EQUINE THERMOREGULATORY RESPONSES DURING SUMMERTIME ROAD TRANSPORT AND STALL CONFINEMENT

RESPOSTAS TERMO-REGULATÓRIAS DE EQUINOS DURANTE TRANSPORTE EM ESTRADAS NO VERÃO E EM CONFINAMENTO EM ESTÁBULO

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ABSTRACT

Thermoregulatory responses of horses subjected to summer-time road transport and stall confinement were investigated in this study. Six mature geldings were transported 168 km in a 4-horse trailer and were monitored while tethered in their stalls, on alternate days. Core body temperature (GT) demonstrated negligible response during transport, but GT following transport was higher than GT for non-transport. GT tended to increase with increased temperature humidity index (THI). THI within the trailer was greatest for positions near the front, and was influenced by daily weather which varied over experiment days from heat stress conditions to moderate discomfort.

Keywords: horse, physiology, temperature, thermoregulation, telemetry, heat stress

RESUMO

As respostas termo-regulatórias em cavalos sujeitos a transporte em estradas durante o verão e em confinamento em estábulos foram pesquisadas nesse estudo. Seis machos adultos castrados foram transportados 168 km em um trailer para quarto cavalos e também monitorados em dias alternados, enquanto alojados nos estábulos. A temperatura corporal (GT) demonstrou resposta não significativa durante o transporte, entretanto os valores foram maiores durante o transporte quando comparadas com o período sem transporte. GT tendeu a aumentar quando houve acréscimo no índice de temperatura e umidade (THI). THI dentro do trailer foi maior em posições próximas à parte anterior e foi influenciado pelos dados climáticos diários, que por sua vez variou durante o experimento, de estresse térmico até desconforto moderado.

Palavras-chave: Cavalo, fisiologia, temperatura, termo-regulação, telemetria, estresse térmico

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INTRODUCTION

Horse transport is associated with increased incidence of injuries, dehydration, and respiratory infections (CREIGER, 1982). A satisfactory horse transport environment should provide thermal and physical comfort, minimal disease exposure, and meet behavioral needs (STULL, 1997). Studies have indicated that these needs may not be met during extended duration transport, reporting immune function suppression and thermoregulatory challenge (WARAN & CUDDEFORD, 1995; STULL, 1999). Increased heart rate and core body temperature have been reported during transport (STULL, 1999). Changes in blood variables after transport were also reported, including increased blood cortisol concentration, packed cell volume (hematocrit), and neutrophil:lymphocyte ratio (SMITH et al., 1996; STULL & RODIEK 2000).

While studies have been conducted to characterize and improve the transport environment for poultry and livestock (KETTLEWELL et al., 2001), few studies addressed the environment of a horse trailer. PURSWELL et al. (2003, 2006) reported an increase in trailer temperature of 4°C (+/-2°C) above ambient conditions for an empty, moving trailer on a warm, sunny day. Presence of animals in the trailer further increased the temperature by adding additional heat and moisture into the trailer and by blocking ventilation from open windows and doors. This unsuitable thermal environment within the trailer resulted for ambient conditions that were not considered thermally challenging, and more extreme trailer conditions would be expected under more extreme outdoor conditions.

While studies have measured equine physiological responses to travel, most did not identify factors that induce the responses, such as thermal environment or impact of confinement. This study partially addresses the complicating factor of confinement by tethering horses in both the trailer and in a stall, and comparing thermoregulatory responses to each. This paper also thermal environment during transport and its relationship with core body temperature during transport.

MATERIALS AND METHODS

Animals

Six previously trailered mature geldings (body weight 548 kg ± 23 kg, mean ± SE) were selected for this experiment. Horses were familiarized with both the stall and trailer environments, including loading into and unloading from the trailer several times the week before the trial. Horses were housed in the individual stalls for two days before start of the trial. All procedures were approved by the Institutional Animal Care and Use Committee at the University of Kentucky.

Treatment Environments and Experimental Design

All horses were subjected to both trailer and stall conditions. For non-transport days, measurements were taken while horses remained tethered in an individual pen. Each pen was approximately 3 m x 12 m, and partially roofed. The horses were tethered in the shaded covered area to reduce effects of solar radiation. Tether length was similar inside the trailer and the stall.

During transport, measurements were collected while horses were trailered approximately 168 km (approximately 4 h) in a goose-neck four-horse trailer. The trailer was a slant-load configuration with a front dressing room and an access door to each horse compartment (Figure 1; see also PURSWELL et al., 2006).

Figure 1. Horses tethered in trailer with access doors open

Transport was conducted with recommended hauling practices (FASS, 1999) and an experienced driver. The transportation route included stop-and-go traffic followed by highway (maximum speed 92 km/h), each about 50% of the distance. A 42 km route (approximately 50 min) was repeated 4 times to achieve the total 168 km. All vents were fully open during transport, with total open vent area of 1.4 m^2 (Figure 2).

Figure 2. Goose-neck four-horse trailer used in Experiment 2

A vent was located near the head and tail of each horse, and each opened a maximum of 50%. Head vent dimensions were 39.4 cm x 34.0 cm and tail vent dimensions were 83.8 cm x 34.0 cm. A small roof vent (25.4 cm x 10.16 cm) was located above each horse, opening 45o forward or rearward (opened rearward for this study). The upper portion of the rear door (81.28 cm x 55.88 cm) remained open as well.

Monitoring Procedures

During the monitoring period each day, horses received no food or water for either treatment. All measurements were made between 08h:30min and 15h:00min on each study day. Core body temperature was measured according to a telemetry-based gastrointestinal temperature (GT) system previously validated by GREEN et al (2005). This telemetry system (CorTemp, HQ, Inc, 9th Street Drive West, Palmetto, FL) consisted of a battery powered ingestible transmitter and external receiver inside a protective box (Digi-Key, Thief River Falls, MN, part #HM142) attached to a girth strap (Figure 3). Telemetry sensors were inserted at approximately 15:00 the afternoon before the first day of study for each animal. During data collection, GT readings were saved once every 20 s. Following data collection, GT data were averaged over 5 min intervals for each daily monitoring period.

Figure 3. Horse instrumented with heart rate monitor and telemetry receiver

To provide the desired transport conditions, four horses were trailered at one time (additional horses were included to achieve the desired environment), but at most two were monitored for physiological responses. In the trailer, one non-instrumented horse separated each instrumented horse to avoid radio frequency interference from nearby sensors and receivers. Each horse was monitored on two consecutive days (one day in the trailer and one day in the stall).

Weather Data

Environmental conditions (temperature and relative humidity) were recorded on-site for trailer and stall. Daily weather conditions were obtained from weather data collected at a nearby facility (UKAWC, 2003) and varied over the four experiment days (Table 1). Livestock heat stress index (LHI) and categories were assigned according to the National Weather Service (NWSCR, 1976), and ranged from Danger (day 1) to Acceptable (day 4).

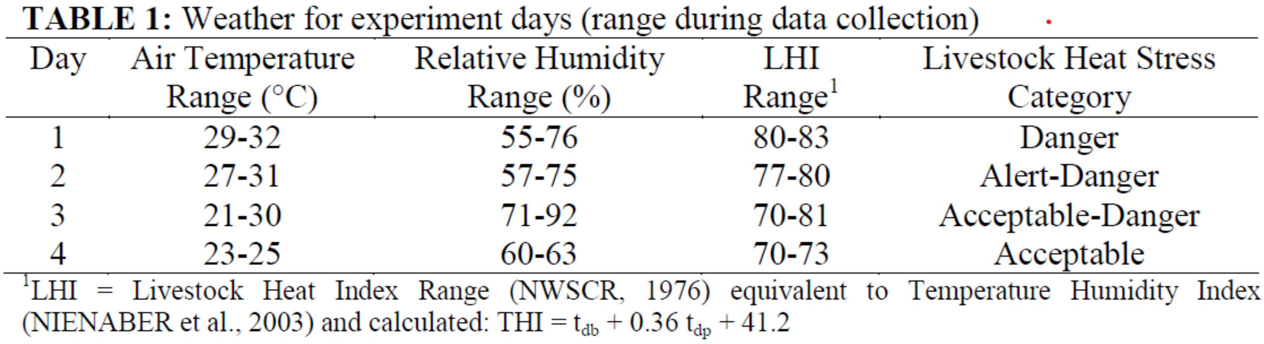

TABLE 1: Weather for experiment days (range during data collection)

Day	Air Temperature Range (°C)	Relative Humidity Range (%)	LHI Range[1]	Livestock Heat Stress Category
1	29-32	55-76	80-83	Danger
2	27-31	57-75	77-80	Alert-Danger
3	21-30	71-92	70-81	Acceptable-Danger
4	23-25	60-63	70-73	Acceptable

[1] LHI = Livestock Heat Index Range (NWSCR, 1976) equivalent to Temperature Humidity Index (NIENABER et al., 2003) and calculated: THI = $t_{db} + 0.36\ t_{dp} + 41.2$

Trailer Environment

Temperature Humidity Index (THI) was calculated for each position within the trailer and for a centrally located stall using Equation 1, which is modified from wet bulb globe temperature index (ASHRAE, 2005) by replacing the black globe temperature with dry bulb temperature (which assumes minimal thermal radiation effects).

$$THI = 0.7*t_{wb} + 0.3*t_{db} \quad \textit{Equation 1}$$

where: t_{wb} = wet bulb temperature and t_{db} = dry bulb temperature.

THI data were summarized into 5 min intervals for trailer conditions and hourly values for stall conditions.

RESULTS

Telemetry-Based Temperature Comparisons

GT data were complete for five horses, but were lost for the sixth horse on the nontransport day due to equipment failure. No differences were observed (Figure 4) between transport and non-transport GT, before or during transport. GT for transported horses was slightly elevated following transport.

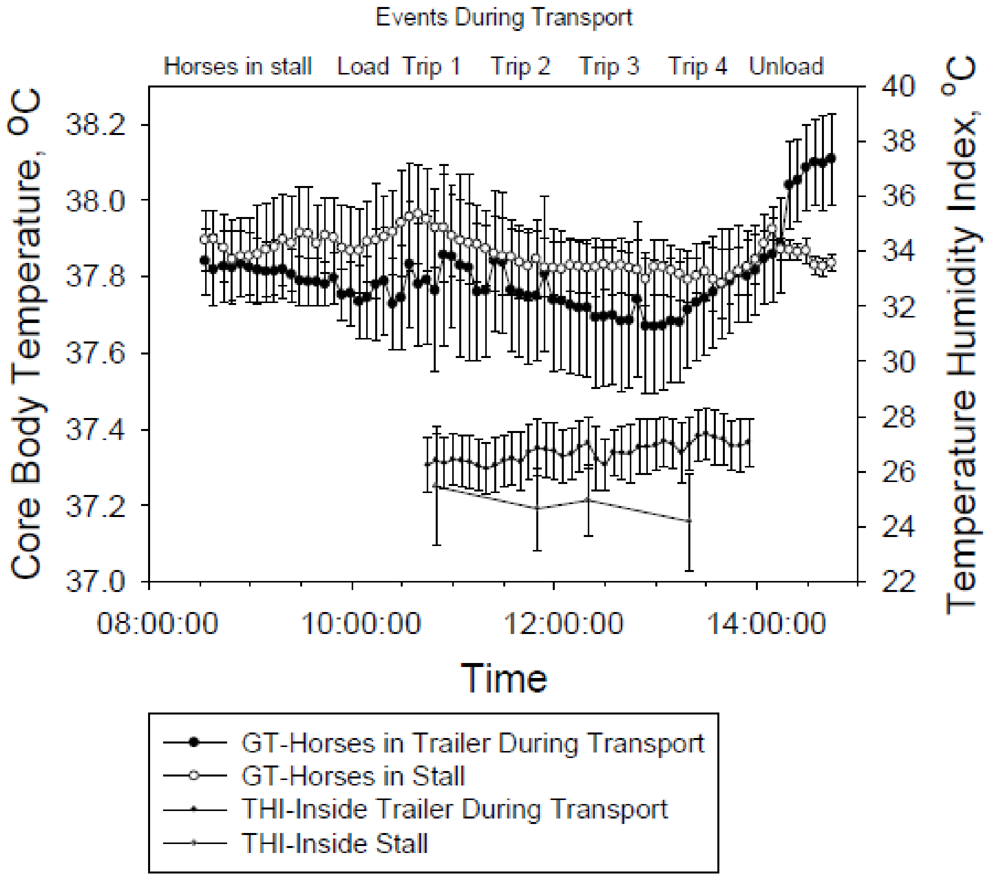

Figure 4. Mean (+/-SE) telemetry-based core body temperature (GT) in trailer and stall and temperature humidity index (THI), averaged over 5 min intervals.

Trailer and Stall Conditions

The average (±SE) time to complete the 168 km trip was 202 min (±3 min). Weather during the study period was hot and humid during days 1 and 2, with a cool down experienced during day 3 that extended to day 4. Conditions were in the Livestock Alert to Danger Category on the first 3 days (Table 1).

Daily average stall and trailer environmental conditions were calculated during the experiment timeframe (Table 2). Equipment failure prohibited calculation of THI for one trailer position on the first day and all trailer positions on the second day. On each experiment day trailer air temperature was, on average, 2.7^{o}C (±0.5oC) greater than stall conditions. Relative humidity (RH) exhibited different trends for experiment days. On the first day, RH was greater in the trailer, but on the third and fourth days, RH was greater in the stall. LHI was greater in the trailer than in the stall on days 1, 3, and 4, but cannot be calculated for day 2.

THI varied by position within the trailer. The two front positions tended to be more thermally challenging, with THI 0.5°C greater than the two rear positions. This agrees with the substantially lower air exchange measured at the front of this same trailer by PURSWELL et al. (2006). Varying weather conditions from day to day impacted THI within the trailer much more than location within the trailer, with daily THI differing as much as 4°C (Figure 5).

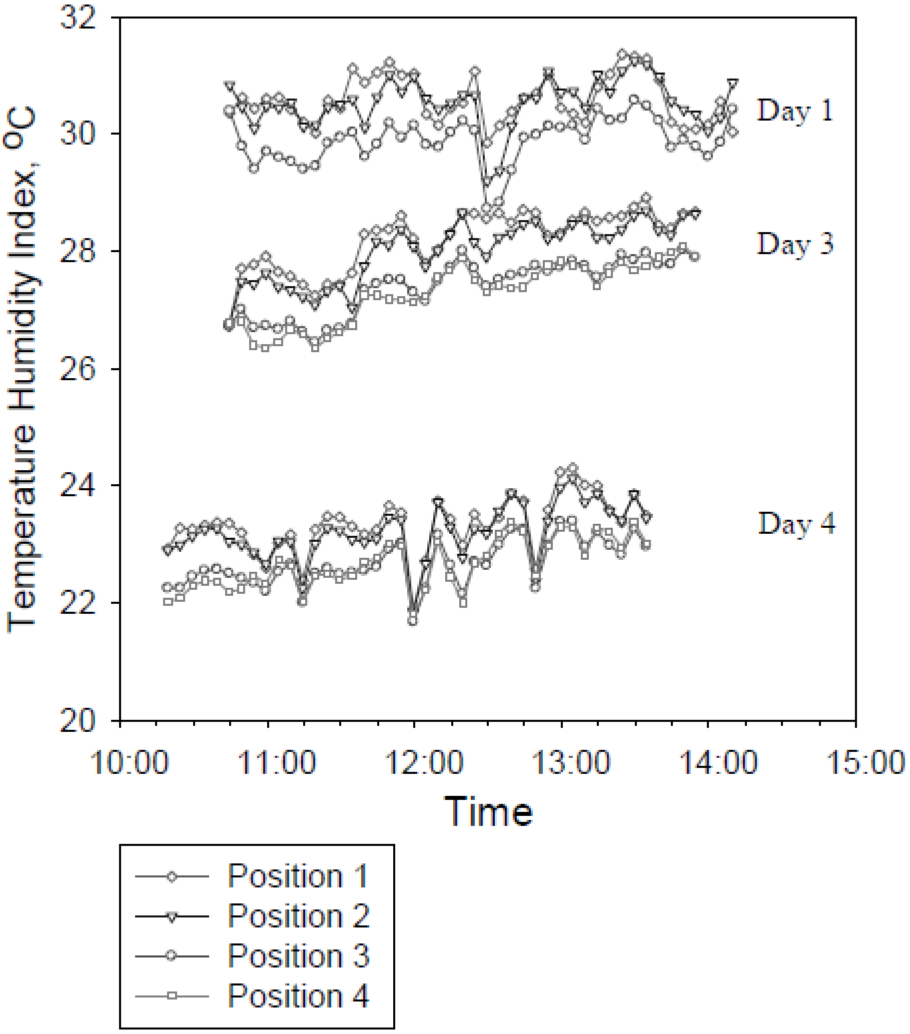

Figure 5. Temperature humidity index (THI) for trailer positions on experiment days

Table 2: Daily average stall and trailer air temperature (T), relative humidity (RH), and livestock heat stress index (LHI) during data collection for each experiment day.

	Trailer							Stall							Difference		
	T (°C)			RH (%)			LHI1	T (°C)			RH (%)			LHI1	T (°C)	RH (%)	LHI1
Day	Mean	Max	Min	Mean	Max	Min	Mean	Mean	Max	Min	Mean	Max	Min	Mean	Mean	Mean	Mean
1	35.6	37.6	32.8	57.5	72.6	45.4	88	33.1	34.1	32.2	51.5	53.8	45.5	82	2.5	6.0	6
2	33.5	36.1	30.5	*	*	*	**	30.5	33.0	27.0	54.2	68.0	45.1	79	3.0	**	**
3	31.6	33.8	29.3	65.0	76.0	55.4	83	29.4	31.7	27.7	70.6	90.3	61.1	81	2.2	-5.6	2
4	28.5	30.7	25.8	49.7	59.1	41.8	76	25.3	26.0	24.4	55.1	60.2	52.5	72	3.2	-5.4	4

[1] Livestock Heat Stress Index (NWSCR, 1976) corresponding to mean air temperature and mean relative humidity

*Data not available due to monitoring equipment failure

**Cannot calculate due to missing data

Thermoregulatory Response to Trailer and Stall Environment

Based on the relationship between THI and GT for horses in the trailer and stall, some horses experienced more severe conditions in the trailer and others in the stall (Figure 6). Regardless of which environment was more severe, a positive correlation between THI and GT may be observed for each horse individually, as well as overall for the group. The prediction equation resulting from the overall regression demonstrates the positive correlation, with an estimate SE of 0.3^{o}C, but a poor correlation r^2 of 0.48.

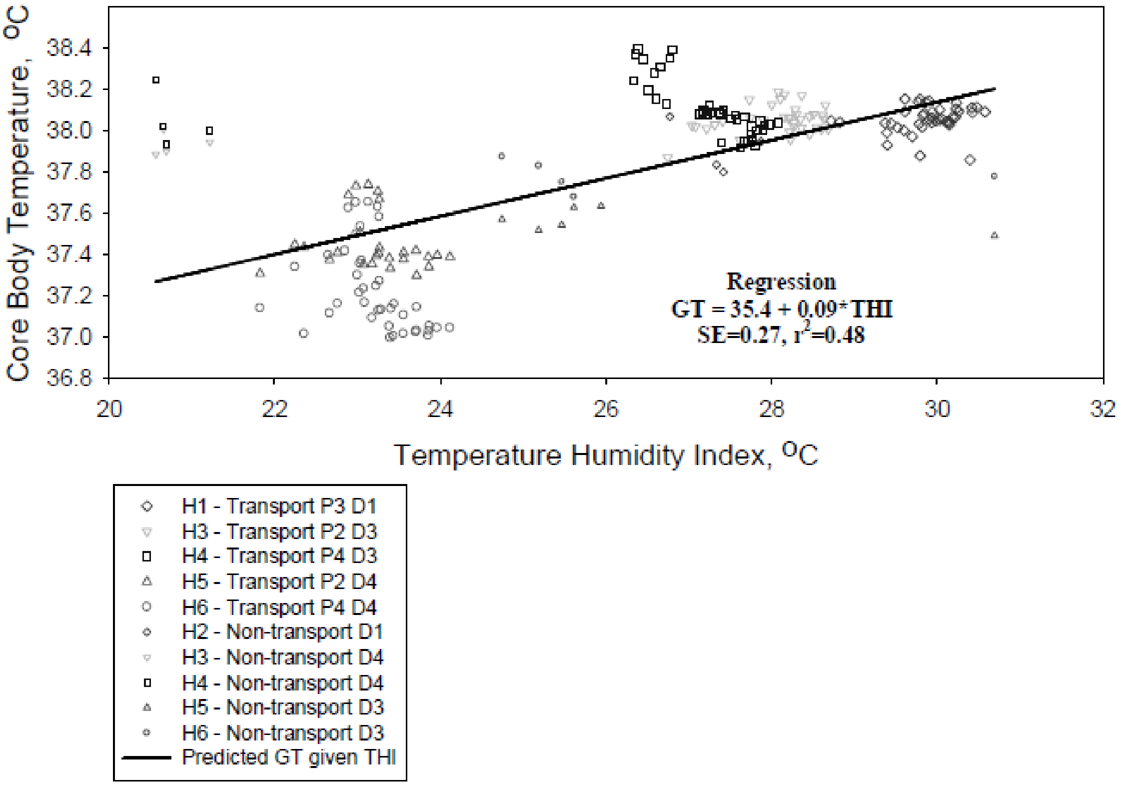

Figure 6. Positive correlation between temperature humidity index (THI) and horse core body temperature (GT) for days (D) of transport and non-transport. For transport days, THI corresponding position (P) within the trailer has been paired with GT of the horse (H) in that position.

DISCUSSION

The lack of significant GT response from the animals during travel indicates that the horses were able to thermoregulate for the transport duration. It is possible that trailer environment conditions did not exceed a threshold to induce the response, or that trip duration was insufficient. It has been shown for poultry that not only conditions, but also duration of exposure determines level of response (YANAGI et al., 2002). Because response may be linked to duration, it is possible that short trips in extreme conditions may not present a sufficiently significant challenge to induce measurable response from the horses. Based on trailer environment work by PURSWELL et al. (2003, 2006), the trailer provides inadequate ventilation and thermal conditions in hot weather. Those studies were conducted with the back window closed, which further reduced air exchange.

The trend observed for GT was a cooling effect for horses being transported, with increasing GT during the recovery period. It is possible that GT response demonstrated a lag between thermoregulatory challenge and the point at which the regulation was unable to maintain constant GT. Alternatively, evaporative cooling of the horse from perspiration was probably reduced once transport was completed since there was less air velocity in the stall environment. The trailer environment greatly depended on outdoor conditions, and increased THI within the trailer on more severe days resulted in increased GT for the horses transported on that day. Presumably, if THI were sustained at dangerous levels within the trailer, GT would likely rise to dangerous levels as well.

To build upon the results presented here, future transport studies should be extended, both for transport duration and recovery period to further demonstrate and characterize thermoregulatory response. Additional studies should include more horses and variety of conditions to provide a better prediction of thermoregulatory response (GT) to thermal environment (THI). Limitations were experienced with the telemetry temperature system, and these should be accounted for in preparations for future studies. A thorough discussion of telemetry system performance is given in GREEN (2004).

CONCLUSIONS

Trends were observed that indicate increases in core body temperature with increases in temperature humidity index for trailer environment. Temperature humidity index within the trailer was greatest for positions near the front, but was influenced much more by daily weather, which varied greatly over experiment days.

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