstitial fluid and blood and urine. The typical electrolyte composition of mammalian interstitial fluid, intracellular fluid of muscle (Mountcastle, 1980) and blood (serum from cattle; Radostits et al, 1999) is shown in Table 2.

Table 2 – Electrolyte composition of body fluids*

	Interstitial fluid	Intracellular fluid (muscle)	Serum
Sodium	141	10	132 - 152
Potassium	4	150	3.9 – 5.8
Magnesium plus calcium	6	40	-
Magnesium	-	-	0.74 – 1.10
Total calcium	-	-	2.43 – 3.10
Chloride	115	-	95 - 110
Bicarbonate	29	10	20 – 30

*Units are mmol/L of water.

A virtually constant pH (acid-alkali balance) of 7.4 ± 0.05 in the interstitial fluid that bathes the cells and tissues of animals, including cattle, is regarded as second in importance to oxygen for sustaining life (Ruckebusch et al, 1991). This constancy is

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maintained by blood and is threatened when the normal pH of blood, 7.35 – 7.45, moves either towards acidity (acidosis) or alkalinity (alkalosis). Acidosis can result from poor pulmonary ventilation leading to the retention of carbon, muscular exertion with the production of lactate and metabolic disorders such as ketosis. Alkalosis can result from high respiratory activity and the excessive elimination of carbon dioxide from the lungs. Metabolic alkalosis is seen in association with gain engorgement and the consequent loss of rumen motility.

The clinical entities of acidosis and alkalosis require different electrolyte therapies. For example, sodium bicarbonate is used to treat acidosis and a cow of 400kg may require 120-125 grams (Barragry, 1997). Alkalosis is treated with balanced electrolyte solutions such as McSherry's solution, high potassium acidifying solutions or mixtures of ammonium and potassium chloride. Acidosis and alkalosis may both occur during live export and the implication is that different electrolyte preparations may be required at different points in the process. Acidosis can be expected in cattle after the physical exertion involved in road transport. Alkalosis has been diagnosed by urine analysis in cattle on board ship and eliminating excessive carbon dioxide as a result of increased respiratory activity in hot conditions (Ainsworth, personal communication).

The water content of a healthy animal is about 57% of liveweight in adults and 75% of liveweight in newborns. The consequences of losing body water depend upon how well animals are adapted to hot arid conditions. Some species may die after losing 15% of their body water but ruminants can tolerate the loss of larger amounts; up to 18% in cattle, 20% in sheep and 25% in camels (Silanikove, 1989). Relative to other ruminants, however, cattle have a poor capacity for retaining water through mechanisms involving the gut and kidneys and may use twice as much water as sheep on the basis of metabolic weight (Silanikove and Tadmor, 1989). As for genotypic differences, normally hydrated *Bos taurus* animals had higher flow rates of urine and excretion rates of sodium than similar *Bos indicus* animals but the differences narrowed to only 10% during mild dehydration (Johnson, 1971).

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Like other ruminants and dogs and donkeys, cattle replenish lost water rapidly after a period of dehydration and belong to the class of "rapid replenishers". Individual cattle can drink about 25 litres or 63 litres in a 20 minute period after 24 or 72 hours of dehydration respectively (Silanikove, 1989). Ingested water is stored in the rumen and released slowly to the blood and tissues. Large intakes of water over short periods, the storage of water in the rumen (highly important) and the flow of sodium in saliva are regarded as adaptations by cattle to the cycles of severe hydration and rehydration that occur in tropical and desert areas (Silanikove, 1994).

Water is required by cattle in sufficient amounts for four main functions.

- First is the elimination the waste products of digestion and metabolism. Cattle faeces contain 75-85% water (NRC, 1981). The inefficiency of kidney function in retaining water in cattle compared to other ruminants has been mentioned earlier.
- Second is the regulation of conditions in blood so that the demanding conditions required in interstitial fluid are maintained.
- Third is to provide for secretions such as milk and saliva. High salivary flows in cattle are required for digestive function.
- Fourth is the regulation of body temperature through evaporative heat loss, which is extremely important in hot conditions and extremely effective because of the high latent heat of vaporisation of water (2260 calories per gram). *Bos indicus* cattle may secrete up to 15 ml of water per minute for each square metre of skin during heat stress (NRC, 1981). Within the thermoneutral zone, cattle may lose 0.42 litres of water through evaporation for each MJ lost as heat (Ruminants Subcommittee, 1990).

Estimates of water requirements by cattle are available in various feeding standards. The NRC (1981) points to requirements of 4 to 10 litres of water per kilogram of ingested dry matter when cattle are held at temperatures between 25ºC and 35ºC. This rises to 8 to 15 litres per kilogram of dry matter above 35ºC.

Many of the components of electrolyte solutions are also dietary requirements and are mentioned in the Australian Feeding Standards (Ruminants Subcommittee, 1990). The requirement for chlorine is 0.67 – 1.0 grams per kg dry matter of feed. The daily

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allowance of calcium is 8 grams for 300 kg cattle. The requirement for potassium is 5 grams per kg dry matter. The daily requirement of sodium is reckoned to be 0.8 g per kg dry matter. A lower requirement for sodium compared with potassium provides food for thought. Feeding standards may not apply to the conditions of live export and basic requirements could be higher. Electrolytes may be beneficial for this reason.

6.3 RISK FACTORS AND BEST PRACTICE FOR NUTRITIONAL STRESSORS

6.3.1 Condition scores

Section 3.1.4.(I) states that "animals in condition score one [or those with undesirable temperament] are [also] unsuitable for export". Condition score 1 is the second lowest score in the system described in the Australian Feeding Standards (Ruminant Subcommittee, 1990) and the lowest score in the system of the US National Research Council (1996). According condition score 1 of the Australian Feeding Standards, "the individual spinous processes are still fairly sharp to the touch and there is no fat around the tail head. The hip bones, tail head and ribs are still prominent but appear less obvious". Condition score 1 in the NRC system has cattle "emaciated; bone structure of shoulder, ribs, back, hooks, and pins sharp to touch and easily visible; little evidence of fat deposits or muscling". The system for condition scoring in actual use in Australia is that of AUSMEAT which corresponds to the system of the US NRC. The presence of a different system in the Australian feeding Standards is a source of confusion.

The scientific support for best practice here comes from basic principles rather than deliberate studies with very thin cattle placed under conditions of transport. Cattle at condition score 1 do not have muscular strength and are unlikely to be able to cope with the physical exertion of transport. Nor do they have the stored reserves of energy and body fluid to deal with the demands made by transport. In addition, the odd animal at condition score 1 in a herd at around score 3 is likely to have a contributing disease.

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6.3.2 Introduction to rations

Section 3.2.1 of SBMR 003 refers to the introduction of cattle to shipboard rations while on farms or at assembly points. This best practice is supported by the fact that cattle presented for live export come from a variety of sources and their ruminant digestive tract will require adjustment from a familiar to an unaccustomed diet. Time is required for this adjustment. For example, deprivation of feed and water decreases the fermentative activity of the rumen and depressed rumen function may persist for five or more days (NSW Feedlot Advisory Unit, 1990; Cole, 1985). The experience from feedlots is that cattle may not return to full feed intake until the third or fourth week after introduction to a feedlot and some individuals may been off feed for 10 days (see NSW Feedlot Advisory Unit, 1990). Feedlots manage the change through introduction diets and feeding regimes. A receiving diet recommended in NSW contains 50% concentrate or more for cattle less than 300kg with more roughage being recommended for heavier cattle. Feedlotters in the USA increase the level of concentrates in the ration from 50-55% in the first two weeks to 70-75 % in the third and fourth week and then move to the final ration in the fifth week.

6.3.3 Feed and water curfews

Best practice 3.2.2 refers to feed and water curfews before loading cattle onto trucks. Best practice (3.2.2.iv) refers to withholding feed and water from cattle for at least 6 hours before before transportation from the property of origin or assembly depot. Reduction or waiver of the curfew can occur if transportation time is expected to be more than 24 hours or if the environmental temperature and humidity are very high. The best practice recommendation in section 3.2.2.iv qualifies the transportation time to include loading, trucking, waiting time in the truck and unloading. The *Australian Model Code for the Welfare of Animals – Transport of Cattle* now refers to time off water rather than transportation time.

Feed and water curfews were considered by Wythes (1994) in relation to bruising and carcase quality. She stated: “A conflict of interest may arise between strategies to reduce bruising and those to increase carcase weight, since denying water to cattle increases the likelihood of dehydration. This has animal welfare implications”. Three contradictory reports were found on the link between bruising during transport, an indicator of welfare, and fasting before transport (Bond et al, 1981; Dodt et al, 1979;

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Wythes et al. 1985). Road transport operators prefer cattle to be off feed and water before loading.

SBMR 003 recognises the complexity of the curfew issue. The argument that cattle are more agile and can resist injury from slipping and so on if their gut fill is not maximum has to be balanced with the problem of dehydration. The solution to this problem is to recognise that "while curfew does play an important role in the welfare of travelling stock, the associated rest periods are probably more critical". This solution embraces the view of stress as the cost of adaptation (see Appendix 2) that has to be defrayed between stages of the transportation process and must not be allowed to accumulate.

6.3.4 Access to feed and water on ships

Section 3.4.4.iv of the best practice recommendations recommends that wash down management should aim to minimise the time cattle are off feed and water. Continuous access to water will be crucial under hot conditions. Another issue here is the human-animal interaction, which is raised in the section on behavioural stressors. Some approaches to wash down could arouse cattle unnecessarily.

6.3.5 Feed intake

Three matters are raised about feed intake in relation to best practice.

(1) Section 3.4.5.i of the best practice recommendations points to the aim of maintaining rather than gaining body weight. The heat of increment from the extra feed intake to increase body weight will add to heat loads in the environment. However, the maintenance ration on board ship is not the same as the maintenance ration referred to in various feeding standards. An additional energy expenditure may be brought about by being at sea. It will probably be less than the energy expended in grazing on pasture. By and large there is a small weight loss in cattle during long haul voyages and weight losses are more common than weight gains.

(2) Section 3.4.5.iv refers to the minimisation of wastage of feed by monitoring consumption carefully and feeding according to appetite and budget parameters. This is a housekeeping measure and requires no support from science.

(3) Section 3.4.5.iv refers to feed consumption as an excellent indicator of health and welfare of stock. "Whenever a reduction in intake is observed,

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immediately initiate an investigation into the possible cause”. The maintenance of feed intake is a fundamental requirement for sustaining life.

6.3.6 Bloat

Three references are made to bloat in SBMR 003.

- 3.4.5.iv - When levels of fines are high, the incidence of bloat observed on board is elevated. In these circumstances, chaff or other roughage should be fed.
- 3.4.5. iv - Bloat is commonly noted to develop about day 8-10 of the voyage. Roughage should be fed some days beforehand as a preventive measure.
- 3.4.5.iv - Where pellet handling systems on board are likely to lead to the production of high levels of pellet dust, the volume of chaff or other roughage loaded on board should be adequate to treat all cattle with about 1 kg every 6 days.

The bloat in question is grain bloat and the connection with finely ground grain and the preventive measure fibrous fodder such as chaff is well established (see Blood and Radostits, 1989). A comparison with a later edition of the same textbook (Radostits et al, 1999) shows virtually no progress in the understanding of grain bloat.

6.3.7 Shy feeders

Section 3.4.5.iv recommends that shy feeders should be identified as early as possible and removed to a pen to receive appropriate treatment as described in the Stockman’s Handbook.

The incidence of shy feeders among exported cattle is not known. Shy feeders are a concern with exported sheep and an attempt is made to identify problem animals in pre-embarkation feedlots. Treatment with the corticosteroid, dexamethasone, can improve feed intake in sheep (Adams and Sanders, 1992) but is not recommended for cattle exposed to stressors. Introduction to grain and concentrate rations at the time of weaning is useful for helping cattle adjust to different rations when they enter feedlots (Fell et al, 1998) and may also be useful for cattle destined for the live export trade. Social transmission of feeding behaviour is important in sheep and may also be important for sheep. Sheep will accept various grain readily as adult if they have been exposed to grain eating at an early age and with their mothers (Chapple et al, 1987).

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6.3.8 Water and electrolytes

Three mentions are made of electrolytes in SBMR 003 and it is difficult to deal with them separately the issue of water.

- 3.4.5.i – Hard scientific evidence on appropriate electrolyte composition and use is lacking. Best strategies for electrolytes require further research. Physiological changes in cattle during periods of heat stress are different to those of cattle on land.
- 3.4.1.iv – Prior to loading, drinking water should be medicated with electrolytes.
- 3.4.5.iv – Electrolytes will benefit cattle when they are under stress or recovering from stress, particularly heat stress. Recommended that they be provided to stock after loading, at any time during the voyage when there is exposure to stressors and before the discharge process.

The three references to electrolytes come from observation of and insight into the live export trade and can be the starting point for research. The paucity of information on electrolytes is obvious upon examination of the literature (see review Schaefer et al, 1997). The published work is related to specific situations and the intake of various electrolytes in feed as opposed to medication is unclear (Hutcheson and Cole, 1986; Schaefer et al, 1990; Schaefer et al, 1992). Furthermore, it is difficult to understand the value of each constituent in an electrolyte preparation given the design of the studies examined. Finally, it is not clear whether electrolytes have a behavioural value. Their taste in water may make animals drink more.

Part of the problem for establishing the value of electrolytes may be the methods to establish disturbances in salt-water balance. Changes in electrolyte concentration are obvious in disease when mechanisms for homeostasis have gone awry. The challenge is to determine when mechanisms for homeostasis are under challenge and can be aided by electrolytes. A highly imaginative approach to the investigation of electrolytes may be called for. The starting point could be the physiological state of cattle at different points in the live export chain. Cattle may be either acidosis or alkalosis, depending on muscular exertion or panting to relieve heat stress, and different electrolyte preparations, plus other interventions, may need to be customised to meet particular circumstances.

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7. BEHAVIOURAL STRESSORS

Behaviour is an issue for animal welfare in two ways. Firstly, observed behaviour is an important indicator of welfare and particularly so when combined with physiological indicators to form the functions-based or homeostatic approach (Duncan and Fraser, 1997). Secondly, interference with behavioural systems can cause poor welfare as encapsulated in two of the five freedoms (see Appendix 1). These are the freedom to express normal behaviour by providing sufficient space, proper facilities and company of the animal's own kind and freedom from fear and distress by ensuring conditions and treatment which avoid mental suffering. Psychological stress may be a more descriptive and comprehensible term than "mental suffering" since all suffering is a product of consciousness and mind. Grandin (1997b) relates the causes of psychological stress, or fear stress, during handling and transport as restraint, conact with and handling by people and exposure to new and unfamiliar experiences.

Handling and good stockmanship is central to the management of behavioural stressors. Written information on cattle handling and cattle handling facilities includes work by Grandin (1990, 1993 and 1997a), Holmes (1984), the Standing Committee on Agriculture (1991), and Dickfos (undated). The quality of contact with humans is important in the generation of undesirable fear responses in cattle and other animals. Animal welfare can be enhanced by selection and training procedures directed at the attitude and behaviour of stock handlers (Hemsworth and Gonyou, 1997).

Potent behavioural methodologies are now available for application to problems in the live export of cattle. These include software to track the behaviour of focal animals and hardware such as closed circuit television to observe behaviour. Among other things, an understanding of the daily time budget of cattle that are adapted and coping well with shipboard conditions could be used to flag deviations in behaviour that point to incipient problems. Obvious and subtle behaviours related to drinking and feeding behaviour can be a major guide to present and future hydration and nutritional states and an indicator of whether animals will be able to cope with heat stress through evaporative cooling. These behaviours plus resting behaviour and the total time budget can be used to gauge whether animals have received adequate rest

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and have recovered after particular stages of the transport process. They can be used to determine whether animals are coping with stress or continuing to accumulate a cost of adaptation.

The observation of behaviour is recommended as a potent, simple, non-invasive and perhaps under-utilised means for obtaining information about the husbandry of cattle during live export. Behavioural observations can be structured into epidemiological surveys.

7.1 RISK FACTORS AND BEST PRACTICE FOR BEHAVIOURAL STRESSORS

7.1.1 Temperament

Section 3.1.4.(i) of SBMR 003 states that animals [in condition score 1 or] with undesirable temperament are [also] unsuitable for export. Animals with undesirable temperaments are a consideration for both animal welfare and occupational health and safety of people. The problem of flightiness as a risk factor for heat-related disorders in exported cattle has been discussed earlier. To repeat, flightiness is the tendency to display the alarm reaction more prominently and with lower stimulation that expected in cattle (Beaver, 1994). The alarm reaction is associated with higher heat production. Flighty animals are likely to injure themselves and others as a result of their over-reaction to stimuli.

Best practice can be helped by the available knowledge on temperament and the problem can be mitigated on farms. According to one appraisal, temperament is not significantly influenced by management practices such as training but has a moderate heritability and will respond to genetic selection (Burrow, 1997). An impediment to progress is the absence of a common method for measuring temperament and allocating temperament scores. Another study has shown that cattle handled frequently before 18 months of age are more docile than cattle handled frequently only after 18 months of age (Fordyce et al, 1985). Best practice can commence on farms with the genetic selection for good temperament in lines of cattle destined for the live export trade.

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7.1.2 Social interactions

Best practice recommendations in section 3.3.1.iv of SBMR refer to social interactions between cattle and the problems of dominance and aggressive interaction between cattle. The recommendations are made in connection with loading and refer to the need to "maintain lot integrity where possible and ensure that animals are penned with cattle of the same sex, weight range and breed".

The general practical experience that supports this best practice can be augmented by what is known of dominance behaviour in cattle. The determinants of dominance in cattle are height, weight, age, sex, the presence or absence of horns and defence of territory with horns, age and weight being most important (Houpt, 1998). In a study by Bouissou (1972), horns were of major importance in establishing social rank in newly formed groups of heifers and size was secondary – another case against horned animals.

7.1.3 Arousal

The question of arousal and the need for continual good stockmanship is raised in section 3.4.3. iv with best practice to "ensure that the crew are aware that hosing activities should be carried out in such a way as to cause least disturbance to the cattle". Arousal, with its elevation of heart rate and consequent increase in metabolic rate, has been discussed in relation to heat stress.

8. INFECTIOUS DISEASE STRESSORS

Apart from being an animal welfare concern in its own right, the presence of infectious disease can point to other welfare concerns. For example, most forms of stress increase susceptibility to infection (Kelley, 1980, Peterson et al, 1991) mainly but not solely through the influence of hormones such as cortisol which are released from the adrenal cortex (Stratakis and Chrousos, 1995). Heat stress may be an exception since it leads to a lower production of cortisol (Alvarez and Johnson, 1973). The impact of heat stress on resistance to infectious diseases is not known. The stress associated with fasting is known to favour the presence of salmonella organisms in the bovine gut (Brownlie and Grau, 1967: Grau et al, 1968) but there is no suggestion that this is important in disease of cattle during live export by sea.

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8.1 BEST PRACTICE FOR INFECTIOUS DISEASE STRESSORS

Infectious disease is not specifically mentioned in SBMR 003. The more general subject of animal health is treated in section 3.4.6. “It appears there are a relatively small range of common problems which are regularly recognised by stockmen and veterinarians accompanying long haul voyages”. “Further research into the causes of ill health and mortalities during long haul voyages is being undertaken at the present time”. “As research findings come to hand and experience is gradually built up by stockmen and veterinarians, the accurate recognition and appropriate response to problems is constantly being improved”.

Comments are not necessary on the best practice recommendations, which speak for themselves. However, two other matters should be raised because they have implications for the management of cattle on ships. First is that infectious disease incidents have the potential of blowing out the morbidity and mortality figures for the export trade in live cattle. Is anticipation possible and is there full preparedness for emergency responses? The possibility of emergencies is good reason for best practice recommendation 3.4.6 which states that stockmen should communicate with shore if health problems are encountered which cannot be identified and which may endanger significant numbers of stock. Second is the possibility for improving the health accreditation of cattle at their point of origin on farms.

The pooling of cattle from different sources and their intensive housing on board ships means that carrier animals for particular disease agents will be brought into close contact with susceptible animals. The experience of beef feedlots with the bovine respiratory disease (BRD) complex provides a guide on possible consequences and forms of management for these so-called crowd diseases. This BRD complex is caused variously and interactively by the bovine pestivirus (bovine viral diarrhoea or mucosal disease virus), bovine herpesvirus 1 (bovine rhinotracheitis viurs), bovine parainfluenza-3 virus and the bacteria, *Pasteurella haemolytica* and *Pasteurella multocida* which are associated with transport fever in cattle (see coverage in Blood and Radostits, 1989). All these organisms are found in Australian cattle (Irwin et al, 1979) and the bovine respiratory disease complex is recognised in feedlots in Australia (Nichols, 1996). Pestivirus is a concern because of marked differences in

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the virulence of strains and the range of clinical signs observed ranging from inapparent infection to mucosal disease (Harkness and van der Lugt, 1994).

Accurate screening for BRD in new arrivals at beef feedlots is not available and subjective assessments of health are the only possibility (Galyean et al, 1999). Events in the early life of cattle, such as sufficient exposure to maternal antibodies, may be important. A higher protein content in receiving rations at the feedlot may be beneficial. However, equivocal benefit has been obtained from supplementation with either the vitamin B complex, zinc, copper, selenium or chromium. Studies in Australia have demonstrated the worth of a novel method of weaning management, together with immunisation against BRD with experimental vaccines (Fell et al, 1998). The novel weaning method was yard weaning with a hay or silage ration and a training procedure to introduce animals to grain in troughs. Yard weaning of this sort could have more general benefit to cattle destined for export regardless of its impact on infectious disease.

Results of prophylactic mass medication for bovine respiratory disease (BRD) in feedlot cattle with antibiotics such as tilmicosin are contradictory. A meta-analysis or formal quantitative statistical review showed no value of mass medicaiton (Van Donkersgoed, 1992). Recent work, however, shows benefit when prohylactic treatment with the antibiotic, tilmicosin, (metaphylaxis, sic) is given on arrival at the destination rather than before shipment (McClary and Vogel, 1999).

If an anticipatory risk assessment been not been made for infectious disease and cattle during sea transport, it could be valuable. Suggested models are the disease risk assessment made for purposes of quarantine or food safety risk assessments. Both follow the same logic path of (1) identifying the possible hazards, (2) the properties and characteristics of the hazards, (3) assessing the possible exposure and (4) integrating all the information to characterise the risk and preparing for contingencies. The preparation of an enterprise manual for the live export of cattle as part of the Australian Veterinary Emergency Management Plan (AUSVETPLAN) may also be valuable.

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The second matter is the possibility for improving the health accreditation of cattle at their point of origin on farms. Bovine babesiosis provides an illustrative example. This disease is controlled through immunity generated by managed exposure to the causative organism (Mahoney and Ross, 1972). Integrated control programs based on the natural history of piroplasms and their vector tick are available. On-farm use of these programs could speak for the resistance status of export cattle. In this connection, the report of Independent Reference Group on the Live Export of Cattle recommends that Australian standards for the health of cattle should provide a baseline for accrediting the health of cattle before export. These would be augmented by the health and sanitary requirements of the importing country. The Australian standards would be an amalgam of those expected of a professional veterinarian and best practice considerations arising from current experience and established knowledge. They would mean the use of integrated pest management programs wherever these are available.

9. OTHER PHYSICAL ATTRIBUTES AND PHYSIOLOGICAL STATES

9.1 HORNS

SBMR 003 is explicit that cattle with horns are not suited to long ocean voyages and should be avoided. Best practice is that cattle exported as slaughter or feeder animals should not have horns because horns are a major cause of bruising and other injury. A delay until January 2000 was placed on this requirement to allow time for cattle producers to change on-farm management practices. In the meantime, animals with horns “should be penned together at a reduced stocking density of at least 10% and all horned cattle were to be tipped as per the LEAP standards”.

The scientific support for horns as a major husbandry and welfare problem and the desirability of polledness on welfare grounds is well established. Nevertheless, a recent publication (Goonewardene et al, 1999) was able to conclude that “if horned cattle are more aggressive the behaviour is ameliorated by dehorning and that breeding for polledness is a welfare friendly alternative to dehorning”. Knowledge about the inheritance of polledness for both *Bos taurus* and *Bis indicus* supports the feasibility of genetic selection for this trait (Frisch et al, 1980; Brenneman et al,

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1996). An abundance of papers show the significance of horns in bruising and injury of cattle (Meischke et al, 1974; Kretzmann et al, 1985; Ramsay et al., 1976; Shaw et al, 1976; Wythes et al, 1979; Wythes et al, 1985).

9.2 PREGNANCY

Section 3.1.4 of SBMR 003 states that pregnant cows are not suited to long ocean voyages but recognises that sea transport may be the best option for pregnant animals under some circumstances. Best practice (section 3.1.4.iv) for pregnant cattle in the first two trimesters requires provision of adequate bedding to last the entire voyage and a minimum of 15% more space. If cattle must be exported during the third trimester of pregnancy, they must be allocated 100% more space, provided with soft bedding such as sawdust and be accompanied by an Accredited Stockman experienced in the care of pregnant stock. Considerations of behaviour, heat stress and nutrition apply.

These best practice provisions are based on experience with pregnant cattle in the trade and more general experience with pregnant cattle. The underlying principle is that pregnancy and the demands of the developing foetus make inroads into an animal's physiological reserve. This is the extra capacity in body systems that allows an animal to cope with demanding circumstances. For example, the capacity for exercise and physical exertion is lower in pregnant animals. Specific information from scientific investigations into the loss of physiological reserve and the function of various body systems during pregnancy was sought for cattle but not found. Starvation ketosis or pregnancy toxaemia in cows (Caple et al.,1977) was mentioned earlier. Quantitative information on the loss of physiological reserve in cattle may not have been a priority for scientific investigation. However, such information will only provide secondary support for the best practice recommendation on pregnancy. Experience with the pregnant cows in the export trade and more generally should be regarded as sufficient scientific support.

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APPENDICES

APPENDIX 1:

The connection between disease, health and welfare and the nature of welfare

Welfare, health and disease are interrelated concepts that provide a frame of reference for the science applying to the protection of animals during international transport. A shared view of crucial concepts about animal welfare is helpful for preventing misunderstandings and cross-purposes in the public arena both within Australia and overseas. These misunderstandings and cross-purposes remain a perennial problem for the development of policy on animal welfare. An attempt is made here to describe the boundaries of animal welfare so that quality management for animal husbandry[4] will actually address it, and be seen to address it, in the live export trade. Some pertinent literature on animal welfare are articles by Broom (1996), Ödberg (1996) and Simonsen (1996) and a book edited by Appleby (1997).

Disease means the same thing whether one is talking about people or animals. Diseases involve pathological processes and the malfunction of any part, organ or system of the body. Health goes beyond the absence of disease and is defined as a state of physical, mental and social wellbeing. Welfare may go beyond both health and disease. The consequence is a hierarchy of concepts. Good welfare is not possible in the presence of disease or the absence of good health. On the other hand, the absence of disease and the presence of health do not necessarily add up to wholly satisfactory welfare. At the operational level, animal welfare can often translate to animal health minus infectious disease, pests and parasites.

Hurnik and others (1985) describe welfare as a "state of condition of physiological harmony between the organism and its surroundings with the most reliable indicators being "good health and manifestation of a normal (sic) behavioural repertoire". The

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[4] A simple description of animal husbandry is the practice, art and science of raising rearing and caring for animals

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Brambell Report published in the United Kingdom in 1965 described welfare as a "wide term that embraces both the physical and mental well-being of the animal". It also said: "any attempt to evaluate welfare must therefore take into account the scientific evidence available concerning the feelings of animals that can be derived from their structure and functions and also from their behaviour".

Broom (1986, 1996) describes welfare as "the state of an individual [animal] as regards its attempts to cope with its environment". The words "state" and "individual" mean that stress and disease provoke welfare concern because they have an impact on an individual animal's state. Broom's definition states the importance for welfare of the fit between an animal and its environment but does not spell out the component of feeling or subjective experience. The problem of definition lies in dealing simultaneously with a mental state that must be satisfactory and a physical condition that must be satisfactory and stating that both are linked and both are prerequisites for good welfare.

Duncan and Fraser (1997) describe three approaches to animal welfare in a recent textbook. First is the feelings-based approach that makes assessments in terms of the subjective experience of animals. It emphasises the reduction of negative or aversive feelings (pain, malaise and so on) and the promotion of positive ones (comfort, pleasure and so on). The feelings-based approach to animal welfare depends upon the possibility of subjective experience and feeling in animals and the prospect that this experience or feeling may have unpleasant tones and thus constitute "suffering". Second is the functioning or homeostasis-based approach that sees welfare in terms of normal or satisfactory biological functioning of the animal. This approach can embrace "suffering" through the concept of motivational state (McFarland, 1993). Motivational state combines the physiological state monitored by the brain and the state of the brain resulting from external stimuli and their processing. The third approach to animal welfare described by Duncan and Fraser is the "nature of the species approach", which calls for animals to display their full repertoire of behaviour without a consideration of "suffering" being necessary.

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The three classes of approach to animal welfare are useful for understanding the flow of public debate about animal welfare. However, they are misconceived as classes because boundaries between them are clear-cut only when extreme positions are taken. Crucial overlaps are obvious when it is considered that the form and functions of an animal (its anatomy and physiology) determine it nature and also the possibility of unpleasant affective or feeling states (suffering) under certain circumstances, particularly when homeostasis is placed under pressure by factors in the environment.

Fortunately, there is wide agreement among scientist on the fundamental nature of animal welfare, the methods for its assessment and the need for good scientific evidence in making decisions about it. The gist of animal welfare is that more effort an animal puts into coping with its environment and the greater biological cost of adapting, the worse an animal is likely to feel and the poorer its welfare is likely to be (Broom, 1996; Duncan, 1996; Moberg, 1996). Welfare assessment is based on information about the mechanisms animals use to cope with their environment. It depends upon notions of adaptation and biological fitness. In this regard, “fitness to travel” is the core concept for managing the welfare of cattle during live export. Behavioural, physiological, health and production indicators can be used to assess different aspects of an animal’s state. Observations around these four indicators can be integrated to provide an overall assessment. Difficulties arise when any of these indicators tell a different story.

With these ideas in mind, the present report takes the practical view that animal welfare concerns the human care and use of animals and is delivered through good animal husbandry. The five freedoms used to guide animal welfare in the UK (see Box 1) are mentioned as a convenient checklist for welfare but will not be used expressly to frame the present report. They can be usefully associated with what has been called the five obligations (Box 1).

Box 1 – The five freedoms and five obligations (after Broom and Johnson, 1993)

FREEDOMS

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1. Freedom from hunger and thirst – by ready access to fresh water and a diet to maintain full health and vigour.
2. Freedom from discomfort – by providing an appropriate environment including shelter and an appropriate resting area.
3. Freedom from pain, injury and disease – by prevention or rapid diagnosis and treatment.
4. Freedom to express normal behaviour – by providing sufficient space, proper facilities and company of the animal's own kind.
5. Freedom from fear and distress – by ensuring conditions and treatment which avoid mental suffering.

OBLIGATIONS

1. Caring and responsible planning and management.
2. Skilled, knowledgeable and conscientious stockmanship
3. Appropriate environmental design
4. Considerate handling and transport
5. Humane slaughter

Since welfare refers to the "state" of an animal and since "states" arise from the operation of life processes, welfare can be validly described and appraised by the language and principles of biology and is a suitable subject for scientific analysis. For this reason and notwithstanding important reservations about a "pure science model of animal welfare" (Tannenbaum, 1991), science can provide a common frame of reference for discussions on the welfare of animals during transport. In the language of quality assurance described in ISO 8402, science is the source of objective evidence.

To sum up, animal welfare is a matter for both science and morality and neither alone can explain the issue or provide the answers. The scientific and moral aspects of welfare are mutually dependent and their relationship can be viewed as follows. Science provides the methods and understanding necessary for describing and appraising the state of an animal in the light of criteria for welfare. The processes for determining what is acceptable or unacceptable, and for setting standards, falls within the scope of morality. This link between the scientific and moral aspects of animal

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welfare suggests an approach towards policy that can account for both facts and values. Issues of animal welfare cannot be resolved by value-judgements alone.

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APPENDIX 2

General aspects of animal welfare during transportation

General aspects of animal welfare during transportation were treated in an exercise of the Office International des Épizooties in 1992 (Adams, 1994). Various writers have described the set of needs that must be met for animals during transport or listed the stressors that could act on animals. Those for the safe carriage of cattle by sea will differ in degree not kind from the set described for sheep (Brennan et al., 1988) which included:

- sufficient palatable, nutritionally balance food, adequate for its physiological requirements;
- sufficient drinkable water;
- air free of noxious gases;
- an environment that provides the opportunity for behavioural expression and which does not cause undue physical restriction;
- natural or artificial protection from adverse weather;
- protection from parasites, disease, predators and injury; and
- access to suitable treatment (including prompt humane slaughter) when required.

Similarly, the stressors applying to cattle during live transport will be the same as those described for the pig and will differ only in their degree of impact. Stressors listed for the pig by Hails (1978) were:

(1) separation from a familiar environment and family groups,
(2) loading and unloading,
(3) overcrowding in confined spaces,
(4) unfamiliar and loud noises,
(5) vibration,
(6) jolting,
(7) extremes of temperature and humidity,
(8) acceleration and deceleration during movement,
(9) long periods of waiting during which there may be no ventilation alternating with rapid air movement when there is motion,

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(10) gases from faeces, urine and fumes,
(11) changes in the biota of bacteria etc. to which animals are exposed, and
(12) deprivation of food and water.

Pearson and Kilgour (1980) set out a similar list of factors to be considered in the transport of animals and aligned them with a set of physiological and behavioural variables that could be used to assess the degree of disturbance during the process. The factors were:

(1) climatic conditions that could be outside the range normally experienced by animals,
(2) handling and the degree of interaction with people before the experience of transport,
(3) food and water intake and the possibility of a diminished appetite exacerbating metabolic disorders of various sorts,
(4) exercise or the lack of it during transport,
(5) social interactions and the breaking of bonds before transport, for example by weaning, and the forced interaction between unfamiliar animals during transport,
(6) transport types and their association with different sorts of mechanical factors such as jolting, swaying and vibration,
(7) environment changes such as new foods, strange smells and sights, and
(8) duration of transport.

The major physiological variable considered by Pearson and Kilgour was the plasma concentration of corticosteroids, a measure of activity of the adrenal cortex. Behavioural variables were restlessness, body orientation to direction of movement, agonistic interaction (that is, fighting and aggression), and behaviour at off-loading.

Stephens (1982) classified the adverse stimuli associated with transportation as physical disturbances and emotional disturbances and related them to the broad responses elicited by stressors. Fear was specially mentioned as an emotion that can trigger the physiological responses of alarm and stress.

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The practical considerations for the welfare of cattle during live export have been listed by Livecorp (April, 1999) as follows.

(1) the condition of the livestock at the time of loading;

(2) the weather conditions at the time of loading;

(3) the weather conditions during the voyage;

(4) ventilation arrangements on board the vessel;

(5) loading densities on board the vessel;

(6) type and availability of food on board the vessel;

(7) weight of individual cattle (lighter cattle generally travel better than heavier ones);

(8) availability and type of bedding material on board the vessel; and

(9) the availability of electrolytes and, as appropriate veterinary supplies.

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APPENDIX 3

Stress and stressors

The stressors on cattle during live export can be classified as physical, nutritional, behavioural and those related to infection. As mentioned earlier, adaptive responses to these stressors involve the action of the nervous, endocrine and immune systems. The interactions between stressors and the persistence of their effects are likely to be important for cattle during live export. A recent depiction of stress as the cost of adaptation to stressors, or the so-called allostatic or homeostatic load (McEwen, 1998), provides a useful way of looking at the interactions between stressors and the persistence of their impact. Allostasis is a more recent variation on the concept of homeostasis. It refers to "stability through change" and is an essential means for maintaining the constant internal environment of animals. Allostatic or homeostatic systems may be overtaxed, leading to disease and the state commonly referred to as "stress".

The innovative view of stress as the cost of adaptation or the allostatic load provides helpful guidance. The cost can be repaid, or the load can be shed, if animals are allowed to adapt or recover. Alternatively, the cost of adaptation can become a rising debt or the load can become larger. Heat stress differs from other forms of stress because it suppresses rather than stimulates the activity of the adrenal cortex. Its interaction with other stressors is unclear. Do the different stresses on cattle compound with one another and build up as a "load" during the process of transportation? Best practice suggests that cattle can adapt to ships as though they were relatively stress-neutral and floating animal houses.

Stress is an important systemic state for animal welfare. It appears when the mechanisms in animals for coping with their environment become overextended and start to breakdown (Stratakis and Chrousos, 1995). The environmental factors that produce stress when they act excessively are termed stressors. Inadequate nutrition, deprivation of water, heat, cold, and overcrowding are examples of stressors. Stress reduces an animal's fitness and this is expressed through disease and death and failure to grow and breed (Fraser and Broom, 1990).

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The notion of stress is linked to the ideas of homeostasis, comfort zones, physiological reserve and the fight/flight or alarm reaction. Stressors can act differentially on different organ systems and sub-systems and distinctly different responses occur to different stressors; for example heat and cold. However, some general responses occur to all stressors as described in the general adaptation syndrome with its three stages of alarm, maintenance of adjustment and then exhaustion (Selye, 1976). According to the model for people, distress is the psychological manifestation of the stress complex and it includes phenomena such as "tension, anxiety, worry, negative affect and emotions" (Steinberg and Ritzmann, 1990).

There are certain warnings about the concept of stress that have implications for other aspects of the diagnosis of welfare. Firstly, stress is not identical with emotional arousal or nervous tension or harassment. Secondly, stress does not always accompany damage to an animal. Thirdly, while blood concentrations of corticosteroids or other hormones may elevate during stress responses, raised concentrations of these hormones alone do not reliably measure stress. Stress is best monitored by changes in both behaviour and physiology.

Stress and infectious disease

One major and well-documented accompaniment of the stress response and the general adaptation syndrome is change in the immune system and a reduced resistance to infection (Kelley, 1980; Riley, 1981). Accordingly, stress is linked with disease in two ways. It has, itself, been categorised as a disease of adaptation (Selye, 1976). It can also predispose to other diseases. Accordingly, the presence of disease can indicate a breakdown in adequate husbandry and point to underlying welfare problems related to the action of stressors.

The onset of disease depends upon factors additional to the presence of a primary causative agent such as a virus. Resistance to infection is compromised under poor nutrition, exposure to extremes of climate and damaging social interactions. As to mechanisms, non-specific immunity or adaptive immunity or both can be

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compromised by environmental factors (see Chrousos et al, 1995). Some, but not all of the effects of these secondary causative factors of disease are mediated by the general adaptation syndrome and by the action of the hypothalamic-pituitary-adrenal axis. Adrenal corticoids, such as cortisone, which are released in stressful situations are known to interfere with immunity, to perturb populations of inflammatory cells and to predispose towards infectious disease (Oppenheim and Shevach, 1990; Annals NY Acad Science).

Stress as the cost of adaptation

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