Chapter 4
Horses

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Abstract

Horse slaughter and the consumption of horsemeat occur worldwide. It is remarkable that there is no evidence of a direct relationship between horse slaughter and horse meat consumption within different countries. For example, horses are slaughtered in Canada and South America, and their meat for human consumption is exported to Japan or Europe. In contrast to the transport of sport and recreational horses, commercial transport of horses, especially slaughter horses, has been studied to a lesser extent. However, it is clear that road transport of horses for slaughter is a complex operation which includes pre-transport handling, loading, transport itself, unloading and lairage. For welfare reasons, the transport must be carried out with the utmost care to induce as little stress to the horses as possible. In the drive to optimise animal welfare, meat quality often improves as well. The welfare of these horses must always be optimal no matter what the final destination of their journey is. Before horses are transported, individual fitness for travel should be determined. Although the practical guidelines on fitness for travel vary from country to country, the general recommendation is not to transport unfit horses. The infrastructure at the loading site and the expertise of the handlers determines the ease of loading and the level of stress experienced by the horses. Several stressors during the transport process influence both behaviour and welfare, for example the skilfulness of the driver, the loading density, duration of journey, vehicle design and internal environmental conditions. In addition, after arrival at the slaughterhouse, the handling during unloading, lairage conditions and stunning and slaughter can have a significant impact on stress and horse welfare.

Keywords: fitness for travel, loading, stunning, transport, unloading

4.1 Introduction

In certain cultures and geographic areas and for many millennia, horses have been and still are a source of red meat suitable for human consumption. Horse bones found at Solutré in France and cave paintings in Lascaux show that Ice Age hunters regularly ate horses (Peeters, 2020). In some European countries, horses were used as food source in periods of war, poverty and famine. Although there was not a previous tradition of horsemeat consumption, the high cost of food products during the French Revolution induced the people to consume horsemeat (Stanciu, 2015). Horse meat consumption became popular in Europe after World War II, due to low availability of beef meat resulting in increased slaughter of draught horses supplying more affordable meat (Padalino, 2015). Around 1960, prosperity following World War II increased and industrialisation and mechanisation made horses, all but obsolete for farm work and transportation. Ever since, the horsemeat industry has been slowly shrinking (Peeters, 2020).

According to FAOSTAT (http://www.fao.org/faostat/en/#data/QL), the number of horses slaughtered in the USA, Australia and Europe has been decreasing strongly since the last decade. But, even so, around five million horses are still slaughtered annually worldwide from an estimated global population of 59 million. China currently slaughters the most horses worldwide, around 1.47 million heads, while the USA owns the largest stock of horses, estimated at 10.7 million heads. After the prohibition of horse slaughter in the USA in 2007, the number of horses transported and slaughtered in Canada and Mexico has increased radically (Stull, 2012; Taylor and Sieverkropp, 2013). This made Mexico the third largest producer of horse meat in the world after China and Kazakhstan (http://www.fao.org/faostat/en/#data/QL). In 2019, the total horsemeat production was reported to be 752,000 tons (http://www.fao.org/faostat/en/#data/QL). It is clear that horse slaughter and consumption of horsemeat occurs worldwide. It is therefore remarkable that there is no direct relationship between horse slaughter and horsemeat consumption within individual countries. For example, horses are slaughtered in Canada and South America, but processed meat for human consumption is exported to Japan or Europe. In Central Asia, horse meat is part of the traditional diet, while some European or African regions consider horse meat a delicacy (Garifulovich *et al.*, 2013).

Horse meat is known to contain a high protein and mineral content, and is especially high in iron (Banu, 2009), and low contents of intramuscular fat (Palenik *et al.*, 1980) and cholesterol (Robelin *et al.*, 1984). It is also characterised by a very dark red colour and yellow fat (Stanislawczyk and Znamirowska, 2005) and presents a slightly sweet taste which is caused by the high content of carbohydrates, and in particular, intramuscular glycogen (Rødbotten *et al.*, 2004; Stanislawczyk and Znamirowska, 2005).

Similarly to other livestock species, for welfare reasons and an optimal horse meat quality, horses should undergo as little stress as possible to prevent from bruises and/or injuries (CATGP, 2018; Marlin *et al.*, 2011; Pawshe *et al.*, 2016). Preslaughter stress is caused by suboptimal environmental temperature and relative humidity, gas concentrations (ammonia, carbon monoxide and dioxide), inappropriate infrastructures (e.g. poor lighting, sharp protrusions and too narrow corridors), social interactions (e.g. fighting for the determination of dominance rank in unfamiliar groups), and transport and handling activities, such as loading, unloading and the transport itself, and weighing (Nivelle *et al.*, 2020).

In the past few decades, the circumstances in which horses are transported has resulted in public concern and discussion, more specifically the transport of slaughter horses (Marlin *et al.*, 2011; Nivelle *et al.*, 2020; Vermeulen *et al.*, 2019). While transport conditions of sport and recreational horses and their responses to transport stress are well studied (Leadon *et al.*, 2008; Marlin *et al.*, 2011; Nivelle *et al.*, 2020), a limited number of studies deals with horses destined for slaughter (Collins *et al.*, 2000; Iacono *et al.*, 2007a; Marlin *et al.*, 2011; Nivelle *et al.*, 2020; Werner and Gallo, 2008). In addition, most studies about loose travelling horses deal with healthy horses that are used to being loaded and transported (Friend *et al.*, 1998; Friend, 2000).

There are two types of horses intended for slaughter: on one hand, extensively kept in feedlots (in USA and South America) naïve horses (Nivelle *et al.*, 2020; Roy *et al.*, 2015a) and, on the other hand, cull animals from the work and recreational groups (Houpt and Wickens, 2014). These latter horses are sent for slaughter when they have reached the end of their productive use as recreational or sport horse (Lenz, 2009) and are commonly culled due to muscle-skeletal and chronic disorders (Ireland *et al.*, 2012; Jonsson *et al.*, 2013). Most of these horses are collected by dealers from multiple sources or from auctions and markets to accumulate sufficient horses to form a load to be shipped to a slaughter plant.

Both groups are generally loaded onto the truck in loose groups (Houpt and Wickens, 2014) and are transported by road or, although to a much lesser extent, by rail (Marlin *et al.*, 2011), by sea (Cavallone *et al.*, 2002; Stull, 2001) or by air (Harper, 2017). Therefore, this chapter focuses on road transport of slaughter horses.

4.2 Pre-transport handling

4.2.1 Fitness for travel

The preparation for the transport procedure starts with the selection of fit animals in order to optimise welfare during and after transport as horses in good physical condition can better cope with transport stress (Vermeulen *et al.*, 2019). Except for transport to a veterinary centre, unfit horses should not be loaded onto a vehicle as they hardly keep their balance on a moving vehicle and require more physical effort, resulting in an earlier onset of fatigue (Vermeulen *et al.*, 2019). In addition, weak, lame or debilitated animals are difficult to handle in a low stress manner (Grandin, 2014a). Many countries have described the fitness for travel requirements in legal regulations (Vermeulen *et al.*, 2019). Although they differ from country to country, according to all legal regulations, it is evident that sick, injured, weak, disabled, or fatigued horses are not to be loaded and transported (Australian Animal Welfare Standards and Guidelines, 2021; European Regulation 1/2005; http://www.oie.int/international-standard-setting/terrestrial-code/accessonline/; TQA, 2011). In addition, horses that cannot stand steadily or cannot walk without pain are not allowed to be transported. Low body condition can also be a feature on which to declare fit or not for travel, especially when the body condition would result in poor welfare because of the expected climatic conditions during transport (http://www.oie.int/international-standard-setting/terrestrial-code/accessonline/; Vermeulen *et al.*, 2019). Miranda-de La Lama *et al.* (2021) suggest nasal discharge, lameness and ocular discharge as key indicators to define fitness for transport and to integrate these criteria in a monitoring tool to measure welfare of slaughter horses. A checklist of nine animal parameters to determine the fitness for travel is described by CATGP (2018). Each regulation also defines that each horse must be inspected by an animal handler, a veterinarian or another person in charge. The person in charge not only must assess the fitness for travel of each equid, but must also take into account other circumstances, such as the weather and the transport distance, in which the horse will be transported.

However, the requirements to declare the animal as fit for transport are sometimes too vague and debatable. For example, the terms 'weak' or 'injured' are not defined and it is not clear what depth of a wound would be considered to render a horse unfit for transport. Because of these concerns, Vermeulen *et al.* (2019) launched a call for a more detailed description around fitness for travel requirements to exclude subjective interpretations.

4.2.2 Hydration and feed withdrawal

Horses must be sufficiently hydrated before departure, irrespective of whether they come from a farm, auction, market or assembly centre. According to Messori *et al.* (2016), water provision before transport is even more preferable than during transport considering the issues in watering horses in a moving truck (see later in this chapter).

While sport and recreational horses are often allowed to eat hay during transport, slaughter horses usually are not fed during transport. To our knowledge, it is not known how long or whether it is necessary to fast slaughter horses before loading and during transport. The application of fasting reduces the risk of soiling and resulting meat contamination (Padalino, 2015). However, it is questioned if fasting before transport is a necessary practice as it may significantly compromise gastrointestinal function and lead to an increased risk of gastric squamous ulceration and colic (Padalino *et al.*, 2020). These findings suggest that horses should have access to forage until the time of loading to decrease the contact between the squamous mucosa and gastric secretions or small intestinal reflux (Padalino *et al.*, 2020).

4.2.3 Regrouping

Regrouping horses before loading is not an uncommon practice to form groups adapted to the size of the vehicle. Regrouping can be done just before loading or a few days before loading at the farm or collection centre. However, mixing groups disturbs the social cohesion between the horses in the original groups (Van Dierendonck and Spruijt, 2012) and may result in fighting (i.e. biting and kicking) to establish a social hierarchy and bruises on the carcass (Houpt and Wickens, 2014), especially in loose transported groups. During the journey, aggression between horses in mixed groups may lead to sudden head movements and difficulty in balancing resulting in a higher risk of the head striking against the interior of the vehicle (Roy *et al.*, 2015b). Furthermore, regrouping can interfere with the loading of the horses because stressed animals within the groups are more difficult to handle. Regrouping usually looks at the negatives of transporting animals in groups, but there is very little evidence showing that transporting equines together is the correct practice. For example, unhandled youngsters display anxiety when not transported in a group and for this reason their individual transport is not recommended (Knowles *et al.*, 2010).

As social animals, the more nervous and agitated horses can affect their neighbours in the vehicle. According to Saslow (2002) and McGreevy (2012) anxiety and arousal can be socially transmitted to herd mates. This should be taken into account when mixing horses with different temperaments and travel experiences (Broom and Johnson, 1993; Fazio *et al.*, 2013). The temperamental horses should be isolated and should be kept separate in the transport vehicle (European Regulation 1/2005; http://www.oie.int/international-standard-setting/terrestrial-code/accessonline/).

4.2.4 Loading

Loading onto a vehicle is the most stressful procedure for both naïve and for experienced horses (Casamassima *et al.*, 2008; Friend *et al.*, 1998) as they are taken out of their familiar surroundings and are confronted with alleys, pens, trailers, limited visual and physical space and interactions with the handlers, all causing a stress response, with effects lasting up to slaughter (Terlouw *et al.*, 2008). This stress response is showed by the greater average heart rate recorded at loading than during transport. The increase in heart rate is caused on one hand by the physical exertion in climbing the ramp, but predominantly by the emotional fear experienced during loading (Waran, 1993).

Loading horses in groups may be easier than loading individual horses as they are herd animals and usually maintain visual contact copying one another and keeping social cohesion (Houpt and Houpt, 1998; Mal *et al.*, 1991). Anyway, when moving horses either in a group or singly stalled, the nature of horses must be taken into account. Horses are driven by a very strong flight response (reactive running) showing blood adrenaline levels around 10 times higher than in humans in stressful situations (Fraser, 2010; Snow *et al.*, 1992). Horses are frightened by sudden and unfamiliar sounds and visual impressions to which they can react by stopping, retreating, stepping or jumping aside, moving backwards, or bolting (Ekesbo and Gunnarsson, 2018).

This response is even greater in slaughter horses that, differently from sport or recreational horses, are either not or barely familiar with transport. Regular loading or transport can be considered as training or conditioning and would facilitate easier and more rapid loading (Fraser, 2010). According to Grandin (1989), there is a correlation between the animal's previous experience with handling and its reaction to handling in the future.

4.2.4.1 Loading facility design

A good loading dock design, featuring a loading ramp, prevents distress, excitement and injury and decreases the time to load the horses (CATGP, 2018; European Regulation 1/2005; Horse Meat Federation, 2016). Ideally, the loading dock/ramp should be level with the floor of the vehicle deck. However, in practice, it is not common to have such a loading facility. There are two ways to overcome the difference in height between the ground and the vehicle deck. Loading can be done by a ramp built into the vehicle or by a stand-alone ramp at the loading place. Loading ramps can be made from wood, concrete, steel or even an earthen raised bank can be used.

The slope of the ramp should not exceed 36.4% (or 20°), but good practice demands a maximum slope of no more than 10° (17.3%; CATGP, 2018). A ramp with a steep angle will induce an elevated heart rate and cause stress (Tateo *et al.*, 2012). If the ramp is steeper than 10°, it should be equipped with stair steps or foot battens reducing the risk of slipping (European Regulation 1/2005; Grandin, 2015a; Horse Meat Federation, 2016). The stair steps should rise a maximum of 10 cm and have a length of 30 cm. In each step two grooves with a minimum of 2.5 cm depth should be made. Wooden or steel cleats can also be used, although placing cleats too far apart can cause slipping, whilst placing cleats too close together will result in hooves sliding over the top of the cleats. Cleats should have a dimension of 5 cm x 5 cm (Grandin, 2015a), 25 mm high and spaced at 20-35cm (SCARM, 2002).

According to Grandin (2015a) a ramp design is inadequate and must be improved if more than 1% of horses fall at loading. To prevent horses from slipping mud on the ramp should be removed and in case of concrete ramps sand or gravel can be used (Nivelle *et al.*, 2020).

Reflections in standing water at the loading place can make horses hesitant and make it more difficult to load (Grandin, 2015b). Sometimes when horses step on a metal ramp, they can be frightened by the noise and flee. In this case, a rubber mat or some sand can be used as it buffers the hollow sound of the ramp when a horse steps on it (Nivelle *et al.*, 2020; Weeks *et al.*, 2012).

To prevent an attempt to escape or falling off, side walls should be placed at each side of the ramp (Fraser, 2010). Side walls limits the distraction of the horses by activities in the near environment and also prevent escape attempts due to the blocked vision of the horses. As an indirect result the ease of loading will increase (as showed by less baulking and less reluctant to move forward) and the loading duration will be shorter (CATGP, 2018; European Regulation 1/2005; Horse Meat Federation, 2016; Nivelle *et al.*, 2020). Nivelle *et al.* (2020) registered an average loading duration of 30 s per horse with a standard deviation of 15 s which indicates a considerable variation in the speed of loading in practical conditions.

The vehicle entry is also an issue. There are two types of entries, i.e. the trapdoor (Figure 4.1) and the broad tail gate. The trapdoors allows the horses to enter the vehicle one after the other, while when using a broad tail gate, two or three horses can be loaded side by side. The height of the

Figure 4.1. South American vehicle for horse transportation featuring a trapdoor entry (B. Driessen, Research, Control & Consult, Belgium).

trapdoors requires consideration because too low trapdoors result in head bumping. The risk of head-bumping is greater in stressed horses that keep their head high (Nivelle *et al.*, 2020). However, closing trapdoors is easy to do, but raising a tail gate can cause a dangerous situation. The latching mechanism should be easy to close to avoid injuries of the handlers when the horses are bumping into the door and the tail gate would open (Houpt and Wickens, 2014). Inexperienced horses can be difficult to load because the vehicle gives them a feeling of enclosure. In that case an open-top type of vehicle can encourage a horse to enter because it creates the illusion of openness or a potential exit (Fraser, 2010).

Horses are reluctant to enter darkened passageways (Ekesbo and Gunnarsson, 2018; Houpt and Wickens, 2014), although they have the capability for both nocturnal and diurnal vision (Ekesbo and Gunnarsson, 2018). Lighting the interior of the vehicle can help loading as, similarly to other livestock species, horses have a tendency to move from a darker to a brighter area (Grandin, 1989), provided that the light does not shine directly in their eyes. Neveux *et al.* (2017) found that if the LED light inside the trailer was stronger than outside, the horses needed significantly less time to enter the trailer. Cross *et al.* (2008) noticed that horses loading from a lit arena to a dark trailer sniffed the ground more, showing increased exploration of their environment. According to the findings of Neveux *et al.* (2017), on non-cloudy days a light intensity above 4,500 lx would be needed to load the horses into the trailer. There are no specific recommendations for lighting to inspect horses. However, similarly to pigs (Faucitano and Lambooij, 2019), a minimum of 40 lx is recommended to inspect horses during the loading process.

4.2.4.2 Handler's attitude

The quality of the handling during loading and unloading is influenced by the experience, attitude, education and training of the handlers (Nivelle *et al.*, 2020). Excessive force during loading only increases fear in horses and may lead to falls and injuries. A calmer approach and communication between handlers to prevent conflicting signals to the horses are recommended (Nivelle *et al.*, 2020). For example, one handler should not stand too close to the passageway at the same time as another handler is driving horses to that direction (Nivelle *et al.*, 2020). According to Grandin (2015b), handlers with expertise in low-stress handling can control the movements of animals by simply adjusting their body position.

To minimise stress to the animals, to avoid their strong reactions and to prevent dangerous work situations during handling, handlers must have knowledge of the concept of flight distance and the point of balance. The horse will start to move away when the handler enters the flight zone. When the person stands still, the horse will turn and face the person. When the handler stands in front of the point of balance at the shoulder, the horse will go backward. To move the horse forward, the handler should enter the flight zone behind the point of balance (Grandin, 2014b).

Handlers should not scream, whistle, clap their hands, flap their arms or make sudden movements in order to keep the horses calm as possible (Grandin, 1999; Horse Meat Federation, 2016; http://www.oie.int/international-standard-setting/terrestrial-code/accessonline/). Flags can be used as moving tools (Figure 4.2), provided they are used calmly as waving flags can cause stress (Houpt and

Figure 4.2. Moving horses inside a trailer using a flag (photo: B. Driessen, Research, Control & Consult, Belgium).

Wickens, 2014). Whips, electric prods, sticks and dogs are not recommended because they induce fear and anxiety to the horses (Dai *et al.*, 2021). More specifically, the use of electric prods, besides not being necessary, is not recommended as it causes agitation and results in dangerous animals (Grandin, 1999; Nivelle *et al.*, 2020).

4.3 Transport

Transport or being in a moving vehicle is a stressful event for horses as showed by the increased activity and use of energy compared to horses that are not transported (Doherty *et al.*, 1997). The welfare of horses during transport depends on their behaviour, environmental conditions, vehicle design, and travel and vehicle driving conditions.

4.3.1 Behavioural response

The normal standing position adopted by horses during transport is a potential risk if horses cannot maintain their balance as they may get injured as a result of falling or hitting the internal structures of the vehicle (Houpt and Wickens, 2014). When horses fall during transport they may be unable to stand again either when being transported in a loose group or in stalls. They thus have to make a physical effort to continually adjust the posture to resist the transport vehicle movements and react to noises and visual stressors, all resulting in anxiety and physical stress as showed by their increased heart rate during transport (Doherty *et al.*, 1997).

4.3.2 Microclimate

The microclimate within the vehicle, in terms of temperature, relative humidity (RH) and solar radiant load and wind speed, has an impact on the behaviour and welfare of horses during transport. For horses, the thermoneutral zone ranges from a minimum of 5 °C to a maximum of 25 °C (Morgan, 1998). When the environmental temperature exceeds these limits of the thermoneutral zone, horses have to invest energy to keep their body temperature constant. When exposed to cold stress conditions (<5 °C), horses exhibit shivering or huddling (Grandin, 2015a), while in warmer conditions (>25 °C), they regulate their temperature initially by increased skin vasodilation (convective heat loss) and then through sweating and increased respiratory rate (CATGP, 2018; Luz *et al.*, 2015). The limits of the thermoneutral zone are not static, but can be influenced by animal characteristics (e.g. condition, winter or summer coat, being acclimated) or operational procedures, i.e. stocking density or rugging (Cuddeford, 2003; Hoopes, 2018; Roy and Cockram, 2015). The only practical way to assess cold or heat stress in horses during transport is by direct observation by trained personnel.

Relative humidity (RH) also plays a crucial role in the horses' ability to thermoregulate. Sweating, as heat dissipation, at higher ambient temperatures will be more efficient at lower RH. There is no temperature humidity index (THI) framework specifically for horses. However, THI must be interpreted carefully, since this parameter does not take solar load and wind speed into account (Gaughan *et al.*, 2008). Moreover, the lack of a reference framework with limit values for heat stress in horses complicates interpretation (Nivelle *et al.*, 2020).

During transport in an open trailer or in closed (roofed) passively- or actively-ventilated vehicles the climate has an impact on the well-being of the horses. In open trailers, commonly used in South America, air displacement enhances heat dissipation through forced convection and accelerate evaporation of sweat (Nivelle *et al.*, 2020). In hot weather conditions, the stationary time of the loaded trailer should be kept to a minimum, because heat stroke can be caused by extreme temperature increases in a passively-ventilated, open or roofed trailer (Houpt and Wickens, 2014). During rest stops in such conditions it is advised to park the van or trailer in shaded areas with all windows (in vans) and ramps open during rest stops (Waran *et al.*, 2007). Research about the ventilation in horse trailers is limited. However, Purswell *et al.* (2006) concluded that in under-ventilated trailers the exposure to ammonia, nitric oxide and carbon monoxide in the trailer can compromise the horses' respiratory clearance mechanism. Long-term exposure to toxic gases, i.e. ammonia and carbon monoxide, in high concentration can cause irritation of the respiratory tract and eyes in horses during transportation. Ammonia, resulting from the degradation of urine by bacteria, is the most important gas to consider. The concentration of ammonia can be reduced by the use of absorbent floor bedding (CATGP, 2018), like sawdust or straw, although this bedding type may worsen respiratory health due to associated dust, pollen, moulds and endotoxin (Padalino, 2017; Stull, 1999). However, no recommendations on the permissible levels of toxic gases are available for horses during transport (Stull, 1999).

In winter conditions one side of a passively-ventilated roofed vehicle can be covered with tarpaulin. However, this protection can negatively influence the ventilation in the vehicle and affect the thermal comfort of horses as showed by increased sweating (Messori *et al.*, 2016). For this reason, the use of tarpaulin is not recommended in warmer climatic conditions (Messori *et al.*, 2016). Houpt and Wickens (2014) advises in very cold weather conditions to use blankets on horses located in open trailers.

4.3.3 Vehicle design

Nowadays, horses are transported in single deck trailers or lorries with or without a ramp. Roy *et al.* (2015c) described the loading of horses in Iceland where a hydraulic tailgate lift was used. Initially, the caged platform was hydraulically lowered to the ground level to load the horses. After moving the horses onto this platform, the platform was lifted until the level of the floor of the vehicle was reached. Horse transport vehicles vary in style from a single horsebox to large stock trailers loading 20 to 40 horses (Nivelle *et al.*, 2020). Nowadays, double deckers used for the transport of other species are not used to transport horses because they lack sufficient height and the internal ramps are difficult for the horses to negotiate (Houpt and Wickens, 2014). Stull (1999) compared horse transports in a potbelly trailer with horse transports in a straight-deck trailer (Figure 4.3A,B). Horses transported in potbelly trailers showed approximately 3.5 times more injuries than in a straight-deck trailers. Because the head and face were the most prevalent area for injury, the width of the door opening may be a factor in the greater injury rate in the horses transported in potbelly trailers (Stull, 1999). Whereas no effect of vehicle type (foot- vs gooseneck trailer) on the prevalence of bruises was reported by Miranda-de la Lama *et al.* (2021).

A

B

Figure 4.3. A typical South American straight-deck trailer to transport horses, (A) unloaded and (B) loaded (B. Driessen, Research, Control & Consult, Belgium).

4.3.3.1 Flooring

The floor of all transport vehicles must be designed to protect horses against slipping as this occurrence is a source of anxiety and stress for them (Grandin, 2015a). To improve their stability, in some vehicles a wire mesh is laid on the floor with a 30×30 cm square pattern (Nivelle *et al.*, 2020). The rods should not lay criss-cross on top of each other, but the mat of rods must lie flat to prevent gaps from injuring the hooves (Grandin, 2015a). In general, aluminium and metal floor can frighten horses due to the noise produced by the hooves stepping on the floor and the lack of grip. For this reason, a rubber mat or a thick layer of litter is preferable as it buffers the hollow sound of the flooring when a horse steps on it (Nivelle *et al.*, 2020; Weeks *et al.*, 2012). According to CATGP (2018), a layer thickness of 1 cm per 100 km is advised for wood shavings. According to European Regulation 1/2005, a layer of bedding material is only required for journeys that exceed 8 h. The bedding material is used to absorb spilled water, faeces and urine produced by the animals during the journey (CATGP, 2018).

4.3.3.2 Vehicle height

The vehicle should be high enough to provide sufficient head room to ensure adequate ventilation and physical comfort while in the standing position (Fraser, 2010). However, the existing recommendations are conflicting, ranging from at least 20 cm of free head space when standing (AATA, 2005) to a minimum internal height of at least 75 cm higher than the height of the withers of the highest animal (European Regulation 1/2005).

4.3.4 Transport conditions

4.3.4.1 Stocking density

Different authorities and guidelines have specified minimum and maximum loading density for horse transport. For example, minimal space allowance for an adult horse during a long journey is 1.75 m^2 in Europe (European Regulation 1/2005), while it is only 1.2 m^2 in Australia (Australian Animal Welfare Standards and Guidelines, 2021).

It has been shown that at high stocking densities (1.28 m^2/horse) the risk of imbalance, falls, fighting and mounting and injuries in loose transported horses is higher (Collins *et al.*, 2000; Iacono *et al.*, 2007b; Knowles *et al.*, 2010) and heat dissipation is reduced during transport. However, it is difficult to make a comparison between transports just based on the stocking densities. Because adult horses can vary in weight, height and length, and thus vary in dimensions and contours, stocking density requirements in terms of m^2 per animal are not reliable. Two vehicles may have the same stocking density in m^2/horse, but in practice the density in kg/m^2 may vary greatly due to differences in body sizes and shape. On the other hand, loading a number of horses based on the estimated the average weight of the group can also lead to estimation errors since this does not take the variation in animal weight into account (Nivelle *et al.*, 2020). Furthermore, the individual horse weight is often not known at the moment of loading.

During transport, horses need more space than just the contours of their body because of their physics. Like all equidae, horses have a high centre of gravity and, in addition, 60% of their weight is carried on the forelegs (Cregier, 1982). To cope with accelerations and decelerations in the moving, horses position their feet outside the normal position under the body to adopt a wider base and adjust their head and neck position in the direction in which they are facing to keep their balance (Broom, 2008; Stull, 1997). To brace and adjust this position, horses require more floor room (Marlin *et al.*, 2011). Besides the floor surface, other factors affecting their ability to balance are vehicle design, the type of suspension, the experience of the driver and the type of road (Houpt and Wickens, 2014; Waran *et al.*, 2007). During transport, horses endeavour not to contact other animals or the sidewalls of the vehicle (Clark *et al.*, 1993; Waran, *et al.*, 1996; Waran *et al.*, 2007). According to Racklyeft and Love (1990), the horse needs space to lower its head, at least to shoulder height, because failure to be able to do so has a negative impact on the respiratory function during journeys of more than a few hours. Hence, horses during transport require more space than when standing still.

4.3.4.2 Compartmentation

Compartmentation (Figure 4.4) is useful and necessary for several reasons. Horses of significantly different sizes or ages and sexually mature mares and stallions, must be handled and transported separately, unless the animals have been reared together (European Regulation EC 1/2005). The use

Figure 4.4. Compartmentation of a group of loose housed horses (B. Driessen, Research, Control & Consult, Belgium).

of separate compartments improves the travel management and reduces the risk of injuries due to kicking and pawing, especially in temperamental and dominant horses, such as stallions (Iacono *et al.*, 2007b; Weeks *et al.*, 2012). Stallions, in fact, are more aggressive and difficult to handle in comparison with mares and geldings (Roy *et al.*, 2015a). However, within a load of slaughter horses, the proportion of stallions is usually small because of their small proportion in the total population and in commercial practical conditions no more than two stallions are usually included in a load. The majority of the transported horses are mares (50 to 58%) and geldings (40 to 47%) (Roy and Cockram, 2015; Stull, 1999). According to Stull (1999), mainly adult horses (average age of 11.4±0.4 years, ranging from 1 to 30 years) are transported to slaughter.

To our knowledge, no scientific information about the optimal dimensions of a compartment or about the partition design are available. Partitions should be solid, start from the floor level encompassing the whole width of the vehicle and should be designed in such a way to protect and isolate physically individuals and groups, but not reducing the ventilation in the trailer and not increasing the risk of overheating.

4.3.4.3 Restraint during transport

Tied and untied animals should not be transported in the same compartment (European Regulation 1/2005). The ropes or other attachments used must be in good condition, resistant and long enough to allow horses to lie down (AATA, 2005). Short ropes can cause entanglement and loss of balance and subsequent panic (Tasker, 1990) or, in the worst case, death due to choking (Broom, 2014). Furthermore, when the rope is too short, horses have to maintain their heads in an elevated position, which increases the accumulation of purulent airway secretions and the risk of running normal pharyngeal flora into the lower respiratory tract (Raidal *et al.*, 1995, 1996; Raycklyeft and Love, 1990) leading to an increased risk of 'shipping fever'.

4.3.4.4 Water provision

During transport, specifically long hauls (defined by the European Regulation 1/2005 as a haul of more than 8 h (EC, 2005)), horses can be provided with water on the vehicle. Transport in hot weather conditions and without water for more than 24 h will induce severe dehydration, even in healthy horses (Friend, 2000). Even in cold weather conditions, horses must have access to drinking water. However, watering horses during transport is questionable. Horses often start drinking between 20 and 60 min after water is offered (Iacono *et al.*, 2007a), but their water intake is low (Iacono *et al.*, 2007a; Mars *et al.*, 1992). Some horses do not drink at all because of the fear of the new, unfamiliar water source (Weeks *et al.*, 2012), taste of the water or transport stress. Horses often may be reluctant to drink when inside a moving vehicle, since to do so they need to adopt a vulnerable position, such as risking banging into the drinkers with their mouth and lips (McGreevy, 2004). Furthermore, providing water in moving trucks may result in slippery floor due to water spillage and thus increasing the risk of poor stability, slips and injuries. Thus, water provision during stops is preferable (Messori *et al.*, 2016).

4.3.4.5 Vehicle driving style

When the transport vehicle is driven smoothly, it is easier for the horses to keep their balance and to avoid contact with the vehicle interior and or others. When the driver negotiates corners and bends at high speed, or drives with too high accelerations or to violent and sudden braking, horses are subjected to substantial lateral and or cranio-caudal movements. This poor driving style may also lead to toppling, sliding and the requirement for excessive corrective muscular action, resulting in bruising, muscular fatigue (as showed by increased muscle enzymes released in the blood), fear and injuries to the animals (Randall *et al.*, 1995; Tateo *et al.*, 2012). In addition, poor condition of the brakes can cause improper braking and loss of balance which can cause the horse to be propelled forward or backwards inside the trailer with consequent injuries to the front of the head (Dai *et al.*, 2021).

4.3.4.6 Journey duration

Medica *et al.* (2019) noticed that the sympatho-adrenal system response (based on blood adrenaline and noradrenaline concentration) of stallions transported in in a trailer featuring individual compartments was greater after short than medium-longer period (100 vs 200-300 km) of transportation which may indicate an adaptation process during transport to alleviate the effects of the perceived transportation stress. In addition, they noticed also a great variability of the sympatho-adrenergic response in different individuals, which may reflect individual variations in response to transport-induced stress (Medica *et al.*, 2019).

There is a wide variation in the length of the legally allowed journey duration. In the current European legislation, long journeys are defined as those exceeding 8 h (European Regulation EC 1/2005). However, this legislation defines that horses may be transported for a maximum period of 24 h (European Regulation EC 1/2005) if they are watered and fed every 8 h. After this journey time, animals must be unloaded, fed and watered and be rested for at least 24 h. Transporting unbroken horses on long journeys is not allowed (European Regulation EC 1/2005). In Canada, the maximum transport time is 28 h without water, feed and rest (CFIA, 2021). Thereafter the horses must have a rest period of at least 8 consecutive hours before resuming their journey. In the US, horses must be offloaded after a maximum duration in confinement of 28 h and be provided rest, water, and feed for at least 6 h (USDA, 1994). Argentinian legislation allows for a transport duration up to 36 h without feeding, watering or rest (SNSCA, 1999). In Uruguay, no maximum transport duration is mentioned (Uruguay Government, 2009).

Journey duration affects horse welfare because of some additive factors, such as restricted space and comfort, fasting and environmental conditions (Broom, 2014). For example, horses that have been fasted for a long period (i.e. during a long journey) are more vulnerable to cold temperatures (Roy and Cockram, 2015). Miranda-de la Lama *et al.* (2021) reported increased prevalence of bruising in horses transported for more than 12 h, independently of the country of origin, lairage duration, vehicle type, commercial category or sex. For this reason, these authors concluded that long journeys should be planned with frequent and long stops, during which horses should be fed and watered. If animals have adequate rest, food and water at resting points, the adverse effects of long journeys are reduced (Broom, 2014). According to European Regulation (EC 1/2005), horses must be given water during long journeys every 8 h without unloading. In addition, stops would also allow vehicle cleaning to prevent horses from slipping during the journey (Padalino, 2015).

4.4 Handling at the slaughter plant

4.4.1 Unloading

After arrival at the slaughter plant, the horses should be unloaded as quickly as possible, especially from passively-ventilated vehicles during hot weather, because the temperature inside these vehicles will increase rapidly whilst stationary (Grandin, 2014c).

The unloading procedure can be hindered by horses' unwillingness to go downhill and their response to an unfamiliar environment characterised by specific sounds and smells, interactions with other animals, etc. (Grandin, 2014c; Messori *et al.*, 2016). As the result of previous experiences at loading or during transport, horses can exhibit reluctance to exit the vehicle or leave it at excessive speed (Siniscalchi *et al.*, 2014). While exiting the vehicle, horses should be allowed additional time to inspect the new environment (e.g. the ramp) and to walk off quietly and calmly, so that the risk of injury is reduced (Messori *et al.*, 2016). To this end, the handler(s), including the driver, should understand the behavioural signals given by the animals during unloading and guiding and adapt their actions accordingly. They also need to assess the effect of their actions on the animals, not only on the horse on which he is focused, but also the horses in the surrounding area which will also pick up the signals and may be stressed by these (Nivelle *et al.*, 2020). Handling aids, such as flags or driving paddles should also be used properly. They should only be used as an extension of the handler's body and never to hit an animal (https://www.hsa.org.uk/; Nivelle *et al.*, 2020). Furthermore, to ease handling out of the vehicle, the exit gate should be as large as possible and the door must be open at its maximum width (SCARM, 2002). Grandin (1980) recommends a width of 2.5-3.0 m at the unloading facility. This provides a wide, clear path for animals to move off the vehicle without crowding and tripping (Grandin, 2008). The minimum door/gate width is not defined, but based on an average-size horse (158 cm tall, approximately 90 cm large and 550 kg body weight; Waran *et al.*, 2007), a walkway width of about 1 m would permit the passage of one horse at a time (CECM, 1987).

At unloading, horses should be observed by the personnel at the slaughter plant to identify unfit, ill or injured animals. If injured horses are detected in the vehicle, sound stock should be unloaded first. In the case of severe injuries, emergency killing and bleeding must be carried out in the vehicle or on the unloading platform. Less severely injured horses should be slaughtered immediately without keeping them for a period in lairage. Holding injured animals with obvious signs of stress or of pain arriving at night or on weekends until the slaughter floor is operating is unacceptable (SCARM, 2002).

When manoeuvred to pull it over to the unloading dock, the vehicle should be correctly aligned with the edge and walls of the dock to avoid gaps (SCARM, 2002). A ramp is needed to fill a gap between the vehicle deck and the unloading dock. Because of the significant correlation (r=0.39) between the steepness of the ramp (steeper than an angle of 20° or 36.4% to the horizontal for horses which is the maximum level specified in European Regulation 1/2005) and the prevalence of falling, the ramp floor should be covered by a rubber to reduce slipping (Messori *et al.*, 2016).

4.4.2 Path to the lairage pens

To avoid stops in the flow of horses to the lairage pens, alleys design should not feature corners. Wide alleys from 3 to 3.5 m as used in cattle facilities can be used to drive the horses from the unloading dock to the pens (Grandin, 2014d). Horses are social animals and experience stress when separated, therefore it is recommended to move them in small groups to help keep them calm (Grandin, 1999). Also the floor should be made of solid, non-slip concrete and be uniform in texture or colour. Solid walls are recommended to calm down nervous horses as they impede visual contacts with other horses (Grandin, 2014c). Rubber or coatings can be used to avoid metal on metal contacts and to dampen loud noises of metal gates, locks and doors.

4.4.3 Lairage time and holding pens design

Recommendations about the lairage time for horses are rare and optimum lairage times, in terms of processing requirements, have not been studied for most horses (FAWC, 2003). Under commercial conditions, after arrival at the slaughter plant, horses are either slaughtered immediately, after a few hours of lairage, after an overnight lairage or are kept some days (Roy *et al.*, 2015a). A minimum lairage time of 6 h for horses is recommended in Chile (Werner and Gallo, 2008). However, Werner and Gallo (2008) state that, in terms of animal welfare, the slaughtering of horses soon after the arrival to the slaughterhouse is good practice, because increasing lairage time results in increasing stress (e.g. noise, fear, thirst, hunger, etc.) and deterioration in the quality of the horse meat. Meat quality losses can occur as a result of excessive stress, bruises or injuries (CATGP, 2018; Nivelle *et al.*, 2020; Pawshe *et al.*, 2016). For the same reasons, regrouping unfamiliar horses should be avoided because of the risk of fighting (Cavallone *et al.*, 2002).

During lairage, horses must have access to drinking water and, should they be kept in lairage for a day or more, they must be fed with forage (European Regulation 1/2005; http://www.oie.int/international-standard-setting/terrestrial-code/accessonline/).

Pens should be long and narrow to allow efficient animal movement, with horses entering through one end of the pen and leaving through the other, and reduce fighting (Grandin, 1990).

Under adverse weather conditions (solar radiation or heavy rainfall), the presence of shelter in the holding pens is recommended to provide shade (e.g. trees) and prevent the floor from becoming soggy/muddy in case the holding pens are not or partially roofed. To prevent muddy, slippery floors, the floor should be permeable to drain water surplus quickly. To ensure adequate drainage, slightly slope the surface of the pen. Laying porous material, such as gravel, crushed stone or sand, on a geotextile in muddy pens, allows drainage of water away from the surface. The geotextile ensures that the layer of porous material is kept in place and lasts longer (Living on the Land, 2021).

4.4.4 The path to the stun box

In the passageway leading to the stun box, horses, which are herd animals, have to follow each other one by one in line, which can induce fear and agitation (Grandin, 1999). Fearful horses can be guided to the stunner using a halter or a head rope. According to Micera *et al.* (2012), applying mentholated ointment on the horse nostrils 45 min before stunning can decrease its olfactory perception of danger at slaughter and reduces the stress response as showed by the lower concentrations of epinephrine and norepinephrine in blood.

In some slaughterhouses, horses are showered (Figure 4.5) before entering the stun box in order to reduce the amount of dust in their coats. However, this practice makes the passageway more slippery and produces stress and panic, i.e. kicking or flight reaction, in horses as they are not familiar to showers (Grandin, 2014c; Vermeulen *et al.*, 2019). A shower that automatically starts up with low pressure and produces a very fine water spray is recommended to reduce stress-related behaviour (B. Driessen, unpublished data).

In lairage, the most important requirement is to reduce disruptive noises. High-pitched noises caused by metal on metal or metal on concrete are the main ones to be avoided as they excite the animals making them more difficult to handle and their stunning less effective (Bulens *et al.*, 2013; Grandin, 2015c). The reduction of these types of noises can be achieved by applying damping rubber

Figure 4.5. In some slaughterhouses, horses are showered before slaughter, but this practice can induce stress (B. Driessen, Research, Control & Consult, Belgium).

to the walls and floors of loading docks, latches, weighing scales, etc. In addition, the lairage area can be separated from the stun box by using sandwich panels, so that disturbing noises coming from the slaughtering area that would cause stress to the horses in the stun box are reduced (Cockram, 2020; Grandin, 2020a).

Horses are flight animals and may only enter the stun box voluntarily if:

- There is no solid wall is in front of them (http://www.oie.int/international-standard-setting/terrestrial-code/accessonline/).
- There are solid sight panels to prevent external distractions (http://www.oie.int/international-standard-setting/terrestrial-code/accessonline/).
- The floor is non-slip and stable (Houpt and Wickens, 2014).
- Lamps light up a dark stun box. LED lighting is recommended as it reduces shadows, but should not be directed in the horse's eyes (Grandin, 2020a).
- There are no light spots causing light reflections on stainless steel (Grandin 2020a).

4.5 Stunning and slaughter

During the stunning phase, the welfare of the horses is determined by the design of the stun box, the calmness of the horses, the type of stunner used, the skilfulness of the operators and the bleeding technique. Regularly training of personnel is necessary to maintain the experiences and understanding about handling (based on behavioural principles, such as flight zone and point of balance), restraining, stunning techniques, signs of (un)consciousness, hoisting, bleeding, and equipment care and maintenance (European Regulation 1/2005; https://www.hsa.org.uk/).

4.5.1 Stun box

The function of the stun box is to restrict the movements of the horse sparing avoidable pain, fear or agitation in order to facilitate effective stunning and killing and to ensure the safety of operators and the proper application of stunning (European Regulation 1/2005). However, restraining is likely to create distress to the animals and should therefore be applied for as short a period as possible. To this end, business operators are required to ensure that animals are not placed in the box until the person in charge of stunning or bleeding is ready to perform these procedures as quickly as possible. However, a specific maximum period between restraining and stunning is not determined in the European Regulation 1/2005.

Stun boxes should be designed to allow horses enter willingly with minimal stress. The appropriate width for stun boxes and chutes tends to be overestimated (AVMA, 2016). The box should not be too wide to prevent an horse from turning around. The European Regulation 1/2005 states that the restraint facilities must be adjustable to the horse size, but does not provide any recommendation for stun box maximum dimensions (EC, 2005). Whereas, AVMA (2016) recommends an appropriate width of 81 cm for a horse stun box. The box must also be easily and safely accessible to handle an animal that is lying down or has fallen (SCARM, 2002).

Clamping the horse's head by a mechanised device is an active restraint form and should not be used (AVMA, 2016). Restraining or trying to restrain a horse's head results in more fear and panic, and due their long neck head restraint cannot be done safely (EC, 2017; Harvey, 2020). Passive devices, such as a tray to prevent the horse from putting its head down, which restrain head movement without clamping the head can be used (AVMA, 2016).

4.5.2 Stunning

Unlike most meat species, there is limited information on the stunning of horses (Gibson *et al.*, 2015). To induce immediate insensibility in horses a penetrating captive bolt gun powered by gunpowder (Western Europe) or compressed air (South America; Figure 4.6) or a long rifle (Canada) can be used (Algers and Atkinson, 2014; Gibson *et al.*, 2015). The length of the bolt and the power of the weapon determine the depth of penetration into the skull (Algers and Atkinson, 2014). Pneumatic/compressed bolt guns have a higher power and bolt velocity than a gun powered captive bolt (Algers and Atkinson, 2014). The use of a non-penetrating captive bolt and the electronarcosis techniques have been also reported by Cáraves and Gallo (2007) in Chilean horse slaughterhouses, but without good results. Failures in gun powered or compressed air captive bolt stunning have been explained by the use of damp cartridges (Grandin, 2015c) and too low air pressure (Bulens *et al.*, 2013), respectively. When using a rifle, ricochet of the bullet is possible and therefore, the operators must use care in positioning of themselves and others when the procedure is performed (see species-related chapters in this book: Gallo *et al.*, 2022; Hultgren, 2022; Needham and Hoffman, 2022; Shearer and Ramirez, 2013).

Figure 4.6. A pneumatic device to stun horses (B. Driessen, Research, Control & Consult, Belgium).

For penetrating captive bolt stunning, the device is held against the animal's forehead so that the bolt can penetrate the skull and brain. Because the brain of the horse is located high on the forehead, the shot must be placed slightly above the intersection of an X drawn on the forehead, with each line beginning at the inside corner of the eye and progressing to the opposite ear (Woods and Shearer, 2015). When properly applied, the shot results in immediate unconsciousness and breathing stop due to trauma to the cerebral hemisphere and the brainstem (Grandin, 2020b), while if the location is not precise, horses may regain consciousness during exsanguination (Werner and Gallo, 2008). However, there have been some questions about whether or not a captive bolt actually kills or just stuns an animal as most horses continue kicking immediately after being killed. An untrained person might confuse these spasms with movements and wrongly assumes that the shot animal would not be stunned (Bulens *et al.*, 2013). The stunning operative must be aware that stressed or agitated horses may lunge forward or rear up when shot (Woods and Shearer, 2015). Similarly to cattle (Finnie, 1995; Gregory *et al.*, 2007), signs of effective captive bolt penetration in horses are immediate collapse and a several seconds period of tetanic spasm, followed by slow hind limb movements of increasing frequency, absence of corneal reflex and open eyes.

4.5.3 Slaughter

After successful stunning, the animal falls into the roll-out area, is hoisted up and exsanguinated immediately to prevent the horse from regaining consciousness (Algers and Atkinson, 2014). The acceptable maximum stun-to-stick interval is 60 s (https://www.hsa.org.uk/). Exsanguination should be performed using a pointed and very sharp knife with a rigid blade (Woods and Shearer, 2015) that severs the jugular vein, carotid artery, and windpipe. In addition, a chest stick can be performed to optimise bleeding. When properly performed, blood should flow freely (Woods and Shearer, 2015). Great care must be practiced while performing exsanguination because horses are still capable of making violent, involuntary, muscle contractions that may injure the handler (Woods and Shearer, 2015).

Animals must be observed during the stun-to-stick interval and during bleeding to detect signs of ineffective stunning. Presence of the corneal reflex, recovery of breathing, spontaneous blinking of the eye lids, vocalisation and the righting reflex are signs of ineffective stunning or slaughter (Bulens *et al.*, 2013). Subsequent port-mortem operations, such as carcass dressing or scalding, shall only be performed once the absence of signs of life of the animal has been verified (Bulens *et al.*, 2013).

4.6 Conclusions

Similarly to other livestock species, the welfare of horses is influenced by a complex range of parameters just before transport (e.g. fitness for transport), during transport to the slaughterhouse, during holding in lairage and in the final hours of the slaughter process. Infrastructures, animal-related factors, environmental conditions, but certainly also the interaction with the handlers, determine the welfare of the horse during the immediate pre-slaughter process. There are similarities with the transport of recreational and sport horses, but the main difference is that slaughter horses are often transported in loose groups at a higher stocking density and in less well adapted vehicles. From region to region, there are also differences in preslaughter handling of slaughter horses in practice. These differences are based on years of habits, regulations and specific regional needs. To obtain more knowledge and to provide more scientific evidence-based recommendations, more research is needed.

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