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A review of recent research on the transportation of horses[1]

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ABSTRACT: Horses are transported more frequently than any other type of livestock. Most of our understanding about horse transport has been based on custom and conjecture, but some recent studies have greatly increased our knowledge. Although some horses adapt to transport much better than others, transport is generally associated with lower reproductive rates, increased disease incidence, a temporary reduction in athletic performance, and the alteration of many other physiological traits that are indicative of stress. Horses show marked dehydration after 24 h and extreme dehydration after 28 h of transport in hot and humid conditions when there is little nighttime cooling. Watering horses onboard trailers alleviates dehydration, but fatigue can become extreme after 28 h of transport. Orientation either toward or away or diagonally from the direction of travel does not seem to significantly affect a horse's ability to maintain its balance. Allowing horses the ability to raise and lower their heads or hind quarters and to take at least one step in any direction seems to be the most important factor in their compensating for changes in inertial forces. Loose horses that are transported in groups at high densities (e.g., slaughter horses) do not hold each other up, but rather inhibit each other's attempts to compensate for changes in inertial forces. High density also increases injuries and inhibits the ability of horses to stand after they fall because other horses standover the downed horses. High density also prevents submissive horses from moving away from aggressive horses, resulting in repeated aggression. However, reducing density greatly increases transportation costs. Recent surveys have also shown that many of the worst injuries seen on horses arriving at slaughter plants originated before their transport to slaughter. Horse trailer design has undergone rapid change with the rise in popularity of slant-load aluminum trailers. A major challenge for the future is determining which of the myriad of trailer designs, suspension systems, and building materials available to horse owners and shippers are preferable.

Key Words: Behavior, Horses, Stress, Transport

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Introduction

Horses have been transported by boats for at least 3,500 yr (Cregier, 1982). There are many later accounts of horses being transported by horse-drawn wagons in many parts of the world. Transport by rail was very common during the middle to late 1800s but gave way to transport by trucks after World War II following the building of the interstate highway system and the development of more reliable trucks and trailers. The 1960s and 1970s became known as the "trailer age" for horse transport (Cregier, 1982), and the 1980s and 1990s are sometimes referred to as the "air age" of horse transport due to the frequent use of large cargo aircraft.

There are an estimated 6.9 million horses in the United States, and their owners spend an estimated $2.17 billion per year transporting those horses (American Horse Council, 1996). Although national estimates are not available, the estimated inventory value for all horse trailers in Texas is $2.16 billion (Gibbs et al., 1998). The typical Texas horse owner transports 2.5 horses (Gibbs et al., 1997) on 24 trips per year averaging 380 km per trip (Gibbs et al., 1998).

There were also 72,120 horses transported to slaughter in 1998 (USDA, 1999). Continuous transport of slaughter horses for 30 h is common (Stull, 1999), and some trips last 36 h or longer. Public concern over the transport of horses going to slaughter was the driving force behind the Safe Commercial Transportation of Equine to Slaughter Act (§ 901–905) that was passed as part of the 1996 U.S. Farm Bill. In an effort to provide a basis for formulating regulations, the

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Transport-Related Stress

Transported horses can be subjected to a wide range of potential stressors, including isolation from herdmates, forced close proximity to unfamiliar or aggressive horses, novel or threatening surroundings, exposure to new pathogens, restraint of normal activity patterns, forced adoption of an abnormal posture, extremes in temperature, water and feed deprivation, and blowing dust and particulate matter. Transport has long been known to be associated with morbidity in horses. The term "shipping fever" was originally used for the pneumonia that commonly developed in shipped horses during World War I (King, 1992). However, with proper training and experience, many horses readily adjust to being transported in a wide range of vehicles.

Transport in general is a stressor in horses that can, for example, lead to the reactivation of salmonellosis (Owen et al., 1983), elevate heart rate (Clark et al., 1993; Smith et al., 1994b; Warren and Cuddeford, 1995), cause hormonal and plasma ascorbic acid (Baucus et al., 1990a) and cortisol (Clark et al., 1993; Friend et al., 1998; Friend, 2000; Stull and Rodiek, 2000) changes indicative of acute stress, and cause dehydration (Friend et al., 1998; Friend, 2000; Stull and Rodiek, 2000). However, short-term transport has been reported to affect neither the incidence of embryonal death (Baucus et al., 1990a) nor estrus behavior, ovulation, the estrous cycle, or estradiol and LH surges (Baucus et al., 1990b). McGee (1969), however, recommended against long-distance transport of mares in late gestation because transport could lead to the rupture of the uterine artery and the subsequent death of the mare. When interpreting these studies, it is important to realize that most researchers have used relatively tame horses that are experienced at being transported or readily accept being transported.

When comparing the percentage in change of some serum enzymes and hematochemical concentrations, Codazza et al. (1974) found that, in general, transportation (300 km) has a different effect on muscular function than exercise. However, they concluded that horses should still be transported at least 48 h before a race to permit the hematochemical values to return to normal. When horses were transported only 90 km, transport had no significant effect on serum concentrations of sodium, potassium, chloride, glucose, or total protein or on submaximal exercise following transport (Beaunoyer and Chapman, 1987).

Transport can also result in physical injury to horses. This can occur through collisions involving the transport vehicle, sudden stops, fatigue, loss of balance, or attacks from aggressive horses. However, Grandin et al. (1999) reported that the majority of severe welfare-threatening injuries observed at slaughter houses were sustained before transport.

Long-Distance Transport

Horse owners and shippers are very concerned about the maximum duration that horses may be safely transported. Provided that horses are healthy and in good physical condition, the maximum duration that horses may be transported is a function of dehydration (weight loss) and fatigue. Data are available from which useful inferences can be drawn regarding the progression of dehydration under different climatic conditions. The database from which to draw inferences regarding fatigue is much more limited.

Weight Loss and Dehydration

Recent research has shown that the rate of weight loss (dehydration) of horses in pens can approximate the dehydration rate of horses being transported under similar climatic conditions (Friend et al., 1998; Friend, 2000). There has been a relatively large number of studies that have deprived stalled horses of water for varying durations to establish the relationship of certain measurements to progressive dehydration. Three of the more notable studies (Tasker, 1967; Carlson, 1979; Sneddon et al., 1991) are summarized in Table 1. The relationship between rate of dehydration and temperature can be seen by comparing those three studies. Some of Tasker's horses went as long as 8 d without water and feed and lost only 10% of their body weight. Tasker described a "tucked-up" appearance of the abdomen on the 5th d of water deprivation and took horses off the study when it began to appear that they were severely dehydrated. It is useful to note that horses that were offered hay and other dry feed would have dehydrated at a much greater rate. All of the horses used in the studies reported in Table 1 recovered with little adverse effect. Horses have a remarkable capability to go for extended periods of time without water and feed during cool weather (e.g., Tasker, 1967). Dehydration rates greatly increase, however, when ambient temperature increases and when the low temperature for the period remains relatively high, as seen in the study by Sneddon et al. (1991). The same general relationship is evident in two relatively similar studies in which the major difference was temperature (Smith et al, 1996a; Stull and Rodiek, 2000). Although the horses in both studies had periodic access to water and continuous access to hay during transport, the horses that experienced the highest maximum and minimum temperatures (Stull and Rodiek, 2000) lost more than twice as much body weight during the same time period.

Recent studies on horses transported in large groups (i.e., "slaughter horses") can also give some useful insights into the relationship of temperature and dehydration rate. The dehydration rates (7 and 6%) of the

Table 1. Summary of recent studies characterizing weight loss during water deprivation and(or) transport of horses

Author(s)	Weight loss, %	Duration of water deprivation	Housing	Temperature range, °C	Mean temperature, °C
Not transported					
Tasker, 1967	10.0	6–8 d	Stalled	0–20	10
Carlson, 1979	10.7	72 h	Penned in sun	11.8–33.2	22.5
Sneddon , et al., 1991	12.0	72 h	Stalled	18.7–29.9	24.5
Transported in small trailers		Duration of transport			
Smith, et al., 1996	2.7	24 h	Covered trailer with hay and water	13–30	21.5
Stull and Rodiek, 2000	6.0	24 h	Covered trailer with hay and water	19–35.5	27.3
Transported in large trailers					
Friend, et al.,1998	9.0	24 h[a]	Penned in sun	26–36	31
	8.0	24 h	Transported in Open top trailer	26–36	31
	7.0	24 h	Penned in sun And watered	26–36	31
	6.0	24 h	Transported in open-top trailer and watered	26–36	31
Stull, 1999	8.0	30 h	Covered trailer with hay and water	13–39	26
Friend, 2000	12.8	30 h[a]	Penned in sun	24–37	30.5
	10.3	30 h	Transported in open-top trailer	24–37	30.5
	4.2	33 h	Transported in open-top trailer and watered	24–37	30.5
	3.8	33 h	Penned in sun and watered	24–37	30.5

[a]Horses were deprived of water for 6 h before transport but were held in shaded stalls, so the overall effect was minimal.

horses in the treatments of Friend et al. (1998) that received periodic water during transport were very similar to those of the horses in a study by Stull and Rodiek (2000) (Table 1). The maximum weight loss observed in the nine shipments of slaughter horses surveyed by Stull (1999) further supports the relationship between temperature and weight loss when compared with the 10.3 and 12.8% losses found in horses transported for 30 h at with a much higher minimum temperature (Friend et al., 2000). The higher the average temperature becomes over a period of time, the greater the rate of weight loss or dehydration in horses. Horses cool largely by sweating, and, under conditions of high sustained temperatures averaging 30°C or more, water loss due to dehydration can become extreme after 28 h (Figures 1 and 2).

Weight loss and dehydration can be greatly reduced or stabilized after an initial weight loss by providing periodic watering on board the transport vehicle (Figure 1). All of the watered horses in Figure 1 readily consumed water when it was offered, but that was water to which those horses were accustomed. Although the tendency for many performance horses to be reluctant to drink water during transport may create concern for their owners, most horses will readily drink on board trailers when they are dehydrated enough. Under relatively hot conditions, that usually occurs about 8 to 24 h after initiation of water deprivation (Friend et al, 1998; Friend 2000; Gibbs and Friend, 2000). Even though weight loss and dehydration may be limited by offering water on board transport vehicles, fatigue will likely become the next limiting factor regarding how long they may be transported.

Recovery from dehydration is extremely fast. Sodium, chloride, and osmolality approach normal ranges within hours of rehydration (Carlson et al., 1979; Friend, 2000), and blood proteins return to basal concentration by 3 (Figure 2) to 12 h, or longer (Tasker, 1967; Carlson, et al., 1979; Stull and Rodiek, 2000), depending on the duration and severity of dehydration.

There are no published studies that were specifically designed to provide a basis for recommended rehydration rates in dehydrated horses. Dehydrated horses may drink to excess and limiting water to 12 L at 30-min intervals is too rapid to avoid mild colic when healthy horses were extremely dehydrated (Friend, 2000). However, no signs of colic were reported when horses were moderately dehydrated and offered 1 h of access to water (Carlson et. al., 1979) or when offered 14 L of water at 30-min intervals. Dehydration rates

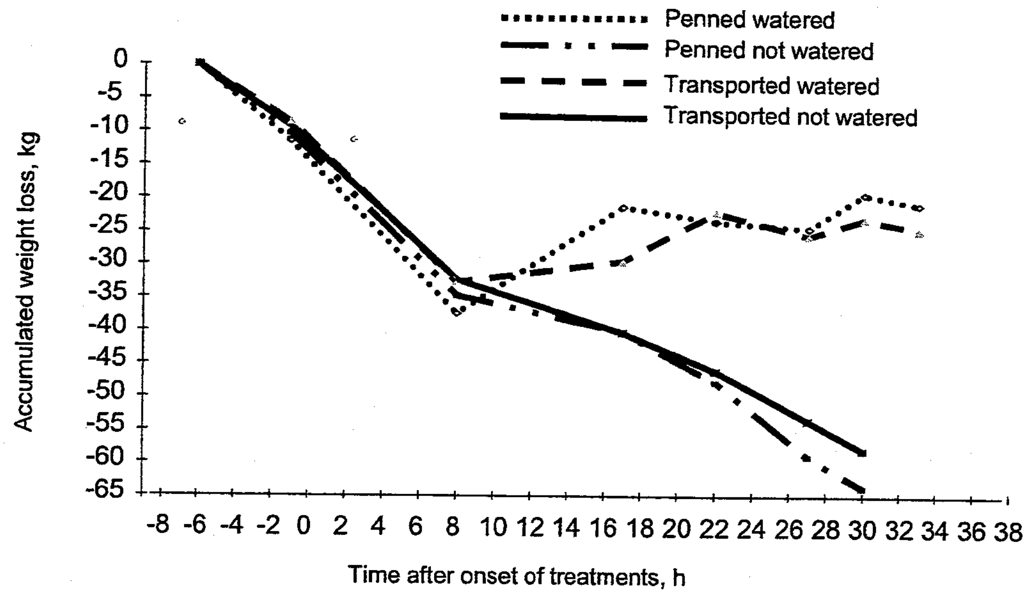

Figure 1. Means of accumulated weight loss before and during treatments and during recovery (Friend, 2000). Before and during treatments, n = 10 per treatment group for the transported horses and n = 5 per treatment group for the penned horses. During recovery, from 36 to 54 h, n = 5 for the transported, unwatered and n = 2 for the penned, unwatered horses.

and mild signs of colic from overly rapid rehydration were similar for horses that were transported or maintained in a pen in full sun (Friend, 2000). It is important to recognize that these rehydration rates are based on horses that had not been worked or exercised.

When the ambient temperature averaged 10°C, horses were deprived of water for up to 8 d without apparent ill effects (Tasker, 1967; Table 1). There are no scientific studies on the effect of transportation of horses during extreme cold weather, although trans-

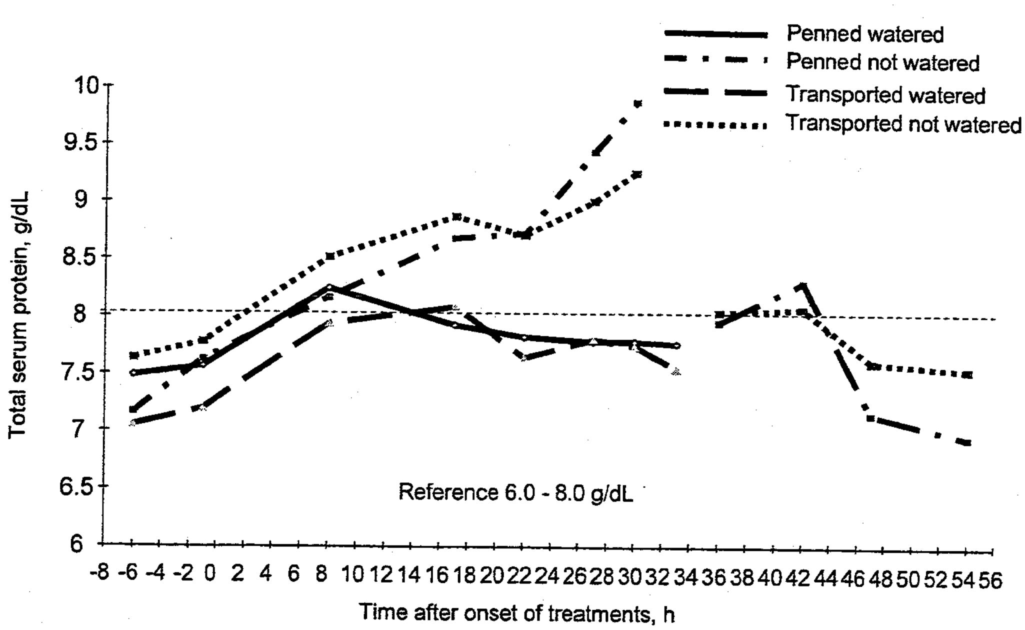

Figure 2. Means of total serum protein before and during treatments and during recovery (Friend, 2000). Before and during treatments, n = 10 per treatments group for the transported horses and n = 5 per treatment group for the penned horses. During recovery, from 36 to 54 h, n = 5 for the transported, unwatered and n = 2 for the penned, unwatered horses. Reference (normal) range is from Boon and Rebar (1998) and is represented by the dashed line.

porting horses under cold and wet conditions could lead to hypothermia and possibly to death. Helping transported animals conserve body heat by reducing ventilation and keeping them dry is easier to accomplish than reducing heat load when ambient temperatures are extremely high. Transporting horses during cool weather will greatly reduce dehydration rates, but fatigue will then become the next limiting factor.

Fatigue

Transportation requires effort on the part of the horse that can be similar to exercise (Codazza et al., 1974). Short trips (90 km) have relatively little effect on the performance of horses (Beaunoyer and Chapman, 1987), whereas longer transport (900 km) should be completed at least 48 h before a race to permit hematochemical values to return to normal (Codazza et al., 1974). There is only one study in the literature in which horses were transported until fatigue became apparent (Friend, 2000). Those horses were transported in two groups of five on a large semi-trailer but were individually watered at regular intervals. Those horses showed increasing signs of fatigue (closing their eyes, lower head carriage, less social interaction, and less response to stimuli) after 24 h. Although not quantified, there was a striking absence of social interactions, especially threats and nipping each other after 27 h of transport. Transport was terminated after 33 h based on the absence of social interactions, a greatly reduced response to stimuli, and the horses' generally depressed appearance.

Although advancing dehydration may be stopped by providing horses water in transport vehicles or by transporting them during cooler weather, fatigue will continue to increase to a threatening level after 28 h of transport of fit and healthy horses. I observed one seemingly healthy, but old, slaughter horse lying down in a crowded trailer after 8 h of transport. Lying down during transport is not necessarily a problem when horses are in individual stalls, but a prone horse will probably be trampled under crowded group conditions.

Orientation

Sharon Cregier, from Prince Edward Island, Canada, was very important in raising the consciousness of people in North America to the importance that orientation of horses may have on the ability of horses to maintain their balance in certain types of trailers. Her inspiration (Cregier, 1982) was the observations of Wentworth Tellington (Tellington and Tellington-Jones, 1979), a California engineer and horse trainer, and David Holmes's informal experiments that resulted in his developing a rear-facing "safety trailer" in New Zealand.

Cregier (1982) hypothesized that horses are instinctively aware of the vulnerability of their head and chest when facing forward during transport. The expectation of decelerations and stops results in the horse's carrying its head in an unnaturally high position that shifts weight to the hindquarters. Because the forequarters carry 60% of the horse's body weight and deal with direction changes, when the horse's weight is shifted to the hindquarters its balancing ability is assumed to be impaired (Cregier, 1982). She also believed that the fleshy rump better absorbs the shock of impacts due to rapid deceleration and stops, and thus transporting horses facing away from the direction of travel is a safer alternative than transporting them facing toward the direction of travel.

Subsequent research on orientation, however, has found inconsistent results, perhaps related to differences in the design of trailers or preferences of certain horses. For example, in two horse trailers, rear-facing horses could better maintain their balance (Clark et al., 1993) and had lower heart rates and less movement (Warren et al., 1996) than forward-facing horses. However, Smith et al. (1994b) were unable to detect a difference in heart rates between horses facing forward and those facing backward when they were transported in the back half of a four-horse stock trailer. In another experiment, horses spent significantly more time facing backward when the trailer was in motion (Smith et al., 1994b). However, some horses showed a very strong preference to face toward the direction of travel, and no differences in heart rates for either forward or backward orientations were evident. Kusunose and Torikai (1996) did find that yearling Thoroughbred horses increasingly oriented away from the direction of travel as the number of trials increased.

A series of experiments using a large semi-trailer to conduct simultaneous comparisons of different treatments (orientations) of horses (Gibbs and Friend, 1999) transported four times over a course containing bumps, high-speed turns, and sudden stops found that orientation had only a slight effect. Individual horses transported loose in pens showed a slight preference (57% of their time) for facing in the direction of travel, but it was not statistically significant. When individual horses were tied to the right side of the trailer, they spent 59% of the time facing the direction of travel. When tied on the left side of the trailer, the horses spent 52% of their time facing away from the direction of travel. The tendency to face forward when tied on the right and to face to the rear when tied on the left side of the trailer indicates a slight preference for the left side to be more exposed and the right side closer to the wall. The horses' ability to maintain balance when confined to stalls set at different orientations within the trailer was also determined in a series of trials. Horses facing backward did slip more than horses that were forward facing, facing forward at a 45° angel, and rear facing at 45° ($P = 0.03$), but leg movement and impacting or leaning on barriers or walls were not influenced by orientation ($P > 0.10$). There was no significant difference between unshod and shod horses. Overall, a slight preference for a 45° orientation was observed, but no preference for facing either toward or away from the direction of travel was detected. Balancing ability was not meaningfully affected by orientation (Gibbs and Friend, 1999). If facing forward is adverse, horses would be expected to spend little time in that orientation, but the research data show only a slight preference, at best, for facing away from the direction of travel.

The strong preference that some horse owners have observed for horses to voluntarily face away from the direction of travel may in part be due to an improved ability to maintain their balance by avoiding saddle compartments that restrict the movement of their head and neck and hence their ability to shift weight and maintain balance. There is also a strong preference to avoid the dark-cave effect associated with most smaller horse trailers and a strong desire to face the more open rear of a trailer that often has a large opening between the top of the rear doors and the roof of the trailer. Informal observations from a large commercial horse transport company that operates large vans in which horses face both toward and away from the direction of travel indicate that having horses tied in such a manner that they can readily raise and lower their heads is the most important factor in reducing transport stress (Robert Maxwell, personal communication).

There may be a slight advantage to slant-load trailers regarding the ability of horses to maintain their balance. Slade (1987) speculated that when turning, horses "in-line" (parallel) must lean diagonally, whereas slant-loaded horses are already oriented more perpendicular to the centrifugal forces of the turn and can therefore more easily maintain balance. Slade (1987) measured the velocities of horses during the last 137.2 m of a 365.8-m run immediately after transport facing forward or backward in a slant-load trailer. Each horse served as its own control; each faced slant-forward for one trip and slant-backward for another. Slade found that horses were only slightly faster after transport facing the rear than after transport facing the front. Although this was not a statistically significant difference, Slade suggested that it may be of importance in a close contest.

From the research that is available, the reduction in transport-related problems that many people report when they switch to a slant-load trailer may be due to attributes other than being transported at a slant. That is, there is less of a "dark-cave" effect because most slant-load trailers have a large window in the front of each stall, the horses usually have an increased ability to raise and lower their heads because of the lack of a saddle compartment, and the stalls are usually longer than in conventional horse trailers.

Density

Because the vast majority of competition, performance, and companion horses are transported in individual stalls, the density of horses during transport is not an issue for many horse owners. However, density is a very important issue for horses being transported in loose groups, as when they are transported to slaughter. The driver in the cab of a tractor that is pulling a large trailer loaded with loose horses (or cattle) can easily feel and hear horses shifting and impacting the sides and deck of the trailer. There is noticeably less banging from the trailer when the horses are tightly loaded, giving rise to the old saying that horses (and other stock) should be loaded tightly so that they "hold each other up." However, recent studies with horses (Collins et al., 2000) and cattle (Eldridge and Winfield, 1988; Tarrant et al., 1988; 1992; Tarrant and Grandin, 1993) have found no basis for that claim and instead concluded that moderate density is preferable. Stull (1999) did report reduced injuries at higher density; however, most of the physiological responses indicative of stress obtained by Stull were less in horses provided with greater floor area. Transportation studies are particularly difficult to do because a large proportion of injuries within a shipment of horses may be caused by one aggressive horse (Grandin, 1999; Collins et al., 2000), making the experimental unit the group or shipment.

The distance that horses were displaced during hard stops was similar between high- and low-density treatments (Collins et al., 2000), indicating that horses in the high-density treatment did not "hold each other up" any more than those in the low-density treatment. In moderate-density situations, horses have more opportunity to move a hoof or change their posture to compensate for changes in speed, and hence there are more body and hoof impacts. This concurs with Tarrant and Grandin's (1993) conclusion that shifting within trailers is inhibited at high stocking density and that there is a corresponding increase in struggles and falls at high stocking density. In addition, the ability of horses to stand up after a fall was clearly hampered by high density (Collins et al., 2000; Table 2), which contributed to the greater number and greater severity of injuries observed in those horses (Collins et al., 2000).

When stocking density increases, horses may not be able to adopt improved balancing strategies because the high density does not allow them any freedom to change their behavior (Collins et al., 2000). Dominant or aggressive horses may repeatedly bite, kick, shove, and displace other horses when establishing their orientation, assuming that even the aggressive horses are successful in obtaining maneuvering room. When horses went down at a high stocking density, they were trapped on the floor by the remaining animals "closing over" and occupying the available standing space (Collins et al., 2000). This can be readily seen in the controlled studies conducted by Collins et al. (2000; Table 2) in which horses that fell in the high-density treatment spent much longer time down. Although those horses were transported over a standardized course for just 25 min, one horse in the third trial ceased attempting to get up and had to be rescued. Most horses that go down under high-density conditions during long

Table 2. Comparison of falls and duration of time down for horses transported at two densities (based on Collins et al., 2000)

Trial	Density	Number of horses	Area per horse, m^2	Number of falls	Horses that fell, %	Mean down time, s/fall
1	Low	8	2.23	1	13%	2
1	High	14	1.28	2	14%	8
2	Low	8	2.23	1	13%	1.5
2	High	14	1.28	8	57%	17.5
3	Low	8	2.23	2	25%	41.5
3	High	14	1.28	7	50%	93.9
Average	Low	8	2.23	1.3	17%[a]	15[b]
	High	14	1.28	5.7	40%[a]	39.8[b]

[a]$P = 0.046$.
[b]$P = 0.14$.

distance transport will likely be trampled if aid is not rendered quickly.

The increased incidence and severity of injuries in high-density conditions may be due to a number of factors. Experienced horses avoid contacting surfaces during transport (Gibbs and Friend, 2000) and prefer to maintain their balance independently of other horses. Horses in high-density conditions are crowded to the point that they can move only several centimeters and are forced to have contact with other horses and the sides of trucks (Collins et al., 2000). They are constantly repositioning their feet in an apparent attempt to maintain their balance and frequently stepped on the hooves and pasterns of other horses. Aggressive horses bit and kicked other horses, resulting in injuries, as they maneuvered for room. A few aggressive horses may inflict most of the injuries incurred in a trailer-load of animals (Grandin, 1999; Collins, et al., 2000). In addition, the attempts of horses being bitten to stop the biting by kicking with their hind feet also contributes to injuries. Horses that fall down in high-density conditions sustain more injuries and severe injuries due to the "closing over" effect. Table 3 illustrates the positive relationship that the number of injuries and severity of injuries has with high density. Injuries may also be influenced by the type of flooring and other factors affecting a horse's traction.

Moderate stocking density would likely reduce injury and bruising during transportation but would also increase transport costs. High stocking densities create a situation of constant struggle for the horses. Decreasing density would reduce the overall stressfulness of long-distance transport by allowing the horses some maneuvering room to avoid aggressive horses, to stand in a more comfortable position, and to adopt their preferred orientation, and perhaps it would allow them to rest during periods when the truck is stopped (Collins et al., 2000).

Engineering Considerations

Suspension

Vertical movement created by running over an artificially created series of bumps that were enough to jounce observers out of their chairs had little observable effect on horses in regard to balancing ability (Gibbs and Friend, 1999). The horses stood still with their feet apart and absorbed the shock for the approximately 10-s duration of the bumps. However, during longer periods of transport the suspension on a vehicle will have a major impact on the fatigue and the well-being of horses. Although there are several types of suspensions available for standard horse trailers, the only scientific

Table 3. Number and severity of injuries for horses transported at two densities (based on Collins et al., 2000)

Trial	Density	Number of horses	Area per horse, m^2	Number of injuries	Horses injured, %	Injuries per horse	Mean severity score
1	Low	8	2.23	0	0	0	0
1	High	14	1.28	11	35%	0.79	1.91
2	Low	8	2.23	6	25%	0.75	1.33
2	High	14	1.28	43	93%	3.07	1.77
3	Low	8	2.23	12	63%	1.50	1.2
3	High	14	1.28	42	64%	3.00	1.64
Average	Low	8	2.23	6	29%[a]	0.75[b]	0.92[c]
High	14	1.28	32	64%[a]	2.29[b]	1.77[c]	

[a]$P = 0.006$.
[b]$P = 0.11$.
[c]$P = 0.48$.

comparison was conducted by Barbara Smith at the University of California at Davis. Leaf-spring suspension with low-pressure radial tires was statistically the smoothest combination tested (Smith et al., 1996b). The torsion-bar suspension with normal-pressure radial tires, which is very popular on newer trailers, was among the roughest. When the effects of transport with leaf-spring suspension with bias-ply tires was compared to torsion-bar suspension with normal-pressure radial tires, the difference was not biologically significant. Although there was a difference in regard to smoothness of the ride, the presence of other stressors during transport probably masked any effect that may exist (Smith et al., 1996b). Unfortunately, Smith did not compare air suspension systems, which are widely accepted as offering the smoothest ride.

Saddle Compartments

Securing a horse's head over a saddle compartment or similar structure forces a horse to keep its head raised in an unnatural position. Not only does restricting the movement of the head increase fatigue and make it more difficult for horses to maintain their balance during transport (Cjrieger, 1982; Clark et al., 1993), but it may also directly lead to pathology. Keeping the heads of healthy horses raised leads to an increased bacterial burden in their tracheobronchial secretions (Racklyeft and Love, 1990). Those authors hypothesized that allowing the horse to lower its head may promote drainage and facilitate clearance of bacteria from the tracheobronchial tree.

Future Research Opportunities

The recent interest in the transport of slaughter horses has stimulated considerable research and greatly increased our knowledge about the transport of loose horses over long and short distances. There has not been a scientific evaluation of what is currently the most popular horse trailer, the aluminum slant load with rubber-torsion suspension. Although air suspensions offer the best rides for larger trailers, there are no scientific data determining the effect alternative suspensions have on reducing fatigue in horses transported long distances. Insulating trucks and trailer roofs and side walls has the potential to greatly reduce the heat load and dehydration rate in horses transported long distances under hot conditions; however, no comparisons have been made. Determining the possible benefit of constructing trailers of insulating materials for transport of horses during cold weather transport may also be useful. There is also a conspicuous lack of scientific data on the transport of horses during cold conditions and the transport of horses by aircraft.

The transportation of horses is certainly a fertile field for research and is justifiable considering the huge investment in horse transportation equipment. There are excellent means of relaying the results of research to horse owners. However, the diffuse nature of the horse industry and the relatively large number of trailer manufacturers and a general reluctance of the manufacturers to fund applied research is problematic.

Implications

Horses show extreme dehydration after 28 h of transport in hot and humid conditions. Watering horses on board trailers will alleviate dehydration, but fatigue can become extreme after 28 h of transport. Orientation (facing forward, back, or diagonal) does not seem to significantly affect a horse's ability to maintain its balance. Loose horses that are transported in groups at high densities (e.g., slaughter horses) do not hold each other up, but inhibit each other's attempts to compensate for changes in inertial forces and have increased injuries; the ability of horses to stand once they fall is also inhibited. High density also prevents submissive horses from moving away from aggressive horses, resulting in repeated aggression. Reducing density, however, greatly increases transportation costs. A major challenge is determining which of the myriad of trailer designs, suspension systems, and building materials available are preferable from the standpoint of the horse.

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