Opinion of the Scientific Panel on Animal Health and Welfare on a request from the Commission related to Standards for the microclimate inside animal road transport vehicles [1]

(Question N° EFSA-Q-2003-085)

Adopted on the 20th October 2004

SUMMARY

The EFSA Scientific Panel on Animal Health and Welfare was asked by the Commission to report on the standards for the micro-climate inside animal transport vehicles. Micro-climate on transporters is composed of factors such as temperature and humidity of the air, air velocity, air quality, ventilation and insulation of the surrounding walls, floor, and roof, and can significantly influence welfare and health of the transported animals if not in an appropriate range. Particularly, overheating in summer and too low temperatures in winter can lead to deaths and suffering of the animals from heat or cold stress.

The environmental temperature experienced by the animal depends on interactions within and between environment and animal related parameters. In addition, large regional differences in climate exist in Europe. Conditions which do not cause poor welfare in animals in Northern countries might not be acceptable in Southern countries. Therefore it is necessary to give a sufficiently broad margin of thresholds for temperature and humidity to make the regulation flexible and practicable.

Another problem is that it is very difficult for those responsible of animal transport to quantify the environment on a transport vehicle with living cargo. Therefore, minimal and maximal temperatures were previously fixed to avoid high risk of losses. These are still the target temperatures for the animals, but they may be difficult to implement in specific field conditions. It is however accepted in the literature that some deviations, as defined in the current scientific opinion, may not result in poor welfare; but the unknown factor is to what extent an animal's adaptation capacity is reduced by handling and transport. It is then difficult to set limits for the duration of any deviation. Some animals may cope easily with the limits defined, while others may suffer, especially depending on journey duration. Hence, journey duration and animal response should be well documented to allow a scientifically based provision of good animal welfare during transport.

The requirements for temperature and ventilation set out in the scientific report adopted by SCAHAW in 1999 on "Standards for the micro-climate inside animal road transport vehicles" (SCAHAW, 1999) remain in general valid in the light of the present scientific knowledge, which is still at a very similar low level with significant gaps as four years ago. However, progress has been made in the understanding of the efficiency of different ventilation systems on transport vehicles such as free ventilation by shutters, sensor controlled side and front vents, and forced ventilation. Taking into account that regional

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and climatic differences exist and different technological standards apply to the vehicle body in Europe, the present temperature regulation should allow for more flexibility according to the technical equipment of the lorry - such as forced ventilation, misting in summer for cooling purposes, and heating the incoming air in cold condition - until more scientific data are available to establish heat balance models for the different species transported including temperature, relative humidity, air velocity, ventilation rate and air quality. It is important that the climatic condition (temperature, relative humidity, air velocity, heating, misting) inside the trucks can be controlled by the person responsible for the transport. This person must have proper technical training.

As previously explained, the temperature limits will depend on many physiological variables (including adaptation), physical parameters (e.g. air velocity) and operational procedures (e.g. stocking density). In spite of the fact that some of the temperature limits need additional explanation and/or allowance for other physical parameters, it seems possible to draw some conclusions and give recommendations both for actual measures and for future activities.

There is an urgent need for more detailed practical research on micro-climate in transport vehicles in order to develop realistic ventilation models for the different animal species in different climatic zones in Europe based on standardised instrumentation and measuring protocols.

Key words : animal welfare, transport, micro-climate, ventilation models.

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ASSESSMENT

1. GLOSSARY

C: degrees Celsius

CIGR: Commission Internationale du Genie Rural (International Commision of Agricultural Engineering)

CK: Creatine Kinase

EC: European Community

EET: Effective environmental temperature

EFSA AHAW Panel: EFSA Animal Health and Welfare Panel

EFSA: European Food Safety Authority

EU: European Union

HR: Heart Rate

h: hours

LCT: Lower Critical Temperature

Max.: Maximum

m: Meters

Min.: Minimum

Pers. comm.: Personnal communication

RH: Relative Humidity

s: seconds

SCAHAW: Scientific Committee on Animal Health and Animal Welfare

Temp.: Temperature

TCZ: Thermal comfort zone

THI: Temperature Humidity Index

TNZ: Thermo-neutral zone

UCT: Upper critical Temperature

2. Background

Council Directive 91/628/EEC (EC, 1991) amended by Directive 95/29/EC (EC, 1995) is the current Community legislative framework on the protection of animals during transport. Council Regulation 411/98/EC (EC, 1998) lays down additional animal protection standards applicable to road vehicles used for the carriage of livestock on journeys exceeding 8 h.

On the 16th of July 2003, the Commission adopted a proposal for a Council Regulation on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC (EC, 2003). The proposal includes requirements for ventilation systems and temperature and humidity monitoring systems for vehicles transporting animals on long distance journeys. It states that ventilation systems on such vehicles shall be capable of maintaining the temperature, adjusted for humidity, between the maximum and minimum temperatures outlined in the proposal. The minimum airflow capacity of the vehicle ventilation systems is also specified.

The requirements for temperatures and ventilation during transport were formulated taking into account a scientific opinion adopted by the Scientific Committee on Animal Health and Animal Welfare (SCAHAW) in 1999 on “Standards for the microclimate inside animal road transport vehicles” (SCAHAW, 1999). This scientific opinion defines minimum and maximum temperatures within animal transport vehicles and also considers the influence of humidity on these limits. During the discussion of the proposal in the Commission meeting, the College of Commissioners insisted upon further consulting the European Food Safety Authority (EFSA) in relation to the microclimate (temperature and ventilation) inside the vehicles during the transport of animals. Furthermore the opportunity to obtain this information within the shortest possible delay was agreed.

As a consequence, the Commission asked EFSA to issue a scientific opinion on whether the precise requirements for temperature and ventilation during transport described in SCAHAW’s 1999 opinion remain valid in the light of more recent scientific data. As stated by the Commission, this EFSA scientific opinion will be taken into consideration in the ongoing legislative procedure.

3. Terms of reference

In view of the above, the Commission asked the AHAW Panel (Animal Health and Welfare) of EFSA:

1) To issue a scientific opinion on whether the precise requirements for temperature and ventilation set out in a scientific opinion adopted by the Scientific Committee on Animal Health and Animal Welfare in 1999 on “Standards for the microclimate inside animal road transport vehicles” (SCAHAW, 1999) remain valid in the light of more recent scientific data.

2) This EFSA scientific opinion should consider in particular:

    a. the minimum and maximum temperatures on animal transport vehicles,

    b. their adjustment taking account of the influence of humidity, and

    c. the ventilation needed to maintain these temperatures.

4. SCOPE OF THE OPINION

The objectives of this opinion are :

1) to deliver additional scientific data to the report on "Standards for the microclimate inside animal road transport vehicles" of 1999 (SCAHAW, 1999),
2) to provide definitions of some frequently used terms in this field,
3) to point out gaps of knowledge which still exist on microclimate in animal transport vehicles.

Where necessary, reference is also made to scientific literature of before 1999.

5. DEFINITION OF THE THERMAL ZONES OF FARM ANIMALS IN TRANSPORT VEHICLES

5.1. Main definitions

There is a bulk of literature defining various thermal zones, thermoregulation and adaptation processes for animals. Because of the intensive and controversial discussions on these terms, definitions of the most frequently used terms are given to facilitate the understanding of the complex animal/environment relationship. During transport several of the mechanisms explained below may occur to various degrees and intensities.

As terrestrial farm animals are homeothermic, they are, within certain limits, able to maintain a relatively constant deep body temperature, different from the environmental temperature. A relatively constant deep body temperature means that heat production and heat loss are equal. An increased difference between deep body temperature and environmental temperature leads to higher heat losses to be compensated by a higher heat production. Body temperature will increase when heat loss is not sufficient (heat stress). Heat may be dissipated through conduction, convection, radiation and evaporation. Figure 1 presents a basic scheme of body core temperature control (Yousef, 1985). The heat production of the animal is minimum within the thermoneutral zone. The body core temperature is kept constant in the zone of homeothermia, but for temperatures lower or higher than the thermoneutral zone, the heat production of the animal increases or decreases. When the loss of heat is higher than the heat production, it causes hypothermia and eventually death. On the opposite, when the loss of heat is lower than heat production, e.g. by too high ambient temperature and humidity, it causes hyperthermia. The animal will die when body temperature continues to stay too low or too high.

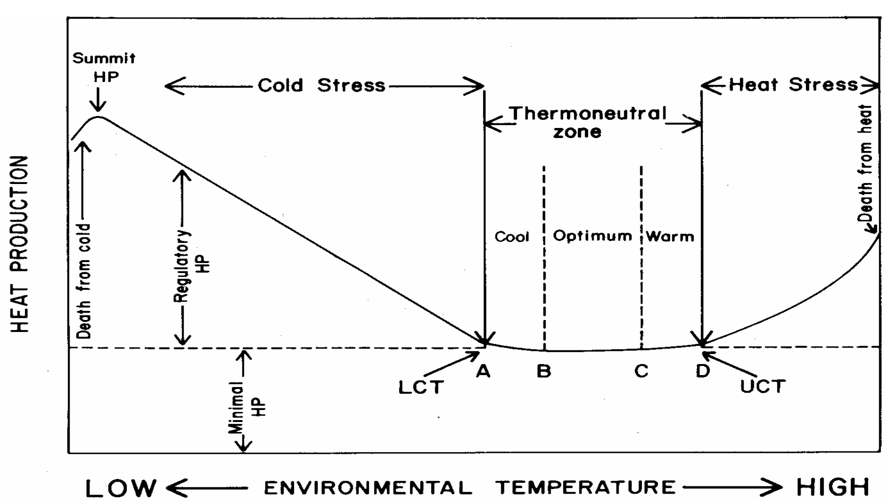

Figure 1: Scheme of the thermoneutral zone of animals (Yousef, 1985). LCT: Lower critical temperature, UCT: Upper critical temperature.

5.1.1. Micro-climate

The term micro-climate is used in a specific way to mean the sum of all physical, chemical and biological factors of the air inside buildings (Hilliger, 1990) or vehicles. It is influenced by ventilation and insulation of the surrounding walls, floor, and roof. The most important components of the micro-climate in vehicles are temperature and relative humidity of the air, air velocity, and air quality (gaseous and viable and non-viable particulate pollutants). They can significantly influence well-being and health of the transported animals. High concentrations of ammonia, dust, and bacteria, can damage the respiratory tract of the animals, enhance the development of respiratory disorders, and supports transmission of infectious agents (Wathes, 1994, and Hartung, 1994). There is little information on the micro-climate in animal transport vehicles (Honkavaara, 2003a, and Wikner *et al.,* 2003).

5.1.2. Effective environmental temperature (EET)

The EET theoretically expresses the total effect of a particular environment on an animal's heat balance. It is the temperature experienced (thermal environment) by an animal, being a combined effect of dry air temperature, air humidity (measured as wet bulb or expressed as RH (relative humidity)), air velocity, radiative and may be conductive heat loss. For example, the effect of a higher ambient temperature or a higher relative humidity of the ambient air on the animal can be compensated for by a higher air velocity that maintains the same or equivalent effective temperature (Curtis, 1983).

5.1.3. Thermo-neutral zone (TNZ)

Within the thermoneutral zone, metabolic heat production and energy expenditure are minimal, most productive processes are at their most efficient level, and an animal is thermally comfortable without the need to change heat production (Ewing *et al.*, 1999). The zone is limited by the lower critical temperature (LCT) and the upper critical temperature (UCT). Within the zone, the regulation of body temperature is physical (e.g. by adjustment of insulation or behavioural), but below LCT and above UCT, there are energy costs of thermoregulation (Charles, 1994, and Richards, 1973).

5.1.4. Lower critical Temperature (LCT)

LCT is the point in effective ambient temperature below which an animal must increase its rate of metabolic heat production to maintain homeothermy. Processes related to conservation of heat, including vasoconstriction in the periphery, piloerection, and behavioural adjustments to reduce heat loss from body surfaces, are at their maximum at this temperature and below (Ewing *et al.*, 1999).

5.1.5. Upper critical Temperature (UCT)

There is no absolute definition of UCT (Webster, 1981 and McArthur, 1987). UTC is described as the point above which an animal must engage physiological mechanisms to stop the rise in body temperatures above normal. These processes are related to cooling by evaporation (through increased perspiration and respiration), and behavioural activities (such as wetting the skin and vasodilatation in the periphery), to enhance heat loss from body surfaces through convection, radiation, conduction and behaviour (Ewing *et al.*, 1999). UCT can also be defined by an increase of evaporative heat loss (CIGR, 2002).

5.1.6. Thermal comfort zone (TCZ)

The range of EET where an animal has thermal comfort (*i.e.* keeping deep body temperature constant is within the broader homeothermic zone) with the least effort through behavioural and physical thermoregulation by changing exposed body surface, tissue insulation (sensible heat loss) and latent (evaporative) heat loss without panting. The respiration rate may vary according to age, weight, activity, resting, feeding which makes it difficult to define what a “normal” respiration frequency is.

5.1.7. Homeothermic zone

That range of EET where an animal is able to keep deep body temperature by all available means at the normal level, which includes normal variability depending on species, age, physiological state, etc.

5.1.8. Survival zone

That range of EET where an animal is able to survive despite being hypo- or hyperthermic.

5.1.9. Thermoregulation

Actions undertaken by an animal to meet its thermal needs, *i.e.* keeping body temperature constant (hypo- and hyperthermia also includes thermoregulation), forced by the physical conditions in the thermal environment (*i.e.* the EET), and influenced by the emotional perception of the surroundings. Consequently, animal temperature regulation starts with change of sensible and latent heat loss (e.g. through the skin) and - if necessary - due to higher environmental temperature more of the total heat must be lost as latent. When ambient temperatures exceed deep body temperatures, all heat must be dissipated as latent. For example, this enables cattle to survive to temperatures higher than 40 °C, if the relative humidity is about 60 % (Mount, 1968, and 1974).

5.1.10. Adaptation

It is nearly impossible for an animal to be continuously in balance or in harmony with its environment. At some point the animal may react or make adjustments to the environmental stimuli (Lindley and Whitacker, 1996). Such an environmental adaptation refers to any functional, structural, or behavioural trait that favours an animal’s survival or reproduction in a given environment, e.g. changing of the reference temperature and/or band width of the regulation mechanisms in the hypothalamus for behavioural, physical and chemical thermoregulation (Curtis, 1983). The adaptation can be acclimation, acclimatisation or habituation.

a) Acclimation

Acclimation refers to an animal’s compensatory alterations due to a single stressor acting alone, usually in an experimental situation, over days or weeks. It is similar to conditioning (Mount, 1979).

b) Acclimatisation

Acclimatisation refers to reactions over days or weeks to environments where many environmental factors vary at the same time, e.g. seasonal variations. Acclimatisation to heat and cold may involve changes in thermoneutral heat production, coat depth and blood flow through the superficial tissues of the body. In extreme cases this has been shown to reduce the LCT of cattle by much as 20 C (Charles, 1994). Long term responses to thermal environment include adaptation of feed and water intake, change of metabolism, and fur or coat insulation.

c) Habituation

Habituation results when certain stimuli are repeated many times and the animal becomes “used” to it (behavioural adaptation) and the response to the stimulus decreases (Mount, 1979). Broom (1981) describes it as the waning of a response to a repeated stimulus. This is different from fatigue (Fraser and Broom, 1990).

5.2. Minimum and maximum temperatures, air velocity and ventilation rates on animal transport vehicles

The ranges of recommended and critical temperatures (LCT, UCT) for different types of animals given in the Report of 1999 on “Standards for the microclimate inside animal transport road vehicles” (SCAHAW, 1999) are still valid for housing and production. They can be useful as an orientation for transport conditions because the body temperature at which animals need to show thermoregulatory responses are basically the same for housing and transport conditions. However, during transport, animals are exposed to a large variety of unknown or unaccustomed factors (Broom, 2003) hence the animals may have more difficulties to cope with the thermal environment during transport, because of social stress and restricted possibilities to behave as in housing conditions. The most important interacting animal related factors are age, body weight, adaptation level, coping capacity, thermal insulation, body cover (structure, colour), sweating capacity, feeding level, production level, previous experience, health status, group size, stocking density, and social behaviour. Animals may be able to cope with extremes of temperatures for short periods but may be unable to cope for long periods. In such extreme conditions, their welfare would be poor if coping is difficult.

Results of recent transport experiments on pigs and cattle together with some earlier literature results are reported below in order to describe suitable ranges of temperatures for the animals and the interactions of temperature, air velocity, relative humidity of the air, and ventilation rate.

5.3. Pigs

There is still a lack of systematic and comprehensive measurements of the microclimate on pig transporters, but some very useful practical experiments were carried out in France, Sweden, Denmark, and Finland since 1999 which included measurements of temperature, air velocity, carbon dioxide (CO_2), humidity of the air, and calculated ventilation rates. No signs of thermal stress were observed in slaughter pigs on transport vehicles at air temperatures between 10 and 25 C (with an optimum at 18 to 20 C) in France (Chevillon *et al.,* 2002). The number of pigs which showed panting increased when the temperatures exceeded 25 C on a Swedish experimental transport vehicle (Sällvik *et al.*, 2004). He reported that an acceptable thermal environment was provided for the transport of 115 kg pigs at outside temperatures of 28 C when the vents in the roof of the lorry were open and the air flow was directed to the pigs. In Denmark, recommendation is given to spray water on the pigs when 25 C are exceeded in the vehicle to enhance the effect of forced ventilation. This can be operated automatically by a sensor controlled device or manually by the driver (Barton Gade and Christensen, 2003; Christensen, 2003, pers. comm.). Spraying for 5 minutes can reduce the body surface temperature of pigs e.g. by 3 to 4 C (Chevillon *et al.,* 1999, and 2004). Spraying of water on pigs is therefore preferably used to reduce the risk of overheating of pigs at loading, unloading, and in the lairage areas of slaughter houses.

This discussion shows that the air temperature is only one part of the thermal environment. It results from outdoor weather conditions and from the heat which is produced by the animals. To avoid overheating, air conditioners can be used to cool the incoming air. These instruments can increase costs. The other opportunity is to increase ventilation rate and remove excessive heat by an efficient ventilation system. When increasing the ventilation rate, heat, moisture and CO_2 are removed and the velocity of the air around the animals is increased. An air speed of 0.7 m/s which passes the skin of an animal can be equivalent to a cooling effect of 3.5 C (Chevillon *et al.*, 1999). The effective temperature felt by the pig is distinctly lower than the environmental air temperature. A general formula of the EET for all animals does not exist, but an example of the influence of the different environmental factors are given by Curtis (1983) for housed fattening pigs: as air speed increases progressively from nil to 0.2, 0.5, and 1.5 m/s, 4, 7, and 10 C, respectively, must be substracted from air temperature to account for higher convective flows and arrive at the first approximation of effective environmental temperature. As in this example no reference is made to air humidity, type of floor, bedding, and surface temperature, the real EET may differ significantly. Good performance was reached in summer with air speeds around 2 m/s when the vehicle is moving and all shutters are open, in fully fan controlled tiers sometimes the air flow reached 0.3 m/s only (Chevillon *et al.,* 2002). It would be useful to create a data base of all environmental factors on a pig transporter to be able to design a realistic model of the microclimate.

In practice, most important for the microclimate on a fully loaded vehicle is an efficient ventilation.

Chevillon *et al.* (2002) compared three types of ventilation on a three-tier vehicle during transports of slaughter pigs for 10 h under summer and winter conditions in France. The first tier was naturally ventilated using side openings with shutters which were automatically controlled by a temperature sensor to keep the air temperature around 22 C. The second tier was equipped with temperature controlled fans working to keep the temperature around 22 C. The third tier was the same as tier 1 but the shutters were fully open all the time of the 10 h transport. Behavioural (lying, sitting, standing), physiological (cortisol saliva) and climatic (temperature, humidity, air velocity) indicators, meat quality (pH) and ventilation rate (CO_2) were taken into account. Best results were observed in winter at outside temperatures around 10 C and relative humidities at about 82 % resulting in inside temperatures between 18 to 20 C in tiers 1 and 2. In tier 3 with fully open flaps the temperature was only little above the ambient temperature.

The concentration of CO_2 was highest in summer in tier 2 (1066 ppm), in the two other tiers the concentrations were around 500 ppm. In winter, nearly 1400 ppm were found in tier 1, 1000 ppm in tier 2 and around 500 ppm in tier 3 during transport. All concentrations were clearly below 3000 ppm CO_2 which is the maximum threshold on Danish pig transport vehicles (Christensen, 2003, pers comm.) and for housing conditions (e.g. DIN, 1992). The results indicate that the temperature controlled shutters provided good air exchange in summer and sufficient ventilation in winter (Chevillon *et al.,* 2002). When temperatures reach 25 C it is necessary to open all vents of natural ventilated lorries. Under such conditions, transport of pigs under 8 h can usually be carried out without forced ventilation on the vehicle. However, during loading and unloading, rear doors and all side shutters should be fully opened. In France, the height of the open side shutters of these vehicles is about 40 cm which helps natural ventilation. Average loading time in France for 100 pigs is meant to be about half an hour (Chevillon *et al.,* 2004).

From experiences with long distance transports over 36 h (20 h transport, 9 h break, 7 h further transport, 2 drivers) in winter (outside temperatures -6 C min to +14 C max) and summer (outside temperatures 13 C min to 30 C max), Chevillon *et al.* (2003) recommend a minimum temperature in the lorry of 12 C for pigs weighing 100 kg (0.42 m^2/pig). This can be reached also in extreme conditions, when outside temperatures are below zero, by partially closing the ventilation shutters. In case of low temperatures the watering system should be protected from freezing, especially the water storage tanks (insulation, electrical heating elements, etc.). In very cold weather, additional troughs should be provided for watering the pigs during the 9-h stops.

Critical situations can arise during loading and when the vehicle is forced to stop during transport. In tiers without ventilation the air speed around the animals drops and the CO_2 concentrations, the temperature, and the humidity rise. This is especially a problem in summer. Sällvik *et al.* (2004) reported that the temperature inside a standing vehicle with natural ventilation at loading increased by 0.15 C/min. This was measured early in the morning with the absence of solar radiation which may have even enhanced the heat load if present. The ventilation rate was calculated at 13 m^3/h/pig in that situation. Loading or resting periods of one hour can result in 9 C higher temperatures in the lorry. It seems necessary to provide either forced ventilation or sufficiently large side shutters which can be fully opened in case of stops. For long distance transport (e.g. 20 h transport, 9 h break), it is desirable to have a system of active ventilation in addition to the side shutters. The active ventilation should be used when the truck is stopped in very hot weather and when there is no wind (Chevillon *et al.*, 2002). This system of ventilation combining flexible shutters and additional fans can ensure an air flow rate of at least 100 $m^3/h/pig$. A system of temperature control is desirable on the pig decks which makes it easier for the drivers to regulate shutters and fans.

A calculation of the ventilation rate is offered by Chevillon *et al.* (1999) in the tiers of a lorry under certain conditions according to the fomula:

$$D = S \times V \times 3600 \times \text{no of pigs per tier}^{-1}$$

D = ventilation rate $m^3/h/pig$ S = total area of the openings

V = speed of the incoming air in m/s Constant speed of the lorry is 80 km/h

If the total area of openings is 1.34 m^2, the wind speed 3.1 m/s measured 70 cm inside the lorry at the average, 54 slaughter pigs are loaded, the head space above the animals is 20 cm and the speed of that lorry is 80 km/h, the resulting ventilation rate is 277 $m^3/h/pig$ which is similar to the 300 $m^3/h/pig$ calculated by the CO_2 balance method (Chevillon *et al.,* 1999). This ventilation rate will significantly change when the speed of the lorry increases or decreases, the vents are closed or the number of pigs change. A ventilation rate of 75-85 $m^3/h/100$ kg pig is recommended for housing conditions in Denmark, Germany and Sweden (Christensen, 2003, pers. comm.; DIN, 1992)

Therefore Chevillon *et al.* (2002) recommend temperature controlled openings both for transports carried out at ambient temperatures higher than 25 C and below 10 C. At least, the driver should have a temperature sensor which gives the air temperature in the tiers close to the animals at any time in order to enable him to mechanically regulate the ventilation openings according to temperature conditions. Forced ventilation is considered an additional security tool for hot situations when loading, during breaks or in emergency situations like traffic jams. Sällvik *et al.* (2004) recommend ventilation rates of 100-200 $m^3/h/pig$ in summer. At temperatures higher than 21 C the air velocity around the pigs should be increased.

The lorries used by Sällvik *et al.* (2004) and Chevillon *et al.* (2002) for their experiments were differently designed. The French vehicle has three tiers with 40 cm wide openings throughout along both sides. The body of the Swedish vehicle has two tiers and solid walls with four separate openings at each side of the lorry on each deck. Further openings are in the roof, in the front and at the rear end. The vehicles are designed for the different prevaling climatic conditions in the different countries. Two-tiered vehicles allow more head-space and better air flow than three-tiered vehicles of the same height. In addition, three-tiered vehicles may not allow adequate inspection, so may be unsuitable for longer journeys (SCAHAW, 2002). A recent Danish research report claims that slaughter pigs can be transported in 3-decker vehicles with a tier height of 90 cm without jeopardizing animal welfare when a loading density of 0.35 m^2 per 100 kg pig for maximum 4 h transport or a loading density of 0.42 m^2 per 100 kg pig for 4-8 h and ventilation and sprinkling are provided (Nielsen et al. 2003)

An unsolved problem in many vehicles is the non-uniform distribution of the ventilation air in the tiers resulting in temperature differences up to 4.1 C at times.

In an EU-funded project tier heights, stocking density and ventilation openings (natural ventilation) in two-tiered vehicles was measured and put in relation to temperature and relative humidity (RH) which was obtained at 5 points above the pigs in each of the 4 compartments on both tiers. Temperature was also measured outside the vehicle above the driver's cabin. The measurements were carried out in winter and summer conditions (Christensen and Barton Gade, 1997). At outside temperatures above 20 C the vehicle's mechanical ventilation system was used, above 25 C a misting system was additionally used to spray water through fine nozzles to cool the skin of the pigs

Table 1 shows the average temperatures within the vehicle for three different outside temperatures. With increasing outside temperatures the inside temperatures increase too.

At 25 C the inside temperatures are only a little above the outside temperature which emphasises the usefullness of forced ventilation. However, the distribution inside the vehicle is poor. In one Danish study, differences in temperature up to 4.1 C occurred between the front and the back of the lower tier at 5 C outside temperature. The differences are 3 C at 15 C ambient temperature and 2 C at 25 C. In the lower tier the air distribution was better, but at 5 C outside temperatures the difference between front and back was 3 C and the inside temperatures were clearly below 10 C. It seems that the upper deck is better ventilated and that the distribution of air has to be improved in the decks particularly at lower temperatures. The better ventilation in the upper tier may result from a greater exposure to the prevailing winds.

Table 1: Average temperatures inside a vehicle at different outside temperatures (Christensen and Barton-Gade, 1997)

Outside temp. (C)	Lower tier				Upper tier			
	Front			Back	Front			Back
5	11.9	10.4	8.7	7.8	9.9	9.0	8.0	7.3
15	19.5	18.4	17.2	16.4	17.7	17.1	16.3	16.3
25	27.1	26.3	25.6	25.1	25.5	25.5	24.6	25.2

When driving, the ventilation increases and hence the temperature, relative humidity and CO_2 levels decrease. Using data for heat and CO_2 dissipation from the transported pigs, the ventilation rate was calculated to be 100 – 200 m^3/pig and hour and the temperature differences between the inside and the outside of the truck were on average 1.5 – 2.0 C on arrival at the abattoir (Sällvik *et al.* 2004). The transport times during these investigations were between 60 to 70 minutes. These investigations were carried out under Scandinavian conditions.

Before setting standards, it seems necessary to include and compare results and experiences between southern and northern European countries. Results from Finland and Sweden need not comply with observations made in Portugal or Spain where the animals may be much better adapted to hot weather. Recent unpublished reports indicate that slaughter pigs were successfully transported under commercial conditions at ambient temperatures around 32 C with efficient ventilation (Kettlewell, 2003, pers. comm.).

There is also still a considerable lack of data for longer distance transport of pigs. The temperatures given in Table 2 correspond to those used in practice in Denmark for short (< 8 h) and long (> 8 h) transports. Those temperatures should be considered as an average; e.g. if 5 C is the nominal value, a lower temperature down to 2°C, for journeys longer than 8 h is acceptable over a shorter (e.g. 10 % of the transport time) period of time (Christensen, 2003, pers. comm.). These Danish experiences are in contrast to the French proposal of a minimum temperature of 10 C on the transporter (Chevillon *et al.,* 2002). Both research groups agree that at outside temperatures above 25 C action has to be taken by full ventilation or additional water spraying when the relative humidity of the air is appropriate. The air speed around the animals should be increased. The ventilation system should be designed so that the air passes directly along the skin of the animal. An air speed of 0.7 m/s can be equivalent to a cooling effect of 3.5 C (Chevillon *et al.,* 1999). A wind speed of 3.1 m/s above the pigs can be achieved during driving when the side shutters are 40 cm high and fully open (Chevillon *et al.,* 1999). When the skin of the pigs is wet, lower air velocities may be sufficient. It would be desirable to have a practical model which includes the temperatures, different air speeds and the cooling effect of spraying.

Table 2: Recommended min. and max. temperatures for pigs (Christensen and Barton-Gade,1995)

PIGS	Weight / Age	Min. Temp. (C)	Max. Temp. (C) adjusted for Humidity	
			RH <80%	RH >80%
Transp.time < 8 h	10 - 30 kg	14	32	29
	30 + kg	(2-)5	25-(35)*	29
Transp.time > 8 h	10 - 30 kg	14	32	29
	30 + kg	(5-)12	25-(35)**	29

* with mechanical ventilation and misting starting sensor-controlled

**with mechanical ventilation starting up manually

Transport of pigs under cold conditions

Most concerns are devoted to heat stress in pig transport. In some European countries cold stress can also play a considerable role. Honkavaara (1989) described difficulties to reach an even distribution of the air inside a vehicle with natural ventilation in Finland. There were eight slots (about 0.5 x 0.8 m) in two lines on both side walls and one big opening (0.4 x 2.55 m) above in the front behind the cabin. The animal density was about 0.42 m^2 /100 kg. When the vehicle was standing, the temperature rose on the average by 9 C within 2 to 5 h in cool weather (-1 to 5 C outside temperature). The air flow was 2 m/s in the middle, 1.3 m/s in the front and lowest at the rear (0.4-0.6 m/s) when the speed of the vehicle was between 40 and 60 km/h. The relatively best air distribution was obtained at a speed of 80 km/h.

He concluded that in Finland it is not possible to use such large ventilation openings as in central or in southern Europe because of the cold winters. After the installation of fans, an adequate and uniform air circulation at the level of the pigs was achieved when external temperatures varied from -1 up to 26 C. Additional fans in the roof and in the walls were found very helpful to improve ventilation during loading.

Honkavaara (1989) investigated creatine kinase (CK) activities as a stress indicator in transported pigs under Finnish summer and winter conditions. The CK was slightly increased at heavy frost (< -20 C outside temperature), higher when the temperatures were around -4 C and highest in warm weather (16 to 26 C). Lowest concentrations were found in mild weather (5 to 14 C). The mortality during these journeys was low during heavy frost (-30 to –20 °C), increased considerably in cold weather (-3 to 0 C) and was highest in warm weather (16 to 26 C).

The high transport losses and CK values in cold weather (-4 to 0 C) were probably caused by poor ventilation. Below 0 C the ventilation slots are usually not opened. When the temperatures rise the drivers do not react sufficiently quickly and the temperatures rise inside the vehicle. Therefore today in Finland most semi-trailers and lorries are equipped with mechanical ventilation including a heating system for the winter. Walls and roofs are made of aluminium or steel and are insulated. Each box has observation cameras and temperature probes (Honkavaara 2003b, pers. comm.).

Transport of young pigs

Increasing numbers of young pigs are transported after weaning from the farrowing units to the fattening units. They can be exposed to cold stress in winter when the transfer boxes (from animal house to vehicle) and the transporters are not heated. Temperature differences of 20 C happen regularly during loading (Göllnitz 2004). Experiences with a temperature controlled (heated) transfer box system from the animal house on the transport vehicle resulted in lower losses and a reduced incidence of respiratory and digestive disorders of the piglets in the first two weeks after arrival, according to personal communications of the farmers (Göllnitz 2004). It was shown earlier that the frequency of coughing of piglets (about 20 kg) during the first housing period after transport is very much related to grouping within the pens (whether or not from the same farm), and to the duration of adverse environmental conditions (air temperature, air velocity) during transportation (Geers *et al.*, 1986). Lewis *et al.* (2003) recommend transport temperatures of 20 to 30 C for weaner piglets. At higher temperatures (35 C) weaners loose significantly more weight (0.5 kg) in the first 24 h post weaning than piglets transported at 20 C (0.42 kg), 25 C (0.34 kg), or 30 C (0.32 kg).

5.4. Cattle

There are a few new experimental data on temperature, humidity, air velocity and air quality on cattle transport vehicles. Honkavaara (2003b, pers. comm.) applied the Temperature Humidity Index (THI) concept which was developed for production conditions to cattle transport conditions. The THI characterises the general heat stress level caused by temperature and relative humidity in cattle (for details see below). Honkavaara took temperature and relative humidity data from measurements carried out inside transporters carrying adult cattle during short (< 4 h transport time), medium (up to 8 h) and long (8 to 14 h) journeys under summer and winter conditions in Finland. For adult cattle the ranges of normal, alert, danger and emergency conditions were given as 73,9 and below; from 74,0 to 78,9; from 79,0 to 82,9 and 83,0 and above. The THI mean values ranged for short journeys in summer between 62.4 (temperature 17.6 C, relative humidity 60 %) and 66.5 (20.4 C, 64 %) and in winter between 28.5 (-3.2 C, 87 %) and 40.8 (4.8 C, 96 %). The respective figures for medium distance tranports were 67.4 THI (20.3 C, 81 %) to 70.5 (22.6 C, 74 %) in summer and 55.5 (12.9 C, 82 %) to 67.1 (21.7 C, 46 %) in winter. During long distance transports the mean THI was between 63.4 (17.8 C, 81 %) and 64.5 (18.5 C, 81%) in summer and from 43.7 (4.2 C, 60 %) to 54.3 (4.9 C, 65 %) in winter.

The value of 74 was exceeded only in stationary vehicles, *i.e.* when the last animals were loaded or a fully loaded vehicle had to wait for a couple of minutes before the journey started. This happened during short (THI 79.3; 26.3 C, 99 %) and more often during medium distance journeys. In summer time at two occasions the THI of 74 was shortly exceeded (THI 79.3; 28.4 C, 73 % and THI 81.1, 28.3 C, 87 %). In winter the THI reached in one situation the alert zone (THI 76.5, 28.5 C, 52 %) and at one occasion even the emergency zone (THI 83, 34.3 C, 46 %). However, these situations lasted for 10 or 15 minutes only. The THI went back to normal (below 74) when the vehicles moved. The reactions of the animals were not specifically investigated, but no negative effects were observed during these periods.

Costa *et al.* (2003) found a slight influence on meat colour and water holding capacity of beef when the animals were transported for 3 h under climatic conditions on the lorry which corresponded to a THI of 75 in Italy. On the other hand, behavioural and physiological reactions of the animals remained more or less normal.

The Temperature Humidity Index (THI)

Adult cattle can much better cope with cold stress when sufficiently fed than with heat stress. An approach to assess the general heat stress level caused by temperature and relative humidity in dairy cattle is the Temperature Humidity Index (THI). It is also called Livestock Weather Safety Index (Esmay and Dixon, 1986) and was used by the U.S. National Weather Service for advisory bodies.The basic formula reads:

$$THI = t_{db} + 0{,}36 t_{dp} + 41.2$$

t_{db}= dry bulb temperature (C)

t_{dp}=dewpoint temperature (C)

Dry bulb temperature is the air temperature as determined with a common dry thermometer or other dry temperature sensor.

Dewpoint temperature is the saturation temperature corresponding to the actual partial pressure of moisture in the air. It is the temperature at which condensation just starts to occur on a polished metal surface.

There are also other THI reported in the literature which use slightly different values and figures like the THI for cattle of Bianca (1965) (0.35 x dry bulb temperature C) + (0.65 x wet bulb temperature C). Convenient to use is the graph of Armstrong (1994) shown in Figure 2 which is based on studies lasting several h. The threshold when stress begins is 75. Below a THI value of 75 no thermal stress is expected. The other zones are mild distress (< 78), moderate distress (< 83), severe distress (< 84) and many deaths from heat stress (> 84).

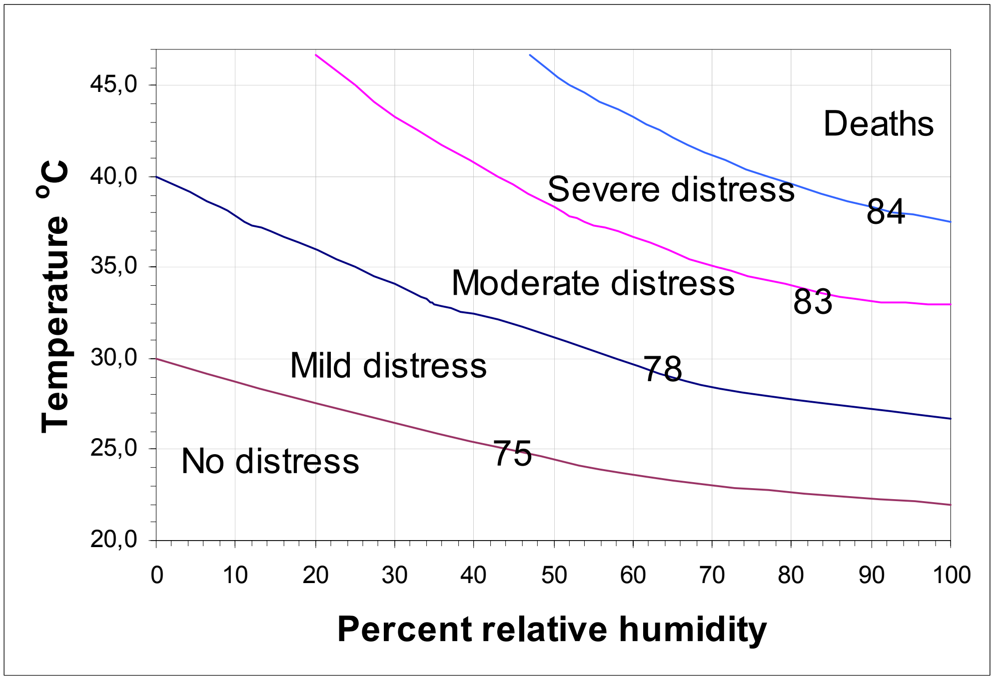

Figure 2: Relationship between temperature and relative humidity with THI-zones of heat stress levels in cattle (modified after Armstrong, 1994).

Some combinations are given below which are suitable for cattle if mild distress is accepted:

- 35 C and 25 % RH
- 30 C and 58 % RH
- 28 C and 80 % RH
- 27 C and 100 % RH

No data on an "acceptable" duration of stress are available.

Air movement around the animals can influence the THI considerably. A few examples from Baeta (1985) are shown below. He used slightly different assessment thresholds which makes detailed comparisons difficult:

- Wind velocity 0.5 m/s:
    - Safe: e.g. 26 C + 90% RH or 32 C + 20% RH
    - Caution: e.g. 28 C + 90% RH or 36 C + 20% RH

- Danger: e.g. 30 C + 90% RH or 42 C + 20% RH

- Wind velocity 6 m/s:
  - Safe: e.g. 28 C + 90% RH or 41 C + 20% RH
  - Caution: e.g. 30 C + 90% RH or 42 C + 20% RH
  - Danger: e.g. 34 C + 90% RH or 43 C + 20% RH

Wind speeds below 0.5 m/s have little effect on heat loads on the animals. Recommendations for wind speeds around housed animals in summer should therefore be at least 0.6 m/s and more (e.g. DIN, 1992). A wind speed of 6 m/s increases the heat dissipation distinctly.

These figures can be influenced by various factors such as different feeding intensities, coat depth of the animals and type of breed and wet skin. If cattle are fed below the maintenance level, LCT rises sharply. Wind and rain influence LCT additionally. An example of Charles (1994) illustrates the impact of these factors. For a 400 kg beef cattle (fed barley, gaining 0.75 kg/day) kept in dry, draught free conditions the LCT is at -9 C. At 4 m/s draught and rain (coat 50% wet), LCT rise to 17 C. On the transport vehicle the animals are usually protected against rain, it may however happen that they are loaded when rain falls. The skin of the animal can become also wet when vehicles are standing for longer periods without sufficient ventilation and the relative humidity increases.

Cattle during transports in Sweden are exposed to temperatures up to nearly 27 C in summer und -16 C in winter when loading takes place. The animals can heat up the lorry within 2 h from -16 C to approximately 0 C (Wikner *et al.,* 2003).

5.5. Sheep and Goats

The working group stated that no new scientific data related to sheep and goats were available since the 1999 SCAHAW report.

6. TECHNICAL ASPECTS OF MEASURING MICROCLIMATE FACTORS IN VEHICLES

6.1. General aspects

Measurements of environmental factors to characterise the full micro-climate on transport vehicles should include:

- dry bulb temperature
- wet bulb or dew point temperature or relative humidity (sensors are available)
- air velocity close to the animals (may be difficult to make in a truck, depends on technique)
- CO_2 concentration in order to characterise ventilation rate (air exchange) and air quality in the truck
- Ammonia, dust and micro-organisms may be useful to measure for hygienic and health related as well as epidemiologic reasons
- black globe temperature to measure radiation effects

All probes should be robust to withstand mechanical influences from the movement of the lorry, the animals, heat, water, dust and disinfectants.

6.2. Temperature measurement

Temperature measurement per se is not difficult. One of the crucial question is where the probes, e.g. for temperature measurements, should be installed on a lorry. On a naturally ventilated vehicle, this is difficult to specify. As long as the truck is driving, the prevailing air movement will be from back to front (Kettlewell *et al.*, 2000) so, measuring behind the front headboard might be the first choice. However, if a stationary vehicle is concerned, the direction and the velocity of the air movement depend on the prevailing wind direction and the situation can be such that air comes in from the sides or the front.

Honkavaara (2003a) found in vehicles without mechanical ventilation temperature differences between outside and inside of 11 to 30 C in Finland, depending on outside temperature and air velocity. In vehicles with mechanical ventilation these differences were much smaller. He recommends that the temperature probes should be installed about 2 m from the front wall and at the level of animal's head. The probes should be able to cope with considerable fluctuations. During loading, temperatures inside the vehicle varied from -5°C to 29°C, and RH from 30 % to 100 % (Honkavaara, 2003a).

Clearly, no single sensor position will give a full and true representation of conditions within one lorry. Multiple sensors located at various, convenient and meaningful locations is the only sensible solution. On multi-deck vehicles, conditions on the decks can differ markedly, for example the upper deck of a vehicle in Spain might be expected to be hotter than the lower deck, simply because of solar gain through the roof. In Denmark the upper deck can be better ventilated (Christensen, 2003, pers. comm.)

If the vehicle is fitted with fans (mechanical ventilation) - as a requirement for journeys over 8 h - the way fans are installed and operated needs to be considered before optimal locations for temperature sensors can be specified. If the vehicle has defined air inlets and outlets, temperature measurement at all stages of the transport journey is reliable (Kettlewell *et al.*, 2001; Kettlewell *et al.*, 2003). It is then possible to have a similar degree of control as in intensive housing systems. If fans are fitted to the sides of vehicles then they will still be prone to the effects of natural cross winds and the ventilation throughput may be reduced.

6.3. Humidity measurement

Measurement of relative humidity is more problematic. The comments made for sensor location apply also here.

In addition though there is a more significant issue of sensor robustness and reliability. Humidity sensors are sensitive and will not tolerate direct contact with water as might occur during vehicle washdown. Consequently they should be protected from such events which may preclude optimal positioning of the sensors.

From practical experience it appears that most humidity sensors are not able to measure 95% correctly. In most cases 100% or "failure" are displayed (Kettlewell, 2003, pers. comm.). Therefore, it is important to consider some practical aspects of measuring RH before introducing instrumentation for control purposes in vehicles.

A successful approach to measuring the thermal conditions has been adopted for broiler chickens, where it proved possible to define practical limits for broiler chickens in transit based solely on temperature limits as the range of humidities within commercial broiler transport containers had been scientifically quantified (Mitchell and Kettlewell, 1998).

6.4. Other devices

The probes for measuring the velocity of the air should preferable put in the same position as the temperature and humidity sensors.

The instrumentation for CO_2 and ammonia is expensive, needs special training of the driver and is not yet introduced in practice. The same is true for radiation measurements. No information exists on instrumentation designed for measuring airborne dust and microorganisms on animal transporters.

CONCLUSIONS

1. GENERAL CONCLUSIONS

There are relevant new data but some of these (from France, Finland, Sweden and Denmark) - although valid - may not justify general conclusions. Therefore, the following conclusions take account of these limitations

1) There is a certain amount of new information available from experiments carried out under practical transport conditions which helps to make the earlier recommendations from 1999 more precise.
2) Temperature measurements are relatively easy to perform on transport vehicles. The measurement of the other components of the microclimate are presently still rather costly and difficult to perform. Devices are available and in place in experimental vehicles.
3) The position of the sensors has important effects on usefulness of measurements and depends on the ventilation system as a whole. In most cases the best position is behind the front board of the lorry.
4) The results reported here are derived either from individual experiments or practical experience from four countries of the EU. They may not apply to all climatic conditions in Europe.

2. PIGS

1) On pig transport vehicles, no signs of thermal stress were observed at air temperatures between 10 and 25 C (with an optimum at 18 to 20 C).
2) Mechanical ventilation is used in some countries above 20 C, and water spraying above 25 C.
3) The cooling effect of an air flow of 0.7 m/s which passes the skin of the pigs (0.42 m^2/pig) is thought to be equivalent to a temperature reduction of 3.5 C. When the skin is wet the skin temperature drops by 10 % within 5 minutes.
4) Suffient ventilation can be reached by natural ventilation depending on height of the openings and the speed of the lorry. Air velocities of 3.1 m/s in the lying area of the pigs on the transporter can be reached by natural ventilation when the side shutters are 40 cm high and fully opened and the lorry drives at a speed of 60 to 80 km/h.
5) Ventilation rates of 277 m^3/pig/h were obtained with vents fully open and a speed of the lorry of 80 km/h. This ventilation rate is about 5 times higher than summer ventilation rates in pig houses.
6) Low outside temperatures influence the inside temperatures depending on ventilation intensity. Temperatures below 10 C (down to 2 C for a short period) in the vehicle had no negative effect on pigs in Danish experiments.
7) The installation of heaters in the transport vehicles avoided high transport losses caused by poor ventilation in winter in Finland at outside temperatures between –1 and 5 C.
8) No clear threshold is worked out for CO_2 on transport vehicles.
9) Temperature differences up to 4.1 C can occur in the same tier indicating poor air distribution.
10) Critical situations can arise during loading and when the vehicle is forced to stop at border lines or by traffic problems. Without forced ventilation the air speed around the animals drops and CO_2 concentration, temperature and humidity rise. The

temperature inside a standing vehicle with natural ventilation at loading increases by 0.15 C/min.

11) Loading or resting periods of one hour can result in 9 C higher temperatures in the lorry.

12) Sufficiently high side openings (e.g. 40 cm) in combination with temperature controlled side shutters can prevent poor ventilation in most temperature situations.

13) With temperatures between 20 and 30 C for piglet transport, no detrimental effects were observed.

14) Considerable differences exist in the design of the vehicles used in the different countries. The northern countries tend to more closed vehicles with forced ventilation and misting devices while the southern countries prefer open lorries and natural ventilation.

3. CATTLE

1) There are only few new data on cattle transport.

2) The THI concept has a potential for the assessment of heat stress in cattle in transit when the air velocity can be included.

3) Air flow around the animals can significantly decrease the heat load and the humidity so temperatures of 30 C can be tolerated by the animals. However, there is no clear information on acceptable conditions on the vehicle for cattle.

4) In northern European countries, low temperatures down to –16 C revealed no negative effects on cattle during loading. The vehicle was heated up to 0 C by the animals within 2 h. Heaters are used if necessary during transport.

4. SHEEP AND GOATS

For sheep and goats, no new data are available since the 1999 scientific report on "Standards for the micro-climate inside animal road transport vehicles" (SCAHAW, 1999).

RECOMMENDATIONS

1. GENERAL RECOMMENDATIONS

The figures given in Table 3 should be used as a guideline to specify an acceptable range of temperature and RH. The data for pig and cattle are based on experimental data and on experience arising from transport practice, the data for sheep and goats refer to housing conditions. The temperatures should not be considered as absolute threshold figures because the effect of temperature on an animal is considerably influenced by air velocity and humidity of the air as well as by the ventilation rate.

When animals adaptated to cold conditions are transported in warmer conditions, greater air flow should be provided than when transport conditions are cool.

For future considerations, it is essential that all technical and organisational conditions related to the animals and the transport are taken into consideration, such as vehicle body (floor, walls, insulation, rubber floor), air suspension, mechanical ventilation, animal density and handling during loading. The use of a misting system seems to be very useful to control the micro-climate inside pig transport vehicles in summer.

Temperature measurements should be carried out at several points on the lorry. In most cases the most representative position is behind the front board of the lorry. At least one sensor per tier should be provided.

The installation of heaters in the transport vehicles is recommended to avoid transport losses caused by poor ventilation in winter at outside temperatures below 5 C. Freezing on surfaces inside the vehicle should be avoided. Species- and gender-specific regulations should be worked out.

Air distribution on transport vehicles should be improved in order to avoid poor air quality in some areas of the tiers.

During loading and when the vehicle is forced to stop at border lines or by traffic problems sufficient ventilation capacity should be provided.

Sufficiently high side openings (e.g. 40 cm) in combination with temperature controlled side shutters can prevent poor ventilation in most temperature situations.

Table 3: Proposed maximum and minimum temperatures within vehicles for the transport of animals, taking into account the influence of humidity on these limits

Species	Type/ weight /age	Minimum. Temperature* (ºC)	Maximum temperature adjusted for humidity (ºC)	
			RH <80 %	RH >80 %
Pigs	<10 kg	20	30	29
	10 – 30 kg	14	32	29
	>30 kg	10	25 (30)*	25 (30)*
Cattle	0 – 2 weeks	10	30	27
	2-26 weeks	5	30	27
	>26 weeks	0	30	27
Sheep	Full fleece	0	28	25
	Shorn	10	32	29
Goats		6	30	27

*with mechanical ventilation and misting devices

Although these are optimal temperature ranges for transport, provided animals are adapted to either higher or lower temperatures, and appropriate action is taken with regard to ventilation, welfare can still be good when ambient temperature is slightly outside the recommended range.

2. Pigs

The target temperatures for slaughter pigs on transport vehicles should be between 10 and 25 C.

Below 10 C, the ventilation should be reduced.

When temperatures inside the vehicle exceed 25 C ventilation rates should be increased. Mechanical ventilation should be used above 20 C, and mechanical ventilation plus water spraying above 25 C. At high ambient temperatures the ventilation system should ensure sufficient air flow around the animals to remove excessive heat. In order to reduce body surface temperature of pigs spraying the skin of the animals with water is a most efficient way. The side shutters of naturally ventilated vehicles should be wide enough (e.g. 40 cm high) to ensure sufficient ventilation when the lorry is driving.

Piglets should be transported at temperatures between 20 and 30 C.

3. CATTLE

A THI value of 74 should not be exceeded in order to avoid heat stress in cattle in transit.

4. SHEEP AND GOATS

For sheep and goats, no new data are available since the 1999 scientific report on "Standards for the micro-climate inside animal road transport vehicles" (SCAHAW, 1999).

SUGGESTIONS FOR FUTURE RESEARCH

There is an urgent need for a multidisciplinary approach to a full understanding of the thermoregulation of animals in transit and the micro-climate on transport vehicles. Animal scientists, veterinarians, physicists and technical engineers from different geographic regions are needed in order to describe optimal transport conditions for animals in Europe.

There is an urgent need for more detailed investigations into cold and heat stress of species which are transported over short (<8 h) and long (>8 h) distances. The regional differences throughout the EU have to be taken in account.

It is necessary to develop and validate, under fully commercial conditions and on journeys over 8 h, sound scientific indices to determine the effects of thermal loads imposed on animals, for example by combinations of temperature and humidity.

Vehicle design is crucial for ensuring good animal welfare during transport. Standardisation seems necessary for the different types and genders of animals. A "heat-load" factor based on animal weight and animal density in terms of area (m^2 per animal) and air space (m^3 per animal) should be worked out.

A proper understanding of the air distribution in one-, two- and more than two-tier/deck vehicles is essential to obtain an even distribution of fresh air and to remove moisture and heat.

Appropriate and reliable instruments for humidity measurements are needed. The approach taken in broiler transport might, if proven scientifically, be applicable to the red meat species too. This requires further scientific investigation.

Sound, scientifically based, practical techniques should be developed to check the functional efficiency of vehicle ventilation systems. This could be based e.g. on temperature, humidity or CO_2 monitoring. The authorities responsible for checking vehicles should be trained to be able to check the proper functioning of such systems.

Fundamental studies are required to determine the possibility of ingress of pollutants (e.g. exhaust gases from the vehicle engine) into the livestock compartment. Air quality inside the vehicle (gases such as ammonia and methane, dust, micro-organisms) is an important part of the micro-climate and should be investigated as a significant health factor for all kind of species of animals which are transported and also from an epidemiological point of view.

Future research should also develop and improve methods on how to measure and evaluate animal stress levels in transit (assessment methods).

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Letter, with ref. SANCO/E2/RH/GP(03)D/521922r2, from Mrs Jaana HUSU-KALLIO from the Health & Consumer Protection Directorate-General on a request from the Commission to the European Food Safety Authority related to Standards for the microclimate inside animal road transport vehicles.

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