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19 October 2018

Technical Reference Panel
Review of the Heat Stress Risk Assessment Model

By email: HRSAreview@agriculture.gov.au

To whom it may concern

Issues Paper for the Heat Stress Risk Assessment (HRSA) model

Thank you for the opportunity to comment on this Issues Paper. Our submission focuses on the role of the HRSA model in the regulatory process, the need for space allowances for all livestock to reflect the science on allometric allowances and the need for all inputs into the model to be accurate and verified.

Where we have not provided detail on the application of the model in our submission, we fully support the extensive analysis and recommendations provided by the Australian Veterinary Association in their submission. The effort expended by the authors of the AVA submission puts into sharp contrast the lack of information available on the implementation of the model in the regulatory process.

We note that while the HSRA model is complex in terms of its inputs and assumptions, it currently does one thing only: makes minor adjustments to the minimum space allowance for animals on-board the vessel. We believe the purpose of the model should fundamentally change from one of adjusting on-board conditions to determining whether or not a voyage should be permitted to occur. Where the model does permit journeys to occur because climatic extremes are avoided, all animals should be allocated sufficient space to meet their basic needs. Under these circumstances it is unlikely that the model would be needed to make adjustments to stocking densities.

Having reviewed a number of industry funded reports on the development and review of the HSRA model, we find it strange that the main author of these reports, Dr Conrad Stacey, has not been directly involved in the review process. Dr Stacey clearly knows more about the model than any other individual. We suggest that Dr Stacey is commissioned to provide technical input into the review process.

While it is outside of the scope of this review, we would like to register our concern over the continued ownership of the HSRA model by Meat and Livestock Australia. The ownership of a key aspect of standard setting by a third party places restrictions on the level of access by the regulator to the data provided by exporters, the uptake of revisions to the model by

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industry, and a lack of public transparency. The ownership of the HSRA model should be transferred to the regulator and made publicly transparent.

Yours sincerely

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RSPCA Australia submission

Issues Paper - Review of the Heat Stress Risk Assessment model

	General comments
	HRSA explanation and history
	We suggest that for the review to be given sufficient context, the Issues Paper should provide detailed information and consideration of the history of the development, review and implementation of the HRSA model (HotStuff). This is lacking in the current document.
	Adoption of revisions to the model
	The Regulator should require that any revisions to the model are required to be adopted in a timely manner. The first version of the model was developed in 2003 and a number of refinements made over the period 2003-2005 (Issues Paper Appendix B). Version 3 of Hotstuff was developed in 2009 yet we note that according to Stacey 2017a: > While the project to develop Version 3 of HotStuff included a revised weather analysis, Version 3 was not adopted. Furthermore, there must be a requirement for limitations to the model identified in the review process to be acted on as soon as they are identified. In the 2011 revision of Hotstuff (V4), Stacey reported three issues which "threatened the efficacy of the HotStuff method" which were: • Lack of independent auditing of PAT values • That mechanically supplied air was treated as 'fresh' air (this was identified as an issue as early as 2001 (MAMIC 2001) • That current practice in two-tier open decks with low mechanical pen air turnover was unsatisfactory from a risk view These exact same issues were listed in the 2017 review (V5; Stacey 2017a). At the time of the McCarthy review they had still not been addressed. It was only due to the McCarthy Review recommendations that the requirement was introduced to require independent verification of PAT scores.
	Accurate data are required to support the assumptions of the model
	A number of the reports listed in Appendix B have emphasised the fact that the model is only as good as the data it is based on. It is notable that those aspects of the model where datasets are limited relate mostly to areas where the limitation is industry access. Exporters appear to be disinclined to collect or make data available to the model designers and research on biological parameters is limited: From Stacey 2006 (LIVE.0228): > In reviewing available data sets to estimate heat stress thresholds, the need for data quality again became clear. As long as there is significant doubt about any relevant aspect of a data set, it is very difficult to use that data at all. From Ferguson et al 2008:

	With regard to the data and assumptions used in the model, it is acknowledged that the derivation of livestock mortality limits and scaling factors (condition score, coat length, acclimatisation) is based on relatively limited datasets. From Stacey 2017(b): Many of the Voluntary Observing Ships (VOS) observation records had no value entered for the wet bulb temperature. The wet bulb temperature is central to the HotStuff method and without a wet bulb value the records cannot be used.
	Access to the literature cited in the Issues Paper
	The Issues Paper cites the following reference: Stacey, C. (2018) Effect of livestock heat stress risk standard on stocking densities for sheep on live export vessels—Prepared by Stacey Agnew Pty Ltd for MLA/LiveCorp, as part of a response to the review being conducted by Dr Michael McCarthy This reference is not publicly available. We understand that the reference was requested from the TRC but has not been provided.
3.1	**Questions about mortality limit and heat stress threshold:** How should the effects of heat on animals be defined? How would you detect heat load in the animal? (How is the animal acting?) 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?) 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? 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? What animal welfare indicators could be considered in assessing the effects of heat on animals?
	Several authors have questioned whether the model Merino estimates for heat stress threshold (30.6˚C WBT) and mortality limit (35.5˚C WBT) are appropriate or accurate. The AVA (2018) submission to the McCarthy review states: In the original HotStuff document, that pre-dated the research of Stockman (2006), the authors stated "*while the animal HST and ML are uncertain, the trends of there (sic) parameters with the risk influences of weight, breed, coat, acclimatisation and fat score are less clear*" (Maunsell-Australia 2003). The Stockman studies were funded by industry, based on the uncertainty of HST in the original model. The parameters of the HSRA model should be reassessed as results set out in Stockman (2006) strongly suggest the HST should be lowered, and is supported by comments by Shiell and co-workers (Shiell, Perkins et al. 2013). Collins et al. (2018) state: *The definition of HST and the use of this definition in the HSRA may not sufficiently account for the effects of environmental conditions, acclimatisation, and thermoregulatory responses of animals. The concept of HST and the HSRA model also does not take into account the cumulative effects of heat load over time and the capacity of the animals to recover during periods of respite*.* It should be noted that while 'the capacity of animals to recover' may help to prevent them from dying, it does not prevent them from suffering during periods of prolonged heat stress.

Heat stress is, by definition, stressful, and the aim of the HRSA model should be to prevent sheep and other animals from any risk of this occurring.

We support the recommendations made by the AVA that sheep should never be exposed to a heat stress threshold (HST) of 3 and that sheep should not be exposed to HST 2 for more than 3 consecutive days where there is no diurnal variation in temperature. We also support the AVA's proposed definitions of HST scores as outlined in Table 1 of their submission.

Recommendation from MAMIC 2001:

> The stockmen should be trained in the use of hand held sensors to measure dry bulb and wet bulb temperature and CO2 concentration, with representative measurements to be recorded whenever animal stress is noted. Ventilation arrangement and pen air speeds should also be noted. The data and animal observations should be recorded on a standard form and forwarded to MLA and LiveCorp to expand the available heat stress database. The data should include a photograph of the beasts and pens involved.

4.1 Outputs of the current HRSA model

In order to understand the relevance of the HRSA model to animal welfare, the reader needs to understand what effect the model actually has on the loading of sheep. Some information is presented on this in Section 4.1 where it is made clear that in cases where the deck PAT is above 200m/h the model has no effect whatsoever:

> *Decks carrying 40kg adult Merinos will not be subject to destocking as a result of the risk of heat stress if the deck PAT is 200m/h or higher.*

However, the issues paper provides no information on what the deck PAT scores of vessels in current use are. We urge the panel to ensure that in the next stage of this process, examples are generated to demonstrate whet the model actually means in terms of outputs with reference to the current fleet of ships, including those with double tiers and open and closed decks.

The following examples of the space allowances generated by the model for sheep exported to Middle Eastern ports are from HRSA reports released through freedom of information requests – a more details table of this type showing results for the same weight sheep, would help in the general understanding of the effect of the model when different risk factors are applied.

Arrival month	Weight	Fat score	Coat type	Acc. Zone	WBT	Deck PAT	Space/head (m^2)	ASEL (m^2)	Increase (m^2)
Aug	50kg	2	Shorn 10mm	3	10.3	250	0.329	0.315	0.014
Sep	55kg	3	Shorn 10mm	1	7.53	366	0.351	0.351	0
Oct	52kg	2	Shorn 10mm	3	13.0	61	0.339	0.329	0.010
Nov	52kg	2	Shorn 10mm	3	16.6	61	0.324	0.324	0

What this clearly indicates is that despite the complex inputs into the current model, the effect on stocking density is minimal or non-existent.

4.1 Questions about HSRA settings:

How should the probability settings used in the HSRA model be determined?

How might the change from mortality to heat load be incorporated in the mathematical model?

	What other probability settings might be considered for inclusion in the HSRA model and on what basis?
	We support the principle that the HSRA model be used to actually assess the risk of heat stress, and provide outputs which will ensure that animals do not experience heat stress during live export voyages. This obviously means that the model must change its probability settings from the risk of mortality to the risk of heat stress as recommended by the McCarthy Review. It also means that the output of the model must shift from adjusting space allowances on board the vessel to determining whether or not a voyage should be permitted to occur.
	Inputs into the model We have concerns about the reliance on industry to provide accurate information on the consignment-based inputs into the model and the way in which these inputs are averaged across decks. This relates to the animal's weight, fat score, coat type, acclimatisation zone and WBT for each deck. For example, the practice of 'topping up' consignments of sheep from saleyards in the days prior to loading means that these sheep are will differ from the profile of inputs into the HSRA. One aspect missing from any previous review of the implementation of the model is an assessment of how accurate these data are. There should be an auditing requirement during the export process to assess whether the data supplied match the details of the consignment (i.e. does the profile of weight, fat score, coat type etc. match the actual sheep loaded. If this were carried out during real time, adjustments should be made to loading where specifications differ from those input into the model. The panel should also consider whether inputs averaged over an entire deck are able to reduce the risk for individual sheep to an acceptable level. For example, it is unclear how the variation in PAT scores in different areas of the deck are accounted for in the deck PAT.
4.2	**Questions about allometric stocking densities:** How can allometric stocking densities most effectively be used? What k-value (constant) should be used in the allometric equation, and what is the scientific basis for this choice?
	Stocking densities should ensure that they are consistent with allometric principles, that is, they should be consistent with the space an animal occupies as a consequence of its mass when performing the normal behaviours. The RSPCA supports the use of allometric stocking densities for all species for all voyages at all times of the year. However, the k-value assigned should not just be sufficient to avoid consistent harm: they must be sufficient for all animals to be lying down at the same time, for all animals to easily access food and water providers, for the identification of shy feeders and for visual inspection of all animals. This is consistent with OIE requirements which state: ***7.2.5. Planning the journey*** *7. Space allowance* *b) Each animal should be able to assume its natural position for transport … When animals lie down, there should be enough space for every animal to adopt a normal lying posture.* ***7.2.9. Travel*** *1. General considerations* *d) Adequate access to suitable feed and water should be ensured for all animals in each pen.* In intensive housing systems, the threshold below which **there are consistent adverse effects on welfare** has been described by the allometric equation: Area (m^2) = $0.033 \times W^{0.66}$ However, to provide sufficient space for all animals to be able to move from a standing to a lying position, and *vice versa*, a larger space allowance is required. During sea transport, a key requirement is that animals in pens are able to move and access feed and water with ease. This means that space

	allowance should take into account the lying down and standing up behaviours of animals. An animal lying down in a pen, should not be hindered in its attempt to rise by other animals standing over/near it. The area required for animals **to move between lying and standing** is described by the allometric formula: Area (m^2) = 0.047 x $W^{0.66}$ Current ASEL requirements for sheep on-board ship provide a k-value of **0.024** (for cattle the k-value is **0.028)**. This allowance provides sheep and cattle with just enough room to stand without contacting other animals, but not enough room for all animals in a group to lie down. Studies of sheep transport indicate that it may be that a k-value of **0.039** is required for **the majority** of sheep to be able to lie down. A k-value of **0.047** allows for **all animals** to lie down at the same time. The same values can be applied to calculating stocking densities for both sheep and cattle. This is a basic requirement irrespective of the risk of heat stress and should apply as the basic minimum all year round for all species.
5.1	**Questions about heat load exposure and destination ports:** How might potential duration and repeated exposure to high heat loads be incorporated into the HSRA model? How might minimum daily temperatures be factored into the HSRA model? How might multiple discharge ports be taken into account when assessing heat stress risk?
	The model should be adjusted to take into account: • The duration of exposure to elevated wet bulb temperatures (WBT) • The level of diurnal variation in WBT, as this has is directly connected to cumulative heat load • The potential for repeated exposure to elevated WBT We support the AVA's recommendation that sheep should never be exposed to a HST level of 3 and should not be exposed to a HST level of 2 for more than 3 consecutive days where there is no diurnal variation in temperature. This risk calculation should be carried out for all voyages where there is a risk that animals may be exposed to consecutive days of temperatures exceeding their heat stress thresholds. This many occur when crossing the equator at any time of year.
	According to Stacey (2017a), the risk of mortality while sailing is assessed using weather data from voluntary observing ships. However, it appears that the majority of these ships have failed to record WBT Stacey 2017(b) states: Many of the Voluntary Observing Ships (VOS) observation records had no value entered for the wet bulb temperature. The wet bulb temperature is central to the HotStuff method and without a wet bulb value the records cannot be used. Concerns have also been raised about the accuracy of WBT readings on board vessels in terms of the location of thermometers and the times of day when WBT is recorded. Given the reliance on the WBT as a means of determining the risk of heat stress the absence of accurate voyage data is a significant problem. In the absence of sufficient accurate data on WBT from actual voyages, the most conservative estimate of WBT should be used if risk is to be properly mitigated. In situations where there is clear historical evidence that heat stress events cannot be avoided (i.e. for voyages carrying live sheep to the Middle East during May to October), these voyages should not be permitted.

	Factors to reduce heat load Collins et al (2018) suggest a number of factors that could be used to reduce heat load, including: • improved heat load forecasting with the capacity to deal with the effects of cumulative heat load • reducing stocking densities across all voyages • improving bedding management • wetting of animals (more appropriate for cattle than sheep) These suggestions reflect those made in previous reports. The authors also suggest a number of areas where further research is needed to determine how adverse heat load events can be avoided. Given what we know already about the outcomes of voyages where heat load events have occurred, and the suffering experienced by affected animals, our view is that the focus should not be on exploring management solutions which are unlikely to be effective, but on setting clear parameters for <u>when</u> voyages should be avoided because there is a risk that animals will be exposed to a heat stress threshold of 3 or above.
5.2	**Questions about ventilation:** What elements or factors contribute to good ventilation performance on a vessel? How might ventilation performance be incorporated into the HSRA model? How might we ensure ventilation design delivers efficiency/performance/output requirements?
	We draw your attention to the following statements in Stacey 2017a: The HotStuff method relies on accurate vessel data. Where deck PAT values are uncertain, the results will be similarly uncertain. (P2) The pen air turnover (PAT) values have not been independently audited for all vessels. Any vessel which is using incorrectly high figures will be underestimating risk. (P4) There is also no treatment yet in HotStuff for reingestion of exhaust air into mechanical ventilation systems. (P2) All mechanically supplied air is treated as being fresh. For some vessel intakes and winds, re-ingestion of air discharged from the animal house will reduce the effective fresh air flow. (P4) The current practice in two-tier open decks with low mechanical pen air turnover is still unsatisfactory from a risk view. In this context, 'low' PAT describes any deck which relies on crosswind to meet the heat stress risk criterion. That PAT cut-off depends on the tier height and deck width, but would be in the range of 60 to 120 m/hr. The effective pen air turnover at the rear of wide two-tier decks with superstructure behind them could become extremely low in still conditions, even when sailing fast. Such decks should be ventilated and assessed as if they were closed at the sides.(P4) While the McCarthy Review recommendations for independent auditing of PATs have gone some way to addressing these concerns, the issue of reingestion of exhaust air and the assumption in the HSRA model that all air is ‘fresh’ need to be addressed.
	The results of independent verification of PAT scores for all live export vessels should be required to be publicly available.
5.2	**Questions about open decks:** How should open decks be treated for the purposes of assessment in the model? What other things need to be considered in assessing heat stress risk on open decks?

	The results of industry funded modelling have already demonstrated that open decks should be ventilated and assessed in terms of PAT as if they were closed.
	The conclusions from Computational Fluid Dynamics (CFD) simulations performed as an initial investigation of the natural ventilation on live sheep transport ships as reported by Stacey (2017a) were: • The conditions on two-tier open decks sailing through still air will be very uneven, with excellent air exchange at the front, and very poor air exchange at the back. • For a deck with an obstruction (such as a bridge structure) at the rear, perhaps a half of the deck at the rear may have very poor air exchange. Note that this study has not considered bluff walls in front of the animal housing. That case would give extremely poor results in still air. • For the rear half or so of two-tier open decks, forward movement and turbulent mixing down the sides of the vessel are not sufficient to generate air exchange equivalent to either a 5 or 7 knot cross wind. • The very uneven nature of air exchange due solely to forward vessel movement makes comparisons to a single equivalent crosswind misleading. It would be preferable to categorise the areas of the deck which may become unsafe in such conditions. • **The risk of low still-air ventilation rates at the rear of large open decks is such that an individual assessment should be made of all vessel decks which cannot rely on fans alone to achieve a PAT appropriate for their livestock and destination. This can obviously be avoided by provision of appropriate levels of mechanical ventilation such that risk assessment need not rely on the decks being open.**
	The following statements in Stacey 2017a provide further explanation: The wider the vessel and the lower the deck height, the harder it is for natural ventilation to effect the necessary air exchange. Consequently, the vessels of primary interest at this stage are those which have very wide open decks and in which each deck level is a double-tier deck that consists of two tiers of sheep pens, each approximately 1.2 m in height. A review of the effectiveness of air exchange while sailing in still air has indicated that the technique should not be relied on for two-tier open decks. The resulting air exchange had previously been taken as equivalent to a 5 knot crosswind, and more recently a 7 knot crosswind. For the rear half of two-tier open decks, with superstructure behind the pens, the equivalent effective crosswind is close to zero. **To manage heat stress risk, open decks should be ventilated and assessed as if they were closed**. No modelling was done for single-tier decks. It is seen that sailing forward in still air is ineffective at generating air exchange for the rear half of two-tier open decks. The equivalent effective crosswind toward the rear of the animal housing is not 7 knots or 5 knots, but close to zero.
	Appendix B **Selected Livecorp/MLA research and development projects**
	This Appendix summarises reports on the development of the HRSA model, it is not a full list of these reports. Neither does it explain whether or when each iteration of the model was adopted (e.g. at what point in time was each version adopted as part of the regulatory process). We urge the panel to include this information as it is apparent that there have been times when important revisions have not been taken up by the industry – a situation that must be avoided in the future. Also, several of these reports have made recommendations for changes to the model – it would be informative if these recommendations were be listed together with details of when the recommendations were acted on.

	Finally, several dates listed here do not match up to the reports that they are connected to. For example: • LIVE.0116 – finish date is listed as 7/05/2003 but the date on the report is 3/12/2003 • LIVE.0228 Summary "the 'HotStuff model released in 2001' – but the first report on the model LIVE.0116 was released in 2003 • W.LIV.0264 – finish date is listed 31/01/2009 but the date of the report is December 2008. What makes this more confusing is that the review is of HotStuff V3.0, yet the report on V3.0 was not published until September 2009 and it appears that V3.0 was never adopted. • B.LIV.0249 – finish date is listed as 30/06/2009 but the report is dates September 2009 There may be more errors of this type – we urge you to check the entire table.