Guide to the ventilation of livestock during transport

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Within the UK, DEFRA (Department for Environment, Food and Rural Affairs) have funded research into improving the welfare of farmed animals during road transport. The accompanying article(s) summarise some of the findings from this research, in particular the importance of understanding vehicle ventilation and how inadequate ventilation can promote thermal stress in livestock during transport.

[Note: For the purpose of this guide "transport" is defined as the entire transit period from the time the first animal is loaded until the last animal is unloaded.]

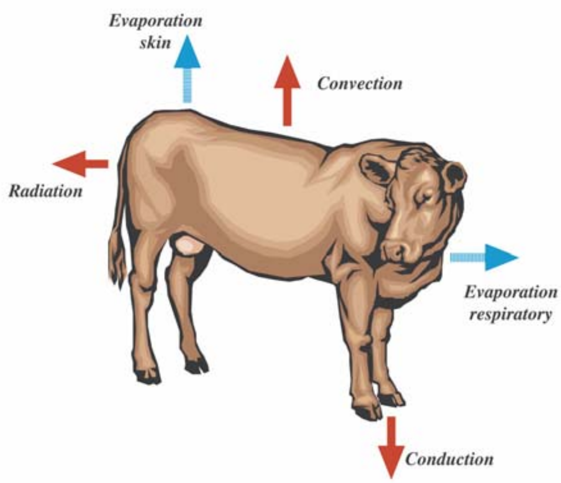
Ventilation of vehicles

Air movement amongst the animals is essential to remove (a) heat and moisture generated by the animals and (b) airborne pollutants (dust and gases).

The transport of animals can be a stressful procedure and, aside from the effects of loading and unloading, the major stressor during transport is the thermal micro-environment within the livestock container. Other stressors may compromise the welfare of the animals, and therefore their productivity and product quality, but the thermal effects can, under extremes, result in mortality during transport.

Heat exchange between animals and their environment

Animals produce heat from their metabolism and this heat can be lost to the environment by several routes.



The avenues of heat exchange are:

Convection - transfer by flow of air

Radiation - transfer by emission of heat

Conduction - transmission by contact with another surface

Evaporation - transfer by evaporation of water e.g. by panting or sweating

Convective, radiative and conductive transfer are “dry” and depend on the temperature gradient between the animal and its surroundings, e.g. the air and the ground or floor. They are grouped together and called “sensible heat loss”.

Evaporative transfer depends upon the gradient of water vapour between the evaporating surfaces of the animal and its surroundings, i.e. the humidity. It is known as “insensible heat loss”.

If the animal is in hot conditions then sensible heat loss will be reduced and body temperature will tend to rise. The animal will come to depend more upon evaporative cooling to maintain body temperature and will start to pant or sweat.

If, however, humidity increases, this will impair the effectiveness of the insensible heat loss (evaporation) and the animal will be less able to control its body temperature.

During animal transportation, the large numbers of animals carried will be producing large amounts of both heat and water inside the vehicle. In warm conditions they will produce even more water by panting or sweating.

The net effect is the creation of a hot, humid transport micro-environment (in close proximity to the animals) which will be harmful to the animals.

*** High temperatures combined with high humidities will cause severe heat stress in transported livestock.**

*** It is essential to control both the “on-board” temperature AND humidity.**

- **The ventilation system of the vehicle must be able to dissipate both the heat and moisture loads.**

Thermal stress in transit

Livestock are homeotherms, that is they maintain a constant deep body temperature. They exhibit many thermoregulatory responses to control both heat loss and heat production.

When:

Total heat loss = Heat production

then body temperature is kept constant.

Normal body temperatures in livestock are:

Species	Body temperature	
	°C	°F
Cattle	38.7	101.7
Calves	38.6 – 39.3	101.5 – 102.7
Pigs	39.2	102 – 103
Sheep	39.4	103 – 104

If the transport thermal micro-environment is unfavourable then heat loss will be increased or decreased beyond the capacity of the thermoregulatory systems and body temperature will change.

*** If deep body temperature falls the animals are HYPOthermic.**

*** If deep body temperature rises the animals are HYPERthermic.**

Cold stress and heat stress will compromise the welfare of transported livestock, may affect product quality of those animals in transit to slaughter and extreme hypothermia or hyperthermia will result in death.

*** Animals will generally tolerate a greater fall in body temperature than a rise.**

A hyperthermia of 5°C will almost always be fatal whereas hypothermia of 7-8°C, whilst undesirable, may often be followed by complete recovery.

Cold stress and hypothermia Will cause	**Heat stress and hyperthermia will cause**
Increased use of energy substrates	Dehydration
Depletion of glycogen reserves	Increased use of energy substrates
Muscle damage	Depletion of glycogen reserves
Altered meat quality	Altered acid-base status
Poor bleed-out and processing	Muscle damage
Fatigue and lethargy	Altered meat quality
Death	Death

It is important to control the transport thermal micro-environment within those limits which impose the least thermal stress upon the animals. If weather conditions suggest that there is a risk of heat stress or cold stress it is essential to inspect the animals regularly during the journey and to recognise the signs of thermal stress.

Signs of Cold stress	**Signs of heat stress**
Shivering	Panting and/or sweating
Ptiloerection – raising of fur coat	Postural changes (increasing heat loss)
Huddling	Agitation, restlessness and "fear"
Postural changes (reducing heat loss)	Salivation
Lassitude, lethargy and drowsiness	Exhaustion
Collapse	Collapse

*** Reduce the risk of heat and cold stress by controlling the environment.**

*** Inspect the animals regularly and recognise the signs of thermal stress.**

*** Where possible use rectal temperature to determine if thermal stress is present.**

Natural ventilation of livestock transport vehicles

The vast majority of livestock transport vehicles are naturally ventilated, which means that they rely upon natural sources of air movement to provide ventilation for the animals. In practice, this air movement can arise from:

wind passing through the vehicle,
external pressure changes produced on a moving vehicle, and
convective air flow from the heat of the animals (a relatively small factor).

On most occasions, it is the fact that the vehicle is moving that produces the greatest air movement within the livestock container.

Air movement occurs when there is a difference in pressure, air moving from regions of relatively high pressure to regions of relatively low pressure. If there is no pressure difference then there will be no air movement.

Understanding how air moves through the container requires an understanding of the external pressure field around the moving vehicle. The fundamental principles are irrespective of the size of the vehicle and apply equally to large articulated trailers and small agricultural trailers.

A typical livestock transporter has a solid headboard and standard side grille vents. As the vehicle travels down the road, air passing over the front edge of the container separates from the vehicle creating a region of low pressure (suction). The air flow re-attaches along the length of the vehicle and by the rear grilles, although there is still a region of suction, the magnitude of that suction is much less than at the front grilles.

*** The net effect of this pressure field is that air tends to enter at the rear grilles, move forward within the container over the animals and leave through the front grilles.**

It should also be noted that any holes drilled through the front headboard will allow air to enter the container but this air stream will tend to be drawn out through the front grilles. It will not travel through the length of the vehicle and may therefore reduce ventilation efficiency.

When the vehicle is stationary the external pressure field associated with vehicle movement disappears and internal air flows are driven primarily by the prevailing wind. As there is little control over the air flow through the container, on windy days the prevailing wind direction will dominate the air flow pattern. On occasions when there are strong cross winds the resultant air flow will be across the vehicle.

*** Parking vehicles at right angles to the wind direction can be used to allow air flow amongst the animals during hot weather.**

Control of natural ventilation on the moving vehicle is achieved by opening and closing ventilation apertures as is perceived appropriate by the driver. As adjustment requires the vehicle to stop, it is often the case that the ventilation regime for the whole journey is set at departure.

Forced ventilation of livestock transport vehicles

Forced ventilation means that fans are used to provide air movement within the transport container. It is not sufficient simply to attach fans indiscriminately to a vehicle and expect them (a) to operate effectively, or (b) provide appropriate ventilation for all the animals throughout the whole transit period.

The success of mechanical ventilation systems depends upon:

Understanding the requirements of the animals and the consequences of inadequate or excessive ventilation on the welfare of the animals.

Ensuring that the airflow passes over all the animals.

Having defined inlets and outlets at specific locations on the vehicle.

Providing sufficient ventilation for all the animals throughout the entire transport period.

Controlling the ventilation rate to maintain stable and acceptable thermal conditions around all the animals.

Adjusting the ventilation to changes in ambient conditions.

Optimising the system design and operation to reduce running costs.

Two approaches can be used, either forcing air into, or extracting air from the livestock container.

If the requirement is to force air into the vehicle then this is better accomplished using ducted air that avoids having excessive air movement over animals close to the fans. However ducted systems introduce greater pressure losses and therefore require more power than comparable non-ducted systems.

Extracting air from the vehicle, which is the preferred approach, is more efficient if fans are mounted in regions of low external pressure. This enhances their performance when the vehicle is moving.

Typical values of heat and moisture production by animals during transport

Using the data derived from this research it is possible to predict the typical levels of heat and moisture production by animals during transport.

It is important to recognise that though heat production is independent of time, water production is time dependent. To determine the total water production during a given journey the rate of water production must be multiplied by the duration of the journey.

Heat and moisture production of animals during transport				
		Pigs	Sheep	Calves
Liveweight	kg	100	45	70
Heat production	W/kg	2.0	1.5	2.5
	W/tonne	2000	1500	2500
	tonne/deck	8	4	5
	kW/deck	16	6	12.5
Moisture production	g/kg/hr	1.2	0.8	1.0
	kg/tonne/hr	1.2	0.8	1.0
	tonne/deck	8	4	5
	kg/deck/hr	9.6	3.2	5.0
4 hour journey	kg/deck	38.4	12.8	20.0
8 hour journey	kg/deck	76.8	25.6	40.0

To express this is practical terms, for an 8 hour journey transporting pigs, on each deck of the vehicle the heat production is equivalent to having 16 electric fires and the total water production on that journey is equivalent to 8 buckets of water.

Summary of main points

* Air movement amongst the animals is essential to remove (a) heat and moisture generated by the animals and (b) airborne pollutants (dust and gases).

* Avenues of heat exchange for the animals are:
  Convection - transfer by flow of air
  Radiation - transfer by emission of heat
  Conduction - transmission by contact with another surface
  Evaporation - transfer by evaporation of water e.g. by panting or sweating.

* High temperatures combined with high humidities will cause severe heat stress in transported livestock.

* It is essential to control both the “on-board” temperature **AND** humidity.

* The ventilation system of the vehicle must be able to dissipate both the heat and moisture loads.

* If deep body temperature falls the animals may become **HYPO**thermic.

* If deep body temperature rises the animals may become **HYPER**thermic.

* Animals will generally tolerate a greater fall than rise in body temperature.

* Reduce the risk of heat and cold stress by controlling the environment on the vehicle.

* Inspect the animals regularly and recognise the signs of thermal stress.

* Where possible use rectal temperature to determine if thermal stress is present.

* On a moving vehicle, the external pressure field generated by the vehicle movement promotes air to enter at the rear grilles, move forward within the container over the animals and leave through the front grilles.

* The net effect is that air within the container is moving in the **same direction** as the vehicle.

* Parking vehicles at right angles to the wind direction can be used to allow air flow amongst the animals during hot weather.

* The success of any mechanical ventilation systems depends upon:

  Understanding the requirements of the animals and the consequences of inadequate or excessive ventilation on the welfare of the animals.

  Ensuring that the airflow passes over all the animals.

Having defined inlets and outlets at specific locations on the vehicle.

Providing sufficient ventilation for all the animals throughout the entire transport period.

Controlling the ventilation rate to maintain stable and acceptable thermal conditions around all the animals.

Adjusting the ventilation to changes in ambient conditions.

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