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Physiology, Balance, and Management of Horses During Transportation

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Introduction

Horses throughout the ages have been transported for a variety of reasons including breeding, military endeavors, competitions, ceremonial proceedings, pleasure activities, biomedical purposes, and slaughter. Transformation of the modes in transporting horses has progressed from the utilization of boats or ships to move calvary horses, to conveying racehorses in vehicles drawn by other horses in the early 1800's, followed by railways until the 1920's. Motorized conveyances were developed in the middle 1900's, and trailers or vans hauling pleasure, show, and race horses became essential in the horse industry. The 1960's to 1970's were known as the "trailer age," since it was commonplace for powerful cars to pull horse trailers. The veterinary literature of this era also documents an increase in trailering accidents, ailments, and other related stress incurred while transporting horses. Today, airlines expediently fly horses around the world. Queen Anne (1702-1714) may have played a key role in the development of transportation vehicles. One of her charges arrived at the race track in a large, horse drawn conveyance which carried the horse in a sling surrounded by a gondola (Cregier, 1989).

Throughout history the management practices and other considerations in transporting horses have changed very little from ships to jets. As early as 1902, Horace Hayes wrote the book "Horses on Board Ship, A Guide to their Management" describing the voyages between England and South Africa of remount military horses on cattle steamers between 1899 and 1901. These steamers could provide transit for close to 1000 horses on several different decks. In his book, Hayes discusses topics on preparation of horses to bear transit, ventilation, feeding, halters, embarking and disembarking, costs, and veterinary remarks. These are similar types of topics applicable to contemporary equine traveling.

Stress

Everyone knows what stress is, however, it is not easily defined. One definition defines stress as adverse effects in the environment or management system which force changes in an animal's physiology or behavior to avoid physiological malfunctioning, thus, assisting the animal in coping with its environment. Animals respond to challenges in their immediate environment by several interacting mechanisms including physiological, biochemical, immunological, anatomical and behavioral parameters. Identifying and minimizing stressful situations allows for greater well being, health, and reproductive efficiency of the horse as well as protecting its performance and economic potential.

Stressors in Transit

A satisfactory transportation environment for a horse provides for thermal comfort, physical comfort, minimal disease or maximum health, and behavioral needs. Each of these four areas can be a potential source of stress for the horse.

Thermal stress

Cold or heat stress can affect younger or sick animals much more severely than mature, healthy horses. Thermal comfort may be quantified as the thermal neutral zone and may differ depending on the species (Curtis, 1983). In the horse, the temperature range is estimated between 30^o to 75^o F in still air. This optimal thermal environment promotes maximum performance and provides the least amount of stress for the horse. Within this thermal neutral zone, the horse maintains body temperature, or homeothermy, by constriction or dilation of the blood vessels, changing postures or behavior, changes in hair, or by sweating. As air temperature falls below 30^o F, known as the lower critical temperature (LCT), the horse must divert food energy from production, performance or growth to produce additional metabolic heat and maintain body temperature. For each 10^o F drop in temperature below the LCT, a 15 to 20% increase of total calories is required (Young and Coote, 1973). Thin horses, clipped horses, or young horses may require an additional amount of feed in cold weather. The combination of factors such as wind, rain, and mud in temperatures below the LCT also affects the energy requirement with up to an additional 80% increase in calories. Thus, transporting a horse in cold weather depending on transit time, requires appropriate management of the diet to maintain body weight, growth, reproduction, or maximize performance.

The upper critical temperature (UCT), approximately 75^o to 90^o F, is reached when the horse cannot dissipate enough metabolic heat to the environment to maintain homeothermy. Humidity is a major factor in the determination of the UCT. The horse dissipates heat through respiration and sweating mechanisms. In hot environmental conditions, the horse's feed intake may decrease. Water availability is essential to avoid dehydration. Transportation in hot, humid conditions should attempt to minimize thermal stress by carefully selecting departure/arrival time schedules to avoid the hottest portion of the day, frequently offering (every 4-6 hours) water to the horses, and limiting the duration of the trip. In hot conditions, it is important to keep the trailer moving and avoid parking for long periods. Temperature in a trailer usually is 10^o to 15^o F greater than outside temperatures (Smith, 1996).

Environmental

The physical component of the horse's environment includes the space available and the surfaces with which the animal comes into contact with. Flooring materials such as bedding, feeders and space allocation in transport systems are examples of environmental factors. These factors can determine the safety of the animal's environment. Slippery surfaces on loading ramps and/or during transportation on floors are factors under the control of the hauler. Diffuse lighting should be provided in dark environmental conditions for the safe loading/unloading procedures.

Accidents from these types of deficiencies usually are due to poor judgement or lack of necessary precautions.

Other environmental stressors of the horse's environment which may have a greater impact on health and well-being during transport are toxic gases from either exhaust fumes or build-up of waste products (feces and urine). Toxic gases, especially elevated ammonia or carbon monoxide levels, can cause damage to the lung epithelium, precipitate respiratory disease, or alter or depress behavior.

Disease

This stressor is that which results in the onset and spread of disease. The susceptibility of the horse depends on many factors including its immunity level, the pathogen challenge, capability of defense mechanisms, and its preventive health program. Vaccine programs provide immunity to many common equine diseases. However, mixing of horses from different environments and under stressful conditions may precipitate susceptibility to disease. Cleanliness and stocking density can affect the pathogen challenge to the horse. Dry, sanitized, and clean vehicles are important in minimizing disease. Proper ventilation and low dust levels are essential to maintain proper respiratory function.

Other Stressors

There are numerous other examples of common stressors in the management and transportation of horses. These may include behavioral stressors such as social isolation from stable mates, aggressive interaction of other horses during transportation, lack of security in novel environments, training regimes and interrupted feeding schedules. These management techniques should be planned to minimize the total additive effect of all stressors on the individual horse. One stressor which is easily eliminated is the improper handling of horses by handlers and/or poor driving techniques which can cause both behavioral and physiological stress effects.

Effects of Stress

The reaction of the animal to stressors depends on the duration and intensity of the stressors, the animal's previous experience to the stressors, its physiological status, and the immediate environmental restraints. An animal may react either by a behavioral or a physiological response, but most often a combination of both. The duration and intensity of stress can impact the horse's capacity to grow, reproduce, train, perform and maintain health.

A normal behavioral response to an immediate and acute type of stress is easily observed. The horse usually will exhibit a fleeing response. An example of this type of stressor is a loud noise or a short term, painful event such as delivered with the impact of biting or kicking.

Some abnormal behavioral responses are categorized as "stereotypies." Stereotypies are sequences of movements which are repeated over and over without any apparent function.

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Examples of stereotypical activities in horses are stall weaving, pawing, shifting, and repetitive licking and/or scraping of objects. Stressors which induce stereotypic behaviors can be situations in which horses are isolated from herd mates for extended periods, nervous situations such as standing in the trailer, or anticipation of some stressful event. Sometimes, poor driving techniques or hazardous road conditions can initiate the onset on a stereotypic behavior.

Physiological responses to stress have been investigated more than behavioral profiles. However, no one physiological parameter has been identified to quantify a stress response. In both humans and animals, parameters which have been utilized in studying the stress response include measuring levels of hormones released from the brain and other organs, fluctuations in white blood cell parameters, and changes in the heart rate. A short term stressor, such as a loud noise, increases the heart rate and may cause constriction of the blood vessels. A stressor which lasts several seconds to a minute may increase heart rate, respiration rate, and cause digestive upset or decreased feed intake.

A long term, chronic stress, usually 24 to 48 hours, can occur in horse which are shipped or experience thermal discomfort. This longer term stress influences a number of systems in the animal including the immune, digestive, and reproductive systems. Long term stress can influence hormones essential in reproduction, growth, energy metabolism, and response to disease or infection. These deficiencies can continue after the stimulus from the stressor has been diminished or eliminated.

Assessing Stress

The quantification of a stress response by scientists often has been designed to examine only the behavioral or the physiological responses. Behavioral responses to chronic or long term stress can be very difficult to observe. This may be seen in a horse by an increase in ambulatory movements, less interaction between herd mates, more aggressive behavior toward handlers and other horses, or less time spent eating or drinking. All of these behavioral responses can manifest a physiological effect by body weight changes or possibly a compromised immune system.

Physiological measurements of stress are dependent on the interaction of many systems. Some stress responses can be measured by the functionality of the primary system involved. An example includes an elevated environmental temperature which would increase respiration rate, induce sweating and raise body temperature. Changes in hormones such as cortisol, or the reproductive hormones are utilized in quantifying the response to stress. One indicator of the impact of stress on the immune system is characterized by the ratio of neutrophils to lymphocytes, which are types of white blood cells. Heart rates can be recorded by telemetric systems to monitor the stress response of the cardiovascular system. Stress is important to the horse breeder, since longer term stress may influence reproductive cycles or behavioral display of estrus.

Controlling Stress

The first step to minimizing stress during transportation is to be able to identify the signs and symptoms of stress in both the individual animal and load of horses. This will include observations on appropriate or abnormal behavior, indicators of sickness, and injuries. Once a stressor is identified, its rapid elimination will assist in termination of the stress response. Proper management of the horses to minimize stress during transport includes space allocation, waste management, sanitation, preventive health programs, training, and nutrition. The proper training of horses, prevention of accidents, sorting of horses prior to loading, loading area design, suitable transportation vehicle and loading density are all factors controllable by haulers.

Orientation during Transit

Orientation of the horse within a transportation vehicle has been identified as a potential source of stress. Several studies have examined horses facing toward or away from the direction of travel. The advantages of facing away from the direction of travel or "backwards" includes the ease of loading a horse backwards into a trailer rather than facing a dark, small opening which may be perceived by the horse as a scary cave (Creiger,1989). Also, the hindquarters of the horse are positioned at the area of impact during braking or acceleration. In the back facing position, the horse's head is not constantly carried in an elevated position such that the horse may use its head and neck to balance more effectively. It may also be advantageous that the forelegs are placed in the rear of the trailer and may adapt to swaying motions more readily than the hind legs. This "buttress" posture adaptation is commonly exhibited during grazing, whereby the shoulder provides better lateral support than the rear legs. Often, the rear legs engage in a side stepping action when responding to lateral pressure.

A study examining the response to traveling forwards or backwards during a one hour journey showed a significant decrease in heart rate in the horses traveling backwards. These horses also tended to rest more often on their rumps in maintaining their balance. The forward facing horses held their heads in a higher than average position and also moved more frequently due to difficulty in balancing. Interestingly, the forward facing horses vocalized more frequently. Heart rates increased at loading and unloading, and decreased during the journey as the horses became accustomed to the motion of transport. The authors concluded that the forward orientation may be more physically demanding due to efforts implemented to maintain balance (Waran, et al., 1996).

Heart rates were also measured in another study examining horses tethered facing forward or backward in a stock trailer undergoing road transportation for about 40 minutes compared to controls which were loaded but remained in a parked trailer for the same duration. Heart rates were not significantly different for horses facing forward or backwards during transport or while parked. However, heart rates were increased in the horses undergoing transportation. Transient increases and decreases in heart rate during transportation were attributed to the decelerations and accelerations of driving. Heart rates were highest at the start of the ride, then decreased during the first 15 minutes, until heart rate stabilized as the horses adapted to the motion of the trailer (Smith, et al., 1994).

Balance

Loss of balance can be the source of both minor and catastrophic injuries, and behavioral problems in horses. If extreme, damage can be caused to the vehicle and the horses may become unsuitable for safe transportation. In a competitive equine world, a horse that "can't handle traveling" is drastically disadvantaged economically. It is important to understand how a horse attempts to balance with the motion of transportation, thus assisting in the design of vehicles and handling of horses during transportation.

Transportation produces horizontal forces due to acceleration. The response of the horse to this motion has been defined as passive, yielding, or reactive sway (Roberts, 1990). See Figures 1-3 Passive sway is the elastic balancing mechanism uses when the support platform is moved under the horse's hooves. If moved too quickly, such as accelerating too fast, the horse will actually attempt to take several steps in the direction of the travel. Yielding sway involves the trunk to remain stationary while the head becomes more upright. Yielding sway is appropriate for balancing during small temporary accelerations. For longer horizontal accelerations, reactive sway involves the movement of the feet in a repositioning movement. The head may move forward while the horse's body leans inward over the inside leg. This type of balancing is performed when a vehicle is turning; reactive sway may maintain balance without staggering.

The stance is the most noticeable change observed during balancing. A quiet, but alert horse will have all four legs vertically placed directly below the body. A horse reacting to the motion of transportation, will place the forelegs apart in a "buttress" position, while the hind legs may take a less splayed position. This wide stance allows the horse to retain balance by exerting thrust with one leg or the other.

As compared to a backward facing horse, a forward facing positioned horse has noticeable differences in the handling mechanism of acceleration and braking. Severe braking may force a horse to take forward steps to preserve its balance, bring its head closer to the bulkhead. Roberts (1990) has suggested that braking may be perceived as a threatening situation. The horse may become progressively more fearful with the repetition of braking and acceleration. This may lead to injury or other safety problems. The inexperienced horse may show a similar behavior as a young horse pulling against a lead rope, with the front legs spread apart and weight displaced to the rear legs, while the head is jerked upwards. This type of posture was not observed in horses oriented backwards. During deceleration, the backward facing horse may take on the "plow horse" look. Braking caused these horses to displace weight to their hindquarters and even rest the large muscle mass of the rump on the trailer. Acceleration is easier to handle since the front legs and head have more floor area to utilize than in a conventional trailer.

The scientific data shows differences and similarities in the orientation of the placement of the horse in a trailer. The behavioral data demonstrates differences in the balancing mechanisms between the forward and backward orientation, while the physiological data is inconclusive on supporting either position. Other factors make this decision rather complex including the previous transportation experience of the horse, health of the horse, driving conditions of the route, driver influences, the behavior of other traveling mates (excitement and fear are often contagious!), axle placement, and environmental factors. Safety of the handlers in loading and unloading also should be taken into account. Thus, orientation may only be one of many complex parameters that determine the safety and physiological response to transport.

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Metabolic Energy Pathways

Transportation is an athletic endeavor and the horse will utilize metabolic energy pathways similar to those of exercise to maintain balance. Of course, other systems such as the muscles for coordination, and the respiratory and cardiovascular systems for metabolic supplies are also important. Depending on conditioning, age, previous experience, and conditions and duration of the transport, different energy pathways will be utilized. This is a concept that is particularly an important consideration in performance horses, particulary if they are expected to perform upon arrival.

The physiology of the energy generating pathways of the horse will depend on several different substrates which are ultimately derived from their diet. The physiology of work or physical performance depends on the ability of the horse to transform chemical energy into mechanical energy. The most abundant chemical energy compound in biological systems is in the form of **adenosine triphosphate** (ATP). During the breakdown of ATP to **adenosine diphosphate** (ADP) and phosphate, energy is liberated. This energy is required for muscles to contract; thus, providing the horse with the spectrum of physical movements needed in performance.

After ATP has been split to ADP during the contractile process, the ADP must be reconstituted to ATP to provide a continual energy source for contraction. Another high-energy compound, **phosphocreatine** (PCr), rapidly regenerates ATP stores by donating a phosphate molecule to ADP. However, the stores of PCr are also rapidly depleted, especially during intense muscular exertion. Therefore, other more complex organic compounds such as carbohydrates, fats, and proteins are utilized to yield energy in the form of ATP and are derived from nutrients in the diet. Carbohydrates and fats are the primary fuels utilized in the conditioned horse, while proteins provide little energy for the working horse.

The combustion of carbohydrates in the form of glycogen or glucose, which yields ATP, occurs using two different biochemical pathways. The presence or absence of oxygen at the muscle cell level will determine which pathway is utilized. If no oxygen is present, or **anaerobic** conditions exist, glucose is metabolized to yield ATP and another byproduct, lactate. Unfortunately, the byproduct lactate is not beneficial to the continuation of muscle contraction because the steady accumulation of lactate will decrease the pH of the muscle cell. This lowered pH will inhibit muscle contraction and fatigue will be observed. Lactate is also responsible for the muscle soreness or stiffness following exercise or disembarking after transit.

If oxygen is available at the muscle cell level, an aerobic condition, then glycogen is metabolized to yield carbon dioxide, water, and ATP. No lactate is produced under strict aerobic conditions. Carbon dioxide, a waste product, enters the circulation and is expelled by the lungs. Fats may also be broken down to yield ATP molecules under aerobic conditions.

The aerobic energy pathway is much more efficient in the number of ATP molecules produced per glucose molecule. One molecule of glucose will yield 38 ATP molecules aerobically, while anaerobically only two ATP molecules will be produced. Thus, during physical exertion by the horse, his energy sources will be depleted at a faster rate during the anaerobic metabolism than when oxygen is present at the muscle level. Also the build-up of lactate may be undesirable and may produce soreness.

The determination of which pathway contributes ATP molecules during exercise depends on the duration and intensity of the exercise performed, along with the degree of excitement or psychological input. For a calm or resting horse, the aerobic pathway is the primary energy yielding pathway. About two-thirds of the fuel is contributed by fats and one-third from carbohydrates. At the onset of exercise in the form of balancing, or with nervousness or anxiety, energy is supplied first by existing ATP and PCr in the muscles, and then through anaerobic metabolism. Even though oxygen is available at the lungs at the onset of exercise, it takes two to three minutes for the oxygen to travel to the muscle cell. During this short period at the beginning of exercise, when muscular oxygen demand exceeds circulating oxygen supply, anaerobic metabolism supplies the required ATP.

During submaximal exercise such as a horse successfully and easily maintaining balance, oxygen supply reaches adequate, steady-state levels within two to three minutes. Once aerobic conditions are established in the muscles, both carbohydrates and fats supply the energy for contraction. The extent of the metabolism of carbohydrates or fats depends on the level of fitness. Initial glycogen levels in the muscle, dietary factors, the length of transport and the intensity of balancing, and hormonal influences. During intense, maximal exercise, such as during a maximal struggle to maintain balance, oxygen supply may never meet or equal the demand for energy production. Glycogen depletion and lactic acid accumulation due to anaerobic metabolism usually result in severe fatigue within a few minutes.

It is important to understand the biological energy system utilized during transportation which will depend on the additive effects of the stressors, the inability/ability of the horse to maintain balance, and the duration of the transportation. A horse trained to calmly load and remain quiet during transportation will fats as fuels, thus "sparing" glycogen. Brain tissue is only capable of utilizing energy in the form of glucose, the precursor of glycogen. Thus, it is important not to totally exhaust the glycogen stores, but to "glycogen spare." Struggling to maintain balance may anaerobically utilize glycogen and deplete glycogen stores and/or produce lactic acid. .

Health and Disease Related Problems during Transit

Health in Transportation

Stress manifests with a variety of symptoms depending on the individual's health capacity, the duration of the stressors, and intensity. Death is the ultimate culmination of the many complex factors involved in stress. Some horses show behavioral signs of stress during or following transportation bu exhibiting stereotypies such as pawing or stall weaving. Less milder behavioral signs include a depression in appetite or nervousness. Trauma and disease are physiological manifestations of stress. Some physiological changes may include immunological compromise, which may not show effects until days later; whereas, increases in respiration rate, injuries or the presence of sweating are mechanisms easily observed. A major risk factor for the development of pleuropneumonia is transportation further than 500 miles (Austin et al., 1995). Horses following air transportation have been shown to have elevations in neutrophil counts and fibrinogen levels, both recognized to be measurements of stress (Leadon et al, 1990).

Head Position- Respiratory Dilemma

The major defense mechanism of the lungs to infections are the mucociliary epithelial lining in the airways and the presence of alveolar macrophages in the lower respiratory tract. The deeper the particles penetrate into the lower respiratory tract, the greater the potential for disease. The increase in bacteria numbers along with the ability to travel deep into the lung determine the health of the lung. Mucociliary barriers work as a filter to invading particles, by utilizing a sweeping action to push the particles back out of the lung. Macrophages are cellular defenders of the lung, and are important in controlling bacteria, toxins and dust which successfully invade the lung. Macrophages usually follow a three step process to control the infectious challenge which include the binding of the microorganism to the macrophage's membrane, followed by ingestion, and finally the inactivation of the microorganism. Alveolar macrophages are also capable of initiating immune and inflammatory responses in the lung. Cortisol, a major hormone released during stress, dramatically decreases the ability of the macrophages to kill bacteria.

Horses are often tied within the confines of the trailer during transport. The head and neck are position above the withers with very little allowance for lateral or horizontal movement. This practice of restricted movement for long intervals may precipitate the accumulation of microorganisms deep into the respiratory tract. The posture of a grazing horse facilitates the clearance of bacteria from the lower tract. Any lowering of the head is a more favorable position for the clearance of mucus.

Hay is often offered to a horse using a hay net or in an elevated feed manger. As the horse nibbles the hay, mold and dust is liberated into the air directly at the level of the horse's nostrils. Thus, the respiratory system is challenged with the expulsion of these particles (Mansmann and Woodie, 1995). The number or concentration of microorganisms and dust particles within the vehicle may be greater than the normal environment. An increase in the environmental temperature and relative humidity, as often reported in vehicles loaded with animals (Smith, 1996), supports the growth of bacteria and fungi. This may challenge the ability of the mucociliary mechanisms in the clearance of the microorganisms from the respiratory tract. The restricted head movement also will aid in the spread of normal nasopharyngeal organisms deeper into the lower respiratory tract, thus potentiating the development of respiratory disease (Racklyeft et al., 1989). In healthy horses traveling 36 hours in a trailer, the number and bactericidal function of alveolar macrophages were decreased one week after transport; whereas, cortisol showed elevations throughout this period. Interestingly, 12 hours following transport, there was an increase in particular matter observed inside the macrophages. This was suspected to be road and food dust or pollen inhaled during transit (Laegreid et al., 1988). Noxious gases including ammonia from waste products and gases from the fumes of motorized vehicles can also insult the respiratory system by disrupting the barrier between the alveoli and the capillaries (Smith et al., 1991).

Early Embryonic Death

Pregnancy loss due to transportation has been shown in several species. In early pregnancy (week 3 or 5) mares undergoing 9 hours of trailer transportation, cortisol levels and progesterone levels increased during transportation in mares that did not abort. In all the control and transported mares which aborted, there was a decrease in progesterone concentration. Even though early embryonic death rates or the transported mares were not different from control mares, there were effects of transportation on important hormones of gestation (Baucus et al., 1990).

Preparation and Care During Transit

** Horses with subclinical or clinical respiratory disease should avoid transport, except in emergency situations. Veterinarian consultation is recommended with these cases prior to shipping.
**Dietary adjustments are not necessary in horses being shipped a short distance. Horses intended to endure long transportation schedules should be provided with feed and water on a regular schedule. Laxatives, such as bran mashes, may not be necessary. Many nervous horses may develop loose feces or diarrhea, and may loose enough fluid to become dehydrated.
**Hay should be available on a free choice basis on medium to long journeys. Only quality hay which is free from mold and dust should be fed during transient. Moldy or dusty hay will only contaminate the air and overwork the mucociliary system in the respiratory tract. Allowing freedom of the horse's head during and after transport will assist in alleviating the respiratory stress due to an elevated head position.
**Water should be offered every 6 to 8 hours, if possible. Many horses however, will not drink "on-board."
**Relative humidity and temperature rise quickly in a stationary closed vehicle. Every effort should be made to unload the horse upon arrival, or minimize the thermal stress during stops.
**Respiratory ailments, such as shipping fever (pleuropneumonia), may not show symptoms for 2-3 days following transportation. However, depression in the attitude of the horse, lack of appetite, and the development of coughing or nasal discharge may indicate the symptoms of shipping fever. Recording of a daily rectal temperature in horses transported long distances is advisable. Veterinarian attention should be sought for the care and appropriate treatment of these horses. Death within 30 days post-transit due to pneumonia (Streptococcus equi) has been reported in horses transported from 8 to 43 hours (Oikawa et al., 1994).

References

Austin, S.M., J.H. Foreman, and L.L. Hungerford. 1995. Case-control study of risk factors for development of pleuropneumonia in horses. JAVMA 207(3):325-328.

Baucus, K.L., S.L. Ralston, C.F. Nockels, A.O. McKinnon, and E.L. Squires. 1990. Effects of transportation on early embryonic death in mares. J. Anim. Sci. 68:345-351.

Cregier, S.E. 1989. Land Transportation of the Horse. Live Animal Trade and Transport

Magazine. November. pps. 43-44.

Curtis, S.E. 1983. Environmental Management in animal Agriculture. Iowa State University Press, Ames, Iowa.

Friend, T. 1980. Stress: What is it and how can it be quantified? Int. J. Study Animal Problems. 1(6):366-374.

Hayes, M. H. 1902. Horses on Board Ship. A Guide to their Management. Hurst and Blackett, Limited, London.

Laegreid, W.W., L.J. Huston, R.J. Basaraba, and M.V. Crisman. 1988. The effects of stress on alveolar macrophage function in the horse: An overview. Equine Prac. 10(9):9-16

Leadon, D.P., J. Daykin, W. Backhouse, C. Frank, and M.A. Stock. 1990. Environmental, haematological and biochemical changes in equine transit stress. Proc., Am. Assoc. Equine Pract. p.485.

Mansmann, R.A. and B Woodie. 1995. Equine transportation problems and some preventatives: A review. J Equine Vet. Sci. 15(4):141-144.

Oikawa, M., M. Kamada, Y. Yoshikawa, and T. Yoshikawa. 1994. J. Comp. Path. 111:205-212.

Racklyeft, D.J. and D.N. Love. 1989. Influence of head posture on the respiratory tract health of horses. Aust Equine Vet. 8:123.

Roberts, T.M.D. 1990. Staying upright in a moving trailer. The Equine Athlete. 3(3):1-8.

Smith, B. 1996. Transporting horses. In: UCD Book of Horses. M. Siegal, editor. Harper Collins Publishers, New York, NY. pps. 436-440.

Smith, B.L., J. H. Jones., G.P. Carlson and J. R. Pascoe. 1994. Effect of body direction on hear rate in trailered horses. Am. J. Vet. Res., 55(7):1007-1011.

Smith, B.L., J.H. Jones, and G.P. Carlson et al., 1991. Minimizing transportation stress in horses. Proc., Assoc. Equine Sports Med. 39-42. ****

Waran, N.K., V. Robertson, D. Cuddeford, A. Kokoszko, and D.J. Martin. 1996. Effects of transporting horses facing either forwards or backwards on their behaviour and heart rate. The Vet. Record. 139:7-11.

Effects of different positions during transport on physiological and behavioral changes of horses. Article in Journal of Veterinary Behavior Clinical Applications and Research Â· October 2013 with 92 Reads.Â Drawing upon articles published over the last 35 years, this review summarises current knowledge on TRPBs and provides recommendations on their identification, management, and prevention.Â Comparison of 3 different positions (backward, forward, and sideways) during a 3-hour journey for Standardbred trotters accustomed to travel revealed that backward facing was the most ideal orientation. Backward-facing horses moved more but lost their balance less and were able to rest their hindquarters in a 3-leg position during the journey (Padalino et al., 2012).