Institution: University of Edinburgh and SRUC, Scotland's Rural College

Unit of Assessment: 6

Title of case study: Minimising heat and other stresses during animal transportation improves animal welfare and has driven EU legislation.

1. Summary of the impact (indicative maximum 100 words)

Impact: Policy / animal welfare / economic. European Directives on Animal Welfare have been changed to improve animal comfort during transport. Our research has provided a basis for establishing comfort/discomfort at an objective, physiological level through response modelling and the quantitative assessment of the effects of thermal conditions. The definition of optimum transport environments has underpinned improved transport vehicle design and operation and formed the basis of the development of regulations for improved animal welfare.

Significance: ~60 billion animals are transported world-wide each year.

Beneficiaries: EU policy makers (leading to revised Directives), UK Government departments (especially Defra), and animals during transport.

Attribution: Prof. Mitchell (SRUC).

Reach: All EU Member States, Canada, and the US.

2. Underpinning research (indicative maximum 500 words)

Globally, it is estimated that over 60 billion animals are transported annually and the welfare of these animals is an issue of major public and political concern worldwide. Animal welfare in transit is the subject of constantly developing legislation, which must be based on sound scientific evidence that prioritises animal welfare. Prof. Mitchell (Professor of Physiology and Animal Welfare, employed 1981-onwards) developed a research programme that focused on these issues. The research, which has been continuously supported by Defra and a number of industrial partners since 1995, used physiological and behavioural modelling [3.1] to provide quantitative indices of the stress felt by livestock in transit. The severity of the stress and the nature of the responses have been used to define the ideal transport conditions and practices and to identify acceptable ranges and limits for imposed stressors; in particular heat stress [3.3]. This involved the development indices of thermal loads including the development and application of the concept of Apparent Equivalent Temperature (AET), which allows quantification and modelling of the physiological effects of temperature and absolute humidity for poultry in transit. The model has been evaluated and validated under commercial transportation conditions and this was central to the success of the project. A key part of the research has been developing new techniques to measure the stress experienced by animals in transit such as radio-telemetry which was used to record the physiological response of animals to a range of transportation conditions and stressors including temperature [3.2]. Numerous other markers of physiological stress have been identified and applied which allow for continuous assessment and point sampling to determine the degree of stress imposed in transit and the effects upon animal welfare.

Further physiological and welfare outcome modelling has been applied to the design, development and evaluation of non-mechanically ventilated livestock transport systems [3.4] under a wide range of weather conditions. It has also been used to assess the performance of mechanically ventilated vehicles, provide information for improving them, and for assessing the welfare conditions encountered by animals being transported [3.5, 3.6].

3. References to the research (indicative maximum of six references)

3.1) Mitchell, M. A. and Kettlewell, P. J. (1998). Physiological stress and welfare of broiler chickens in transit: Solutions not problems! Poultry Science. 77 (12): 1803-1814. http://tinyurl.com/nplozps

3.2) Kettlewell, P. J., Mitchell, M. A. and Meeks, I. M. (1997). An implantable radio-telemetry system for remote monitoring of heart rate and deep body temperature in poultry. Computers

and Electronics in Agriculture. 17: 161-175. http://dx.doi.org/10.1016/S0168-1699(96)01302-6

3.3) Mitchell, M. A. (2006). Using physiological models to define environmental control strategies. In Mechanistic Modelling in Pig and Poultry Production, Eds. R.M. Gous, T.R. Morris, C. Fisher, CABI International, Wallingford, Oxfordshire, UK, pp 209-228.

3.4) Kettlewell, P. J., Hoxey, R. P., Hampson, C. J., Green, N. R., Veale, B. M. and Mitchell, M. A. (2001). Design and operation of a prototype mechanical ventilation system for livestock transport vehicles. Journal of Agricultural Engineering Research. 79: 429-439. http://dx.doi.org/10.1006/jaer.2001.0713

3.5) Knezacek, T. D., Olkowski, A. A., Kettlewell, P. J., Mitchell, M. A. and Classen, H. L. (2010). Temperature Gradients and Physiological Responses During Winter Broiler Transportation In Saskatchewan. Canadian Journal of Animal Science. 90: 321-330. http://dx.doi.org/10.4141/CJAS09083

3.6) Villarroel, M., Barreiro, P., Kettlewell, P., Farish, M. and Mitchell, M. A. 2011. Time derivatives in air temperature and enthalpy as non-invasive welfare indicators during long distance animal transport. Biosystems Engineering. 110 (3): 253-260. http://dx.doi.org/10.1016/j.biosystemseng.2011.07.011

4. Details of the impact (indicative maximum 750 words)

The impact of our research has been improved animal welfare through changes in legislation, new codes of practice and better vehicle design and operation. Specifically:

Definition of thermal comforts ranges for livestock made available to the industry to improving transportation practices: The concept of AET is one of our most important contributions to the field. It has been adopted in both industry and in regulatory practice, as well as by breeding companies (e.g. Ross – Aviagen Manual).

Direct inputs to European and UK animal transport legislation (EC 1/2005): The research has enhanced the understanding of the conditions animals face during transportation and the stress that places upon them. The definition of optimal or target thermal conditions in transit and acceptable limits for temperature and absolute humidity is the foundation of legislation relating the thermal conditions in transit for poultry, cattle, pigs and sheep (e.g. EC 411/98 and EC 1/2005) and the on-going review of legislation.

Our work features in European Food Safety Authority (EFSA) Opinions on which European Transportation Legislation was based (EC411/98 and EC 1/2005). The impact is apparent in the recommendations made concerning poultry transportation in the EFSA Opinion / Report of 2011 which in turn forms the basis of the recommendations for future revision of EC 1/2005.

Provision of the basis for the design and operation of mechanical and improved passive ventilation systems on commercial transport vehicles (as embodied in legislation): our research demonstrated the efficacy of mechanical ventilation of animal transport vehicles in reducing thermal stress and improving animal welfare. This led directly to the development and evaluation of improved passive and mechanical ventilation systems on commercial vehicles, which has also been incorporated into current legislation.

The earliest modelling studies underpinned the development of the Concept 2000 poultry transporter, which uses mechanical ventilation. The manufacturers developed fan-ventilated animal transporters for red meat species using our research and the associated legislative requirements. Indeed mechanical ventilation is now mandatory for all higher standard vehicles in Europe taking livestock on long journeys, defined as exceeding 8 hours duration.

More recent work (e.g. for Defra) has directly addressed the long distance transport of pigs, acceptable thermal envelopes for livestock and the influence of journey times on the welfare of pigs. The outputs of these studies have fed directly into Defra policy development and the revision and amendment of current European legislation.

Economic benefits due to the reduction of mortality during transport and improved product quality (e.g. in broiler chicken transportation): The work has improved animal welfare by

reducing stress during transportation and with over 56 billion broiler chickens transported world wide every year, better vehicle ventilation and control of the on-board temperature could decrease previously significant economic losses. Animals that die whilst being transported cannot be sold, and so represent a loss of profit, but the new transportation systems are estimated to have reduced the in-transit mortality rates by 50%. An estimate of mortality under UK transport conditions prior to the introduction of ventilated systems, was *ca* 0.1%, which means with production of *ca* 850 million chickens every year, losses of 850,000 birds was commonplace. Improvements to transportation are conservatively estimated to have saved 425,000 birds per annum.

5. Sources to corroborate the impact (indicative maximum of 10 references)

5.1) European Food Safety Authority, 2011; EFSA Panel on Animal Health and Welfare (AHAW); Scientific Opinion concerning the welfare of animals during transport. EFSA Journal. 9 (1): 1966. [125pp.]. http://dx.doi.org/10.2903/j.efsa.2011.1966

5.2) "The welfare of animals during transport". Scientific Report of the Scientific Panel on Animal Health and Welfare on a request from the Commission related to the welfare of animals during transport (Question N° EFSA-Q-2003-094). Adopted on 30th March 2004. http://tinyurl.com/nlohok3

Defra research reports (contact John.Tayleur@ahvla.gsi.gov.uk) or:

5.3) AW0940 – Epidemiological studies to determine travel times for pigs: Defra – (2008-2012) http://tinyurl.com/pj9rc8w

5.4) AW0820 – Transcontinental road transport of breeder pigs – effects of hot climates: Defra – (2006-2009) http://tinyurl.com/oc8djz6

5.5) AW0939 – A review to appraise the evidence for acceptable temperature envelopes for pigs (2008-2009) http://tinyurl.com/qzcl7np

5.6) The Animal Transport Association http://tinyurl.com/qz8thke

5.7) Heerings (Netherlands) Vehicle Construction http://tinyurl.com/p2nomjh

5.8) Veterinary Consulting Services. David Pritchard (formerly senior veterinary consultant for animal welfare at Defra) http://tinyurl.com/oqb9amu

5.9) Defra. Welfare in Transport Team http://tinyurl.com/p5vo8y6

5.10) Pennsylvania State University – A quality assurance program for handlers and transporters of poultry – training manual for certification. http://tinyurl.com/nsgj85y

5.11) Livestock transport requirements in Canada. http://tinyurl.com/okkgpsv