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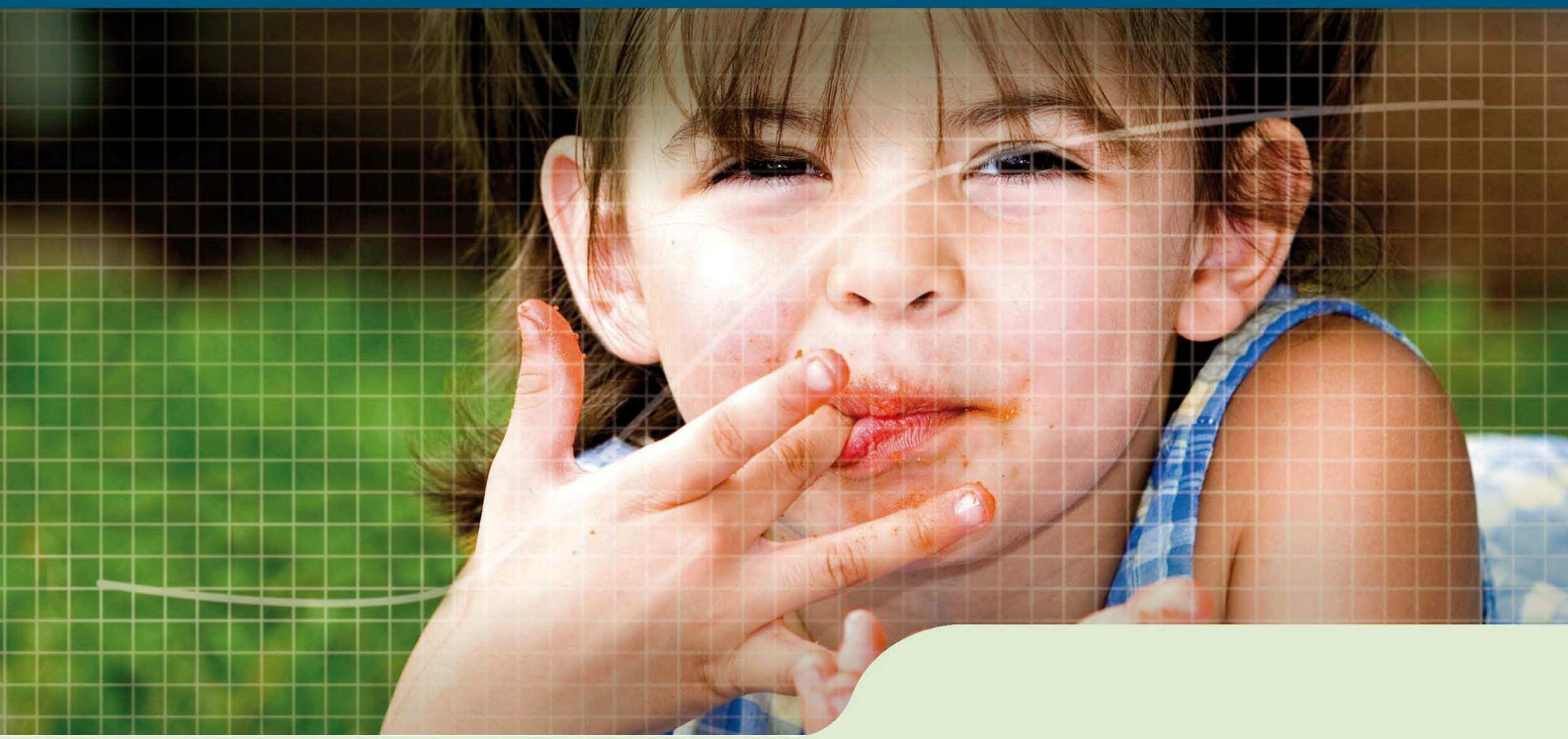

Report 407

Compartment height in cattle transport vehicles

November 2010

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Abstract
Space requirements for the height of the compartment ceiling in transport vehicles for cattle were examined to determine standing comfort. Adult dairy cattle displayed more explorative behavior when the ceiling was set at 20 cm above the withers. Rosé veal calves displayed more explorative behavior, moved and pushed more. The combination of sufficient height - (40 cm space between shoulder and ceiling) - floor space and rest, feeding and watering with familiar animals may result in quiet and fit animals during (long duration) transport.

Keywords
Transport, behavior, heart rate, blood parameters, compartment height.

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Voorwoord

Naast ethische aspecten is de behandeling van dieren door de mens een belangrijke component van de kwaliteit en veiligheid in de vleesproductie keten. Burgers vragen een betere behandeling van dieren in de gehele productieketen, dus inclusief het transport van dieren en heeft consequenties voor de vleesconsumptie in de toekomst en voor de producenten en verkopers van dierlijke producten in de EU. De mens is moreel verplicht om respectvol om te gaan met dieren, die de capaciteit hebben om te lijden. Het huidige niveau van bescherming van dieren in de EU, is de hoogste in de wereld. Momenteel heeft de EU de beste bescherming van dieren in de wereld. Echter het Europese model staat onder druk door de verschillende welzijnsstandaarden in de wereld. De huidige situatie wordt bekritiseerd door welzijnsorganisaties die regulier inspecties uitvoeren.
Hoewel de definitie van “acceptabel” welzijn, dat gebaseerd is op cultuur, filosofische en religieuze waarden, verschilt, is er een algemene consensus dat landbouwhuisdieren gespaard dienen te blijven van onnodig lijden tijdens hun levens cyclus. En wel speciaal tijdens de groei, transport of bedwelmen en doden. De “Council Directive (93/119/EC) on the protection of animals during transport (1991) and European Council Regulation (EC) on the protection of animals during transport and related operations (2005)” zijn gebaseerd op de aanname van bekende regels die vast gelegd zijn de “European Convention for the Protection of Animals during International Transport” (1968 and revised version 2003).

Het principe dat dieren adequate ruimte hebben, kunnen staan en liggen in hun natuurlijke positie in hun thermische comfort zone en zonder beschadigingen en lijden met voldoende hoogte in het compartiment zijn de belangrijkste factoren, die het welzijn beïnvloeden. Vooral de hoogte is belangrijk bij veewagens met meerdere dekken, omdat deze veewagens gehouden zijn aan maximale hoogten om onder bruggen en viaducten te kunnen gaan. De maximale hoogte is in Nederland 4 m. Om deze en financiële redenen worden de hoogten van de compartimenten zo veel mogelijk beperkt. Deze vermindering kan een negatief effect hebben op het gedrag van de dieren en de hoogte van de ventilatie in het compartiment. De adviezen voor de hoogte van compartimenten zijn gebaseerd op een comfortabele houding van het dier en wel 20 cm boven de kruin (SCAHAW, 2002). Het is niet duidelijk wat wordt bedoeld met een comfortabele houding.
Er is geen onderzoek bekend in de literatuur naar de effecten van verschillende hoogten van het compartiment op het welzijn van het dier. De hoogten boven de kruin, die worden aanbevolen voor runderen zijn niet gebaseerd op onderzoek.

Dit onderzoek is uitgevoerd in opdracht van het Ministerie van Landbouw, Natuurbeheer en voedselkwaliteit. BO-12.02.002-036

Preface

In addition to ethical aspects, humane treatment of animals throughout the production chain is an important component of the quality and safety of meat. Consumers' concerns for animal welfare have important implications for the future consumption of meat and for producers and retailers of animal-based food products within the EU. It is considered by many, that man has a moral obligation to respect all animals and to have due consideration for their capacity for suffering. The current level of protection of animal welfare in the EU is among the best in the world. However, the European model is under pressure, in particular because of differences in animal welfare standards worldwide. The current situation is subject to criticism based on regular surveys performed by organizations concerned about animal protection.
Although the definition of "acceptable" animal welfare conditions can vary considerably, based on cultural, philosophical or religious differences between individuals, there is a general consensus that farmed animals should be spared unnecessary suffering throughout their lifecycle. Particularly, during their periods of development and growth, transportation or at stunning and killing. The Council Directive (93/119/EC) on the protection of animals during transport (1991) and European Council Regulation (EC) on the protection of animals during transport and related operations (2005) are based on the adoption of common provisions laid down in the "European Convention for the Protection of Animals during International Transport" (1968 and revised version 2003).

Space allowance for an animal during transport is one of the most imported factors influencing its welfare. One component of this is the floor space where the animal can stand and lay down. Another important component is the height of the compartment in which the animal is transported. Especially, with multi-decked road vehicles this may be important because there are practical constraints on the overall maximum height of the vehicles, for example to enable them to pass under bridges or viaducts. The maximum height is 4 m in the Netherlands. For this and financial reasons there have been occasional attempts to reduce the deck height and thus the volume of space above the animal's head. This reduction may adversely affect adequate ventilation inside the compartment in which the animal is held. It is stated that compartment height for cattle should be at least 20 cm above the crown of the head of each animal when it is standing in a comfortable position. However, this statement is not based on research.

This research was performed for and sponsored by the Dutch Ministry for Agriculture, Nature and Food Quality. BO-12.02.002-036

Samenvatting

Inleiding

De huidige Europese Transportverordening 1/2005 is gebaseerd op de EU Council Directive van 1993, die weer gebaseerd is op de “European Convention for the Protection of Animals during International Transport” (1968 en herzien in 2003). De regelgeving vereist onder andere dat er voldoende ruimte boven de dieren dient te zijn om voor een adequate ventilatie boven de dieren te zorgen wanneer deze in hun natuurlijke houding rechtop staan en zonder dat zij gehinderd worden in hun natuurlijke bewegingen.
Het doel van het onderzoek is vast te stellen welke ruimte minimaal nodig is om te kunnen waarborgen dat voldaan wordt aan de voorwaarden uit de boven genoemde Transportverordening. Er wordt hierbij ook in ogenschouw genomen of het vervoermiddel de beschikking heeft over natuurlijke ventilatie of mechanische ventilatie.

Materiaal en methode

In totaal zijn er 7 kort (ongeveer 2 uur) en 1 lang (ongeveer 27 uur) transporten uitgevoerd met volwassen runderen (melkvee), drachtige vaarzen en rosé vleeskalveren in een dubbeldeks veewagen met natuurlijke of geforceerde ventilatie naar het slachthuis of verzamelplaats voor verder transport. Het plafond was op 10, 15, 20 of 40 cm boven de hoogte van de schouder van het hoogste dier ingesteld.
Bloed werd verzameld en de rectale temperatuur gemeten voor en na het transport. Gedrag werd geregistreerd m.b.v. video, hartslag en huid en omgevingstemperatuur met een speciaal gebouwde niet-invasieve data-logger. De gegevens werden na het transport geanalyseerd.

Resultaten

In het gedrag van volwassen runderen en rosé vleeskalveren werd een significant ($P<0.01$) verschil in activiteit waargenomen. Volwassen runderen waren veel langer in contact met het plafond onafhankelijk van de hoogte hiervan in vergelijking met de kalveren. Wanneer het plafond hoger is werd er ook meer geëxploreerd, meer bewogen en ook meer geduwd. Drachtige vaarzen raken het plafond weinig, omdat het plafond meer is dan 20 cm hoger dan de schouder. Bij geen van de hoogten werden uitwendige verwondingen aan de rughuid waargenomen.
De rectale temperatuur steeg soms iets, maar bleef binnen normale waarden ($38.6 \pm 0.5^{o}C$). Verder steeg de hartslag sterk tijdens het laden en wel van 80 naar 110 slagen/min in vleeskalveren, van 80 naar 140 slagen/min in drachtige vaarzen en van 60 naar 75 in volwassen runderen.
De meeste bloed parameters veranderden niet of marginaal. De Ht waarden verschilden significant tussen de verschillende plafond hoogten, hoewel de basis waarde bij het begin al lager lag bij 15 cm tussen ruimte door een groep dieren afkomstig van een boerderij. De glucose waarden lagen bij de vlees kalveren hoger na het transport bij alle groepen. Echter steeg de Hb waarde significant het meest bij een ruimte van 10 en 20 cm tussen de schouder en het plafond.

Discussie

De mogelijkheid van bewegen en omdraaien, verzorgen, opstaan, gaan liggen en het lichaam strekken of fladderen wordt al lange tijd als basis elementen van goed welzijn beschouwd. Deze bewegingen behoren tot het normale gedragspatroon van alle dieren en ze zijn veelal sterk gemotiveerd om deze gedragingen uit te voeren. Bij hogere plafondhoogten boven de schouder exploreerden, bewogen en duwden vleeskalveren meer in tijd, wat betekent dat ze meer vrijheid hebben om te bewegen. Hierbij raken volwassen runderen langer het plafond aan, maar bewegen minder dan vleeskalveren, mogelijk door een hogere beladingsgraad.
Het huidige advies is dieren, die tijdens het transport staan zoals runderen, het plafond ruim boven de hoofden van alle dieren te plaatsen als zij in hun natuurlijke houding staan. Deze hoogte verzekert een adequate vrijheid van beweging. Helaas is het niet duidelijk welke hoogte van de kop een natuurlijke houding is. De hoogte van rundvee wordt wel vastgesteld aan de hoogte van de schouder. Daarom dient ook de hoogte van het plafond vastgesteld te worden aan de hoogte van de schouder van het hoogste dier in het compartiment.
Een verhoogde rectale temperatuur is de beste indicator van hitte stress. Tijdens onze transporten beef de temperatuur binnen de normale waarden van $38.6 \pm 0.5^{o}C$. Een ander punt is dat de hartslag sterk steeg tijdens het laden, die wijst op en verhoogde inspanning en stress. De waarden komen overeen met die waargenomen tijdens andere studies.

De verschillen in Ht en glucose waarden in het bloed zijn terug te voeren naar een groep dieren afkomstig van een boerderij. Dit duidt op verschillen in omstandigheden op de boerderij (bv. management, voeding).

Conclusies en aanbevelingen

- Bij meer ruimte tussen plafond en schouder, exploreerden volwassen runderen meer en exploreerden, bewogen en duwden vleeskalveren meer. Dit betekent dat de dieren meer ruimte hebben om hun gedrag uit te voeren, waarbij volwassen runderen langer het plafond raakten. Deze bewegingen horen tot het normale gedragspatroon van alle dieren en ze zijn sterk gemotiveerd dit gedrag uit te voeren.
- De hoogte van een rund wordt gedefinieerd als de hoogte van de schouders. Deze hoogte was ook gebruikt in de huidige experimenten. De hoogte van de runderen varieerde sterk. Er werden bij de verschillende hoogten van het plafond geen verwondingen aan de huid op de rug waargenomen.
- Zoals ook in andere studies werd waargenomen, steeg de hartslag sterk tijdens het laden op de veewagen dat een indicator is voor inspanning en stress. De hartslag daalde weer tijdens het transport.
- Een verhoogde rectale temperatuur is de beste indicator voor stress door een verhoogde omgevingstemperatuur. In onze experimenten bleef de rectale temperatuur binnen de normale waarden.
- De combinatie van voldoende hoogte -(40 cm ruimte tussen schouder en plafond)-, vloeroppervlak en rust, voeding en water met bekende dieren resulteerde in rustige en fitte dieren tijden het (langdurig) transport.

Het advies is om

- het dier zoveel mogelijk zijn gedragspatroon te kunnen laten uitvoeren met zo min mogelijk aanraken van het plafond, dat mogelijk is als het plafond meer dan 20 cm boven de schouder is,
- de plafondhoogte vast te stellen aan de hand van de hoogte van de schouder van het hoogste dier in het compartiment.
- dieren fit te houden met voldoende ruimte in het compartiment, rust, voeding en water en bekende dieren,
- onderzoek initiëren naar de minimale hoogte van het plafond boven de schouder.

Summary

Introduction

The Council Directive (93/119/EC) on the protection of animals during transport (1991) and Council Regulation (EC) on the protection of animals during transport and related operations (2005) are based on the adoption of common provisions laid down in the "European Convention for the Protection of Animals during International Transport" (1968 and revised version 2003). Different EU-member states do have legislation based on health and welfare of animals, ethical considerations and/or protection and safety of man and animal. It is recommended for animals, which may stand during the journey, the roof must be well above the heads of all animals when they are standing with their heads up in a natural position. This height will ensure adequate freedom of movement and ventilation and will depend on the species and breed concern
The objective of this study was to determine the space between the height of the cattle and the ceiling for a comfortable standing position and sufficient ventilation. For the examination physical, biochemical and behavioral measurements were used during commercial transports.

Material and methods

In total 7 short (approx. 2 h) and 1 long (approx. 27 h) transports with cattle (adult dairy cattle, pregnant and rosé veal calves) were performed in a double deck vehicle with natural or forced ventilation to the slaughter house or assembly place for further transport. The ceiling was set at 10, 15, 20 and 40 cm, respectively, above the withers of the highest animal.
Blood was sampled and rectal temperatures were measured before and after transport from a farm or an assembly point to the slaughter house or assembly point. Behavior was recorded by video, heart rate and skin temperature and environmental temperatures were measured using specially designed non-invasive equipment. The data were analyzed afterwards.

Results

When behaviors of adult dairy cattle and rosé veal calves were compared it was observed that adult dairy cattle were in contact with the ceiling for a much longer period of time ($P < 0.01$), independent of the height of the compartment than rosé veal calves did. When the ceiling is at a higher level they explore, move and push more. Pregnant heifer were in contact with the ceiling only a short time. They had 40 cm of space above the withers of the tallest animal. In none of the cases superficial skin bruising was observed after transport.
The rectal temperature remained within the normal values, where these values are $38.6 \pm 0.5^{o}C$. An other aspect is that the heart rate increased during loading. The heart rate increased from approximately 80 to 110 beats/min in calves, from 80 to 140 beats/min in pregnant heifers and 60 to 75 in adult cattle during loading and decreased after wards during transport.
Most blood parameters did not change more than marginally. Blood Ht levels appeared to differ significantly due to treatment ($P<0.05$). However this was compounded due to a lower base level (on-farm) for the 15cm group (all from taken from one farm). Blood glucose levels were significantly higher in calves ($P<0.05$). Although no significant effect was observed due to treatment. This once again was confounded by farm of origin (same as above). Hemoglobin levels differed significantly between treatments ($P<0.05$). This observed as increases in Hb during transportations at 10 and 20 cm while transportations with the ceiling set at 15cm displayed a significant decrease. However, these results are once again confounded by animal type. Rosé calves displayed increased Hb levels and adult cattle displaying decreases in Hb levels during transport. Source of the calves was once again influential.

Discussion

Ease of movement, the ability of animals to turn round, groom, get up, lie down and stretch their legs or wings, has long been considered a basic requisite for good welfare. These movements are part of the behavioral repertoire of all species, and animals are highly motivated to perform them. With a higher height of the ceiling above the withers adult cattle explore more and rosé veal calves explore, move and push more in time. This means that they have more freedom of movement. May the stocking density should be taken into account. Adult dairy cattle were in contact with the ceiling for a much longer period of time, independent of the height of the compartment than pink veal calves did. For animals, which may stand during the journey, the roof must be well above the heads of all animals when they are standing with their heads up in a natural position. This height will ensure adequate

freedom of movement. However, it is not clear from this statement, which is the height of the animal. The height of cattle is defined as the height of the withers. The height in a couple of animals may differ. Therefore, the space between the withers of the highest animal in the compartment and the ceiling is the needed height.
Elevated rectal temperature is the best indicator of thermal stress. In our experiments the rectal temperature remained within the normal values, where these values are 38.6 ± 0.5^{o}C. An other aspect is that the heart rate increased during loading, which is a sign of exercise and stress. The figures measured in our commercial transport are in agreement with other studies.
Blood Ht and glucose levels differed due to a group taken from one farm. This may indicate some difference in on-farm circumstances (i.e. management, feeding).

Conclusions and recommendations

- Adult dairy cattle displayed more explorative behavior when the ceiling was set at 20 cm above the withers. Rosé veal calves displayed more explorative behavior, moved and pushed more, indicating a greater freedom of movement enabling them to exhibit their natural behavior.
- Adult dairy cattle were in contact with the ceiling for a much longer period of time, independent of the height of the compartment than rosé veal calves did.
- The height of cattle is defined as the height of the withers, which was the height as used in this experiment. The height may differ a lot in a couple of animals. In none of the cases superficial skin bruising was observed after transport.
- As in other studies observed the heart rate increased strongly during loading which is a sign of exercise and stress. The heart rate decreased again during the real transport.
- Elevated rectal temperature is the best indicator of thermal stress. In our experiments the rectal temperature was not affected by treatment. However it was observed that calves had on average a higher basal temperature than adult cattle
- The combination of sufficient height - (40 cm space between shoulder and ceiling) - floor space and rest, feeding and watering with familiar animals may result in quiet and fit animals during (long duration) transport.

It recommended to

- allow animals to move partly their behavioral repertoire and minimize contact with the ceiling, which might be possible with a space between the height of the shoulder and the ceiling of more than 20 cm,
- set the withers of the tallest animal in the compartment as the height of the animals,
- keep animals fit by sufficient space and rest, feeding and watering with familiar animals,
- initiate research to examine the minimum space between the shoulder and ceiling of the compartment.

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1 Introduction

Europe has a long history of transporting livestock over long distances. In the fifteenth century, Hungary, Poland as well as Denmark and Schleswig-Holstein carved out their position as the main suppliers of oxen to the more westerly, growing urban centers. Around 1570 no less than a quarter of a million oxen were traded on the continent each year (Gijsberts & Lambooij, 2005). By way of comparison: in 2006, there were approximately 128 thousand bovine transports - (approximately 2.1 million animals) - in Europe, of which 42% were long distance transports. Germany, France and Poland are the major exporting countries, while Spain, Italy and the Netherlands import the majority of cattle (TRACES, 2006, TRAW, 2009). Nowadays transport distances of farm animals by road to other farms or slaughterhouse are increasing due to the economic benefits and greater opportunities for long distance and international trade, improved infrastructure and increased demand for live animals for fattening and slaughtering. Within the EU, free movement of animals from one member state to another and more uniformity has stimulated an increase in long distance travel between farms or from farm to slaughterhouse.

These transportations can affect the environment, animal health, animal welfare and the spread of animal diseases (Adams & Tomber, 2008; Van Reenen et al, 2008). Along with ethical aspects, humane treatment of animals in the production chain is an important component of the quality and safety of meat (Smith et al., 2004). Although there are immense variations in the definition of “acceptable” animal welfare conditions, due to cultural, philosophical or religious differences between individuals (Vanhonacker et al, 2008), it is generally agreed that farmed animals should be spared unnecessary suffering throughout their lifecycle, including raising, transporting or killing (EFSA, 2004). The European Council Directive (93/119/EC) on the protection of animals during transport (1991) and European Council Regulation (EC) on the protection of animals during transport and related operations (2005) are based on the adoption of common provisions laid down in the “European Convention for the Protection of Animals during International Transport” (2004). Different EU-member states do have legislation based on health and welfare of animals, ethical considerations and/or protection and safety of man and animal.

There is no doubt that transport is an unknown procedure for cattle which can be irritating and aversive. The most aversive factors are seen in loading and unloading, bad handling, inappropriate driving performance, poor road conditions, extreme weather conditions, insufficient ventilation, high stocking densities, mixing of unfamiliar animals in groups, deck height, lack of water and food, vibration, vehicle motion and length of the journey (Hartung et al, 2003). The space above the animals’ back is important for ventilation (Warriss et al, 1995). Ventilation of cattle vehicles is usually through apertures positioned along the sides. Air exchange through these apertures occurs by forced ventilation, from vehicle motion or wind, or by thermally induced ventilation generated by heat from the animals causing internal to external air temperature gradients. Thermally induced ventilation is always present, but forced ventilation may be intermittent; particularly for a stationary vehicle on an enclosed roll-on roll-off ferry deck (Randall and Patel, 1994). For a given vent area, reducing stocking density, and thus animal heat, reduces the ventilation rate resulting in an internal air temperature which is largely self compensating. A mechanically ventilated, livestock transport vehicle has been developed and tested by Kettlewell et al. (2001a,b). Extraction fans are located at regions of low external pressure on the moving vehicle to optimize performance in transit and provide a controlled throughput of air. The system provides air movement over all the animals and is independent of vehicle movement.

It is recommended that the height of the compartment should be at least 20 cm above the top of the head of each animal when it is standing in a comfortable position (SCAHAW, 2002). However, the position of the head is not known, because the behavior varies. A normal position might be the standing behavior as presented in Photo 1. According to CIGR (2003) the height dimension of cattle are defined as the height at the withers (Figure 1) which can be easily measured. It is generally accepted that animals must be able to stand in their natural position and all must be able to lie down at the same time. For animals, which may stand during the journey, the roof must be well above the heads of all animals when they are standing with their heads up in a natural position. This height will ensure adequate freedom of movement and ventilation and will depend on the species and breed concerned (SCAHAW, 2004, TRAW, 2009).The height of cattle varies considerately, which makes it difficult to specify a universally applicable minimum deck height in absolute terms, which makes it impossible for the official authority to control the height.

The driver of the vehicle is responsible for ensuring that the animals are provided with reasonable comfort and secure accommodation, this includes the height of the compartment. As explained previously the height is under discussion and might be lowered to accommodate the design of double decked trailers. When animals are too tall for the compartment, ventilation might be insufficient, the animal's back may be damaged or injured and behavior disturbed, all of which induce stress. To determine stress clinical, physiological (e.g. heart rate, body temperature), biochemical (e.g. cortisol, catechol amines, lactate, creatine kinase) and behavioral measurements (video observations) can be carried out both during short and long distance transportations (Broom, 2003). The objective of this study was to determine the space between the height of the cattle and the compartment ceiling to facilitate a comfortable standing position and sufficient ventilation. Examination was performed using physical, biochemical and behavioral measurements during commercial transports from a farm or assembly point to the slaughter house or assembly point.

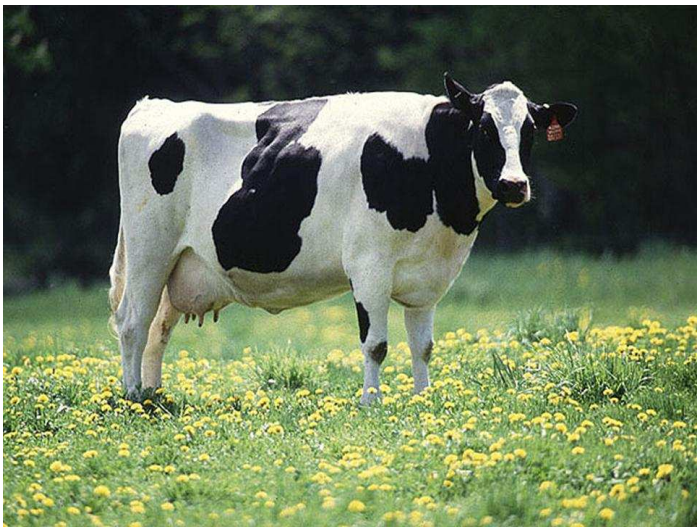

Photo 1 Friesian Holstein Cow

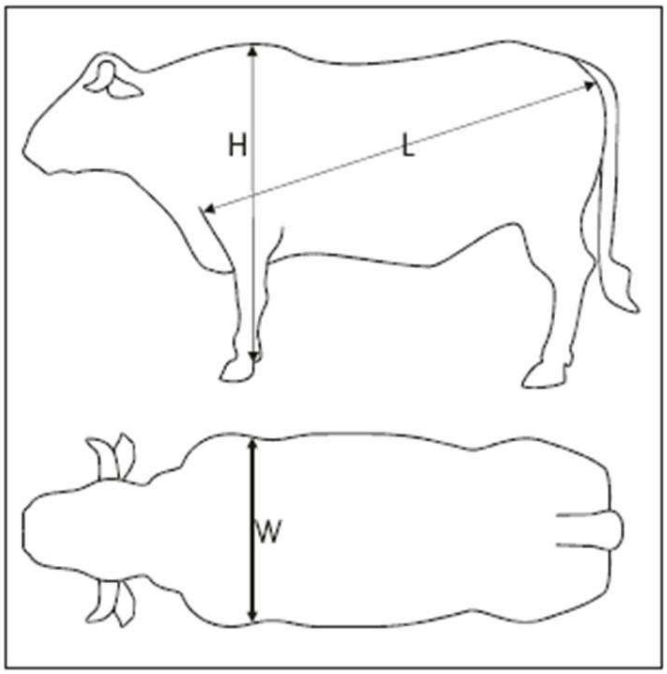

Figure 1 Body dimensions of cattle according to CIGR 2003

2 Materials and Methods

2.1 Experimental design

In total 7 short (approx. 2 h) and 1 long (approx. 26 h) cattle transportations were performed. Adult dairy cattle were transported from an assembly point in a double deck vehicle with natural ventilation to the slaughter house with ceiling settings of 10, 15 and 20 cm, respectively, above the withers of the tallest animal (Table 1). Available floor space was 9 m^2. Rosé veal calves were transported from a farm in a double deck vehicle with natural ventilation to the slaughter house with ceiling settings of 10, 15 and 20 cm, respectively, above the withers of the tallest animal. The height of trailer was limited, which for the journeys with calves this meant that the combination of 20 cm and 10 cm upper and lower or vice versa together with 15:15cm. The 20:20 variant was impossible to perform due to the height restriction (Table 1). Journeys with adult animals were performed on the lower deck with 6 animals in each compartment. The available floor space for pregnant heifers that were transported from an assembly point to an assembly point for further sea transport in a double deck vehicle was 15 m^2 with a ceiling permanently set at approximately 40cm above the withers of the tallest animal. The long transport vehicle (Cattle Cruiser) used for the pregnant heifers was equipped with artificial mechanical ventilation. The heifers had the ability to drink for the whole transport and were fed during an overnight stop (11 pm – 8 am) with hay. All animals are transported under commercial conditions. The driving schedule was: 11 hours transport with 2 stops of 1 hour, a resting period of 9 hours and again 7 hours with 1 stop of 1 hour.
Two video cameras were fixed in a frame in the corner under the roof in each compartment of the front trailer.

Before the transport the animals were placed one by one in a lairage pen in order to sample blood (tail vein), take the rectal temperature, measure the height at the withers and equip them with ECG electrodes. (Photo 5). Afterwards they were loaded on to the vehicle. After arrival at the destination (slaughterhouse or assembly point) the animals were unloaded and placed in a suitable lairage pen were blood (tail vein) was sampled, rectal temperature measured and the ECG logging device deactivated and removed. The logging data was stored on a mass data storage device for analyze later.

Photo 2 Trailer for cattle transport.

Photo 3 Trailer for rosé calves

Photo 4 Trailer for long distance transport of pregnant heifers.

2.2 Animals

Adult (un-horned) dairy cattle designated for slaughter (n=36) with a different age and breed supplied by 3 farms were delivered at an assembly point and used for the commercial transport. Six animals were transported in each of the 2 compartments one of the lower deck. The weight range was estimated between 450 – 750 kg. The ceiling of the compartment was set above the highest wither of an animal of the deck. Unfortunately, the video recordings of behavior failed during the first journey with the ceiling set at 20 cm above the withers and was therefore repeated later (Table 1).
Rosé veal calves (n=96) designated for slaughter (n=48) aged between 8 to 11 months and weighing approximately 200 - 250 kg were loaded at 3 different farms. They were transported on an upper or lower deck in 2 compartments containing 8 animals (Table 1). Pregnant (un-horned)heifers (n=40) destined for Northern Africa were transported from the Netherlands to Seté in southern France in 3 upper and 2 lower deck compartments. They remained in the familiar groups approximate live weight was 350 - 400 kg.
Blood was sampled from 3 animals per compartment and 7 animals (2 in front and rear upper and 3 in the lower compartments) were equipped with ECG (Table 1).

Table 1 Scheme of the animals followed during transport in a truck.

Adult dairy cattle						
Clearance above withers cm	20	20	15		10	
N	2 x 6	2 x 6	2 x 6		2 x 6	
Withers range cm	139 - 151	132 – 146	134 – 154		127 – 148	
Journey time h	2.15	1.25	1.48		1.54	
Distance km	80	84	95		95	
Rosé veal calves						
	Upper deck	Lower deck	Upper deck	Lower deck	Upper deck	Lower deck
Clearance above withers cm	10	20	15	15	20	10
N	2 x 8	2 x 8	2 x 8	2 x 8	2 x 8	2 x 8
Withers range cm	114 - 116	112 - 120	112 - 118	114 - 121	112 - 130	110 - 126
Journey time h	1.15		0.97		0.58	
Distance km	73		34		61	
Pregnant heifers						
	Upper deck		Lower deck			
Clearance above withers cm	40		40			
N	2 x 8		2 x 8			
Withers range cm	130 - 133		131 - 138			
Journey time h	27					
Distance km	1164					

2.3 Behavior

Animal behavior was continuously recorded with wide angle cameras (Sanyo Tc506CH) and digital video recorders. All but two compartments in the study were equipped with two cameras in the upper corners, one in the front and one in the rear. The remaining two compartments (in the trailer for pregnant heifers) had just one camera fitted. In general, the behavior of 2-4 animals nearest to the camera could be analyzed, and care was taken not to analyze behavior of the same animal from different views.
Behavior analyses for adult cattle and rosé veal calves started when the ceiling was in the right position and doors were closed at departure, until doors opened or ceiling raised at arrival. Behavior analyses for pregnant heifers on long distance transport were sampled during four 30 min observational periods: just after departure, before night stop, after night stop, and before arrival.

Video analyses were carried out with the aid of the software programme The Observer® (Noldus B.V., Wageningen, The Netherlands).
The ethogram used was:

Head butting	the animal butted or touched the ceiling with its head or nose other than exploration (duration)
Exploration	The animal sniffed at an object or in the air, sometimes followed by licking the object (duration)
Pushing	The animal pushed its body against another animal causing movement or displacement of the pushed animal (instances)
Movement	The animal moves voluntarily (instances)

Head butting and exploration are expressed as percentage of time per animal as recorded in the visible animals. Pushes and movements are expressed as count per animal per hour as recorded in the visible animals

Superficial skin damage was visually scored at the dorsal site of the animal before and after transport

2.4 Heart activity and temperature

Prior to loading 2 animals per compartment were equipped with ECG electrodes covered with surgical tape on the electrode leads and an elasticated belt around the body which contained a leather pouch to hold the logging device in position (Photo 5). This belt was secured with heavy duty duct tape. The measuring equipment (data logger) used was specially designed by the Royal Veterinary College in London (Lowe et al, 2007). This data logger was housed in a steel box and placed in the leather pouch attached to the belt. Before positioning the band and the electrode pads the skin was shaved, cleaned with 70^{o} alcohol and surgical glue was applied to secure the electrode pads to the surface of the skin. The ECG electrodes were placed caudal the olecranon on both sites of the breast. The earth electrode was placed on the breast dorsally to the right electrode. Recording started immediately after a data logger was installed and terminated upon arrival at the destination but after a blood sample had been taken and the rectal temperature had been measured. The ECG was analyzed for heart rate in beats per minute.
Rectal temperature was measured before loading and after unloading using an Hg device.

2.5 Blood parameters

In addition to the animals from which ECG recordings were made, three or four animals were selected at random from a group to be transported in a compartment, fastened with a rope holster and blood was sampled from the vena in the tail (*V.caudalis media*) (70 µm). Blood was also sampled after unloading in heparinised tubes. Directly after sampling the blood was analyzed using an ABL80 Flex (Radiometer Medical ApS Brønshøj, Denmark)

The following parameters were analyzed:

pH	acidity or alkalinity of the venous blood
pCO_2	pressure of carbon dioxide in the venous blood
pO_2	pressure of oxygen in the venous blood
sO_2	saturation of oxygen in the venous blood
BE	base excess (indication of acidity /alkalinity in the blood))
Hb	hemoglobin content
Ht	hematocrit
glucose	level of glucose in the venous blood

Photo 5 Cow equipped with ECG electrodes

2.6 Ethics

The experiment was approved beforehand by the Ethical Committee of the Animal Sciences Group of Wageningen UR.

2.7 Data analyzes

Behavioral data (total time activities) was analyzed according to REML variance analysis and individual events (e.g. head butting) with a generalized linear mixed model. REML variance analysis was used for analysis of body temperature and blood parameter data.
The behavioral data were analyzed using an ANOVA and a GLM (Genstat, 2010).

3 Results

3.1 Behavior

Comparison of behavior in adult dairy cattle and rosé veal calves revealed that adult cattle head-butted the ceiling for longer periods ($P < 0.001$) than rosé veal calves did. Moreover adult cattle move less ($P < 0.001$) than rosé veal calves during transport (Table 2), where the stocking density was calculated at approximately 1.1 and 1.5 m^2/animal, respectively. At a ceiling height of 15 and 20 cm above the withers adult cattle touched the ceiling more than at a ceiling height of 10 cm above the withers and moved and pushed less. Rosé veal calves tend to touch the ceiling less when the ceiling is at a higher level, however this phenomenon was not observed on the lower deck when the ceiling was at 10 cm above the withers. When the ceiling was above 10 cm they explored, moved and pushed more.
No additional superficial skin damage was observed after transport.
Pregnant heifers touched, explored, moved and pushed less and the stocking density was calculated to be approximately 1.8 m^2/animal

Table 2 Behavior of adult cattle rosé veal calves and pregnant heifers during transportation with ceiling set 10, 15, 20 or 40 cm above the withers of the tallest animal.

Ceiling height cm		Head butting % time	Exploration % time	Movement n/h	Pushing n/h
		Adult dairy cattle			
	10	4.6	14	48	11
	15	6.0	23	10	3
	20	9.8	1	3	3
		Rosé veal calves			
upper	10	0.4	8	72	9
	15	0.2	16	71	9
	20	0.1	16	84	16
lower	10	0	10	100	15
	15	0.3	17	117	28
	20	0.1	30	83	16
		Pregnant heifers			
	40	0	4	9	3

3.2 Heart activity and temperature

Heart rate and body temperatures are presented in the Figures 2, 3 and 4 and Table 3. Heart rate increased in both adult cattle (Figure 2) and rosé veal calves (Figure 3) during loading and decreased as transport commenced. The rectal temperature increased slightly during transport, however not in all cases, and remained within normal values. However it was observed that calves had on average a higher basal temperature than adult cattle.

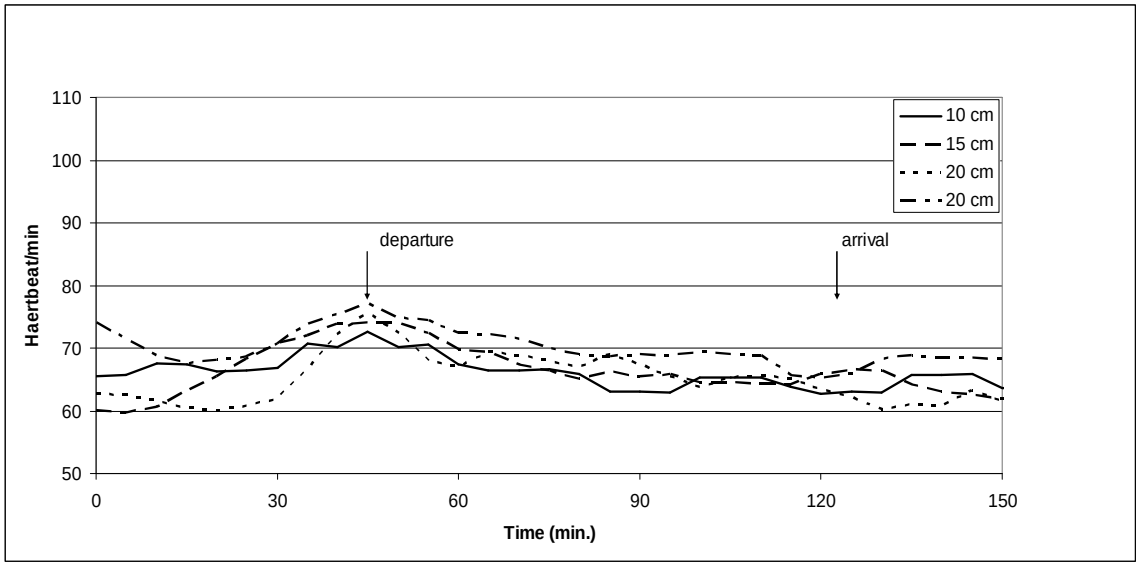

Figure 2 Average heart rate (beats/min) adult dairy cattle before and during transport with the ceiling set 10, 15 or 20 cm above the withers.

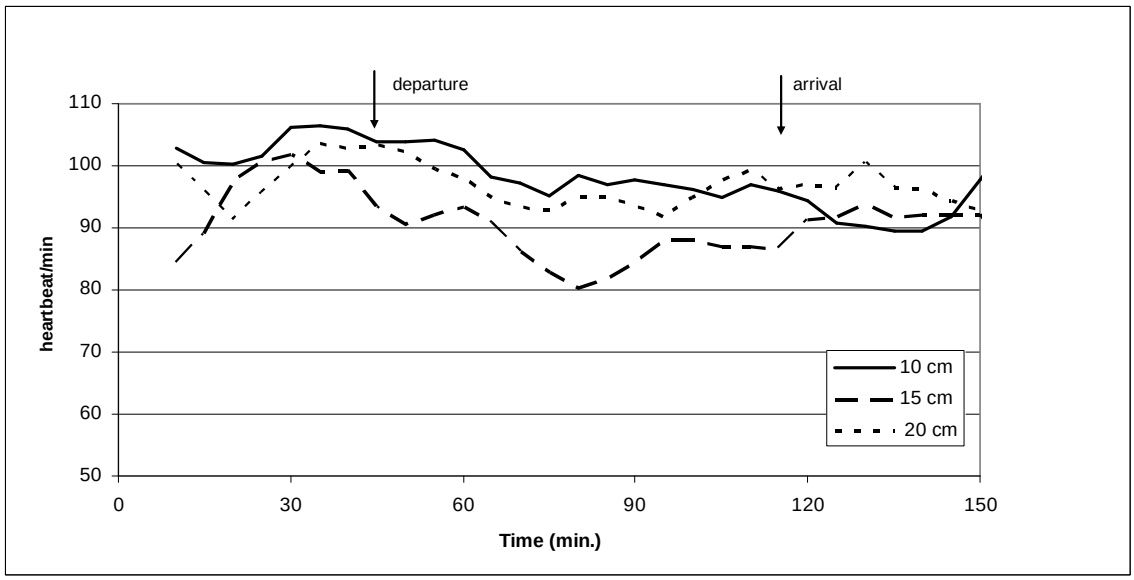

Figure 3 Average heart rate (beats/min) of rosé veal calves before and during transport with the ceiling set 10, 15 or 20 cm above the withers.

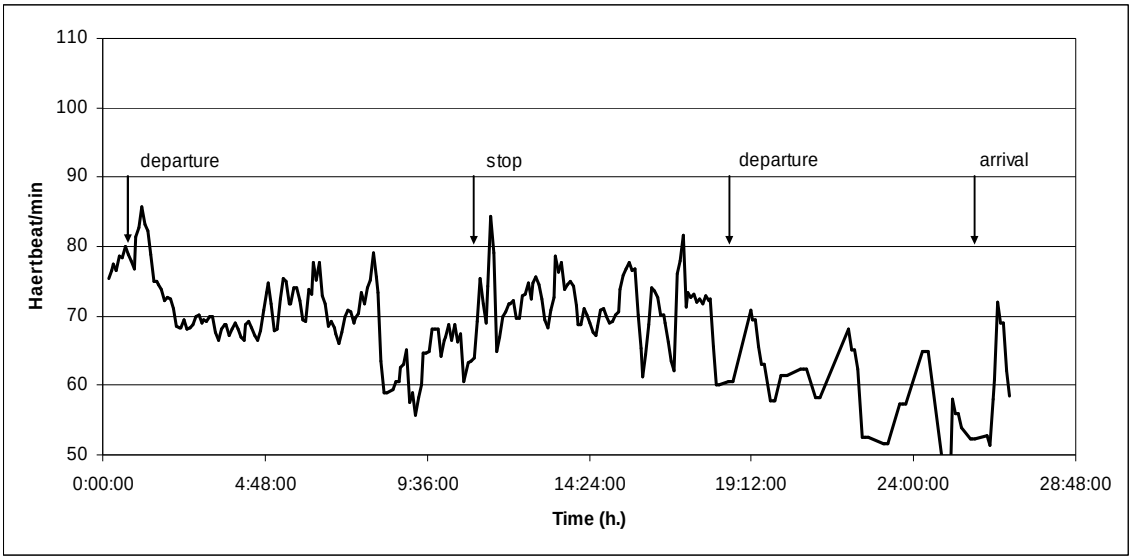

Figure 4 Average heart rate (beats/min) of pregnant heifers before and during transport with the ceiling set 40 cm above the withers.

Table 3 Rectal temperature (mean ± SD) of adult dairy cattle rosé veal calves and pregnant heifers before and after transportation. Outside temperature before and after transport.

Ceiling height cm	10	15	20	20
		Adult dairy cattle		
Rectal °C				
before	38.2 ± 0.7	38.3 ± 0.3	38.3 ± 0.1	38.0 ± 0.5
after	38.5 ± 0.2	38.3 ± 0.3	38.4 ± 0.5	38.2 ± 0.3
		Outside Temperature °C		
before	10	11	10	22
after	11	12	11	25
		Rosé veal calves		
before	39.0 ± 0.3	38.8 ± 0.3	38.9 ± 0.3	
after	39.5 ± 0.6	39.3 ± 0.3	39.3 ± 0.4	
		Outside Temperature °C		
	4-8	7	4-8	
	4-8	7	4-8	
		Pregnant heifers[1]		
before				38.6 ± 0.4
after				38.6 ± 0.4
		Outside Temperature °C		
before				16
after				21

1: Ceiling height pregnant heifers 40 cm

3.3 Blood parameters

The results of the blood parameters before and after transport are presented in Table 4. Blood Ht levels appeared to differ significantly due to treatment (P<0.05). However this was compounded due to a lower base level (on-farm) for the 15 cm group (all from taken from one farm). Blood glucose levels were significantly higher in rosé calves (P<0.05). Although no significant effect was observed due to treatment. This once again was confounded by farm of origin (same as above). Hemoglobin levels differed significantly between treatments (P<0.05). This observed as increases in Hb during transportations at 10 and 20 cm while transportations with the ceiling set at 15cm displayed a significant decrease. However, these results are once again confounded by animal type. Calves displaying increased Hb levels and adult cattle displaying decreases in Hb during transport. Source of the calves was once again influential.

Table 4 Blood parameters (mean ± SD) of the cattle measured before (B) and after (A) transport

		Adult dairy cattle				Rosé veal calves			Pregnant heifers
Ceiling height cm		10	15	20	20	10	15	20	40
		N=8	N=8	N=8	N=12	N=13	N=14	N=12	N=15
pH	B	7.45 ± 0.05	7.51 ± 0.11	7.50 ± 0.05	7.49 ± 0.04	7.50 ± 0.13	7.45 ± 0.04	7.43 ± 0.08	7.48 ± 0.05
	A	7.46 ± 0.04	7.51 ± 0.07	7.49 ± 0.04	7.50 ± 0.06	7.46 ± 0.04	7.41 ± 0.05	7.45 ± 0.04	7.46 ± 0.06
pCO2	B	42 ± 7	39 ± 10	39 ± 7	38 ± 5	43 ± 5	42 ± 4	47 ± 10	38 ± 6
mmHg	A	42 ± 6	38 ± 5	39 ± 4	37 ± 7	44 ± 3	46 ± 5	45 ± 4	39 ± 7
pO2	B	63 ± 35	75 ± 31	84 ± 35	71 ± 38	83 ± 26	75 ± 27	75 ± 40	78 ± 29
mmHg	A	69 ± 45	102 ± 58	88 ± 33	85 ± 29	67 ± 31	52 ± 27	57 ± 23	76 ± 30
sO2 %	B	82 ± 17	91 ± 12	89 ± 18	83 ± 20	94 ± 8	92 ± 7	82 ± 27	90 ± 14
	A	81 ± 16	91 ± 12	91 ± 15	90 ± 19	84 ± 20	76 ± 17	83 ± 14	89 ± 13
BE	B	4.9 ± 2.8	6.9 ± 3.1	6.5 ± 3.2	5.2 ± 1.6	7.4 ± 3.2	4.2 ± 1.6	4.5 ± 2.2	4.3 ± 2.2
mmol/l	A	5.0 ± 3.4	6.9 ± 3.3	6.2 ± 2.7	5.3 ± 1.5	6.3 ± 2.0	3.5 ± 1.5	6.3 ± 0.9	3.0 ± 3.4
Hb	B	13.6 ± 6.7	8.8 ± 0.3	10.3 ± 1.7	6.6 ± 2.7	9.2 ± 1.1	7.0 ± 1.2	9.8 ± 1.6	9.5 ± 0.8
mmol/l	A	8.8 ± 1.5	10.6 ± 1.1	8.3 ± 2.1	5.0 ± 1.5	9.2 ± 0.8	10.1 ± 1.2	9.0 ± 0.8	8.4 ± 1.4
Ht %	B	63 ± 35	27 ± 1	32 ± 5	31 ± 4	28 ± 3	22 ± 4	30 ± 5	29 ± 2
	A	69 ± 45	33 ± 3	26 ± 6	29 ± 3	28 ± 3	31 ± 4	28 ± 2	26 ± 4
Glucose	B	4.8 ± 0.5	5.0 ± 0.5	5.1 ± 0.5	6.6 ± 2.7	5.4 ± 1.4	7.0 ± 0.6	5.8 ± 0.5	4.1 ± 0.3
mmol/l	A	5.2 ± 0.8	5.7 ± 0.5	5.5 ± 0.8	5.0 ± 1.5	6.0 ± 0.4	6.7 ± 0.4	5.9 ± 0.6	4.6 ± 0.6

4 Discussion

The major factors determining the welfare of farm animals during road transport are vehicle design, stocking density, ventilation, standard of driving and quality of the road (Broom, 2008). Ease of movement, the ability of animals to turn round, groom, get up, lie down and stretch their legs or wings, has long been considered a basic prerequisite for good welfare (Brambell Committee, 1965). These movements are part of the behavioral repertoire of all species, and animals are highly motivated to perform them. Stocking density has an important influence on ease of movement and preventing falls. Earlier work has shown that animals at higher stocking densities display lower heart rates and movement scores than at lower stocking rates. Also, animals in smaller rather than larger pens had lower heart rates (Eldridge et al., 1988). Loss of balance on moving trucks has been shown to be accounted for by driving events. Three quarters of losses of balance were associated with braking, cornering and situations when two driving events coincided (Kenney and Tarrant, 1987a,b).
When the ceiling was set at higher levels above the withers rosé veal calves explored, moved and pushed more in time, which means that they have more freedom of movement related a lower stocking density. Petherick & Phillips (2009) have applied allometric equations for stocking densities and recommended 0.9 and 1.2 m^2/animal. During the journeys in our study stocking densities were rather low i.e. for rose veal calves, adult cattle and heifers at 1.1, 1.5 and 1.8 m^2/animal, respectively. An additional behavioral aspect is that cattle tend to avoid contact with other individuals when they are able to maintain their balance (Broom, 2008). It was observed that adult cattle raised their heads and touched the ceiling for significantly longer periods ($P<0.001$). The frequency of sniffing of a novel object, the number of times the head was recorded in an upright position and the frequency of vocalizations were negatively correlated with the reference measurement in the test room and are thus considered as expressing low levels of fear (Boissy & Bouissou, 1995). Cows are considered to be more vigilant when their heads were raised than when their heads were lowered. It has been observed that cattle were found to be more vigilant in novel locations (Welp et al., 2004). Loose animals experienced more events in the vehicle than tied animals, which was not a surprise because loose animals have more freedom of movement (Wikner et al., 2003). This may also be the case when they have more space above their heads, as in our study. Pregnant heifers stand in the position they prefer when loose and with sufficient space (Lambooy et al, 1988). Pregnant heifers remained quiet and calm during the whole journey. This may have been helped by the fact that they remained in the familiar groups and have sufficient space.

According to EU regulation (Council Regulation (EC), 2005) animals must be able to stand in their natural position and all must be able to lie down at the same time. For animals, that tend to stand during the journey, the ceiling must be set well above all the animals when they are standing with their heads up in a natural position. This headroom will ensure adequate freedom of movement (SCAHAW, 2004). However, it remains unclear from this statement, how the height of the animal is determined. One definition of the height of cattle is taken as the height at the withers (CIGR, 2003), which is the height we used as reference in this experiment. The range in height can vary between animals as seen in our measurements (Table 1). Therefore it is recommended to determine the height of the deck or compartment as the space between the withers of the tallest animal per deck. Recommendations indicate this to be influenced by species and breed (SCAHAW, 2004). When the ceiling was set 10 cm above the withers no skin damage was observed. Holleben et al., (2003) observed more and severe bruising when the space above the animals was small i.e. 10 cm. To prevent mounting the height was fixed at 10 cm above the withers, which increased the bruising at tail and back for bulls and at tail and perianal positions for heifers. It was concluded (Holleben et al., 2003) that during transport and lairage the ceiling should not be fixed lower than 20 cm above withers.

Most of the changes in body variables during animal transportations result from loading, unloading and handling. During assembly of cattle prior to transport animals will be exposed to numerous stimuli that could potentially prove stressful: unfamiliar cattle; confinement in yards; novel food delivered in a novel way; and novel-tasting water delivered in novel ways. The sudden loading and confinement of animals into a vehicle is an unusual exercise. Other stress factors acting upon the animals just before transportation include the rough road along which the animals are chased and prolonged standing of the animal while awaiting the vehicle or its departure. All these deleterious factors acting simultaneously make the journey right from the onset very stressful to the animals (Knowles et al., 1999; Hartung, 2003; Minka and Ayo, 2007a; 2009). Elevated rectal temperature is a very good indicator of thermal stress. In our experiments the rectal temperature remained within the normal values (Table 3), where these values are 38.6 ± 0.5^{o}C. Although calves displayed on average a

significantly higher temperature (39.1 vs. 38.3: $P<0.05$), no significant treatment effects were observed in body temperature levels. In addition, the heart rate increased during loading (Figures 2, 3, 4), which is an indication of increased exercise and stress. Heart rate increased from approximately 80 to 110 beats/min in calves, from 80 to 140 beats/min in pregnant heifers and 60 to 75 in adult cattle. These figures are in agreement with other studies where the increase in heart rate was suggested to be associated with stress (Holleben et al, 2003). Each measurement has to be evaluated concerning whether or not the information acquired differs from baseline measurements. Small effects e.g., a 10% increase in heart rate (Broom et al., 2003) can indicate a considerable effect which means an event such as loading has a great effect which was also the case in our experiments.

Mitchell et al (2010) developed a remote physiological monitoring system for livestock in production and transportation. Deep body temperature was elevated and heart rate increased in calves during transit. Studies on the assessment of stress during animal transportation require non-invasive methods because classical approaches to data collection with direct human interference (i.e., blood collection and heart-rate measurement) might directly alter the stress response. A non-invasive method was used for heart rate (Lowe et al., 2007), however blood collection was invasive. In this study blood samples were taken before and after transportation.

Provision of ventilation during livestock transport, including cattle vehicles, is usually through apertures positioned along the sides of the vehicle. Air exchange through these apertures occurs by forced ventilation, from vehicle motion or wind (EFSA, 2004; Villa et al., 2009). According to the EC regulation 1/2005 the minimum air flow rate of fans should have a minimum capacity of 60 m^3/h per 100 kg live weight. Ventilation is also important in limiting and reducing the levels of ammonia from feces and urine and carbon dioxide from exhalation inside the vehicle. Wikner et al. (2003) could not determine any hazardous increases of these gases during Swedish commercial cattle transportations in winter or summer. In our study blood Ht levels appeared to differ significantly due to treatment ($P<0.05$). However this was compounded due to a lower base level (on-farm) for the 15cm group (all from taken from one farm). This may indicate some difference in on-farm circumstances (i.e. management, feeding).Blood glucose levels were significantly higher in calves ($P<0.05$). Although no significant effect was observed due to treatment. This once again was confounded by farm of origin (same as above).

5 Conclusions and recommendations

- Adult dairy cattle displayed more explorative behavior when the ceiling was set at 20 cm above the withers. Rosé veal calves displayed more explorative behavior, moved and pushed more, indicating a greater freedom of movement enabling them to exhibit their natural behavior.
- Adult dairy cattle were in contact with the ceiling for a much longer period of time, independent of the height of the compartment than rosé veal calves did.
- The height of cattle is defined as the height at the withers, which was the height as used in this experiment. The range in height varies considerably between animals. No superficial skin damage was observed after transport.
- As observed in other studies, heart rate increased strongly during loading which is an indication of increased exercise and stress. The heart rate decreased as transport commenced.
- Elevated rectal temperature is the best indicator of thermal stress. In our experiments the rectal temperature was not affected by treatment. However it was observed that calves had on average a higher basal temperature than adult cattle
- The combination of sufficient height - (40 cm space between shoulder and ceiling) - floor space and rest, feeding and watering with familiar animals may result in quiet and fit animals during (long duration) transport.

It recommended to

- allow them to move partly their behavioral repertoire and minimize touching the ceiling, which might be possible with a space between the height of the shoulder and the ceiling of more than 20 cm,
- set the withers of the tallest animal in the compartment as the height of the animals,
- keep animals fit by sufficient space and rest, feeding and watering with familiar animals,
- initiate research to examine the minimum space between the shoulder and ceiling of the compartment.

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