Temperature controlled transport of poultry

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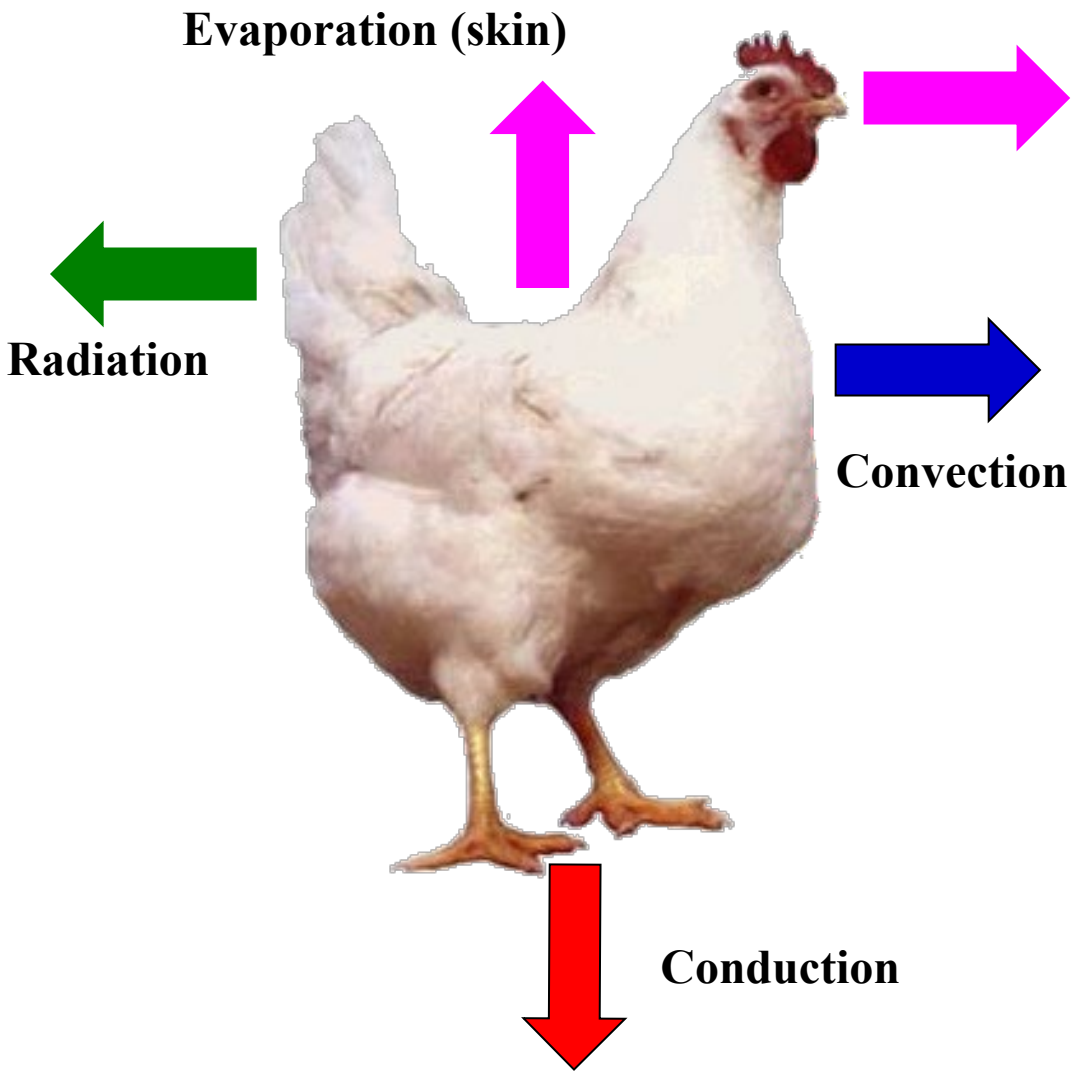
Building the future of livestock protection

Outline of presentation

- Thermoregulation in poultry
- Thermal profiles during transport
- Temperature limits during transport
- Temperature controlled transport?

Avenues of heat exchange from a bird



Poultry do NOT sweat – evaporation from the skin is a passive cutaneous loss

When heat stressed birds start to pant to lose heat by respiratory evaporation

Parameters affecting heat gain/loss

	Temperature difference	Moisture difference	Air movement	Surface area
Conduction	✓			✓
Convection	✓		✓	✓
Evaporation	✓	✓	✓	✓
Radiation	✓			

Avenues for heat exchange

Sensible heat loss - temperature gradient between bird and its immediate surroundings

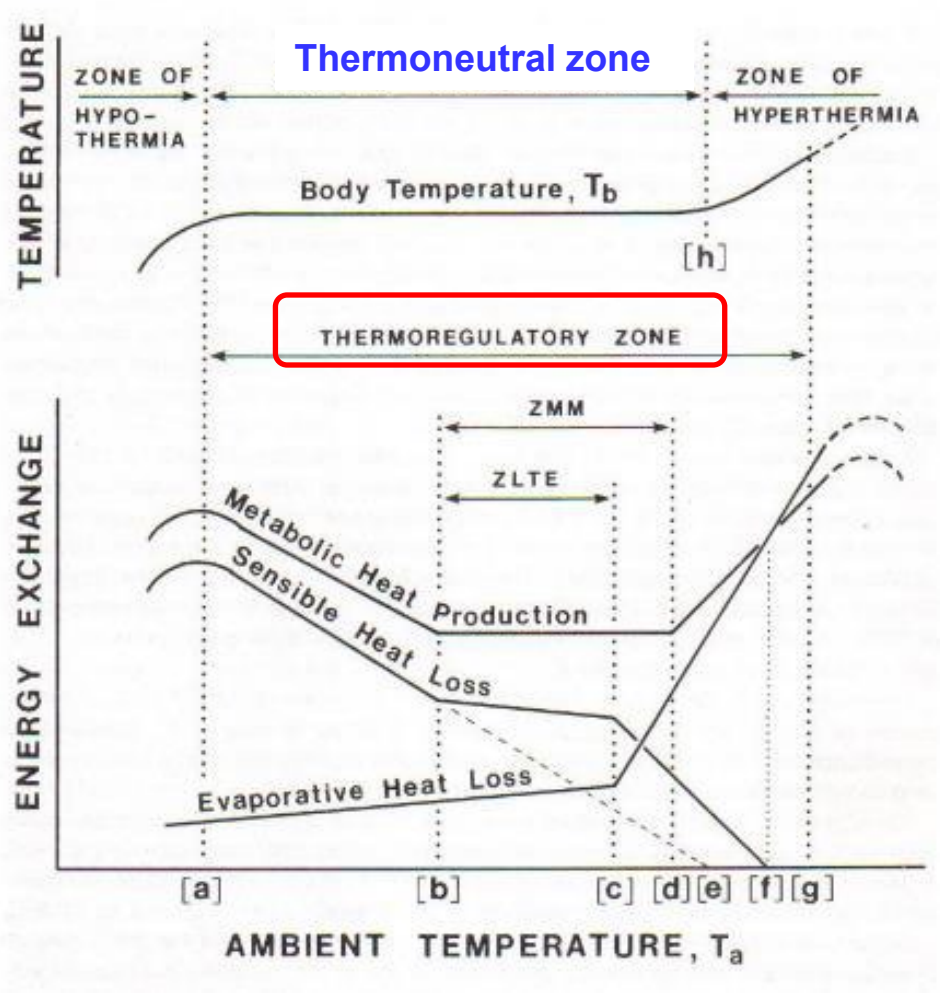
Latent (evaporative) heat loss - moisture gradient between bird and its immediate surroundings (although also temperature dependent)

NOT directly dependent upon relative humidity which is **relative** and dependent upon temperature

↑ air movement → ↑ convective heat exchange

↑ air movement → ↑ evaporative heat exchange

Thermoneutral zone



Thermal equilibrium is the target ideally with minimal thermoregulatory effort

Humidity will influence heat exchange EVEN in the TNZ - will increase/decrease the demand for sensible heat loss

Air movement will influence heat exchange (both evaporative and sensible) EVEN in the TNZ - will alter the partitioning of heat exchange

Thermal stress

The thermal environment may impose thermal loads upon animals i.e. too hot or too cold

Inadequate thermoregulation → body temperature ↑↓

Hyperthermia – ↑ core body temperature – hot/humid

Hypothermia – ↓ core body temperature – cold/wet

Impact of thermal conditions on poultry

Overall impact of thermal conditions on poultry influenced by:

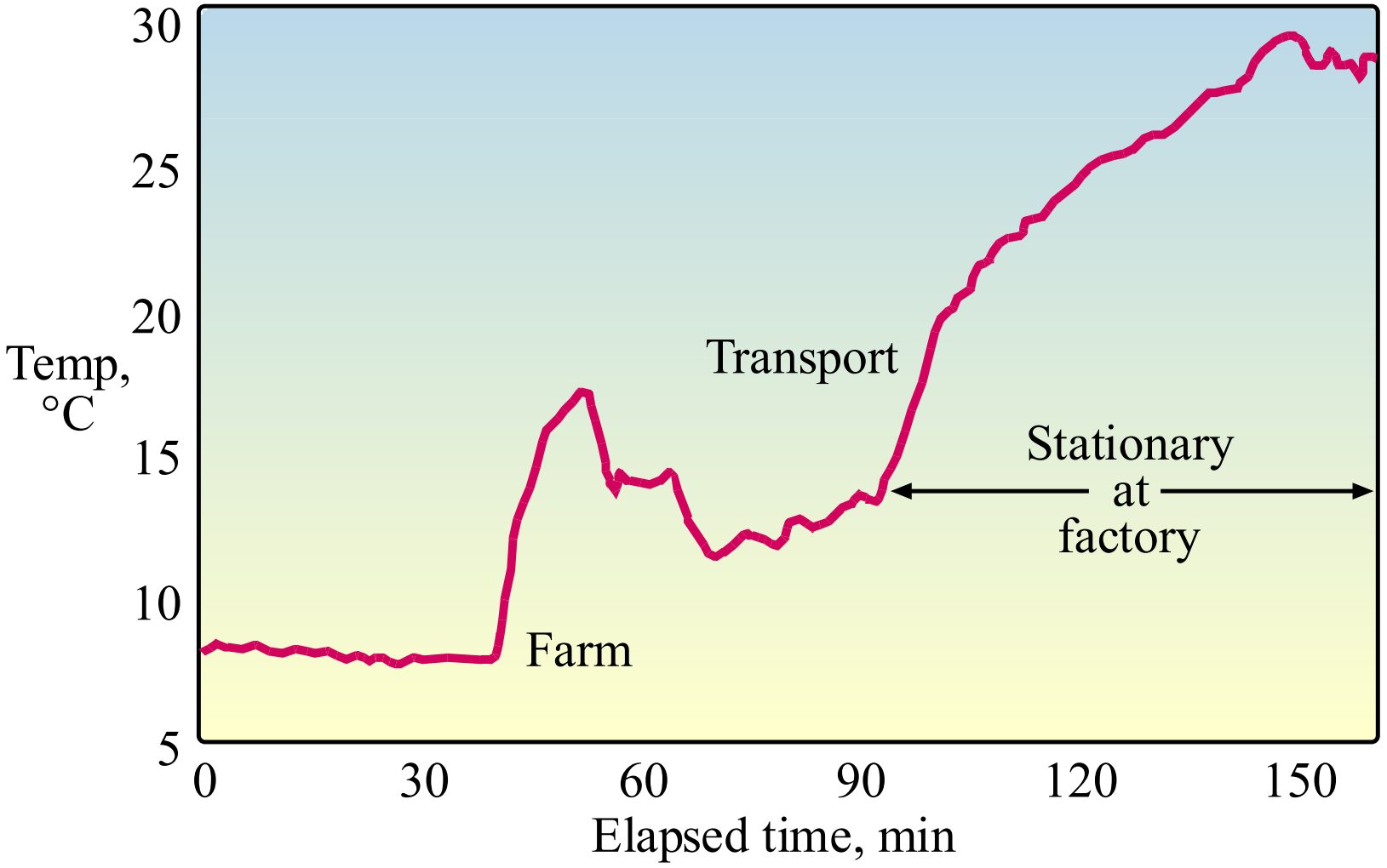
- Temperature
- Moisture content
- [Air movement may modify both of above]
- Duration of exposure – often overlooked!

During transport, must also consider:

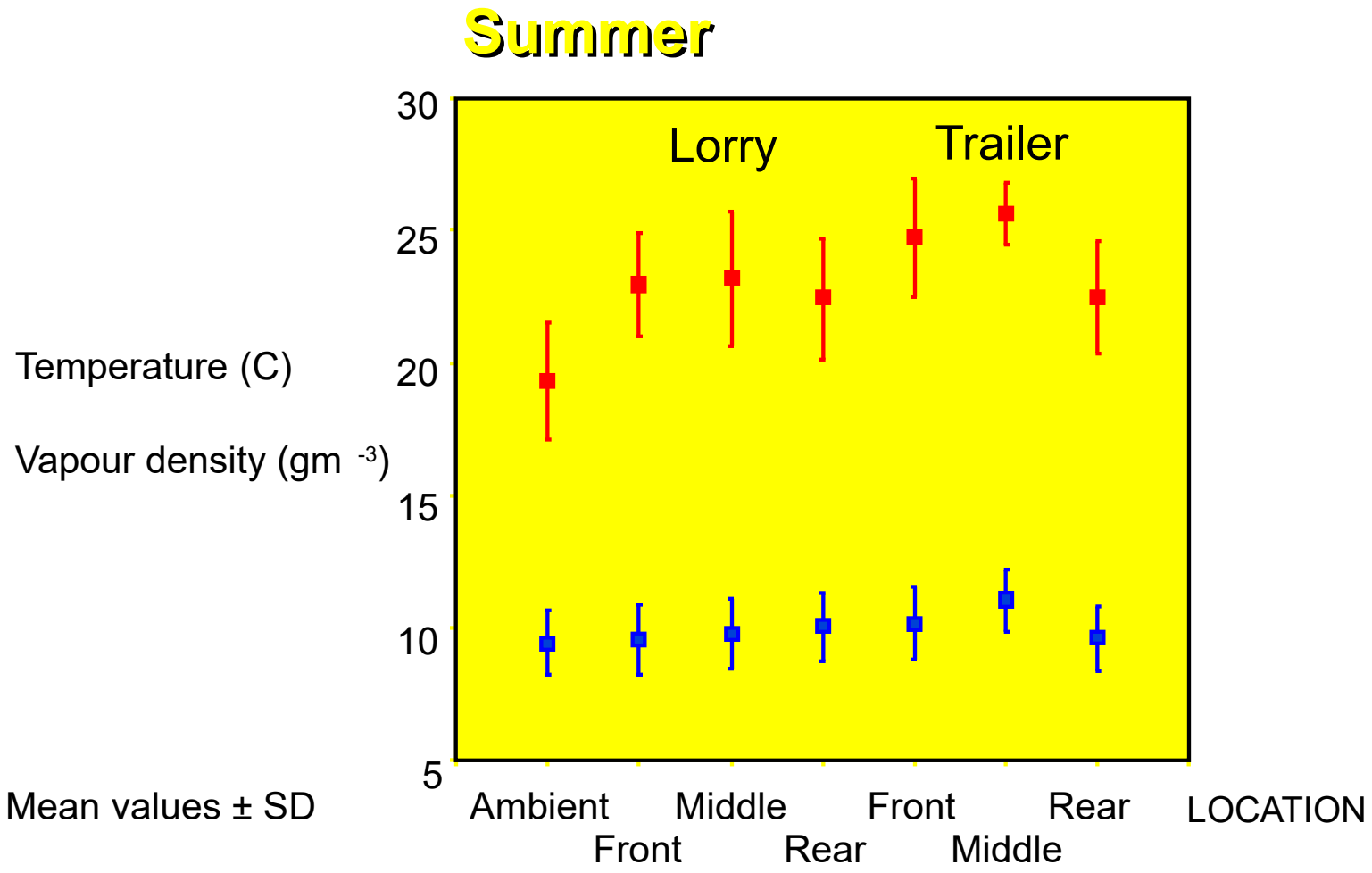
- Spatial variation [on vehicle]
- Geographical variation [during journey]
- Temporal variation [changes during day/night]

Early studies

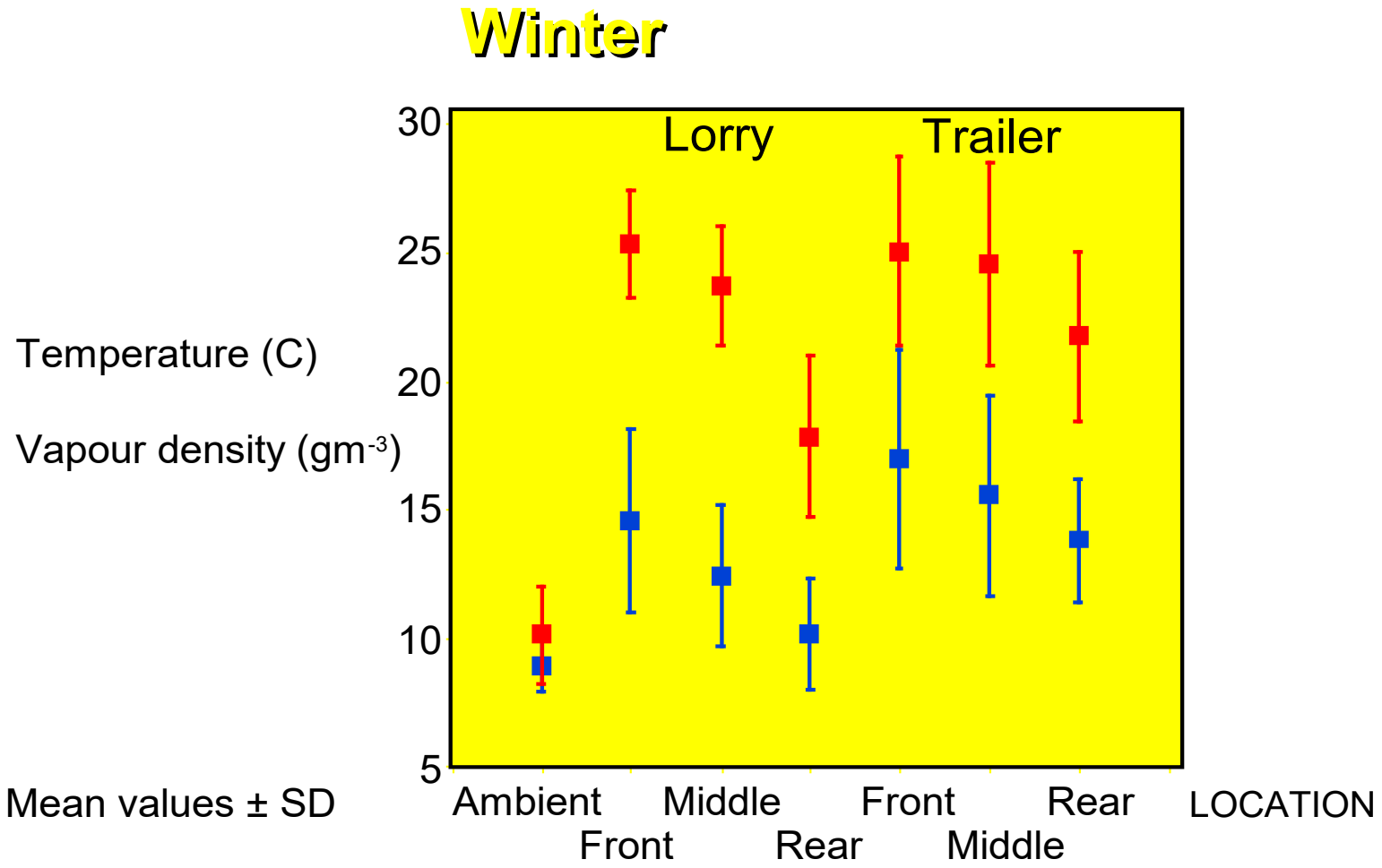
Thermal conditions – temperature within drawers



Conditions during transport – curtains open



Conditions during transport – curtains closed



Heat production from broilers in transit

Typical load of broilers – 6500 birds (@2kg)

10 Watts to 15 Watts per bird

Potential total heat production =

65 kW to 97.5kW

Evaporative water loss from broilers in transit

- Broilers (not heat stressed) in lab

  49.2 mg kg^{-1} min^{-1} water loss

- 2kg broiler the resting water loss is

  100 mg /bird/minute (6 g per bird per hour)

- 3-hour journey

  18g per bird

- Load of 6500 birds this results in a water loss of 117 kg - “minimum weight loss”

Integrated thermal index – Apparent Equivalent Temperature

$$\theta^* = T + e/\gamma^*$$

$$\gamma^* = \gamma (r_v/r_h)$$

where

θ^*_{app} = AET

T = absolute temperature (K)

e = water vapour pressure (mbar)

γ^* = corrected psychrometric constant (mbar K^{-1})

where

r_v = the resistance to water vapour transfer (sm^{-1}) and r_h = the resistance to heat transfer (sm^{-1}).

Integrated thermal index – Apparent Equivalent Temperature

Derived from

- Temperature
- Water vapour pressure
- Psychrometric constant

Relates to

Total heat exchange between a wetted surface and the environment

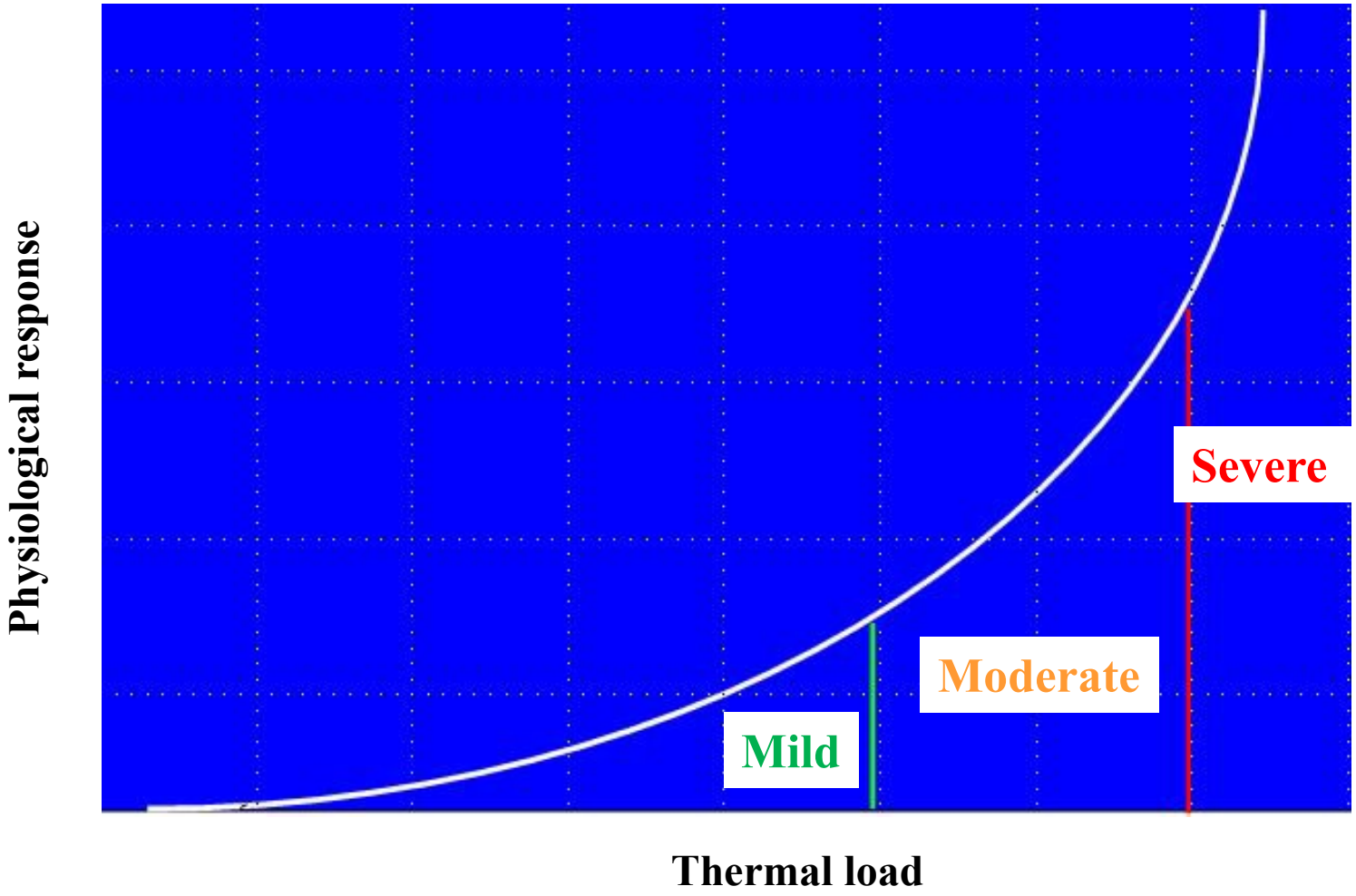
Value

Integrated index of total thermal load: physiologically valid – reflects degree of stress imposed by TOTAL thermal load

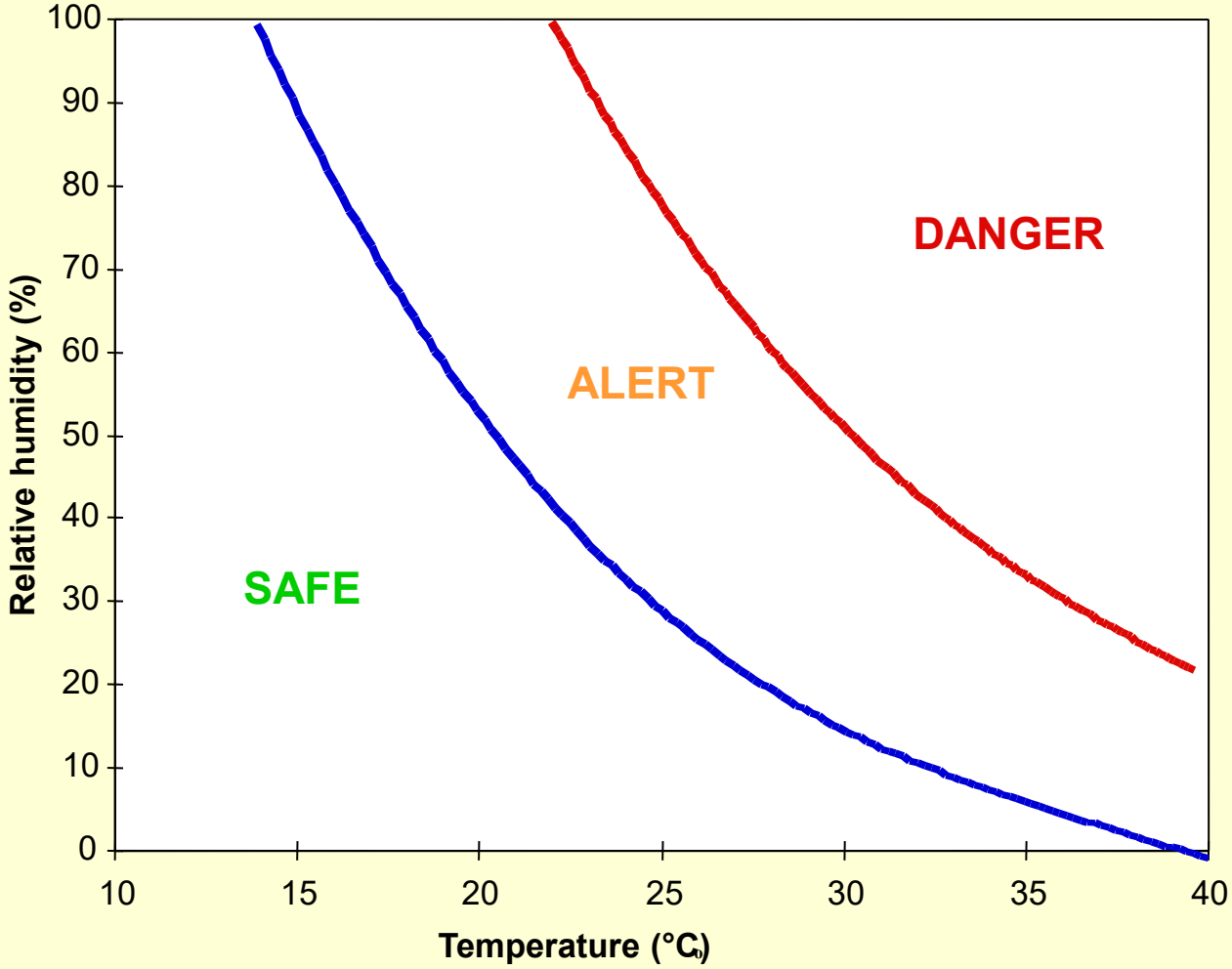
Lab studies in climate chambers under simulated transport conditions

- Birds exposed to temperatures between 15-40°C with relative humidity between 30-90% to yield combinations with AETs between 20-100°C
- NOTE: The units of AET are °C but this is NOT a dry bulb temperature – it is the integrated index taking vapour density into consideration
- Physiological responses measured (3-4 hours)
- Homestatic effort vs Homeostatic success
- Metabolic responses

Theoretical responses to increasing thermal loads – broiler chickens



Theoretical responses to increasing thermal loads – broiler chickens



AET alert limit = 65°C

AET safe limit = 40°C

Ventilation is the key to determining thermal comfort

- Ventilation can remove excess heat and moisture from within the load of birds
- If birds are heat stressed then increased ventilation will remove additional heat and moisture
- If ventilation airflow is distributed throughout the load the air movement will enhance convective and evaporative heat loss
- Uniform distribution of air flow throughout the load is desirable
- Air flow velocity and volume will enhance heat loss when elevated temperatures are encountered but not be so great that it is detrimental (enhanced cooling) at low ambient temperatures
- Hence an ADJUSTABLE/CONTROLLED AIR FLOW is desirable!

Improved (passive) ventilation of trailers

Driven by vehicle movement – so no “driving force” for air movement on a stationary vehicle

Significant industry development to improve ventilation of vehicles

Commercial prototypes (active ventilation)

Powered air movement – so independent of vehicle movement

Commercial prototypes (active ventilation)

Legislation as it relates to transport environments and vehicle ventilation

- Current and proposed legislation

- Retained Council Regulation EC 1/2005 as implemented in the UK
- Defra consultation on improvements to animal welfare in transport – December 2020
- EC proposal for a Regulation … amending EC 1/2005 – December 2023

Retained Council Regulation EC 1/2005

Annex I, Chapter III – Transport practices - Section 2 – During transport

2.6. Sufficient ventilation shall be provided to ensure that the needs of the animals are fully met taking into account in particular the number and type of the animals to be transported and the expected weather conditions during the journey. Containers shall be stored in a way which does not impede their ventilation.

2.7. During transport, animals shall be offered water, feed and the opportunity to rest as appropriate to their species and age, at suitable intervals and in particular as referred to in Chapter V. If not otherwise specified, Mammals and Birds shall be fed at least every 24 hours and watered at least every 12 hours. The water and feed shall be of good quality and presented to the animals in a way which minimises contamination. Due regard shall be paid to the need of animals to become accustomed to the mode of feeding and watering.

Retained Council Regulation EC 1/2005

Annex I, Chapter V – Watering/feeding intervals - Section 2 – Other species

2.1. For **poultry**, domestic birds and domestic rabbits, suitable **food and water shall be available in adequate quantities, save in the case of a journey lasting less than**:

(a) **12 hours disregarding loading and unloading time**; or

(b) 24 hours for chicks of all species, provided that it is completed within 72 hours after hatching.

Retained Council Regulation EC 1/2005

Annex I, Chapter VI – Additional provisions for **long journeys** [over 8 hours] **(horses, cattle, sheep, goats and pigs)** - Section 3 – Ventilation for means of transport

3.1. Ventilation systems on means of transport by road shall be designed, constructed and maintained in such way that, at any time during the journey, whether the means of transport is stationary or moving, they are capable of maintaining a range of temperatures from 5°C to 30°C within the means of transport, for all animals, with a ± 5°C tolerance, depending on the outside temperature.

3.2. The ventilation system must be capable of ensuring even distribution throughout with a minimum airflow of nominal capacity of 60 m^3/h/KN of payload. It must be capable of operating for at least 4 hours, independently of the vehicle engine.

[equivalent to 600m^3/h/tonne]

Defra - Consultation on improvements to animal welfare in transport – December 2020

Proposals: Thermal conditions and ventilation

42. To address this, we are proposing that **no poultry journeys** will be allowed to take place **if the forecast external temperature** for the journey **is outside** of a temperature range of **5-25°C**, unless the vehicle is able to regulate the internal temperature within a 5-25°C temperature range for the duration of the journey by means of a **thermo-regulation system**. This **will apply to both short and long journeys**.

Proposal for a Regulation … amending Council Regulation (EC) No 1255/97 and repealing Council Regulation (EC) No 1/2005

Annex I – Chapter 5 – paragraph 2 – Domestic birds and rabbits transported in containers

2.3 Thermal comfort shall be provided as follows:

(a) When the temperature forecast at the place of departure and at the place of destination at the time animals are expected to be at those places is **below 10°C**, rabbits and domestic birds other than end-of-lay hens shall only be transported in vehicles with **protection against windchill**.

(b) **End-of-lay hens** shall not be transported if **temperatures inside the vehicle of at least 15°C** can be maintained.

Meteorological data

- Thinking back to the Defra proposals

- How often might these temperature limits proposed by Defra preclude the transport of poultry?

Potential impact of proposed temperature limits

Total (Max cont) T>=25°C	2020	2021	2022	2023
Brackley	115 (12)	89 (11)	177 (15)	101 (9)
Coupar Angus	0 (0)	8 (5)	45 (9)	5 (2)
Hereford	83 (10)	96 (10)	157 (14)	90 (9)
Turriff	0 (0)	0 (0)	15 (7)	2 (2)

Total (Max cont) T<=5°C	2020	2021	2022	2023
Brackley	1412 (104)	1942 (251)	1508 (291)	1358 (122)
Coupar Angus	1747 (120)	2422 (237)	1724 (302)	1747 (120)
Hereford	1335 (105)	1807 (238)	1532 (290)	1278 (113)
Turriff	1986 (109)	2609 (346)	1999 (346)	2101 (165)

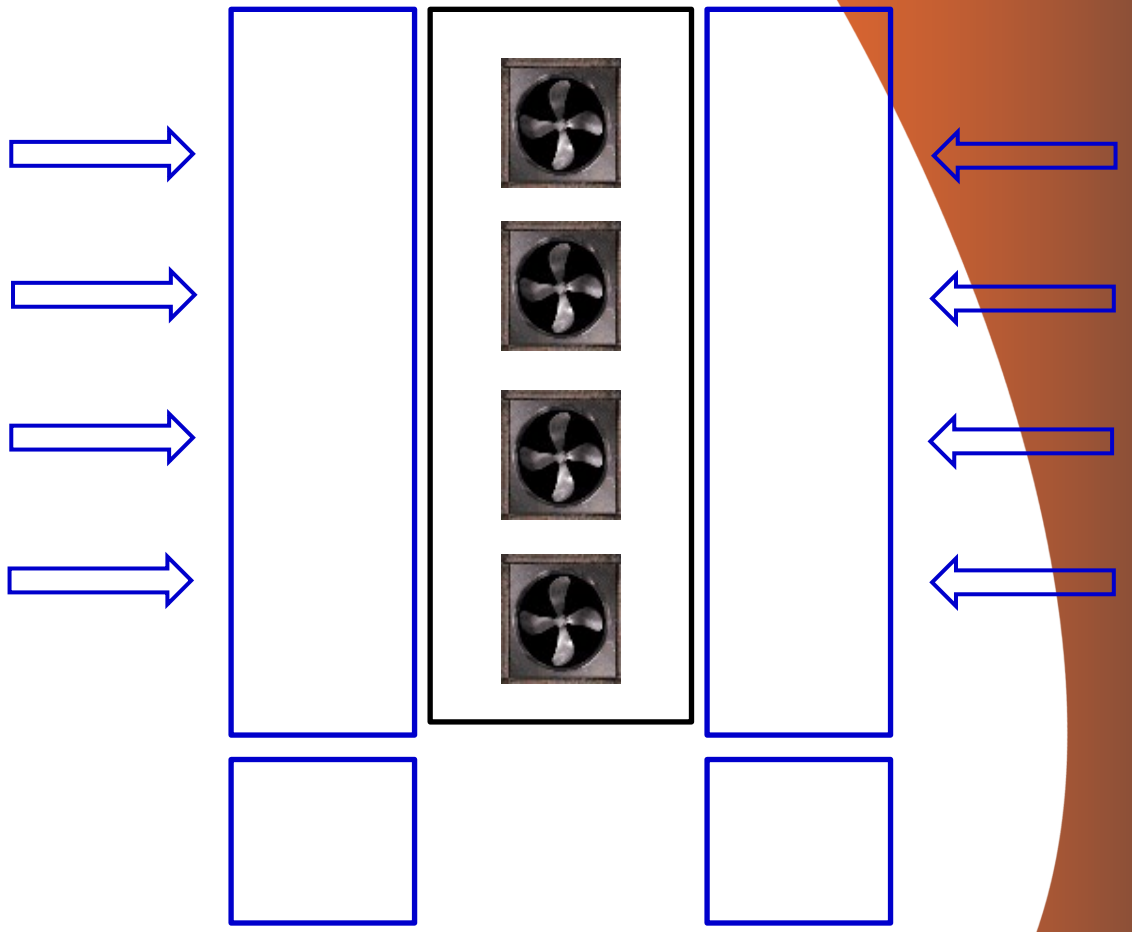
Industry policies and procedures

- Industry very pro-active
- Many policies, procedures and strategies in place to address hot or cold weather conditions
- e.g. reduced stocking density in hot weather (fewer birds per container)
- e.g. protecting birds from wet (rain ingress) and reducing impact of air movement over birds in cold weather

On-farm cooling pre-transport

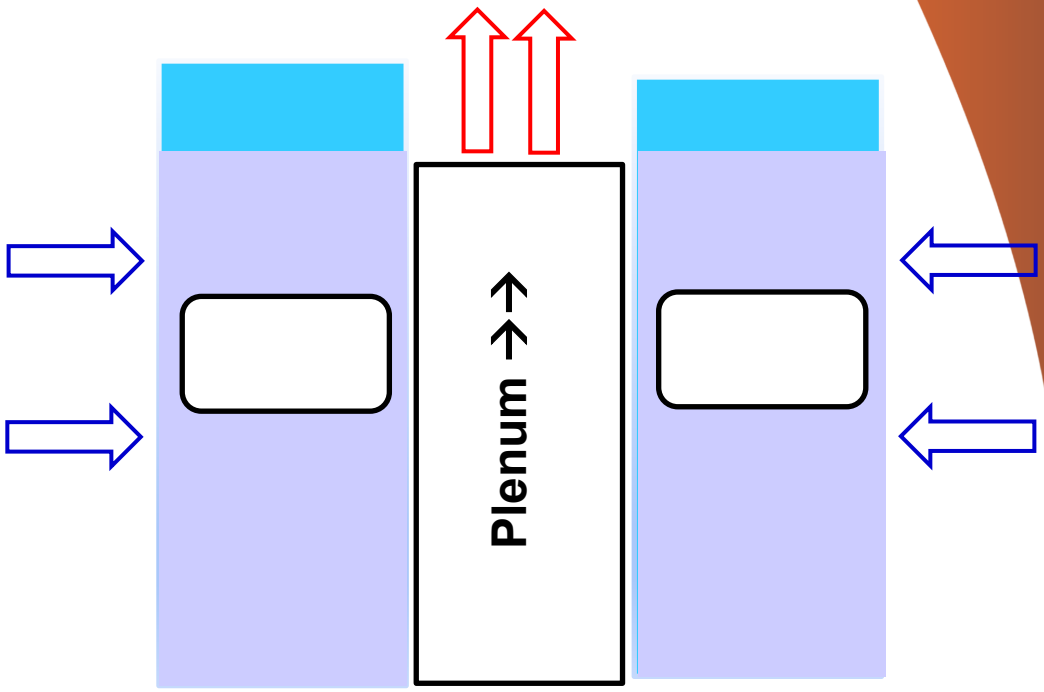
Ventilation bays at factory

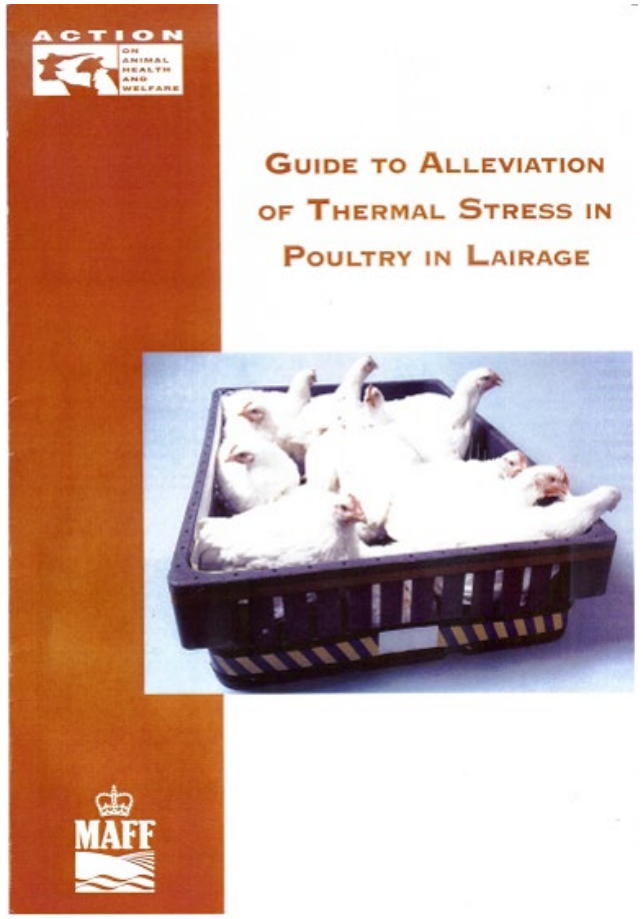
Ventilation bays at factory



Ventilation bays at factory

Drawing air across load – removing both heat AND moisture from load





- Remember to consider the whole transport procedure
- EC 1/2005 covers transport “and related operations”
- Easy to “undo” all the good work done by poor lairage conditions

Final points

- Commercial transport of poultry generates a large amount of heat and moisture (BOTH important) - potentially beneficial in cold weather but detrimental in hot weather
- Duration of exposure to thermal challenge affects “outcome” on birds
- Control of the thermal environment on vehicles would be beneficial especially in hot weather and on longer journeys
- Infrequent number of incidents where high mortality due to thermal conditions BUT such occasions can potentially involve large numbers of birds

Final points

- Air conditioning would ensure uniform thermal conditions amongst birds during transport but
- heat load of 100kW (from birds)
- “typical fridge unit” can cope with about 25kW (and goods transported are not generating heat)
- payload “penalty” if “fridge unit” of sufficient capacity were available
- additional operating and maintenance costs

- Global warming may dictate that some form of control may be required in the future on some journeys?
- Not necessarily air conditioning – improved ventilation?

Thank you for your attention