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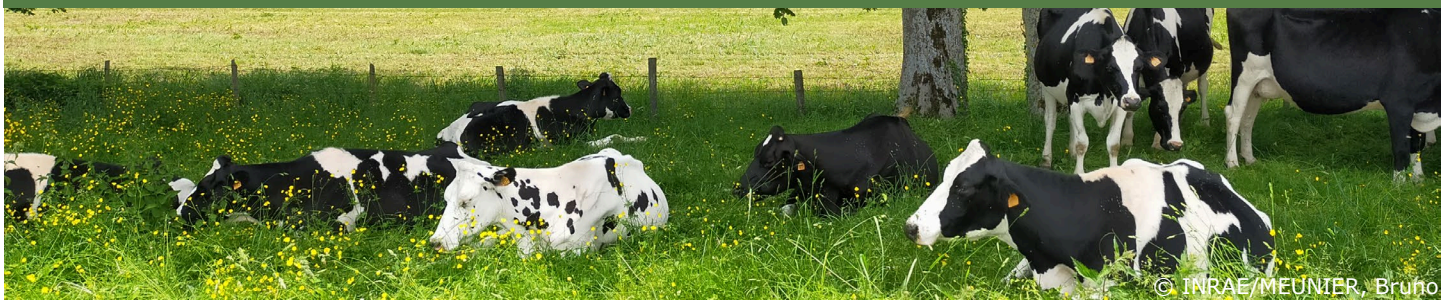
Thermal comfort in ruminants and equines



Introduction

In all EU countries, ruminants and equines can be exposed to weather conditions that affect their thermal comfort. Thermal comfort, and especially heat stress, is a growing issue in most EU countries due to climate change that has led to increased average temperatures as well as more frequent and prolonged heat waves.

Ruminants and equines are homeotherms, meaning they can maintain a stable body temperature despite changes in ambient conditions within a certain range. This is achieved through thermoregulatory mechanisms. Ruminants and equines generate internal heat during e.g. digestion or physical activity. Thermoregulation is also achieved in ruminants and equines through behavioural adaptations, such as seeking shade or huddling together.

Heat exchange between an animal and its environment occurs through radiation, conduction, or convection. Radiation corresponds to heat transfer by electromagnetic waves (e.g. solar radiation). Conduction refers to heat transfer from more to less energetic particles through direct contact (e.g. skin to environment). This process is important during evaporation, whereby liquid water is converted into vapour. The energy required for evaporation is conductively transferred from the animal to water, resulting in a cooling effect. Convection is the transfer of heat through the bulk movement of a fluid (e.g. air or water), which can further support conductive heat loss.

Thermal comfort therefore depends on the temperature of the ambient air, but also on its humidity, velocity (wind), and on solar radiation. Indices that combine these parameters are commonly used to determine whether animals are at risk of heat or cold stress. The most commonly used climatic index is the temperature-humidity index (**THI**), which combines air temperature and humidity. Nevertheless, for practical reasons, temperature is commonly used to describe the thermal conditions.

Legal requirements

Council directive 98/58/EC concerning the protection of animals kept for farming purposes states that:

> 'Air circulation, dust levels, temperature, relative air humidity and gas concentrations must be kept within limits which are not harmful to the animals.'
> (Annex, Paragraph 10.)
> 'Animals not kept in buildings shall where necessary and possible be given protection from adverse weather conditions […]'
> (Annex, Paragraph 12.)

EC Regulation 1/2005 on the protection of animals during transport states that:

> 'Means of transport, containers and their fittings shall be designed, constructed, maintained and operated so as to: […] b) protect the animals from inclement weather, extreme temperatures and adverse changes in climatic conditions […]'
> (Annex 1, Chapter II, Paragraph 1.1.)

Additional information

For more detailed information, see the review ***'Thermal comfort in ruminants and equines'.***

Further details on recommendations for inspection are provided in ***Indicator factsheet 'Thermal comfort'***.

Adaptation of animals to thermal conditions

Animals are adapted to a certain range of thermal conditions. The thermal comfort zone (**TCZ**) corresponds to the animal's preferred thermal environment, where no specific mechanisms are required to maintain its core body temperature. The thermoneutral zone (**TNZ**) is wider than the TCZ and corresponds to the temperature range in which the core body temperature is maintained with little effort (e.g. vasoconstriction in the case of a cold temperature) (see ***Indicator factsheet 'Thermal comfort'*** for details on TCZ and TNZ in ruminants and equines). Temperatures outside the TNZ induce more important thermoregulatory mechanisms, behavioural and physiological changes, that require energy from the animal to maintain its core body temperature (Table 1). These changes are more or less pronounced depending on the severity of the conditions. When these mechanisms are insufficient to maintain body temperature, hypothermia or hyperthermia may occur, and this situation can even lead to death when thermal conditions are out of the survival zone (Figure 1). TCZ and TNZ differ between species, as well as within species according to factors such as breed, age, production stage, body condition, vigour and adaptation capacities.

Table 1: Physiological and behavioural responses of animals to cold and heat. "-" indicates that there is no change from normal

Animal-based indicators	Response to cold	Response to heat
Heart rate	⇩	⇧
Respiration rate	⇩	⇧ (panting, open-mouth breathing)
Peripheral blood flow	Vasoconstriction	Vasodilation
Muscles contraction	Shivering	-
Sweating	-	⇧
Feed intake	⇧	⇩
Water intake	-	⇧
Time spent standing	⇩	⇧
Voluntary exposure to solar radiation	⇧	⇩
Other behaviour	Gathering in groups, shelter seeking, changing position to streamline with wind	Reduced activity, seeking shade
Milk production, fertility and growth	-[1]	⇩

[1]Negative effects restricted to severe cold-stress conditions.

Although thermal zones are usually described in terms of temperature, for some species, these limits are also described

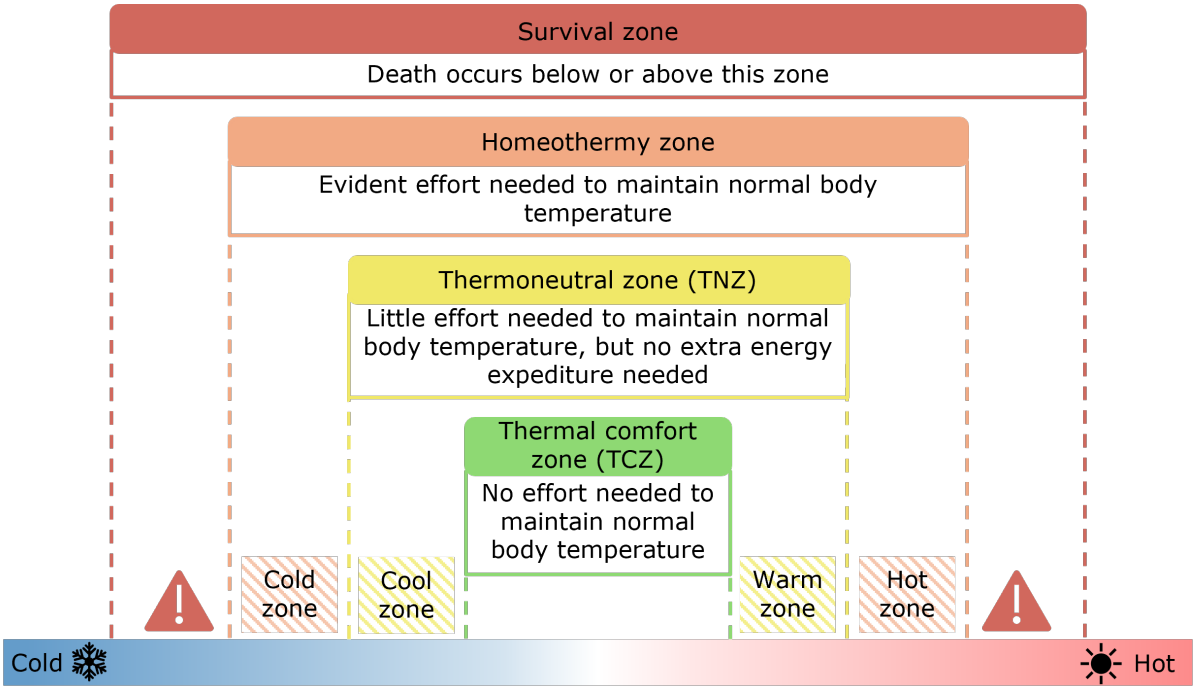


Figure 1: Thermal zones according to environmental temperature.

using the temperature-humidity index (THI), particularly in relation to heat stress. The THI can be calculated using dry

bulb temperature (T_{db}, temperature of air measured by a thermometer shielded from radiation) and relative humidity (RH, amount of water vapour present in air, expressed as a percentage of the amount required for saturation at the same temperature and pressure) as follows (National Research Council, 1971):

$THI = 1.8T_{db} + 32 - (0.55–0.0055RH) \times (1.8T_{db} - 26)$

For example, an air temperature of 25 °C and a relative humidity of 50% gives a THI of 72. THI above 72 induces heat stress in dairy cows.

Recommendations to ensure thermal comfort

The ideal would be to maintain animals within their TCZ or at least within their TNZ. Where necessary, mitigation strategies should be taken to reduce the difference between ambient conditions and the TNZ (Table 2). In case of cold conditions, mitigation strategies include increasing heat production by the animals (mainly through feeding), limiting heat loss (e.g. with shelters) and providing additional external heat sources (e.g. with radiant lamps). In case of hot conditions, mitigation strategies include limiting the production of metabolic heat by the animals (through feeding modifications and avoidance of exercise), limiting solar radiation (e.g. with shade, Figure 2b), increasing heat loss through conduction (e.g. evaporation of water sprinkled on the animal's body) and accelerating convection (e.g. with fans). Moreover, misters are less effective than sprinklers because water does not penetrate the hair coat while increasing the humidity of the air, which in turn increases THI.

Table 2: Mitigation strategies against cold and heat

	Mitigation strategies against cold	Mitigation strategies against heat
Feeding	Large amounts of good quality roughage in diet	Lowering fibre content of diet (in cattle)
Watering	Warm drinking water	Large amount of cool or cold drinking water
Housing	Animals in group (possibility to gather)	Large space allowance per animal (to allow spacing behaviour)
	Shelter, protection against wind (e.g. hedges at pasture)	Protection against radiation: - shade (Figure 2b)
	Jackets (for horses or calves, Figure 2a)	- cool roofs (e.g. white roof) - hutches, paddocks and pastures exposed north to east
	Deep dry bedding	Dry litter or ground
	For young animals: radiant lamps	Fans, sprinklers, misters
Management		Avoidance of physical exercise (handling, moving, transport, work)

Figure 2: a) Horses with jackets to limit heat loss in case of cold conditions; b) Sheep in shade to limit solar radiation at pasture in case of hot conditions

Legal requirements

The legal requirements referred to are based on EU legislation. National regulations in EU Member States may apply stricter requirements.

Council directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes

'Air circulation, dust levels, temperature, relative air humidity and gas concentrations must be kept within limits which are not harmful to the animals.'

(Annex, Buildings and accommodation, Paragraph 10.)

'Animals not kept in buildings shall where necessary and possible be given protection from adverse weather conditions …'

(Annex, Animals not kept in buildings, Paragraph 12.)

Council directive 2008/119/EC of 18 December 2008 laying down minimum standards for the protection of calves

'Insulation, heating and ventilation of the building must ensure that the air circulation, dust level, temperature, relative air humidity and gas concentrations are kept within limits which are not harmful to the calves.'

(Annex 1, Paragraph 3.)

Council regulation (EC) No 1/2005 of 22 December 2004 on the protection of animals during transport and related operations

'Means of transport, containers and their fittings shall be designed, constructed, maintained and operated so as to:

(…)

(b) protect the animals from inclement weather, extreme temperatures and adverse changes in climatic conditions'

(Annex I, Chapter II, Paragraph 1.1.)

'Animals shall be transported only in conditions where air quality, temperature and pressure can be maintained within an appropriate range during the entire journey, having regard to the species of animals.'

(Chapter II, Paragraph 4.2.)

'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.'

(Chapter VI, Paragraph 3.1.)

'Means of transport by road must be fitted with a temperature monitoring system as well as with a means of recording such data. Sensors must be located in the parts of the lorry which, depending on its design characteristics, are most likely to experience the worst climatic conditions. Temperature recordings obtained in such manner shall be dated and made available to the competent authority upon request.'

(Chapter VI, Paragraph 3.3.)

'Means of transport by road must be fitted with a warning system in order to alert the driver when the temperature in the compartments where animals are located reaches the maximum or the minimum limit.'

(Chapter VI, Paragraph 3.4.)

References

Karatzia, M.A., Vecchio, D., Sossidou, E. & Veissier, I. (2025). *Review - Thermal comfort in ruminants and equines*. EURCAW *Ruminants & Equines*. https://doi.org/10.5281/zenodo.15227873