Heat Stress Risk Assessment review for export of sheep to the Middle East during Northern Hemisphere summer

Submission by a group of Australian Government Accredited Veterinarians

Date: 19th October 2018

The follow group of Australian Government Accredited Veterinarian and other veterinarians have prepared this submission for the Heat stress risk assessment for the export of sheep to the Middle East during the northern hemisphere summer review as requested through Heat Stress Risk Assessment technical reference panel:

Editors

- Dr Andrew Way
- Dr Holly Ludeman

AAVs who contributed directly/indirectly

- Dr Peter Arnold
- Dr Adrian Baker
- Dr Anthony Carr
- Dr Peter Lynch
- Dr Bob Nickels
- Dr Colin Scrivener
- Dr David Sharp
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The HSRA review documents (Issue paper) to help with this submission can be found at:

https://haveyoursay.agriculture.gov.au/hsra-review

Contents

Scope

The following document provides opinions and thoughts from AAVs and veterinarians listed. Each section is not a full representation of each submitting contributor. Where vastly differing opinions were received, they are listed. The number of opinions and comments listed is not representative of the number AAVs making comments as similar comments have been grouped.

The document is not exhaustive of all AAVs, and this group recommends the HSRA technical panel interviews and engages directly with AAVs as a key stakeholder group which is currently not represented by any industry or policy body.

AAVs are best placed to review operational effectiveness or practical application of research and proposed monitoring tools. AAVs have a unique skills bases, have a thorough understanding of the structure of international trade and how this relates to Australia's animal health system which is supported by additional training through the APAV and AAV programs. AAVs are a group whose profession dictates that animal welfare is paramount and are regulated by both State/Territory and Federal legislation. AAVs are well placed to report if proposed or implemented changes are effective in improving animal health or welfare.

Method

This submission was developed through input from AAVs and other veterinarians associated with the live export industry.

Telephone conversations were used initially to get a general indication of AAVs willingness to contribute. An email was sent to all currently registered AAVs (94) and other veterinarians asking for their input into the working draft document.

A follow-up email was sent, to all currently registered AAVs, with a link to the more finalised document asking for further input and if the AAVs could advise the editors if they wish their name added or removed from the document.

Contributions, either through written or verbal communications, have been included in the submission. If there were vastly different opinions, these were listed under the relevant questions. A scientific approach and where appropriate supported by individual experiences have been taken.

AAVs are not currently represented by a specific industry or professional body, as a result, each AAVs time has been constrained by work commitments and as a group has not had resources to review all scientific literature (both peer review and grey) to identify appropriate references.

Relevant scientific references to research may be found in the Livecorp and ALEC submissions.

Definitions

- **AAV:** refers to Australian government Accredited Veterinarians
- **Class:** the purpose the animal is being exported (Breeder, Feeder, Slaughter)
- **DAWR:** Department of Agriculture and Water Resources may also be referred to as "the department."
- **EAN:** Export Advisory Notice
- **EOV:** End of Voyage
- **HRSA:** Heat Stress Risk Assessment
- **HLI:** Heat Load Index
- **Industry:** refers to the whole live-stock export industry
- **IO:** Independent Observer
- **ME:** Middle East
- **POO:** Property of Origin
- **RP:** Registered Premises
- **Type:** a characteristic that the can define a group of animals (Breed, Sex, etc.)
- **THI:** Temperature Heat Indices
- **WBT:** Wet Bulb Temperature

Issues paper questions

3 HSRA Model: Mortality limit and heat stress threshold

1) **How should the effects of heat on animals be defined?**

A literature review on available research should be conducted to obtain scientific consensus.

Opinion 1:
Panting is considered a useful measure that indicates sheep are experiencing heat stress on export vessel:

- Population Panting is the thing to assess and measure.
- Heat stress on animals should be defined as the environment in which they are placed causes them to show signs of discomfort demonstrated by 'panting'. You can add body temperature, congested conjunctival membranes, splayed stance etc. but panting is the one.
- VISUAL ASSESSMENT OF PANTING AND SHEEPS BEHAVIOUR, and of course, OVER CROWDING. Don't get too technical, observation of the animal using clearly defined terms.
- Can and should you, get any more technical when there are so many variables, age, breed, body weight, wool length, ventilation, placement of ventilation relative to the sheep's head, load density, humidity, moisture, temperature, deep litter, dead spaces, following seas, following winds.

Opinion 2:
The SMART quantitative outline helps to correctly define useful measures: Specific, Measurable, Achievable, Realistic & Time-limited/bound.

Qualitative statements like "I think…", "it looks like", "showing distress" are subjective interpretations at best, often anthropogenic. These are not measurable definitions and are of little-to-no benefit in managing or measuring if control strategies are change with any problem.

So how can the effects of heat on animals be measured? In general terms:

- Physiological
- Behavioural
- Productivity
- Environmental
- and ultimately, mortality effects in both absolute and change terms

What can be measured and, more importantly, what can be practically measured at any voyage point that will be of benefit to real-time decision making?

- Physiological.
  - Body temperature: variation from normal, rate of change, diurnal fluctuation, absolute and change values including relationships to changing environmental conditions.
  - Respiration rate and depth: change from normal, duration time, relationship to changing environmental conditions.
  - Physiological stress factors: plasma and faecal glucocorticoid level, plasma cortisol level, slow blood clotting time, decreased rumen activity, or dilated pupils.
- Behavioural

    - Flocking – isolation behaviour, panting – mouth breathing (Gaughan scale, n/5), decreased eating / drinking, air-flow directional behaviour, eating/drinking, cuding, sternal recumbency / prostration, wide-base stance.
    - This leaves the very real problem of defining/recommending the incidence and prevalence of any or all of these signs: within a single pen, multiple pens, number of decks – and specific areas on the ship.
- Production.
    - Sheep are assumed to gain weight, albeit small, during the voyage. However, I have never seen sheep weighed either immediately prior to loading or off any ship. As a sheep production specialist, I defy anyone to tell me when a sheep has gained 1kg over three weeks. A FCR of 20:1 on a diet of low energy and even lower protein - really? More realistically the mob will develop a 'head & tail'.
    - Body condition score (BCS), taken at random, could be a more useful and quicker assessment - and requires no equipment.
- Mortality
    - The daily report shows the death rates for each deck and for each stock class. The EOV gives the final count. What is not shown in this raw data is the pattern of mortalities over time. It is well recognised by AAVs, ship's crew etc. that there is a definite pattern of mortalities.
        - Usually only 1 or 2 deaths on day 1-2, increasing to days 5-6 then falling to day 8 – 10, with few deaths after that. This same daily-mortality pattern also occurs after delivery at the export (and import ??) facilities. Changes to this general pattern is a better indicator of a problem then the absolute daily number.
    - The current recommendation of 1% total, long-haul, mortality is totally reasonable, but should be refined to stock class as well. In AAV experience, voyage data shows that deaths occur fully at random across deck and pens – other than in critical event – but may be critical with individual classes.
- Environmental
    - Discussed under answer to other HSRA questions

Opinion 3:
I use and have consistently used in my assessment of whether the ship is getting stressed any one of the Accumulated Thermal Heat Indices developed to assess heat stress of the animal.

Below is the latest Heat Load Index (HLI) formula for Cattle developed by John Gaughan of the University of Queensland which considers radiation and wind speed.

- **Heat Load Index for Cattle**
  HLI$_{BG>25}$ = 8.62 + (0.38 Å~ relative humidity) + (1.55 Å~ BG temperature) − (0.5 Å~ wind speed) [4] + [e$^{2.4 - \text{wind speed}}$], and HLI$_{BG<25}$ = 10.66 + (0.28 Å~ relative humidity) [5] + (1.3 Å~ BG) − wind speed
  *where e = the base of the natural logarithm (approximate value of e = 2.71828) and BG = Black Globe.

The Temperature Heat Indices (THI) was developed in the late 1950s as a measure of human discomfort and has been extensively used.

- **Temperature Heat Indices**
  THI = (0.8 x T_a) + [RH x (T_a – 14.3) + 46.3
  *where T_a = dry bulb temperature (ºC), and RH is expressed as decimal form (Thom 1959)

The development of an accumulated HLI for sheep, as has been done for cattle in Australia, would be of great benefit in both alerting and assessing management options on livestock vessels.

Currently, there is much conjecture about certain control measures that have or have not worked, without a defined protocol. Unfortunately, this is what it is. The accumulated HLI, as presented by Dr Kevin Bell, is good although not wholly applicable to sheep it would still be a valuable tool for voyages to prepare for heat stress incidents. A weather station could be set up on each vessel with black globe capability which this sends information to the current provider to send back information regarding accumulated HLI. Thresholds levels for sheep and cattle and specific for the vessel could be developed.

This could be used in addition to Hotstuff. However, I think it is totally different. The advantage of HLI is that it shows when an animal is giving off heat or the stress is so great that it is unable to and is accumulating heat. Thereby, management control programs to offset this would more readily come into play.

Water meters should be installed on every deck to assist in monitoring animals' response to heat stress. Also, the addition on long haul voyages of at least 10-15% of exotics sheep breeds, such as Awassi, Damara etc., are used to further reduce to heat stress of the vessel.

Opinion 4:
There seems to be many livestock production areas where livestock experience heat stress. Consideration needs to be given to standardising the approach to the heat stress issue and not developing multiple modelling, monitoring, and control strategies for each industry area. Bringing together resources and approaches will lead to better solutions and a greater benefit to animal welfare over all the areas of the industry facing this problem.

There is a cattle heat load toolbox by MLA/ALFA and AHA, (**http://chlt.katestone.com.au).** Understanding the approach used and how this may be built upon seems a reasonable starting point. Removing the siloing of the livestock industry research is needed.

Opinion 5:
However, we need to stress that the research on "Heat Stress" is limited and a lot more needs to be funded and completed before any conclusive recommendations can be made. I am aware of a project at UNE that has been approved, but not yet started.

2) How would you detect heat load in the animal? (How is the animal acting?)

"Heat load" has not been defined. A definition of "Heat load" is needed for meaningful answers to be given and compared.

AAV comments:

- How the animal is acting, yes. 'Panting' then 'rapid panting'. Red congested tongue and eyes. Feel the heat yourself. Even measure it, Temp and humidity
- For sheep includes:
  - increased respiration rates in all animals in excess of 200/min …cannot count and 5% of animals open mouth breathing at any time…
  - all animals standing …any down need checking, animals searching and facing jetting air from ventilators.
  - More animals open mouth breathing with salivation and lolling tongue …and deeper breathing are indicative of animal core temperatures close to limit. Animals will not survive much longer. (perhaps 1-2 hours)
- Prolonged moderate heat load (say crossing tropical latitudes 7 days) will cause "downer" sheep or stiff hind limb or knuckling of hind limbs and difficulty ambulating…presumably a heat related metabolic disturbance (respiratory alkalosis, loss of calcium, magnesium ions etc.)

Opinion 1:
This question leads to what signs and changes can be practically SMART measured and assessed on the ship beyond what theoretical signs could be measured in a clinical situation.

Animal characters must be measured in relation to the local deck environment including:

- dry and wet bulb temperatures
- calculated humidity
- radiant heat in specific areas (engine room etc.),
- air flow characteristics
- noxious gases.

Some solutions to these are:

- Local and exhaust fan measurement of ammonia and hydrogen sulphide levels ($100 - $2500) could be investigated.
- Body temperature: the use of IR Infrared Laser Thermometer Temperature Measurer Gun ($20) is non-invasive, fast and accurate. (Research of correlation IR temp with rumen 'data-logger" implants and environmental temps and humidity would be of value.) Plenty of data logger data available.
- Respiration rate and full panting score, both absolute and change, chewing cud, prostration, rate of approaching feed/water.

3) What level of heat load is tolerable/acceptable? (Considerations might be: What can a sheep's body temperature be before the animal starts to suffer heat stress? / What are the signs the sheep is too hot?)

Opinion 1:
It is obvious when a sheep is heat stressed, they pant, then pant rapidly, splay their stance and seek room. Red in the face. And they are usually not on their own, the vet knows (feels) it too. Moving air at head height, and low humidity usually help even when the ambient temperature exceeds 40 degrees C

Opinion 2
There are many expert opinions on body temperature and tissue destruction that are of dubious value. My experience includes summer voyages to the middle east; two years residence as ESCAS officer in the Gulf including residence at the Kuwait feedlot; and summer at a 30,000 sheep dairy in Qatar.

There are four environmental factors involved in heat stress:

1. ambient temperature
2. humidity/ wet bulb temperature
3. airflow
4. diurnal recovery period.

My observation at dry-bulb ambient temperatures of 50°C, 80% humidity – and strong wind did not cause heat stress: sheep voluntarily slept in the sun.

In Middle East feedlots sheep were regularly measured with a rectal temperature of 41°C without showing any sign of heat stress – these conditions were ambient temps of 45°C, humidity of 30% and strong winds. Floor temperatures under these conditions ranged from 35°C (shade cloth) to 76°C (open pen).

The critical factor, in my opinion, is the direct airflow rate. Because of design many areas on all ships have very poor (if any) airflow. The inlet/outlet values are not indicative of pen airflow contact. On the one vessel I've sailed on, sheep will stand, with mouth open, facing the inlet vents in half of the pen and lay down in the other half of the pens near the floor level exhaust vents. To the casual observer, the sheep with their mouth open are 'stressed' but with repeat (experienced??) observations this is behavioural and occurs under winter conditions as well: consider the dog on the back of a ute!

The signs that the sheep are too hot are covered above. It is important to use quantitative information – not anthropogenic opinion.

4) Are the model standard Merino estimates for heat stress threshold (30.6°C WBT) and mortality limit (35.5°C WBT) appropriate/accurate or are there other estimates, supported by the available science that should be considered?

Opinion 1:
Models are only indicators and the GIGO (garbage in, garbage out) principal always applies.

The HSRA model has been in use for a long time – with refinements. The enormous number of successful voyages demonstrates that the model gives a realistic result. The model uses predictions of (expected) environmental conditions and these can change quickly but I consider that the use of the model itself is not a problem.

Opinion 2:
Consideration needs to be given to the breed and class of sheep being exported. Are standard Merino estimates representative of all class and breeds of sheep? For example, exotic sheep breeds. Currently the model adjusts the estimates for liveweight, body condition, coat type (sheep) and acclimatisation zone.

Opinion 3:
Physiological indicators are panting, splayed stance, head outside the pen, climbing on top of each other, engorged tongue, salivation, conjunctival engorgement. Excessive panting.

5) Are there other physiological indicators linked to the effects of excessive heat on sheep that could be measured and considered for inclusion in the HSRA model?

Opinion 1:
The model uses a large number of factors in the equation:

- (Tcore – ML) = Facc x Fweight x Fcoat x Fcondition x (Tcore – base ML).
  *Formulae addendum – Hotstuff V4, p16

The Formulae addendum – Hotstuff V4 comments include:

- As the probability beta distribution for any one animal is uncertain…the scaling…cannot be any more certain”.
- “…the beta distribution were set by judgement…”

The HotStuff model has a large number of ‘judgement’ within it. That it gives a useful result – as shown by the success of the vast majority of voyages - suggests that small adjustments are of academic value.

Opinion 2:
To assess heat stress, POPULATION PANTING developing into excessive panting. Not just one animal. Fatter British bred sheep will pant more than the Merino and desert breeds, also those of different ages and body condition.

Opinion 3:
The HSRA model value is only as good at the data entered into it by the exporter. Verification of this data entry needs to be interpreted by appropriately experienced regional veterinary officers which in the AAV is extremely lacking. The HSRA model should be verified and reviewed by the engaged AAVs and shipboard AAVs should be actively engaged to provide feedback. The model

has proved to be conservative on a number of voyages if the actual weather data that occurred was compared with voyage mortality rates. More research is needed to validate animal tolerances used rather than additional of more physiological measures to complicate a very good model. Updated weather data and better understanding of the existing HSRA model would be more useful than added additional measures before they are accurately validated.

6) What animal welfare indicators could be considered in assessing the effects of heat on animals?

Opinion 1:
Presently most indicators used in modelling “Hot Stuff” etc - include sheep type, class, body condition, fleece cover, weight gain, WBT’s.

In practice monitoring HS load and evaluating its risk depends on a few precise & some subjective measurements and certain impression.

- How hot is it? - temperatures at vantage points (but not accurate for a deck), animal respiration rates, stocking densities (precise).
- How hot does it feel? - are the animals feeling it, standing, very high RR’s, crowding vent outlets, seeking jetting flows
- What’s happening in dead spaces (usually known and stocked at lower rates)?
- Are pen deck conditions deteriorating? Where are they? - trouble ahead at these places and should destock to reduce heat load on those animals (impressions)

Opinion 2:
Only those parameters that fit the practical and obtainable SMART measurements. There is no place for ‘opinion’ no matter how well meant.

Sheep have many behavioural and physiological responses that are totally different to humans. – e.g. they don’t like cold water!

The first question is to define ‘animal welfare’. The OIE and the American Veterinary Medical Assoc. give definitions in terms of the Five Freedoms. These are reasonably assessable. Defining beyond that in realistic terms requires definition in the terms listed above of physiological, behavioural, productivity, environmental, and, ultimately, mortality effects - in both absolute and change terms. Correlation of those defined terms with ‘something’ is the difficulty.

4 Stocking Densities

4.1 McCarthy review recommendation 4

1) **How should the probability settings used in the HSRA model be determined?**
2) **How might the change from mortality to heat load be incorporated in the mathematical model?**
3) **What other probability settings might be considered for inclusion in the HSRA model and on what basis?**

AAV comments:
Many comments on the current model have been made in answer to previous questions.

The HSRA model has been in use for a long time – with refinements. The enormous number of successful voyages demonstrates that the model gives a realistic result. This model, while successful, is based on a large amount of ‘judgements. Would modification with an undefined ‘heat-load’ or other unknown measure able to be justified and would there be assurance that this would make any significant improvement?

4.2Allometric stocking densities

1) **How can allometric stocking densities most effectively be used?**

Opinion1:
Is it not amazing that one puts a strange word, *allometric,* in front of an equation (remember algebra) and it now becomes a miracle value?

Allometric stocking densities can most effectively be used by research comparing ‘welfare’ results when using the current ASEL model with the allometric model.

The support the McCarthy Report uses is the work of Petherick (2007) and Petherick and Phillips (2009). I consider that these published articles are of dubious value. Petheric (2007) makes the statements:

- “there is little information on the amount of space that animals require”,
- “The amount of space an animal occupies as a consequence of its shape and size can be estimated”,
- Limited studies on the lying down and standing up behaviours of <u>pigs and cattle</u> suggest that the amount of space required can be estimated by area *(m²) = 0.047W^0.66”* $(m^2) = 0.047W^{0.66}$”
- “Determining the amount of space for groups of animals is complex, as the amount of useable space can vary with group size and by how group members share space in time.”
- “Some studies have been conducted on the way in which groups of domestic fowl use space, but overall, we know very little about the ways in which livestock time-share space, synchronicity in the performance of behaviours, and the effects of spatial restrictions on behaviour and welfare.

Petherick and Phillips (2009) also comment that the information must be validated regarding sheep.

It should also be noted that Knowles and Warriss criticised Petherick and Phillips (2009) with: “However, they are not correct when they say, “For example, in his review of sheep transportation, Knowles (1998) incorrectly assumed a linear relationship between space and liveweight by scaling allowances to give a value per 100 kg, for example quoting incorrect values of 0.77 and 1.14 m^2/100 kg for the work conducted by Cockram."

2) What k-value (constant) should be used in the allometric equation, and what is the scientific basis for this choice?

Opinion 1:
Allometry.

The most common expression of space allowance as 'space per animal' has limitations because space requirements increase with body weight.

A second option is to express space allowance as weight / density (i.e. kg/m2), but then space requirements are not directly proportional to body weight.

A third means is to use an allometric approach in which A = k BW 0.667 where A is floor space allowance and k is a space allowance coefficient (Petherick, 1983, Baxter, 1984).

The allometric expression can be applied over a wide range of weights (Gonyou et al., 2006) and is supported by several studies (e.g. Hurnik and Lewis, 1991). Petherick and Baxter (1981) estimated k values for sternal recumbent pigs (k = 0.019) and for laterally recumbent ones (k = 0.047). By applying these k values in the above equation, we can calculate how much physical space a pig needs for each posture at a given body weight. The actual space needed depends on how many pigs want to lie down at any given time and the posture they adopt when lying. Lying posture is to a large extent determined by air temperature (Petherick, 1983): at high temperatures pigs will try to lose body heat by increasing the area in contact with the floor so lateral lying will be preferred. This does not translate to sheep or cattle on a ship or vessel.' And several of my colleagues have already stated this. In a vessel the ship is ventilated to a standard that AMSA monitors and now is being independently monitored.

Using this research is fine to use the allometric principle however this is not translatable in total to the Live Ship Export Trade or any other intensive livestock other than pigs. I believe the k value more applicable to sheep and cattle feedlotted on a ship is more like 0.025. This would be more in line to ASEL and Welfare codes recommendation for their stocking rate and takes into account the decrease stocking rate of 10% already noted for the May to October period.

In addition, if the lines of communication were opened up between the AAV's and stockman to freely report findings and outcomes of voyages to people who are responsible for the running of Hotstuff more accurate data would be available from which to run this program. Thereby validating their numbers and estimates for voyages. Currently this reduction in this period is only 10% but there is so much information from which to draw that it is unfortunately being denied access in the decision-making process.

The research conducted by CSIRO in the development of their 'Guidelines for the Housing of Sheep in Scientific Institutions' has much original research of value to the industry.

*(Guideline 23, 2010, http://www.animalethics.org.au/__data/assets/pdf_file/0010/249913/Guide-23-housing-sheep.pdf)

This estimate of 0.025k would have approximately 70% of animals lying down at any one time. Which is a worthwhile, acceptable and achievable aim on a livestock vessel. This is taken from the FAWC transport of animals 2013

*(https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/324500/FAWC_advice_on_space_and_headroom_allowances_for_transport_of_farm_animals.pdf).

These estimates are fairly robust and take into account much welfare data from the European commission over 28 submissions on travel of sheep were reviewed to a arrive at this stocking rate. It has taken into account the fact of whether sheep should be fully lying for a journey or the requirements to access food and water as well as whether they have ventilation as an additional part of the process which increases the stocking rate component.

The following figure I have adapted poorly, might I add, from the document which shows the decision-making process in policy and how it affects both animal and private enterprise. It is a very simple graph but anyone in the Industry or with an interest can put a donkey pin so to speak on where they think these changes affect both Industry and Animals alike. It is a complex question?

Welfare, Policy and the Role of Government Adapted from Welfare, Economics and Policy by Prof McInerny for DEFRA Feb 2004.

'It is in between these two defined zones of the notional animal welfare scale that government faces the key decisions about setting standards and choosing interventions.

It could feel a responsibility to pursue welfare standards above the socially necessary minimum – at least for some species or production situations. This might be because of a belief among opinion formers, or a growing public interest in animal welfare, or simply a declared choice of government policy that improvements should be made in the general level of welfare standards or some particular aspect of them (housing, space allowances, specific practices, etc).

In effect, policy is to take a lead and encourage farmers to improve standards, on the grounds that it is an element of value in livestock production that society should pay more attention to. This increment on the welfare scale is identified in Figure 9 as relating to 'appropriate standards of good animal care', where 'appropriate' is considered as meaning something more than just 'necessary'. This suggests that government views an element of 'better' animal welfare as a merit good, something that it asserts should be valued more highly in a modern society; so it defines a higher (than the legal minimum) level of welfare standards and makes them an objective of policy. Exactly what amount of extra welfare has this higher economic value placed on it is outside the scope of the economist; however, it will depend to a large extent on a political assessment of the externality aspects of animal welfare.

If it is believed that the number of people who are discomforted by livestock production methods satisfying no more than the minimum acceptable standards is sufficiently large as to become a public value, then there is a case for government to step in and lever welfare standards towards this higher boundary. For example, the status of the welfare codes, which specify above-minimum standards but at present are advisory rather than statutory, might be increased and subject to distinct pressures and incentives for them to become the norm.

The foregoing discussion has rather obviously slithered over the issue of where precisely the critical thresholds lie on the welfare scale, on what information they are defined and by whom. That they exist in concept is implicit in the Defra Animal Health & Welfare Strategy but the issue has not been addressed anywhere in that document (nor, indeed, is the whole topic of animal welfare dealt with in any kind of detail that would guide policy formulation).

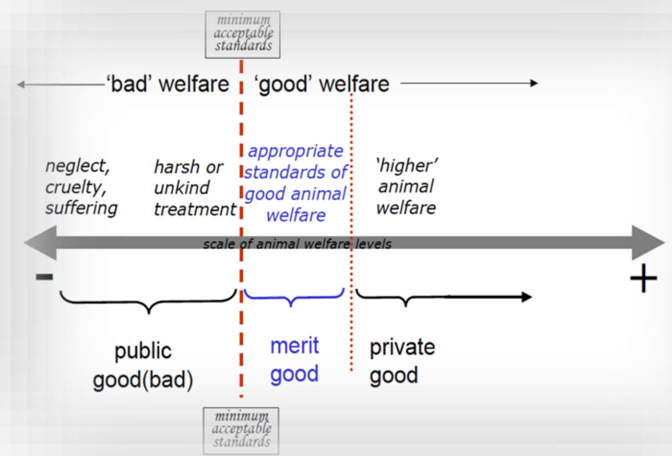
What we have called 'the minimum acceptable standards' are presumed to be captured by the relevant legislation and regulations and by the technical definitions of 'unnecessary pain and unnecessary distress' (UPUD), but these may already be somewhat out of date (i.e. too low) in terms of society's apparent growing sensitivity to animal welfare issues. The difficult problem for contemporary policy formulation, especially if it is to focus on implementing improvements on the grounds that they represent a merit good and therefore need to be the subject of stronger incentives and enforcement, is to define where the upper boundary of welfare standards lies beyond which higher animal welfare becomes a 'private good' interest and therefore not of relevance for public policy.

Notwithstanding the various unresolved issues and accessory questions which arise, the conclusions to which economics can contribute are tolerably clear. The proper role of government policy can be summarised as:

a) rigidly enforcing minimum standards to ensure the public good element in farm animal welfare is uniformly delivered;
b) identifying where the upper boundary of public interest lies to define that increment in welfare which is to be treated as a merit good;
c) devising interventions and policy instruments which deliver these public values as efficiently as possible.'

Figure 9. Animal welfare levels and the definition of economic goods

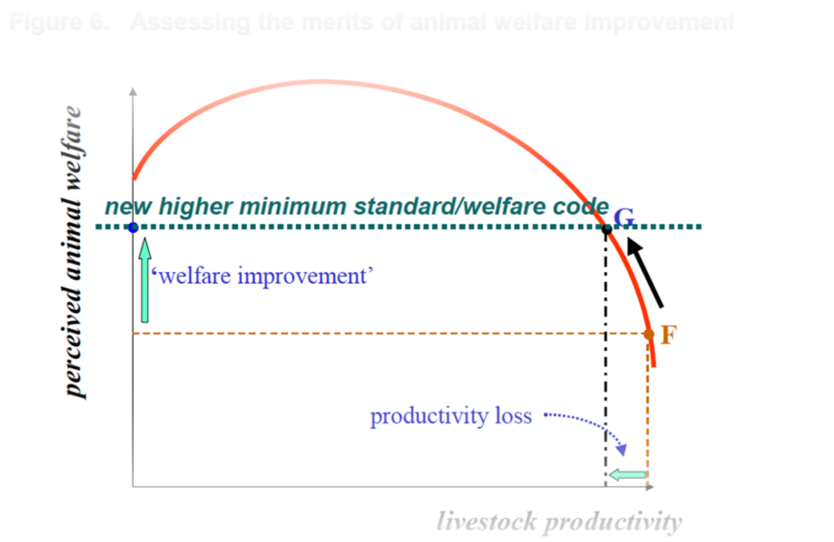
Animal Welfare, Economics and Policy. Prepared for Defra by John McInerney, February 2004 email: J.P.McInerney@exeter.ac.uk



The cost of using a 0.033K value versus 0.025K are clearly represented in Figure 10. Where there is an increase in welfare at a cost to both the Industry and the livestock sector that is unsubstantiated. Clearly, I believe it is a higher animal welfare cost for the private good that is unwarranted and has little or no scientific merit.

I believe as MLA has already done replicated trials on this and found little effect on the lower 0.025k densities. These should be continued as a starting point and data fed into the HSRA model with a variety of classes of sheep including exotics.

Figure 10: Assessing the costs of Welfare Improvement From



Opinion 2:
There does not appear to be any valid scientific basis for the use of this k value.

The approach that should be used if we are to move to using a k values is start at the k value that is representative of the current HSRA/ASEL values. This will allow k values to be quantified to previous voyage history. New values can then be tested on voyages and comparisons made to previous voyages outcomes. i.e. – start where we are currently and test – rather than bring in some guesstimate value.

The McCarthy report states in relation to a k value of 0.033, that "The review found no science to refute this allocation of space.' Yet he offered no science to support it".

The report also stated "A lesser k-value of 0.027 provides sufficient space for animals to stand and lie down but does not, according to the authors, allow free access to troughs and assure…" The animal's space to stand and lie down is the critical requirement, the ability to access feed and water must be considered over a time-period that allow ad lib access.

The McCarthy report inadvertently supports a k value of 0.027 for pen area requirements.

It also states, "This increase in space will assure the health and welfare for sheep being transported to the Middle East during the northern hemisphere summer". There is no supporting data

Opinion 3:

I question the k value of 0.033 having done a voyage on a ship in June 2018 with sheep loaded at that density. Total load 9450 sheep, 3500 cattle. All of the sheep were able to lie down ion the pens and had so much room that they were fighting at the back of the pens. For the summer heat period it should be about 0.025, and lower for cooler periods.

5 HSRA Model—future versions

5.2.1 Prolonged High Heat Load Exposure and Destination Ports

1) **How might potential duration and repeated exposure to high heat loads be incorporated into the HSRA model?**
2) **How might minimum daily temperatures be factored into the HSRA model?**
3) **How might multiple discharge ports be taken into account when assessing heat stress risk?**

Question 1,2, & 3 have been answered together

Opinion 1:

- To the ME Gulf ports, if Kuwait is made the first port of call, which it should be in summer times, then there is a very high probability that it will be very dry. Whereas, it will be highly likely to be extremely humid in the mid and lower gulf areas and the other ports.
- Usually half the load will be discharged in Kuwait, thereby after this there will be a lot of vacant space to spread animals out. Vessel should be loaded to allow lines of sheep to be discharged from decks and tiers to facilitate adjusting the stocking rates after Kuwait.
- The dry weather in Kuwait will assist drying out of decks as well.

To account for these considerations, an adjusted load plan after discharge in Kuwait, along with revised deck conditions, should be part of the AEP and model tested for inclusion in the voyage instruction document.

Opinion 2:
Quick question: why?

Where are any data that shows any welfare improvement would come from such incorporation? There are many opinions but scant data. Why start by attempting to make an immediate change: a characteristic of bad management. Test and validate any suggested changes against the status quo.

Caulfield et al (2014) considered the "The temperature–humidity index, or THI, represents an empirical attempt to weight measures such as DBT and WBT for comparison with measured animal outcomes." However, they also stated "There is no corresponding THI scale for sheep.

Opinion 3:
There are problems which will be present no matter what we, or anyone else in Australia, strives to achieve by this exercise.

- There is a band of heat which is formed from the Ethiopian Highlands and the Iranian Massif. This covers the eastern Arabian Peninsula and there is nothing we can do about it.
    - To cross this band takes approximately 18 hours (variables of time of year and speed of ship)
- Various attitudes of local officials in importing countries are something we have little control over. This requires diplomatic intervention by Australia to circumvent these delay. e.g. religious festival seasons where there can be no one turning up to pilot ships or conduct inspections

5.2.3 Ventilation and air quality

1) What elements or factors contribute to good ventilation performance on a vessel?

Opinion 1:
When ships rely on movement for supplementary ventilation, then multiple ports, and delayed discharging, then these are enormous factors.

- Ventilation needs to drag fresh air from elsewhere and not circulate the already hot air from within.
- Ventilation must be fresh air place above the sheep's head. Not alleyways. Ventilation must be in the inner most corners of the pens, especially adjoining or alongside pens, away from the alleyways. Be very careful of double deck pens.
- Air movement can easily be measured and should be especially deep in the pens and at head height.
- Open decks are dangerous as everybody takes it for granted that air movement of the ship will benefit the sheep. It can and actually accounts for many of the great disasters.
    - All open decked ships must have sufficient ventilation for all circumstances especially following winds, stationary vessels, extreme temperatures. Air at head height. Large volumes and rapid circulation. Placement must be at every corner of a pen.
        - I was on a ship that lost 19,000 head in 3 hours in the Gulf. The ship had high temperatures, high humidity, full to the brim even over crowded. The ship suffered a following wind that equalled its speed. The envelop of enclosed air couldn't escape, the sheep breathed in hotter and more humid air every breath. The sheep trampled each other to death climbing on each other to get to the sides of the pen. Gasping for air and extreme panting. Those deep inside the pen around the ventilation shafts were ok and survived. On the outside and alleyways, they died.
        - When the problem was found, and the ship quickly turned around 180 Degrees, the problem was alleviated. Again, in the middle of the night when all the decision makers were in bed.
- Other conditions must be time of year, type of animal, densities [sought by the animal not by the shipper].
- They air-condition Car Carriers!!

Opinion 2:
Obviously large capacity inlet/outlet fans. Directional airflow down/across the animals. Additional individual fans in hot-spot.

Each ship needs to have its own ventilation rating as some are far more efficient than others particularly when it comes to open decks.

The other point not raised is that sea temperature plays a large part in the heat stress equation. Temperatures on board are not going to change when sea temperatures remain high.

2) How might ventilation performance be incorporated into the HSRA model?

Opinion1:
Let's look at the model like this: the more you factors you incorporate – the less ability to control the outcome. Ventilation is an individual vessel factor – it does not fit to a single model!

3) How might we ensure ventilation design delivers efficiency/performance/output requirements?

Opinion 1:
I consider the development of a laminar flow process along the deck would be a better method. Let's get some materials scientists to have a look at the difficulty.

5.2.4 Open Decks

1) How should open decks be treated for the purposes of assessment in the model?

2) What other things need to be considered in assessing heat stress risk on open decks?

Question 1 & 2 have been answered together

AAV comments/opinions:

- Open decks are OK when there is air movement (head wind etc.) When these ships are bereft of air flow, as in port or with a trailing wind etc., then problems can and will easily occur.
- Ventilation is important an air speed of 2m/sec is basically critical for minimising heat/environmental stress.
- ALEC recommends that no radical changes be implemented to the HSRA model until a new objective has been identified and tested that is simple to collect and explain, robust, reliable and repeatable. Until a new measure has been identified, scientifically validated and tested, the HSRA objective should remain focused on mortalities. While maintaining this focus it would be possible to lower the current 5% mortality setting in the objective.
- Build new ships – if the trade should be successful in continuation
- Open deck boats have a greater opportunity for poor ventilation than closed decks. Two tier boats should be banned.

Scientific references that maybe helpful for the technical panel

There is much relevant literature to help answer these questions that has been conducted outside of Australia and not specifically in relation to export of livestock by sea.

FAO Awassi sheep physiological information: http://www.fao.org/docrep/010/p8550e/P8550E01.htm

Degen, A.A. 1977. Fat-tailed Awassi and German mutton Merino sheep under semi-arid conditions: body temperatures and panting rate. *J. agric. Sci.,* 89: 399-405.

De, K., Kumar, D., Saxena, V. K., Thirumurugan, P., Naqvi, S. M., & Khursheed. (2017). Effect of high ambient temperature on behavior of sheep under semi-arid tropical environment. *International Journal of Biometeorology*, 61(7), 1269-1277. (http://dx.doi.org.elibrary.jcu.edu.au/10.1007/s00484-016-1304-y)

Eyal, E. 1963. Shorn and unshorn Awassi sheep: skin temperature and changes in temperature and humidity in the fleece and its surface. *J. agric. Sci.,* 60: 183-193.

Fadare, A. O., Peters, S. O., Yakubu, A., Sonibare, A. O., Adeleke, M. A., Ozoje, M. O., & Imumorin, I. G. (2012). Physiological and haematological indices suggest superior heat tolerance of white-coloured west african dwarf sheep in the hot humid tropics. *Tropical Animal Health and Production*, 45(1), 157-65. (http://dx.doi.org.elibrary.jcu.edu.au/10.1007/s11250-012-0187-0)

Godfrey, R. W., Preston, W. D., Joseph, S. R., LaPlace, L., Hillman, P. E., Gebremedhin, K. G., . . . Collier, R. J. (2017). Evaluating the impact of breed, pregnancy, and hair coat on body temperature and sweating rate of hair sheep ewes in the tropics 1. *Journal of Animal Science*, 95(7), 2936-2942. (http://dx.doi.org.elibrary.jcu.edu.au/10.2527/jas2016.1125)

Hales, J.R.S. Changes in respiratory activity and body temperature of the severely heat-stressed ox and sheep. *Comparative Biochemistry and Physiology* Volume 31, Issue 6, 15 December 1969, Pages 975-985

Hales J.R.S. Brown G.D. Net energetic and thermoregulatory efficiency during panting in the sheep (CSIRO). *Comp. B&hem. Physiol*., 1974, Vol. 49A, pp. 413 to 422.

Hales, J.R.S., Dampney, R.A.L. & Bennett, J.W. Influences of chronic denervation of the carotid bifurcation regions on panting in the sheep. *Pflugers Arch.* (1975) 360: 243. (https://doi-org.elibrary.jcu.edu.au/10.1007/BF00583719)

Maraia I.F.M. El-Darawanya A.A. FadielbM A. Abdel-Hafezc .A.M. Physiological traits as affected by heat stress in sheep—A review. *Small Ruminant Research* Volume 71, Issues 1–3, August 2007, Pages 1-12

Phillips, C. J. C., Pines, M. K., Latter, M., Muller, T., Petherick, J. C., Norman, S. T., & Gaughan, J. B. (2012). Physiological and behavioral responses of sheep to gaseous ammonia. *Journal of Animal Science*, 90(5), 1562-9. (http://dx.doi.org.elibrary.jcu.edu.au/10.2527/jas.2011-4575)

Tadesse, D; Puchala, R; Gipson, T A; Portugal, I; Sahlu, T; et al. Effects of high heat load conditions on rectal temperature, panting score, and respiration rate of hair sheep breeds from different regions of the United States. *Journal of Animal Science*, suppl. supplement 4; Champaign Vol. 95, (Aug 2017): 337-338.

Other references cited in AAV opinions/comments

https://www.projectsmart.co.uk/smart-goals.php

S - specific, significant, stretching
M - measurable, meaningful, motivational
A - agreed upon, attainable, achievable, acceptable, action-oriented
R - realistic, relevant, reasonable, rewarding, results-oriented
T - time-based, time-bound, timely, tangible, trackable

Malcolm P. Caulfield, Heather Cambridge, Susan F. Foster, Paul D. McGreevy (2014) Heat stress: A major contributor to poor animal welfare associated with long-haul live export voyages. The Veterinary Journal 199 (2014) 223–228

Knowles, TG. and Warriss, PD. (August 2009) Space allowances for confined livestock and their determination from allometric principles: A comment on, Applied Animal Behaviour Science, Volume 120, Issues 1-2, Pages 117–118

Petherick, JC (2007) Spatial requirements of animals: Allometry and beyond. Journal of Veterinary Behavior 2, 197–204.

Petherick, JC, Phillips, CJC (2009) Space allowances for confined livestock and their determination from allometric principles. Applied Animal Behaviour Science 117, 1–12.

Animal Research Review Panel Guideline 23, 2010, http://www.animalethics.org.au/__data/assets/pdf_file/0010/249913/Guide-23-housing-sheep.pdf