Research

Environmental Conditions and Body Temperature of Circus Elephants Transported During Relatively High and Low Temperature Conditions

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Abstract

The purpose of this study was to characterize how circus elephants' body temperatures respond to transport during relatively hot and cold conditions. The environment within the trailers and rail cars in which the elephants were transported, as well as the exterior environment, was also studied. A total of 12 trips with 6 different circuses were surveyed during summer conditions with maximum temperatures of 100°F. During cold conditions, a total of 5 trips with 4 different circuses were surveyed with exterior temperatures reaching below freezing. Temperature, relative humidity, and radiation within and exterior to the trailers or rail cars were recorded at five-minute intervals before, during, and after transport. Body temperature of the elephants was also recorded at five-minute intervals using ingested data loggers that were recovered in the feces after transport was completed. Ammonia and carbon monoxide were also measured within the trailers and rail cars. The elephants readily loaded into the transport trailers or rail cars, and there was no evidence of hyper or hypothermia in the elephants even during the most extreme climatic conditions. The interior of the transport vehicles were maintained at reasonable temperatures for the age and condition of the elephants within the vehicles despite extreme external conditions. Ammonia and carbon monoxide were always below detectable concentrations. These data indicate that, when proper care is taken, the transport of circus elephants does not compromise the well-being of the animals even during relatively extreme environmental conditions. However, it is very important that transport of elephants during extreme weather conditions be attempted only by experienced handlers and that conditions within transport vehicles be carefully monitored.

Introduction

Research of animal transportation has focused largely on livestock species in which transport is essential for moving animals through the production and marketing phases. Research has shown that transportation can be very stressful and negatively influence horses (e.g., Friend et al. 1998; Friend 2001; Stull and Rodiek 2000), swine (e.g., Brown et al. 1999), sheep (e.g., Knowles et al. 1995) and cattle (e.g. Knowles et al. 1999). These effects may be due to a variety of factors, including loading and unloading, the mixing of unfamiliar animals, aggression between animals during transport, crowded conditions, duration of the trip, lack of feed and water, exposure to noxious gasses, and extremes in temperature.

However, animals may also become habituated to transport and avoid discomfort or health problems. Adams (1994), in a review of animal transportation and welfare, suggested that the capacity of animals to adapt to the conditions of transport is essential in minimizing negative impacts on welfare. Grandin (1997) conducted a similar review of adaptation to travel and recommended acclimating animals to stressors early in life to reduce the

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stress response during exposure as an adult. Other evidence of habituation to transport in cattle has been observed by Eldridge and Winfield (1988a) and reviewed by Trunkfield and Broom (1990).

Animals can tolerate a range of environmental temperatures over which their bodies can safely maintain a required body temperature. This range is dependent on species, prior exposure, and type of housing, among other factors which can either raise or lower the upper and lower limits of this tolerance (Randall 1993). Environmental temperatures outside of this range can disrupt thermoregulation processes (Hahn 1999) and cause the animal to suffer from hypothermia/hyperthermia because the animal does not possess the mechanisms to maintain an appropriate body temperature through heat loss/production. Fluctuations in body temperature can be used to determine acceptable temperature ranges during transportation. Elevated body temperature can indicate whether an animal is not successfully coping with temperature loads. Friend et al. (1998) and Stull and Rodiek (2000) found body temperature measurements to be a useful indicator of health during transportation of horses under relatively hot conditions.

Exposure to noxious gases is another critical concern during transport (Randall 1993). Concentrations of ammonia over 25 ppm can elicit irritation, and in larger concentrations is associated with breathing difficulties (CDC 2001). In transportation, the principle source of ammonia is from urine that degrades to ammonia over time. In terms of carbon monoxide, concentrations of 25 ppm is considered the maximum exposure safe for people; effects include headache, nausea, and dizziness (CDC 2001). The principal source of carbon monoxide during transportation is from vehicular emissions.

Despite the public concern over the transport of elephants, no work has been published investigating the transportation environment during transport. During certain periods, some circuses may transport their elephants to a new venue daily. Due to their lengthy travel schedules, some transport is also likely to occur during extreme weather conditions.

The objectives of this study were to characterize the body temperature response of circus elephants to transportation during relatively hot and cold conditions. Excessive changes in body temperature could indicate stressful conditions. The design of the trailers and rail cars, as well as the environment within and exterior to the trailers and rail cars in which the elephants were transported, were also characterized.

Materials and Methods

Overall Procedure

The researchers, with suggestions from circus management, attempted to identify at least two occasions when participating circuses or private exhibitors with elephants were transporting animals under relatively hot and cold conditions reflective of typical seasonal conditions. Due to the rapid and inflexible travel schedule circuses follow, some facets of our procedure could not be performed for some participating circuses. During each trip, instruments were placed in one or more vehicles to characterize environmental conditions (temperature, relative humidity) of the transport environment. Ambient conditions (temperature, relative humidity, and solar radiation) were also monitored concurrently. Air samples were taken when possible to determine concentrations of ammonia and carbon monoxide. Body temperature was continuously measured during transport by using ingested temperature loggers.

Environmental Measures

To record environmental conditions of the railcar or truck, environmental dataloggers (HOBO-H8, Onset Computers, Pocasset, MA) with the capacity to record temperature and relative humidity were mounted throughout the transport vehicle. Additional channels for temperature probes could be used. Probes consisted of a thermocouple at the end of a wire lead of varying length. This specific group of loggers are referred to as *environmental loggers* throughout this report. The environmental loggers were mounted to the wall of the transport vehicle on a piece of styrofoam (4 x 4 x 0.75 inches wide) that insulated the logger from the wall. The environmental loggers were factory tested and found to be accurate within ± 1.8°F. Placing several environmen-

tal loggers within the transport unit was done to investigate temperature gradients within the trailer/railcar and increase the chances that environmental loggers would be recovered after transit. Due to the substantial reach an elephant has with its trunk, an area behind the elephant and significantly in front of other elephants was preferred for placement of the environmental loggers.

The environmental loggers recorded temperature and relative humidity in the vehicle at five-minute intervals. Another environmental logger of the same type was mounted outside of the truck/railcar to determine external temperature, relative humidity, and solar radiation. Solar radiation was estimated using a copper black globe fitted with a temperature probe inside the globe that was then sealed. The globe was then attached to the vehicle's exterior in an area that would receive direct sunlight. Solar radiation values quantify radiant heat from the sun; that is, high black globe temperature indicates the globe was receiving direct sunlight. Comparisons of interior and exterior measures were made to determine whether adequate ventilation was occurring and to establish the relationship between the two environments.

Noxious Gases

Ammonia and carbon monoxide concentrations were determined using a toxic gas detection kit (80140-KA, Matheson-Kitagawa, Parsippany, NJ). Our equipment was capable of detecting concentrations of ammonia between 10–260 ppm and carbon monoxide concentrations of 1–1,000 ppm. In cases where trips lasted less than three hours, measurements were taken immediately upon arrival at the destination before the doors were opened using a flexible plastic tube 3.0 ft in length inserted into a ventilation opening. In cases of transport over several days, recordings were made when possible every 24 hours during transport and upon arrival.

Body Temperature

In order to measure body temperature, our lab developed a procedure using a miniature datalogger (DS1921-F5, Dallas Semiconductor, Dallas, TX) to record continuous body temperature by having the animal ingest the unit. The body temperature loggers are factory tested and claimed by the manufacturer to be accurate within ±1.8°F and exhibit a ±0.9°F level of precision. Each body temperature logger was a round disc with an approximate diameter of 0.64" and 0.23" thick. During the summer and winter of 2000, the loggers were encased in a biologically inert epoxy (EPO-TEK T905, Epoxy Technologies, Bourne, MA). When the epoxy potting process was complete, each unit measured approximately 0.75" wide and 0.5" thick. The end of a ripstop nylon ribbon approximately 0.6" in width and 6" long was embedded in the epoxy to make the body temperature loggers more visible during recovery.

During the summer of 2001, we stopped encapsulating the loggers in favor of inserting the loggers into a pocket sewn on the end of a 0.75" by 8" ribbon of ripstop nylon to greatly reduce overall size of the package. Each recorded temperature reading was time/date stamped, allowing fluctuations in body temperature to be correlated with transportation events (e.g., loading) and/or changes in environmental parameters. To test the body temperature logger's accuracy and precision, two random assortments of a total of 33 unused body temperature loggers were put in a water bath for 30 minutes during which four readings were made with a self correcting digital thermometer. The body temperature loggers read an average of 0.59°F ± 0.13°F less than the thermometer reading. The largest average difference for a single body temperature logger over the four thermometer readings was –1.82°F.

Reported normal Asian elephant body temperature is 95°F to 98.6°F (AAZK 1997), though several ranges have been reported (Benedict 1936; Altevogt 1990), most notably differing in the minimum value for the range. Body temperature data were examined to detect increases of individual elephant temperatures greater than 3.0°F. Fluctuations in body temperature greater than 3.0°F indicate the animals were experiencing a significant heat load. Body temperature was also examined for temperatures greater than 100°F. Actual temperatures greater than 100°F indicate considerable fever (Benedict 1936) or general thermoregulatory difficulties (Schmitt, personal communication).

Transport Vehicle Descriptions

To describe each vehicle, elevations detailing overall dimensions, windows, doors, ventilation equipment (e.g.

fans), and other particulars were developed using computer aided design software (AutoCad 1997).

Results

General

A plot of the environmental and body temperature data is provided for each trip that was surveyed. The legend codes for each parameter indicates the vehicle in which the environmental logger was mounted and whether a probe or the unit itself recorded the measurement. For example, with "temp (60p)", "temp (60)", and "temp(62), each of the three indicated environmental loggers recorded temperature. The first and second environmental loggers recorded in vehicle "60" and the third in "62". The first temperature was recorded by a probe as indicated by the "p"; the remaining two were recorded by the environmental logger itself as indicated by the absence of a "p".

Body temperatures are labeled to indicate duplicates (e.g.. Miniak and Miniak(*)) when more than one body temperature logger was recovered from a single animal during the same time frame. Loggers that were given sequentially during the course of a trip are labeled (e.g., Miniak(1), Miniak(2), etc.). In order to make the graphs easier to read in this article, all of the data obtained for a particular trip was not displayed in these graphs. *In several graphs where multiple body temperatures were plotted, the values for body temperature were increased or decreased by 5° or 10°F so that the plots did not mask each other.* In cases where a constant was added or subtracted from body temperature, the changes are indicated in the legend with a + or – proceeding the constant. Complete copies of the graphs can be down loaded from our Web site at: be http://animalscience.tamu.edu/ethology.

Hot Weather

Ringling Brothers, Barnum and Bailey (Red Unit)

The elephants with Ringling Red travel throughout North America in railcars that are part of a train nearly a mile long. They typically begin take down and prepare to leave an arena at 17:00 on Sunday nights. After the last show, generally 22:00, the animals are walked one to three miles to the railcar and then loaded. The various sections of the train are then assembled, if not done already. The train then departs the next morning for a trip that usually lasts two to three days. Upon arrival, the animals are walked to the arena where a crew that travels by truck has already set up the animal areas. If the train arrives late at night, the animal walk is done at approximately 8:00 the next morning. Most of the equipment, personnel, and circus-owned animals are transported by train, but some equipment is transported over land using a variety of trucks, trailers, and recreational vehicles.

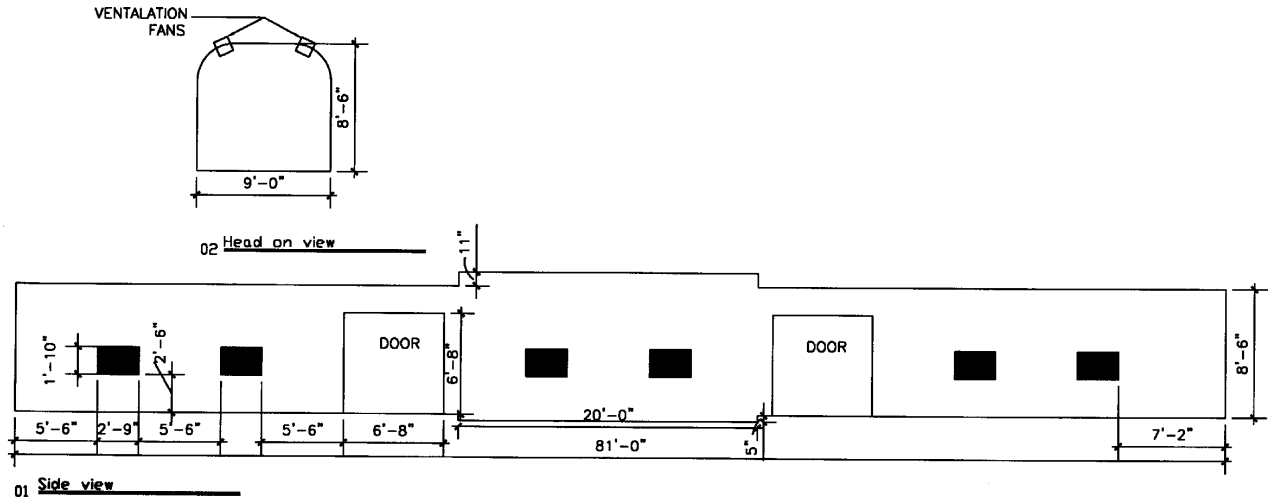


Figure 1. Ringling Red: structural diagram of the rail car that had a dropped floor and raised ceiling for larger elephants. The darkened rectangles represent windows.

Ringling Red transported 14 Asian elephants and a variety of hoofstock using railcars that have insulated walls. The elephants are chained diagonally using the standard method of one forward and one rear leg. Six windows with expanded metal screens were built into each side of the elephant cars (Figure 1). Sixteen vents, each with an electric exhaust fan and covered with expanded metal, were spaced in two rows down the roof of each car. A steel plate ran the length of each car's roof and prevented sun and rain from entering into the car through the vent holes. The entire area provided to the elephants was approximately 6,593 cubic ft. The ceiling of the railcar was rounded (the height provided was the highest point in the car). Twelve drains were spread equidistantly throughout the railcar. One elephant car had a dropped floor and raised roof that increased the height 1' 4". The extra height was needed to accommodate their largest elephants. These elephant cars did not have accommodations for a caretaker to observe the elephants during transport and no misting system existed at the time of the survey. The elephants were divided six into one car and eight in another. During travel, the doors of the Ringling Red elephant cars remained closed due to fear that an elephant could injure its trunk by placing it out the door of the moving train.

Lafayette, LA, to San Antonio, TX. During the Lafayette, LA, to San Antonio, TX, trip (Figure 2), three environmental loggers (one with a probe) were divided among the three cars. One environmental logger was placed in the midsection of car 60 6' 5" high. Two environmental loggers were placed in car 63, one on an end wall 6' 8" high and the other 7' 3" high with the probe mounted 2' below the environmental logger. External relative humidity could not be obtained due to an equipment shortage.

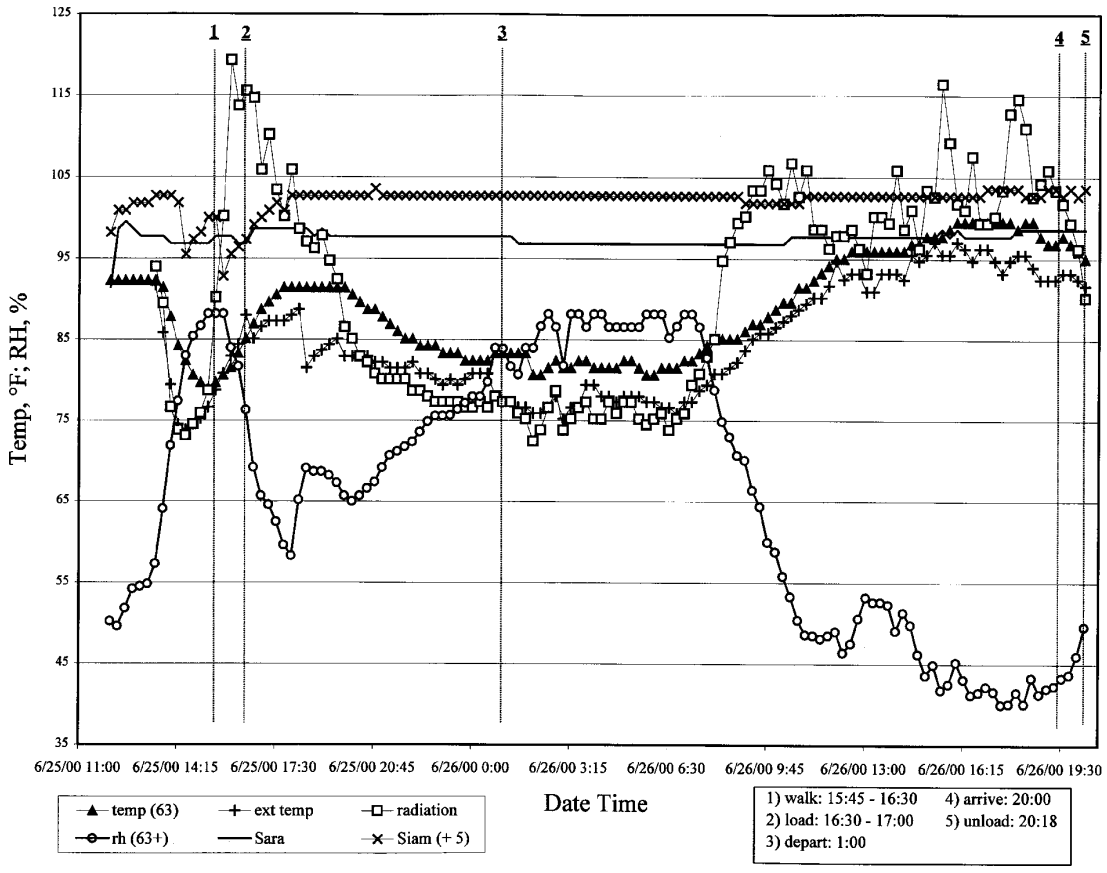


Figure 2. Ringling Red: trip from Lafayette, LA, to San Antonio, TX. Ten degrees were added to each of Siam's body temperature readings to avoid superimposition of her data on Sara's.

The railcars' interior reached a maximum of 99.5°C though never exceeded the external temperature by more than 5.04°C. This variation tended to be greatest during the period after loading (#2) and before departure (#3). Comparison of the stationary (#1–#3) and nonstationary (#3–#4) periods suggests that motion decreased variation between environmental loggers.

A large dip in car 63's interior temperature occurred at 6/26/00 17:47, although it spanned less than 10 minutes (not shown in plot). We are unsure of the cause, though it was most likely a result of the elephants spraying water on the environmental logger during drinking. The drop was recorded by both the environmental logger and attached probe.

Ringling attempted to cool the railcar before loading the elephants by using a large soaker hose to run cool water over the roof of the stockcars for several hours. The attempt lowered the interior temperature a considerable amount, although it had little long-term effect. The interior temperature had returned to within 5.0°F of the prewatering temperature by loading time. Unfortunately, our environmental loggers recording ambient measures (including radiation) were also cooled in the process making accurate comparisons difficult. The sudden rise in radiation after 6/25/00 14:37 indicates that the late afternoon sun would have created high external temperatures.

Tests for the presence of noxious gases were made upon arrival. Ammonia concentrations were found to be 17 ppm, though the plastic collection tube had fallen directly into a pile of feces. No carbon monoxide was detected.

Of eight body temperature loggers given to elephants, four were recovered (two are plotted). Body temperatures were maintained fairly stable between 95.9 °F and 98.6°F with individual loggers for each elephant reading

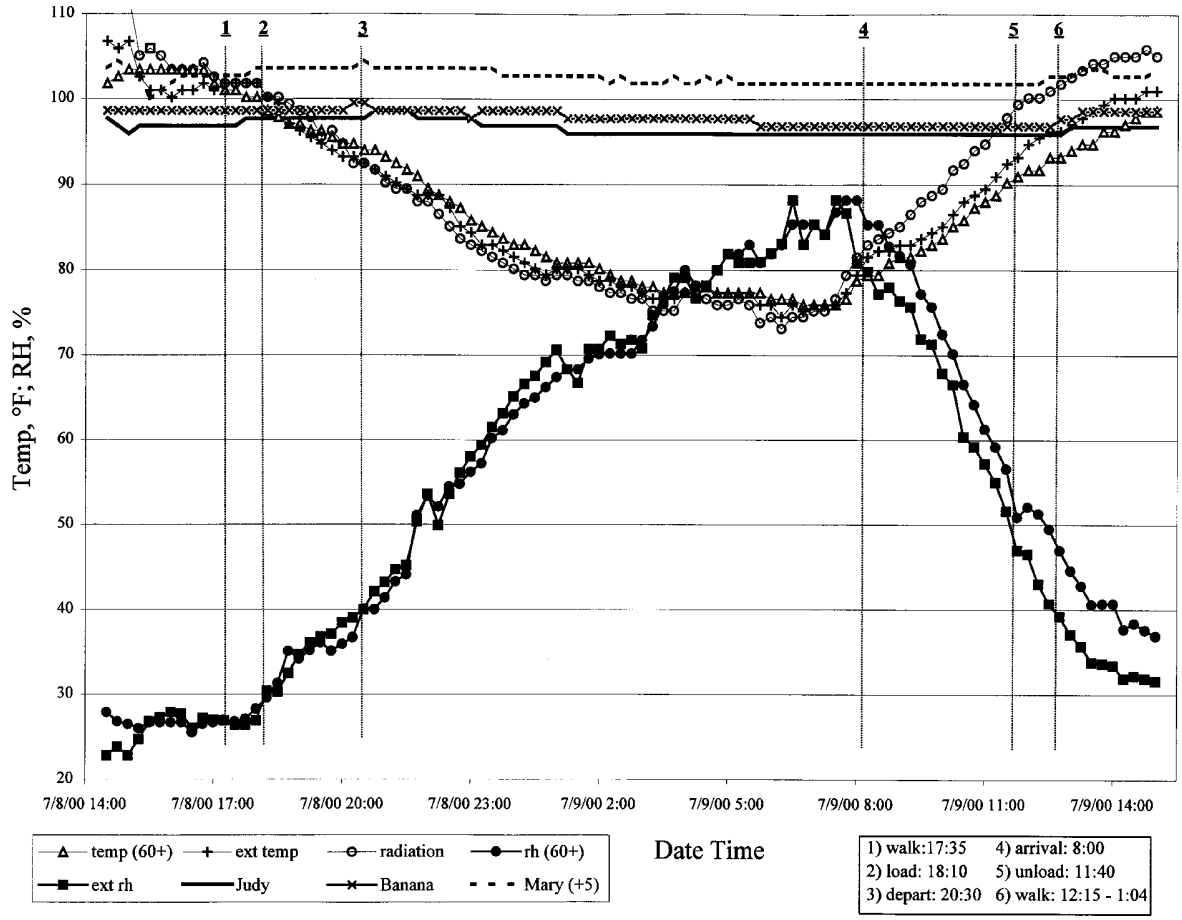


Figure 3. Ringling Red: trip from San Antonio, TX, to College Station, TX. Five degrees were added to each of Mary's body temperature readings to avoid superimposition of her data with Judy and Barbara's.

within a 1.9°F temperature range. A large dip in temperature coinciding with watering sessions occurred in Siam's body temperature (+10 degrees) at 14:27 and 15:52 6/25/00. A similar dip occurred in Banka's body temperature during the same period (not shown).

San Antonio, TX, to College Station, TX. During the San Antonio, TX, to College Station, TX, trip (Figure 3), a total of three environmental loggers were mounted in the cars. The two environmental loggers in car 60 were placed at opposite sides of the midsection of the car 4' 9" and 7' 6" from the floor. The third environmental logger was placed on an end wall of car 63 6' 6" from the floor.

The cars' interior temperatures never exceeded 98.1°F while the elephants were in the cars. During the entire course of the trip, differences between interior and exterior temperatures were negligible (0.18°F ± 1.3°F). Variation between interior environmental loggers was also very slight indicating uniform ventilation.

Relative humidity during both trips was maintained at or below 65% when the interior temperature was greater than 90°F allowing evaporative cooling to function at a high rate.

Tests for the presence of noxious gases were made upon arrival. Within our range of detection, no ammonia or carbon monoxide was detected.

As in the previous trip, eight body temperature loggers were given to the elephants and four were recovered. With the exclusion of what appears to be drinking related dips, body temperatures ranged from 95.9°F to 99.5°F. The sudden drop in temperature for Dutchess at 7/9/00 13:00 indicates when the body temperature logger was expelled.

A minor sustained body temperature increase was seen during this trip. As mentioned earlier, Ringling's units typically walk their elephants to the train for loading and departure within an hour after their last show. During the pre-walk period on 7/8/00 17:25, body temperature for Judy was 96.8°F. Approximately 10 minutes after the walk began, body temperature rose to 97.7°F and remained at that temperature for several hours afterward. Another example of activity related temperature change occurred after arrival on 7/9/00 11:45 when Mary's pre-walk temperature (+ 5 degrees in Figure 3) of 96.8°F rose to an eventual 99.5°F after the walk had begun. It began to drop within an hour after peaking.

Ringling Brothers, Barnum and Bailey (Blue Unit)

Ringling Blue's travel routine was very similar to the Red unit, typically walking their elephants to the train on a Sunday night after the last show.

Ringling Blue transported 10 Asian elephants and a variety of other hoofstock using four stock cars structurally similar to Ringling Red. There are special cases where over-land transportation is used. For instance, three juvenile elephants were transported by truck over land for four months to get the animals acclimated to transport and shorten the overall duration of the trip. During transport, each elephant had one forward and one rear leg chained in the standard diagonal fashion. The elephants were divided among three cars: the adult animals in a whole car (#1), two to three adults in a half car (often referred to as the "alpaca car") (#2), and three juveniles in one half car (#3). The two half cars (#'s 2 and 3) have a climate-controlled room in the car's center from which one or more handlers (and researchers) observed the elephants during transport. At the time of the survey, one set of handlers had the sole responsibility for the juveniles while another set cared for the seven adults. The handlers left the observation room to remove feces, spread fresh bedding, provide feed, water, and observe the animals as needed. Sections of car #3 were used for storage of fresh hay and grain. Water tanks on the train hold a day's supply of water.

The dimensions of the car are structurally similar to Ringling Red, though Ringling Blue did not have a car with a raised ceiling or dropped floor. During trips, Ringling Blue would ventilate the cars by opening two large doors on each side during transport. When the doors are opened, two horizontal pipes block the openings ensuring that a loose elephant could not get out of the car. The ceiling of the railcar was rounded (the height given in this report was the highest point in the car) and had a high-pressure mister system with a separate control system for each car along the length of the ceiling.

Los Angeles, CA, to San Diego, CA. During the Los Angeles, CA, to San Diego, CA, trip (Figure 4), two environmental loggers were placed in the full (#1) car (one with a probe) and two in the alpaca car (#2), though only a single environmental logger was recovered from each. All environmental loggers were placed approximately 5' from the ground and at least 1' 6" from doors and/or windows. The probe was mounted 3' above the environmental logger.

The elephants entered the train at approximately 8/7/00 0:30 when internal temperature was approximately 72°F and remained at that level. External temperature was slightly lower at 69°F. At 8/7/00 8:00, external and internal temperatures began climbing at very different rates. By 8/7/00 10:00, the external temperature was 7°F greater than the internal temperature and continued this trend resulting in a peak internal temperature of 90°F while external temperature reached 100°F. This demonstrates that the temperature buildup was controlled and a safe temperature was maintained. Additionally, during this period, relative humidity was below 60%, allowing evaporative cooling to function unhindered.

By the time of arrival (#5) internal temperature exceeded the external temperature by approximately 7°F. At this point the doors were most likely closed and the lack of movement reduced ventilation rates. However, both external and internal temperatures remained below 70°F, and thus the temperature buildup is of no concern and could even reflect the intent of management to make the internal environment a little warmer. If the nighttime temperature had been above 80°F, the doors could have been opened which would alleviate any problems. The lack of direct sunlight (radiant heat) would most likely make this precaution unnecessary.

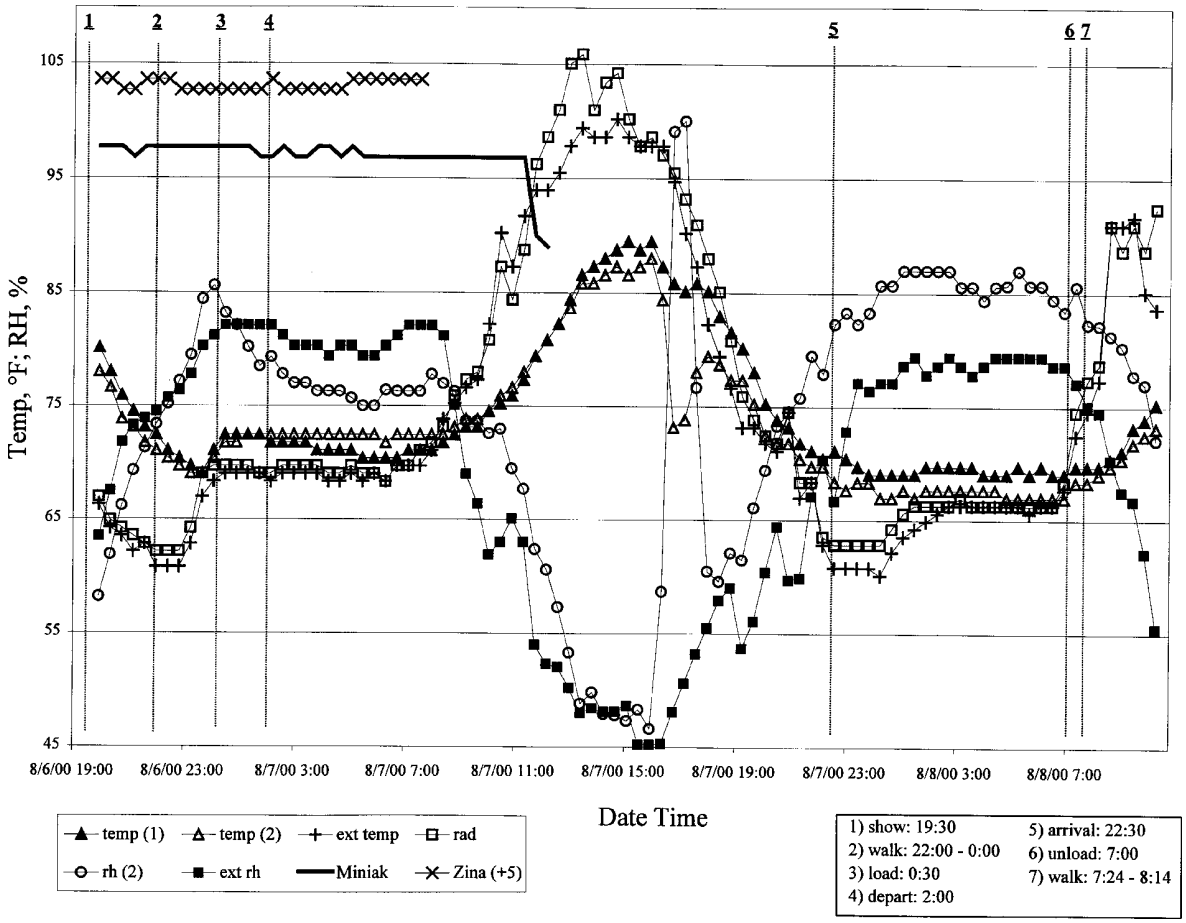


Figure 4. Ringling Blue: trip from Los Angeles, CA, to San Diego, CA. Five degrees were added to each of Zina's body temperature readings "Zina (+5)" to avoid superimposition of her data with Miniak's. The items "temp (1)" and "temp (2)" are the internal temperatures for cars No. 1 and No. 2.

Ventilation appeared to be uniform throughout the trip. At approximately 8/7/00 17:00, a sole environmental logger recorded a drop in temperature and rise in humidity, possibly a result of an elephant spraying the environmental logger. Otherwise, the environmental loggers tended to record uniformly throughout the survey.

Tests for the presence of noxious gases were made approximately halfway through the trip by circus personnel at 8/7/00 10:00, and again upon arrival by the researcher. Within our range of detection, no ammonia or carbon monoxide was detected.

Eight body temperature loggers were given to the elephants and four were recovered. Recorded body temperatures ranged from 95.9°F to 98.6°F. The body temperature loggers were expelled within the first 24 hours (only Miniak and Zina + 5 degrees are shown), which became our first clue as to the variation in passage times that we would see. Excluding drinking related dips, body temperature was fairly stable remaining within a 1.98°F range for each elephant.

San Diego, CA, to Oakland, CA. During the San Diego, CA, to Oakland, CA, trip (Figure 5), environmental loggers were recovered from only the full car (#1), though environmental loggers were placed in positions similar to the first trip. Similar temperatures and trends were recorded as compared to the first trip, although the interior temperature peaked slightly higher at approximately 93.02°F. The distinct difference between external and internal temperatures was not as clear as during the first trip, though the difference was still present with external temperatures reaching above 100°F and internal temperature peaking at 92.5°F for both days of the trip during the afternoon.

An anomalous period of data was recorded between 8/15/00 8:25 and 8/15/00 10:00 when two internal envi-

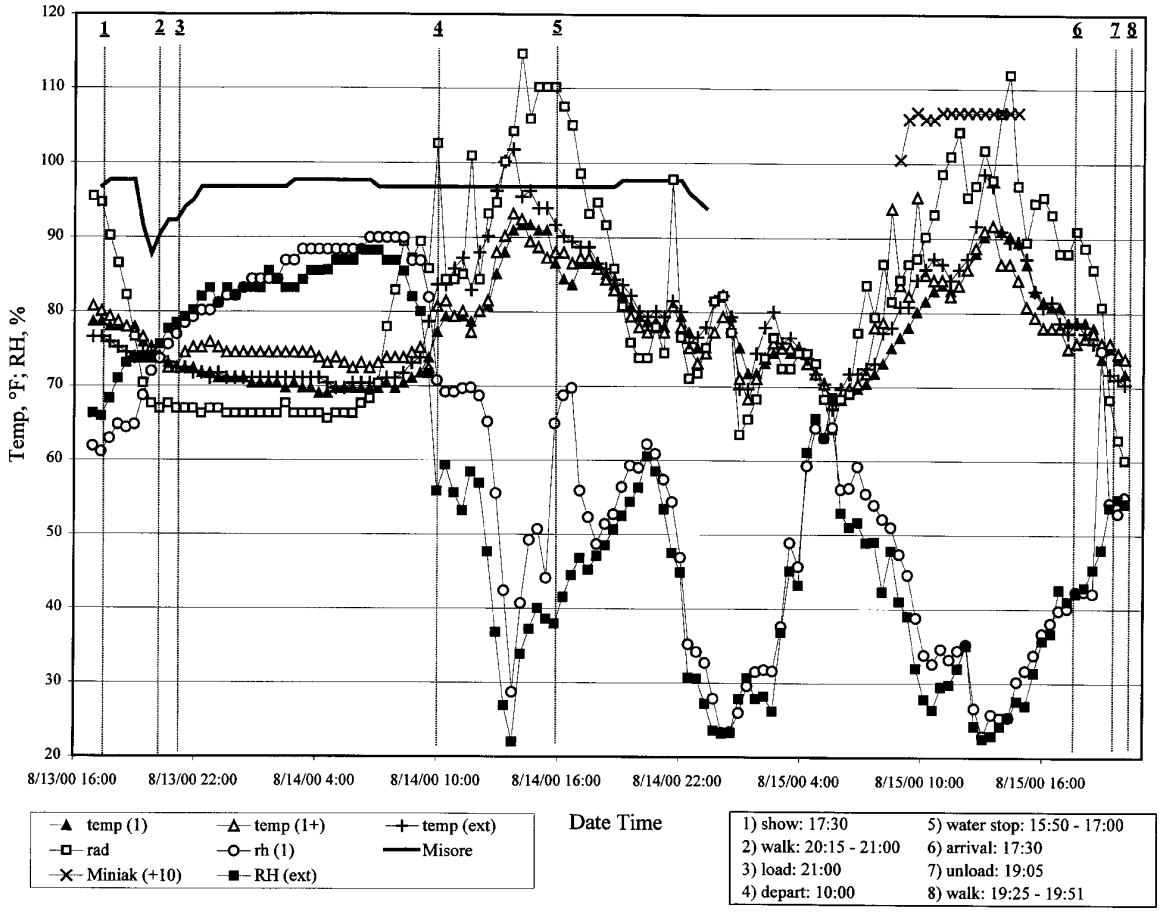


Figure 5. Ringling Red: trip from San Diego, CA, to Oakland, CA. Ten degrees were added to each of Miniak's body temperature readings to avoid superimposition of data.

ronmental loggers (not shown) recorded a temperature in excess of 95°F and then another peak of 104°F and 97.7°F approximately a half-hour later (not shown). Each peak lasted approximately a half-hour and was realized while a third interior environmental logger (1) retained a more constant rise below the external reading. There is no clear explanation for the cause of the peaks. Given the absence of a similar peak in environmental logger 1 and the large difference between the environmental loggers that recorded the spikes and the one that did not, the temperature spikes were not an accurate record of the overall environment within the car at that time. Additionally, at the time of the peaks, relative humidity was at a low enough level to allow evaporative cooling to function well. These were the only periods during both surveys for Ringling Blue where the temperature was equal or greater than the animal's body temperature.

Tests for the presence of noxious gases were made immediately upon arrival. Within our range of detection, no ammonia or carbon monoxide was detected.

In regard to body temperatures, three body temperature loggers were recovered from a total of eight given. During this trip, we attempted to extend the period body temperature was measured by having the handlers feed a second set of body temperature loggers midway through the trip, as demonstrated by the appearance of Miniak's body temperature (+ 10 degrees) at 8/15/00 9:00.

With the exception of drinking-related dips, body temperature maintained a 1.98°F range within each elephant. The sudden rise in temperature at the time of the last show indicates when the body temperature loggers were first ingested. The sudden dip in temperature immediately before the walk coincides with the animal's being watered and suggests the body temperature loggers were still in the stomach at this time. Body temperature loggers during the Los Angeles, CA, to San Diego, CA, trip were given several hours prior to the period shown on the respective figure and thus the corresponding drinking-related dips occurred prior to the time period shown in Figure 6.

Carson and Barnes

Carson and Barnes travels just after dawn, loading their elephants at approximately 5:30 and arriving at the new location usually within a few hours. Relocating to a new performance site is typically done daily, although they will stay at some locations two days in a row.

Carson and Barnes transported 14 Asian and 2 African elephants using five trucks (not including an addi-

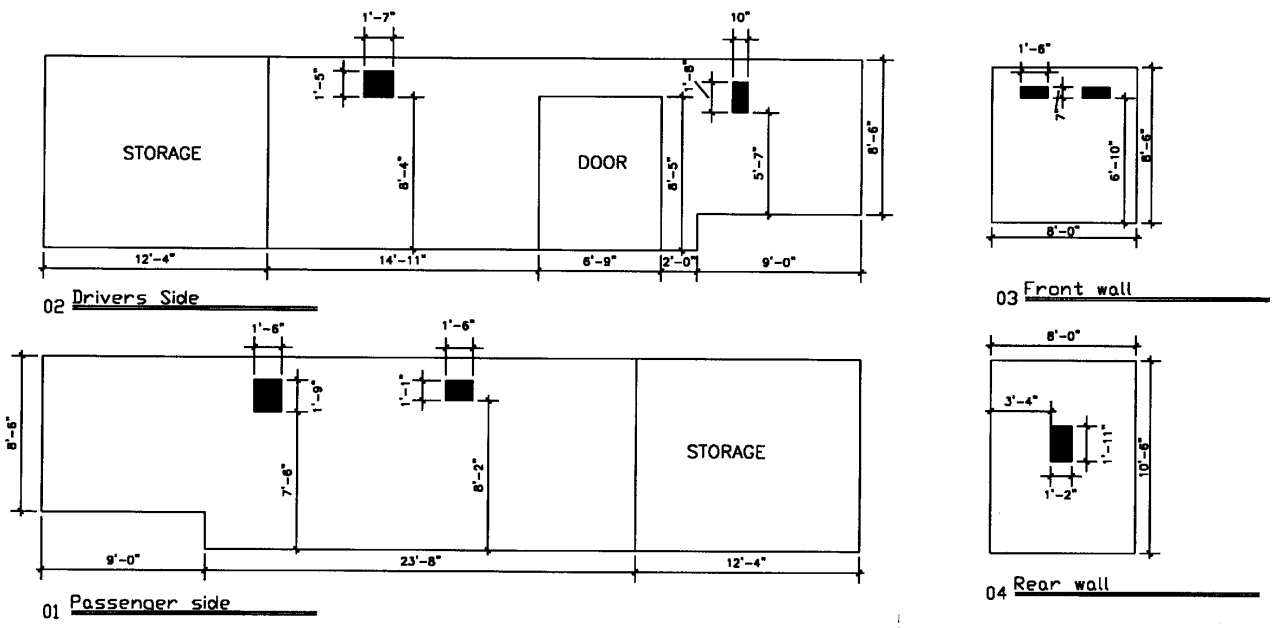


Figure 6. Carson & Barnes: structural diagram of trailer No. 55. The darkened rectangles represent windows.

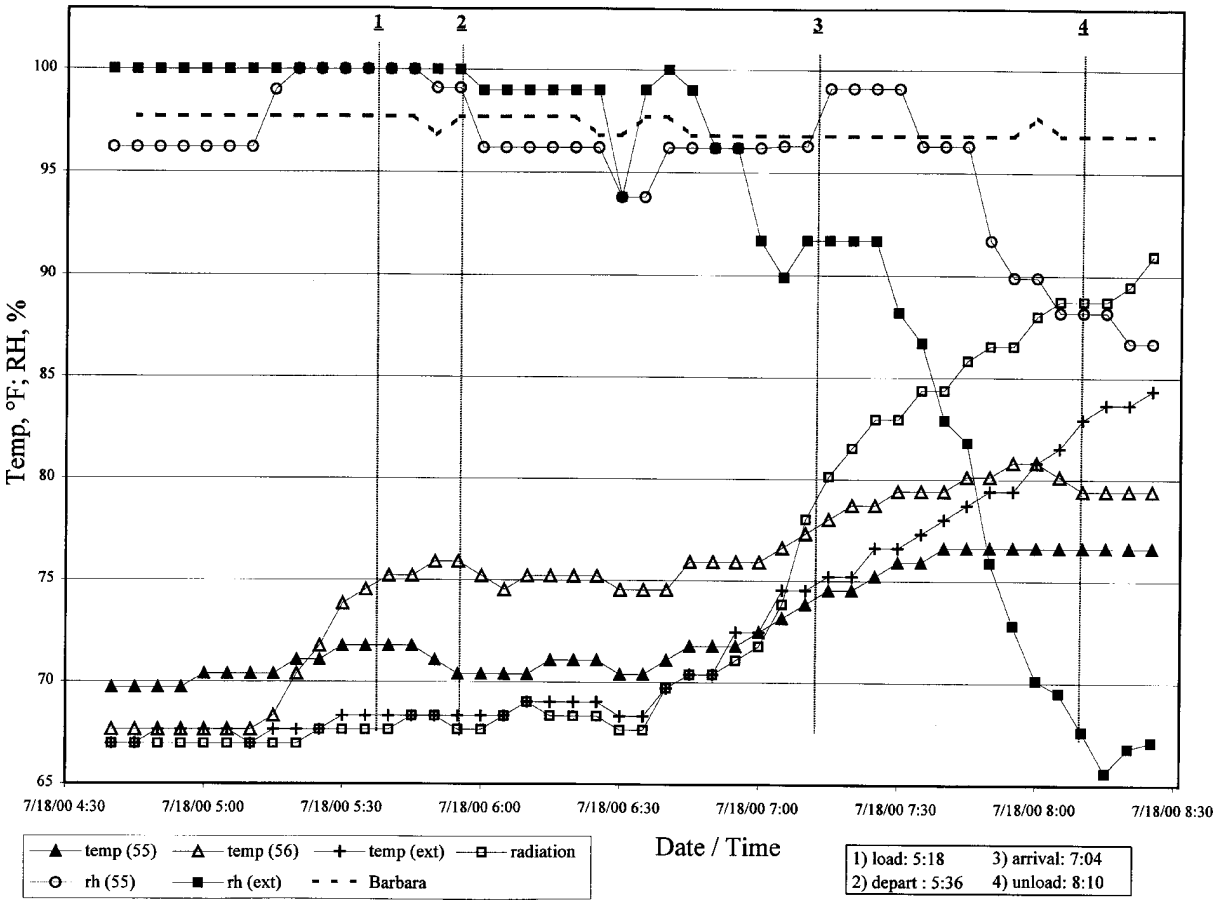


Figure 7. Carson and Barnes: trip from Fort Dix, NJ, to Williamstown, NJ. The items "temp (55)" and "temp (56)" are the internal temperatures for trailers No. 55 and No. 56.

tional trailer that was modified to transport a baby elephant and its aunt). That trailer had a front compartment that served as a residence for one or more staff with an observation port so the staff could easily observe the two elephants during the night. Typically three elephants are transported in each trailer. The rear portion of each trailer served as either a storage compartment or bunk room for several of the staff (Figures 6, 8). The elephant area of the trucks had six vents covered with expanded metal. The vents were positioned two on each side, with two small intake vents located in the front of the trailer. There was a slight variation in the placement and size of the vents and the general layout of each trailer. In addition to these openings, when conditions were judged to be hot enough, ventilation was also provided by replacing the solid main door with a door constructed of heavy expanded metal screen. This allowed for maximum ventilation while preventing the elephants from reaching outside of the truck with their trunks. The amount of ventilation was regulated depending on climatic conditions and whether the trailer was in motion. A typical elephant compartment measured approximately 2,860 cubic ft. Drains were strategically located in the floor of the trailer. The trailers were not insulated and had walls constructed of wood and metal to protect the outer skin of the trailer and had rubber surfaced floors.

Fort Dix, NJ, to Williamstown, NJ. During the Fort Dix, NJ, to Williamstown, NJ, trip (Figure 7), five environmental loggers were divided among three trucks (54, 55, 56). Two environmental loggers were placed on the end walls of trucks 55 and 56 approximately 3' and 5' from the ground, respectively. One of the remaining three environmental loggers was placed on the sidewall

opposite the main door in the midsection of each truck approximately 5' 6" from the floor.

Internal temperature exceeded the external temperature 3.96°F to 7.9°F, indicating that a slight buildup of temperature was occurring during parts of the survey. However, because the trip was made in the early morning, external temperature never rose above 82.9°F, even during stationary times.

The tactic of avoiding the hotter daytime temperatures with early morning travel resulted in a maximum internal temperature of 82.0°F. Additionally, because of the short trip duration and low temperatures, dehydration and effects due to water deprivation are not a concern.

Internal relative humidity tended to equal or remain below the external reading until departure. Relative humidity inside the vehicles was high, exceeding 85 % for almost the entire trip, although humidity at this low temperature is not a problem.

Tests for the presence of noxious gases were made upon arrival. Within our range of detection, no ammonia or carbon monoxide was detected.

During this trip, from a total of eight body temperature loggers ingested, one body temperature logger was recovered for one elephant (Barbara). Her temperature stayed between 96.8°F and 97.7°F. The minor fluctuations did not appear to be related to transportation events.

Williamstown, NJ, to Chester, PA. During the Williamstown, NJ, to Chestertown, DE, trip (Figure 8), the environmental loggers were positioned in the same places as during the Fort Dix, NJ to Williamstown, NJ trip.

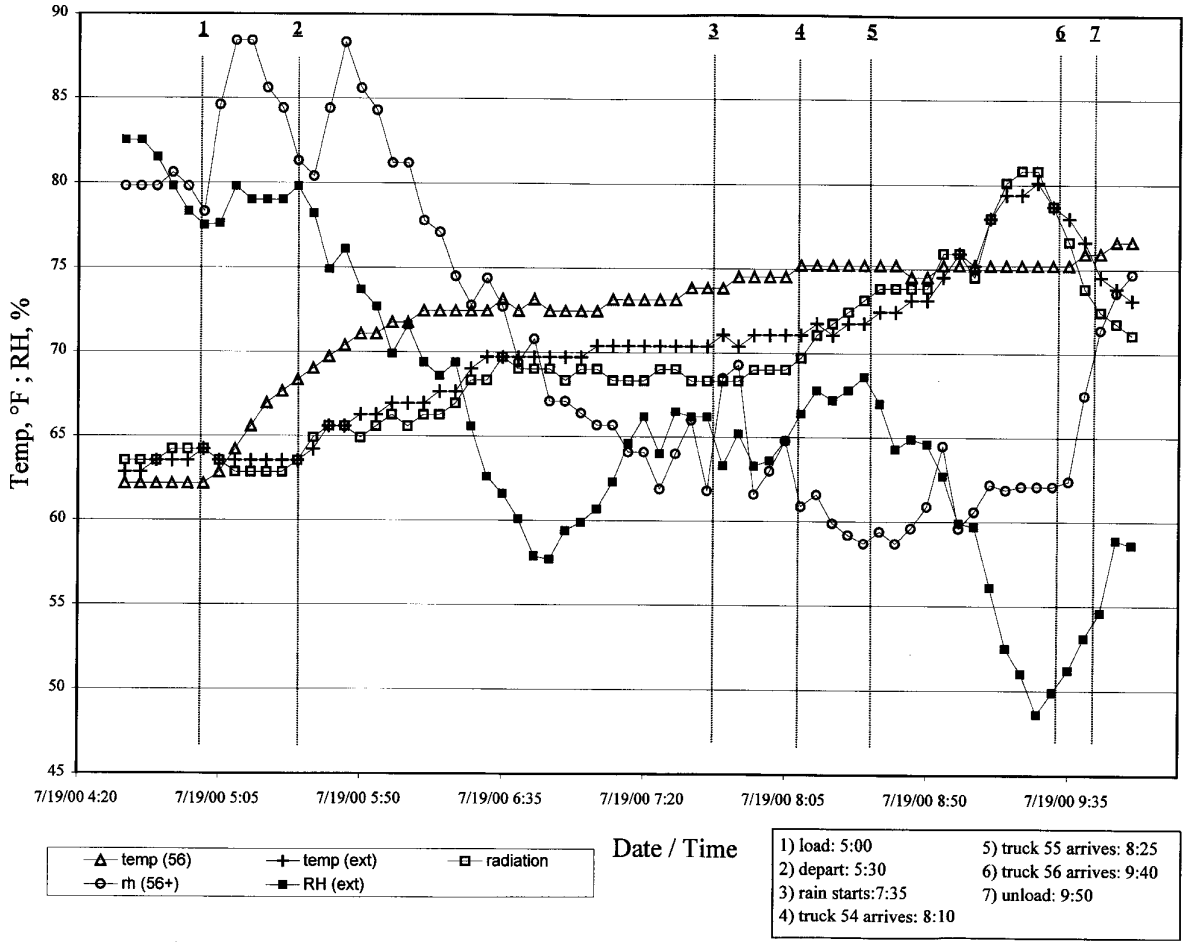


Figure 8. Carson and Barnes: trip from Williamstown, NJ, to Chestertown, DE.

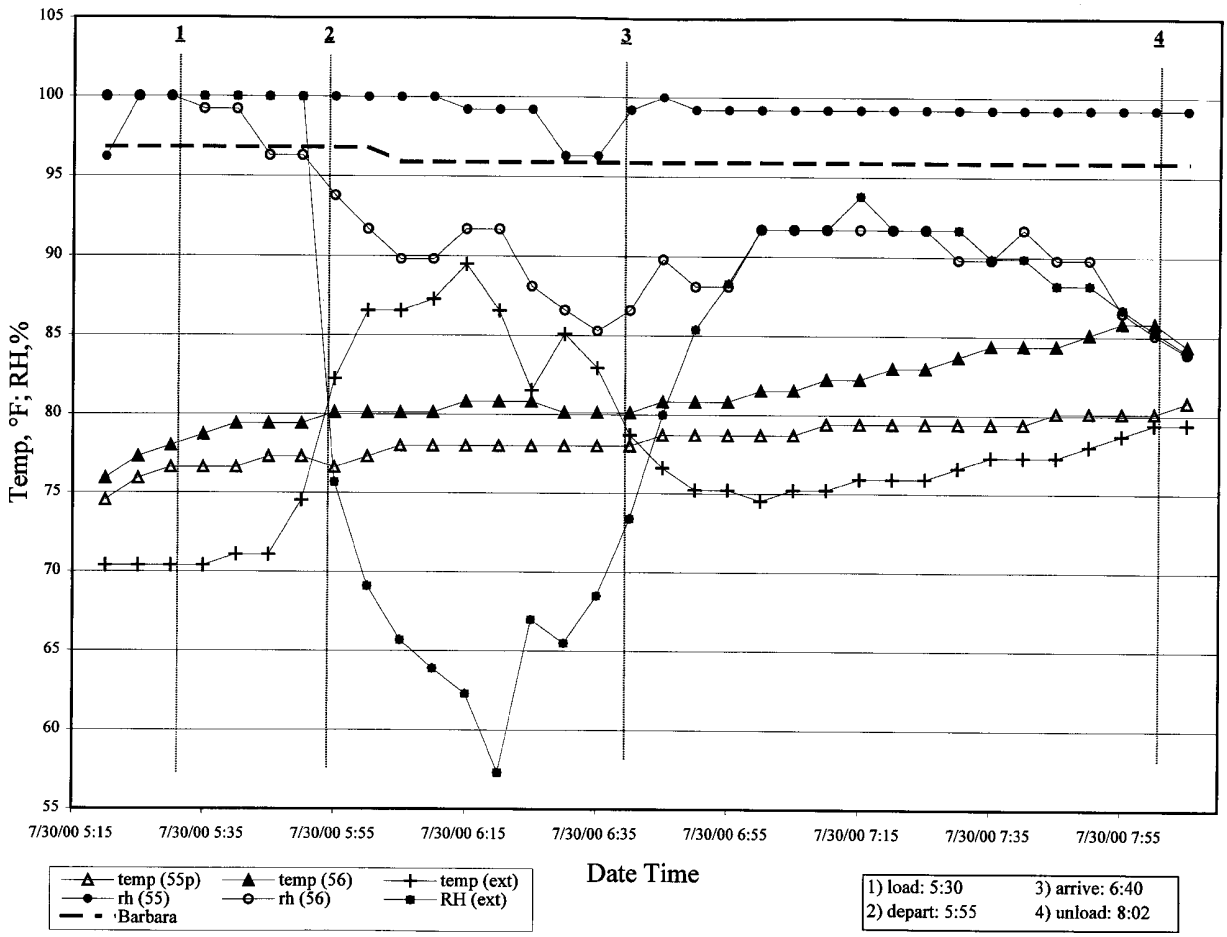


Figure 9. Carson and Barnes. trip from Poquonson, VA, to Smithfield, VA.

Temperatures were relatively constant throughout the trip and maintained a range between 64.9°F and 80.0°F. Differences between the external and internal temperatures were small with a maximum difference of 8.46°F, similar to the Fort Dix, NJ to Williamstown, NJ, trip.

A slight rain was intermittent throughout the morning and thus the large inter-environmental logger differences in relative humidity (>30% at times) were most likely due to the different trucks passing through rain. Internal humidity remained above 70% except for approximately an hour in the middle of travel in truck 54.

Tests for the presence of noxious gases were made upon arrival. Within our range of detection, no ammonia, or carbon monoxide was detected.

Although five body temperature loggers were fed to four elephants, the two recovered body temperature loggers had been damaged by the elephants' teeth. Thus, body temperatures could not be collected during this trip.

Poquonson, VA to Smithfield, VA. During the third trip from Poquonson, VA to Smithfield, VA (Figure 9), three environmental loggers (one with a probe) were divided among two trucks (56, 55). The environmental logger in truck 56 was mounted in the midsection of the truck, while the second with a probe was mounted on the rear wall of truck 55. Another environmental logger was put in truck 55, but was taken down and damaged beyond use during transit by an elephant. The environmental logger units were mounted 5' 6" m from the floor; the probe was mounted 3' above the environmental logger. The datalogger channel recording solar radiation measured erratic recordings that we believe to be a

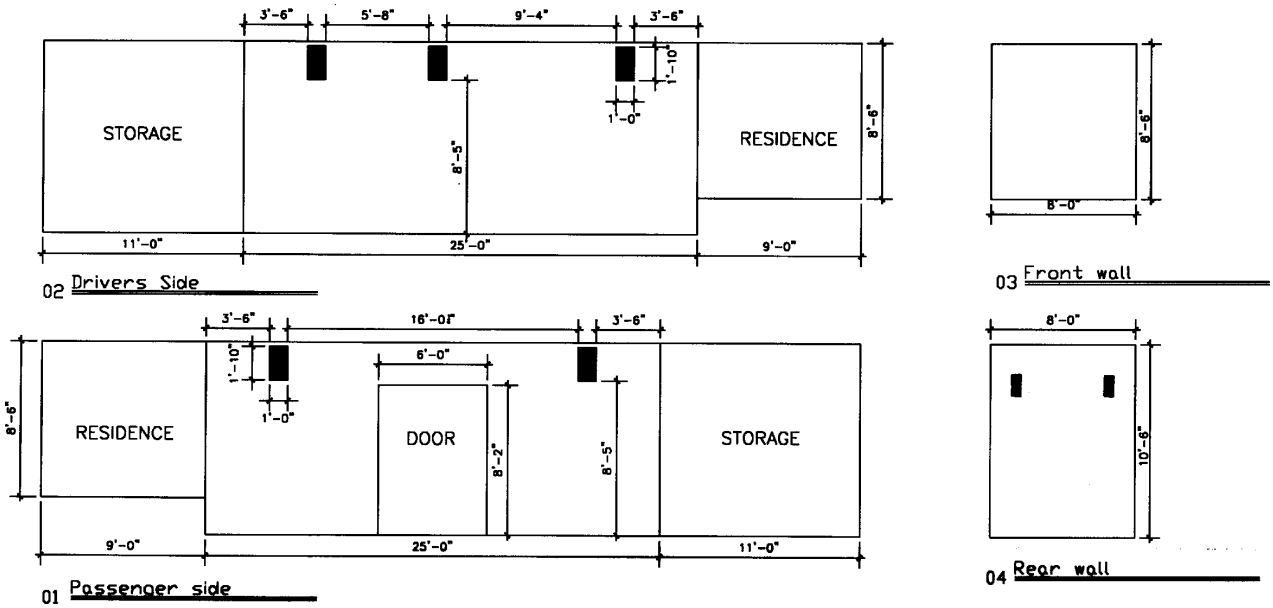


Figure 10. Clyde Beatty-Cole Bros: Structural Diagram, Truck 62. The darkened rectangles represent windows.

malfunction and are not displayed.

In addition to the loggers that were not displayed as a result of damage or malfunction, the logger recording the external measures appears to have been strongly affected by travel as shown by the large changes with the onset of transport. Nonetheless, the internal loggers measured a maximum temperature of 86°F in truck 56 immediately before unloading. All loggers tended to record temperatures above the external when not in motion suggesting a temperature buildup. As in previous instances, the buildup was not hazardous with the relatively cool exterior temperatures.

Internal relative humidity tended to be equal or slightly below the external measure while the animals were in the trailer before departing. After the trailer arrived, internal humidity tended to be equal or within 10% of the external measure depending on which truck.

Tests for the presence of noxious gases were made upon arrival. Within our range of detection, no ammonia or carbon monoxide was detected.

From a total of eight body temperature loggers ingested, a single body temperature logger was recovered from Barbara. Barbara's body temperature was very consistent during the entire trip.

Clyde Beatty – Cole Brothers

Clyde Beatty–Cole Bros. (Clyde Beatty) begins moving after the last show of the day. The circus loads the elephants at approximately 22:00 to 23:00 and then travels to the next lot where they immediately set up the elephant pens and then unload the elephants at approximately 1:00 to 2:00 am. As with Carson and Barnes, Clyde Beatty avoids hot daytime temperatures by traveling during the night.

Clyde Beatty transports four Asian elephants in two semi-trailers (two elephants per trailer). The elephants are positioned parallel to the direction of travel and facing each other. The trailers were relatively similar, with a compartment above the fifth wheel that served as a staff residence and a second compartment over the rear wheels that served as a storage area (Figure 10). The elephant compartment between the residence and storage areas measured 2200 cubic ft and had five air vents along the sides that were covered with bars. There were also two exhaust vents located at the rear of the trailers. One truck had a sheet of expanded metal across the top-rear of elephant area; the other truck had a solid rear-wall. The single doorway had a solid metal door that was closed during transit. Several drain holes were spread through-

out the floor of the elephant compartment. The trailers were not insulated, having walls of steel and wood instead. The floors were wooden and covered with a rubber finish to prevent rotting. During travel, the entrance/exit doors were kept closed.

Brooklyn, NY, to Staten Island, NY. During the first trip from Brooklyn, NY, to Staten Island, NY, (Figure 11), six environmental loggers (six with probes) were divided among the two trucks. In order to make the figure easier to read, and because environmental logger variation was small, not all of the environmental loggers are displayed. In each truck, a single environmental logger-probe combination was mounted on the rear wall approximately 5' from the floor with a probe 2' 6" above the environmental logger. A second combination was mounted on the sidewall of each truck approximately 6" from the front wall and 7' 6" from the floor. The probes were mounted on the wall 3' below the environmental logger. The two environmental loggers without probes were mounted approximately 8.3' from the floor in the midsection of the truck. All environmental loggers were at least 2' from a window.

Internal and external temperatures ranged from 64.9°F to 78.1°F and were closely correlated, staying consistent between trucks. One truck (60) did have an environmental logger that recorded readings several degrees above the other environmental loggers throughout both trips.

In the period before the elephants were loaded, external temperature equaled internal temperature. Loading caused a slight rise of several degrees in the trailer's interior temperature. After departing, internal tempera-

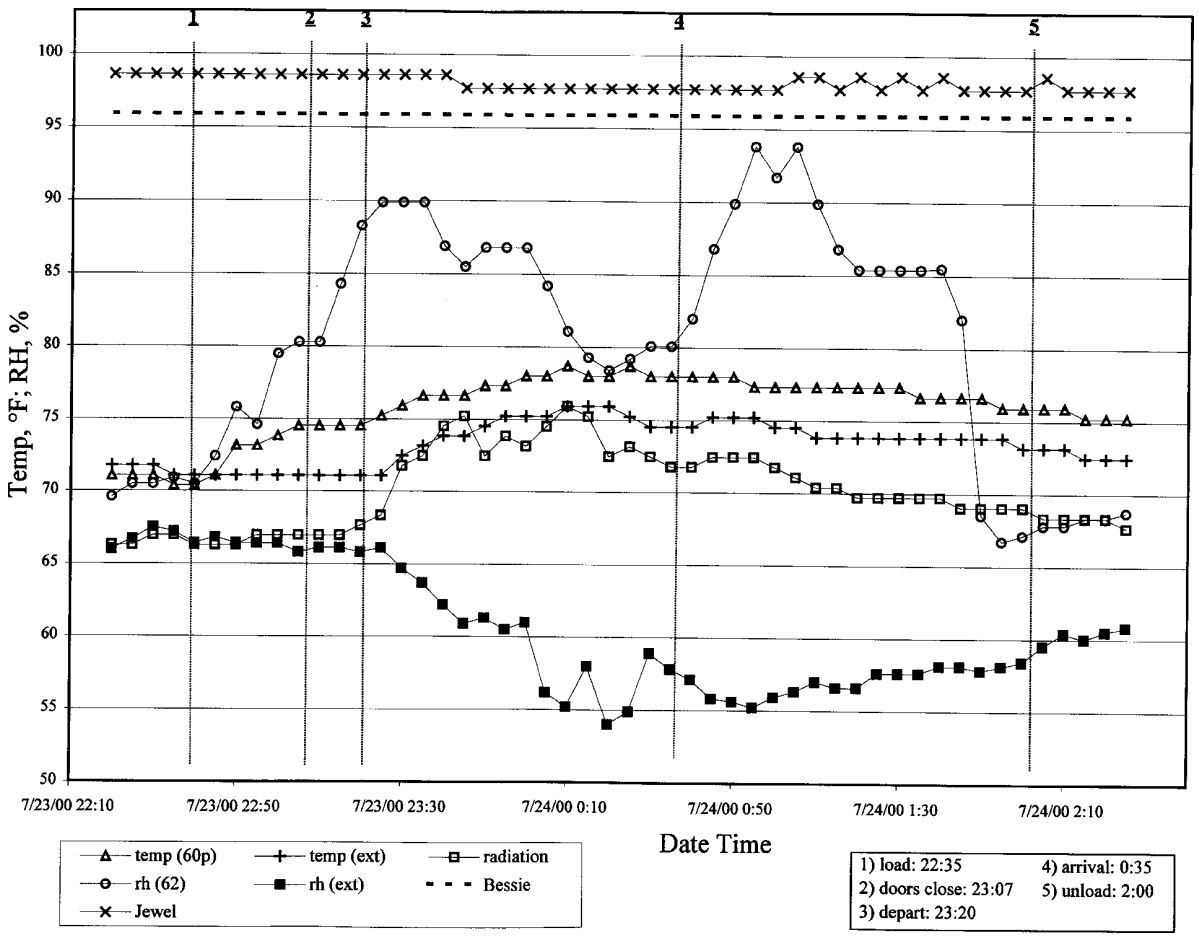


Figure 11. Clyde Beatty: trip from Brooklyn, NY, to Staten Island, NY.

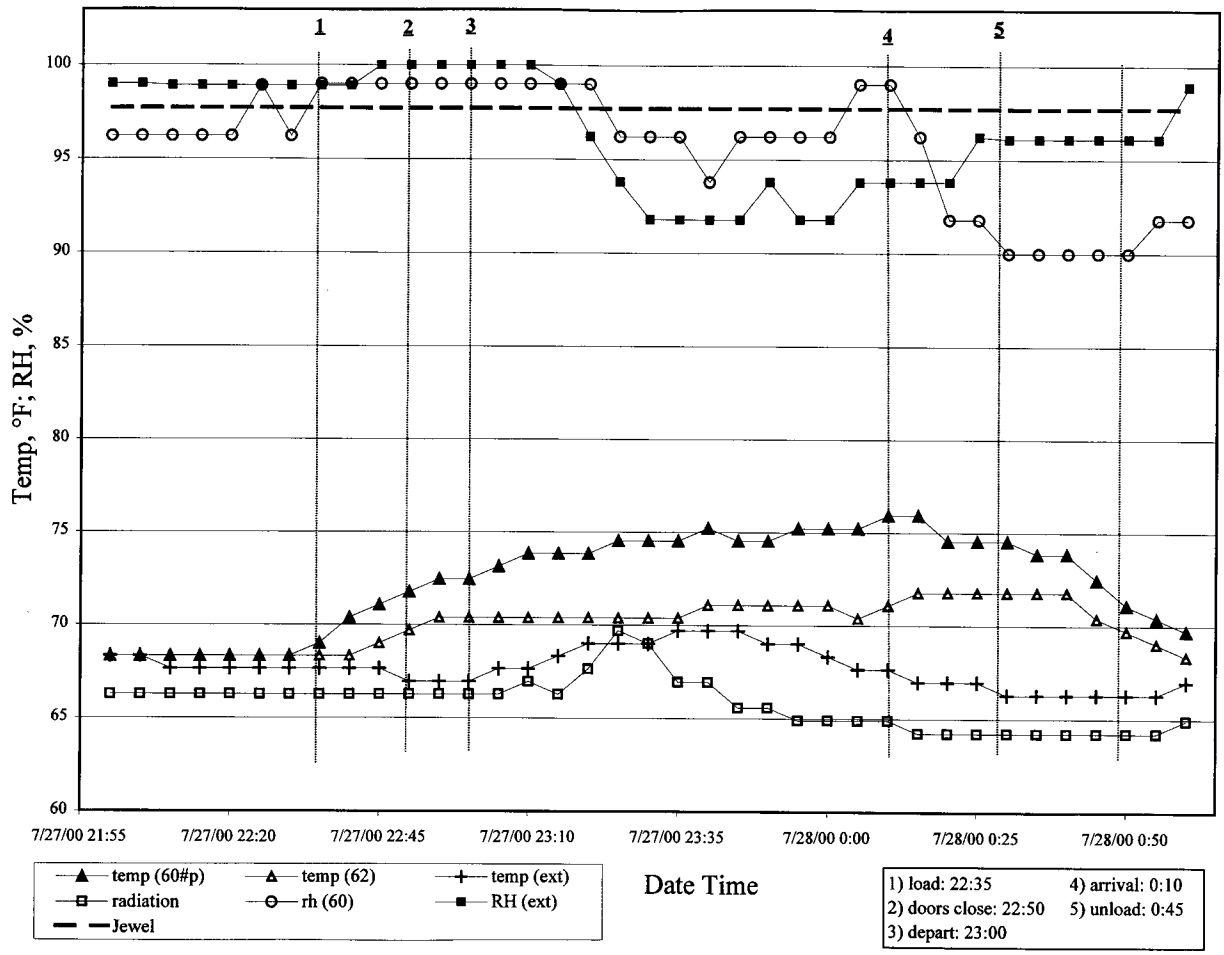


Figure 12. Clyde Beatty: trip from Staten Island, NY, to Forest Park, NY.

ture increased and remained for the most part above the external temperature until even after unloading. Upon arrival, both internal and external temperatures began falling.

Internal relative humidity was significantly greater than external relative humidity for the entire survey. Preloading internal relative humidity averaged less than 5% above external relative humidity and followed the same upward trend. All internal environmental loggers rose steadily after loading until departure when they began falling. Upon arrival, relative humidity began rising again. The maximum difference between the internal and external loggers was after arrival and approximately 40%.

Tests for the presence of noxious gases were made upon arrival. Within our range of detection, no ammonia or carbon monoxide was detected.

From eight body temperature loggers fed to the elephants, four body temperature loggers were collected during this trip, though two were chewed beyond use. Jewel's temperature ranged from 97.7°F to 98.6°F. Bessie's temperature maintained a constant value of 95.9°F during the entire trip.

Staten Island, NY, to Forest Park, NY. Environmental loggers during the Staten Island, NY, to Forest Park, NY, trip (Figure 12), were mounted in the same positions as during the first trip. Temperatures throughout the trip maintained a range between 68.33°F and 75.9°F. After loading, internal temperature began rising and continued to do until arrival whereupon it remained steady.

The decreasing internal temperature after arrival and before unloading seen in both trips suggests that for this temperature range, enough ventilation was present to prevent a buildup of temperatures

Humidity data differed from the Brooklyn, NY, to Staten Island, NY, trip in several aspects: external relative humidity was much higher, never falling below 91% and remaining above the internal readings during the entire transport period. Additionally, internal relative humidity was above 85% for the most of the trip.

The high humidity seen in both trips should not affect the animal's ability to dissipate heat, as the temperature at time of transport was relatively cool.

Tests for the presence of noxious gases were made upon arrival. Within our range of detection, no ammonia or carbon monoxide was detected.

During this trip, only one body temperature logger was recovered (Jewel's) of the six that were ingested. Her body temperature remained constant during the entire trip at 97.7°F, a value within normal elephant body temperature.

Circus Vargas

Circus Vargas travels late at night. Takedown occurs after the last show of the night and the elephant is loaded shortly after. They then travel to the next lot in a trip that typically lasts several hours. Upon arrival, the elephant is left in the truck until setup commences the next morning at approximately 7:30.

Circus Vargas transported one Asian elephant using an 18-wheel truck which is also used to carry an assortment of sheep and miniature goats that are part of the circus' petting zoo (Figure 13). The sheep and goats are transported in forward compartments located over the fifth wheel. The elephant area of the truck had six vents, all of which were covered with expanded metal and positioned on the sides of the truck. Four additional vents of the same size were in the sheep/goat area. The front and forward walls of the elephant area were solid steel panels rising from the floor and leaving a gap between the top of the panels and ceiling. There were three entrance/exit doors to the elephant compartment: two on one side and a single large door on the other. The total area of the elephant portion was 1,547 cubic ft. The truck was not insulated and had wooden sidewalls and floor.

One environmental logger was used to record interior environmental parameters with Circus Vargas. The unit was mounted 8' from the rear panel and 4' high.

Santa Barbara, CA, to San Luis Obispo, CA. Only

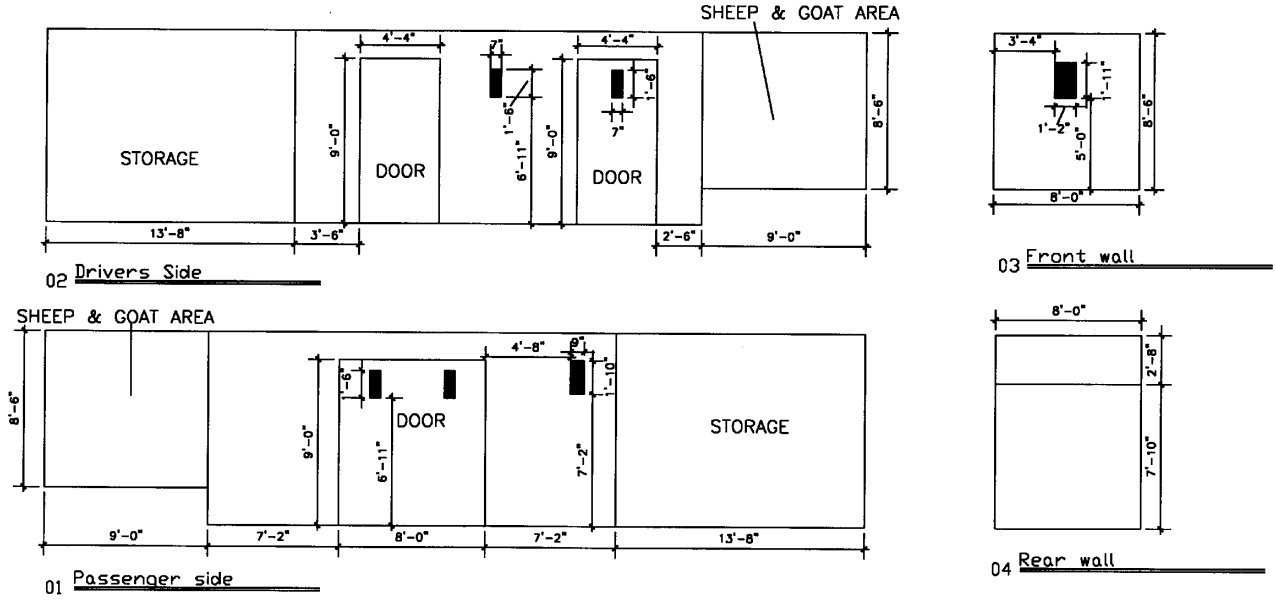


Figure 13. Circus Vargas: structural diagram of trailer. The darkened rectangles represent windows.

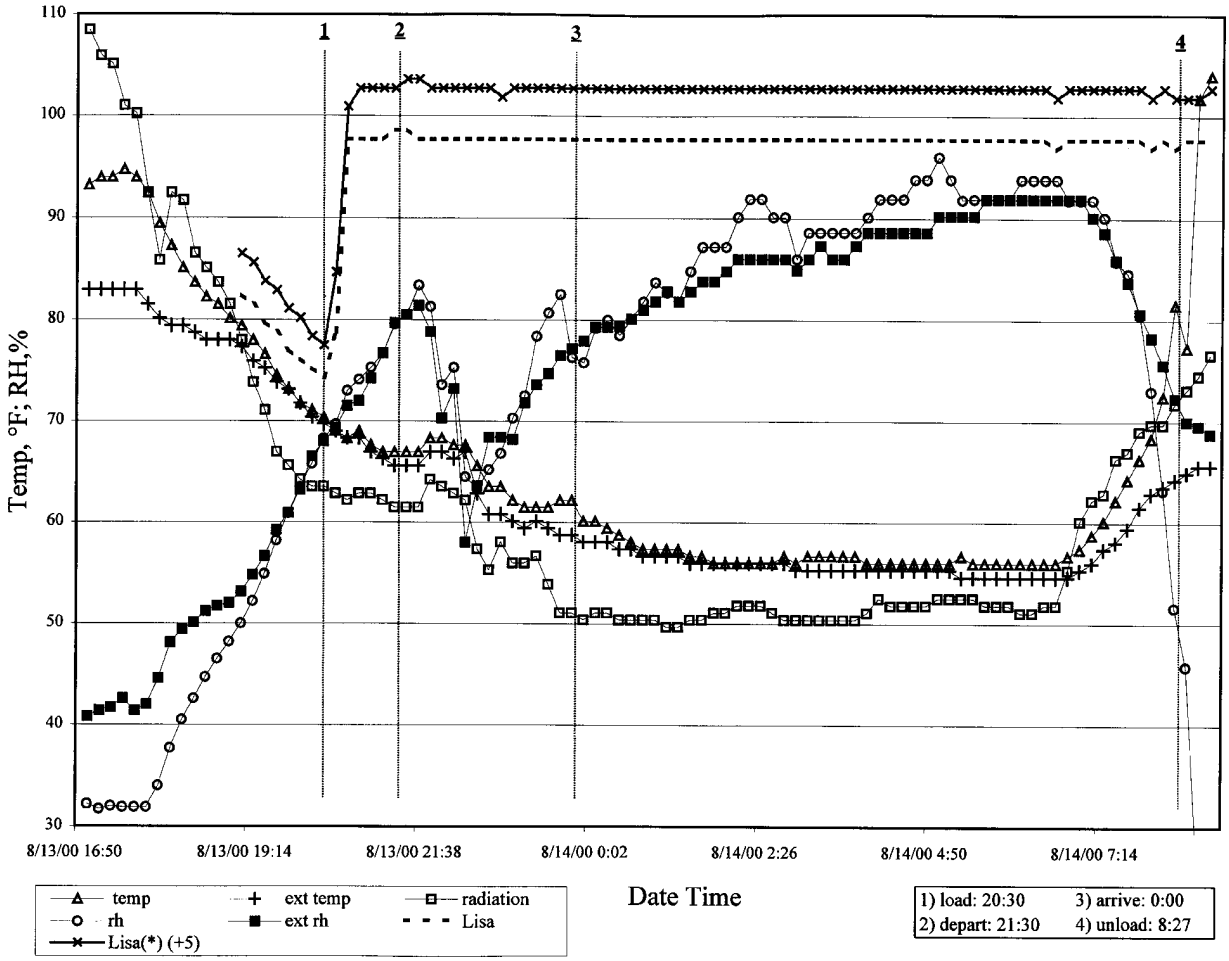


Figure 14. Circus Vargas: trip from Santa Barbara, CA, to San Luis Obispo, CA. Data from two body temperature loggers for Lisa are shown and five degrees were added to each reading from one logger to prevent superimposition of data.

one trip, Santa Barbara, CA, to San Luis Obispo, CA, (Figure 14), could be surveyed, during which the average interior temperature reached a maximum of 82.0°F. A temperature buildup of approximately 10°F did occur in the late afternoon of 8/13/00, though Lisa was not in the trailer at this time. For the majority of the trip, the external temperature was virtually the same as the temperature in the elephant compartment. Beginning 8/14/00 7:00, internal temperature began to rise more steeply than external temperature, though the difference was small until just before unloading. The steep rise in temperature following unloading is believed to be a result of direct sunlight hitting the environmental logger through the trailer's open doorway. This trip highlights the importance of monitoring the internal environment of the trailer as the rise in radiation after 8/14/00 7:00 resulted in a proportional rise in temperature of the uninsulated truck peaking at 82.9°F. This illustrates how rapid the interior of an uninsulated trailer can increase in temperature when the trailer is not moving and ventilation is reduced. For the most part, this effect could not be felt by caretakers outside as external temperature measured 66.9°F. As in previous instances, the elephant was removed from the trailer before the interior temperature became a problem.

During the time that Lisa was in the trailer after arriving, the elephant caretaker reported that the elephant would frequently lie down (apparently to rest or sleep) until being released later that morning.

External and internal measures of relative humidity were variable during the trip and remained below 85% for most of transport though both rose to 90% after

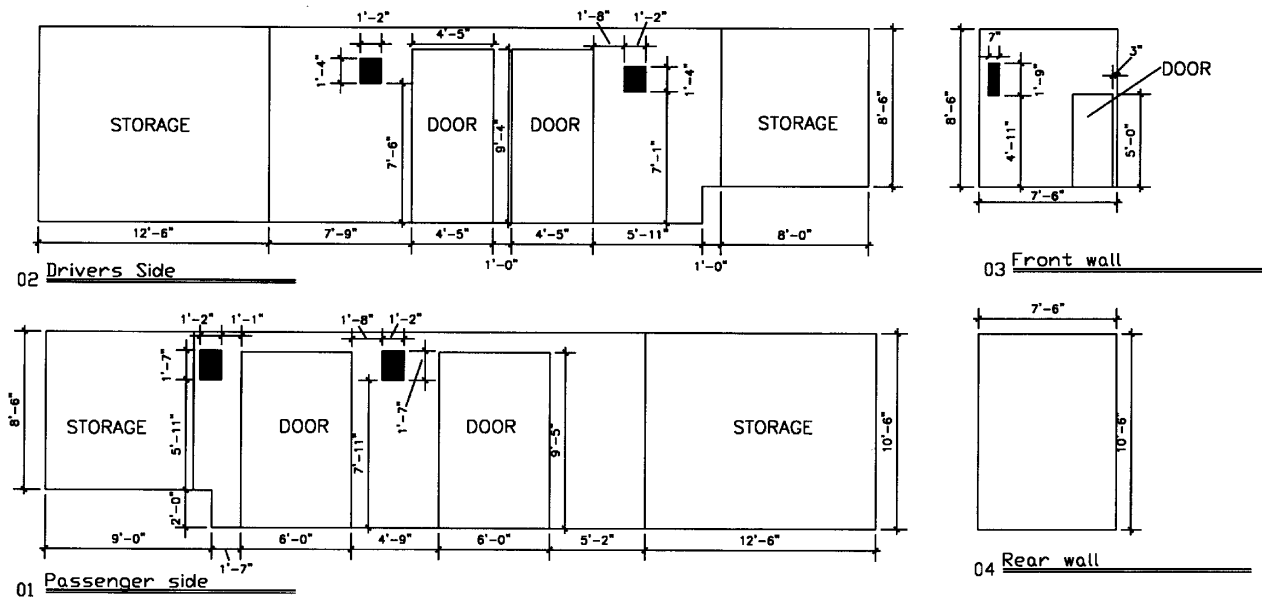


Figure 15. Hawthorn Corporation (No. 1): structural diagram of a trailer. The darkened rectangles represent windows.

arrival. The large dip in both measures of relative humidity after 8/13/00 22:05 is most likely geographically related as the circus was very near the Pacific Coast.

Tests for the presence of noxious gases were made just before unloading. Within our range of detection, no ammonia or carbon monoxide was detected.

Two body temperature loggers were administered to Lisa immediately before loading as indicated by the sudden rise in body temperature at 8/13/00 20:30. The measure was fairly stable and each body temperature logger experienced nearly the same changes indicating the precision of the units. A slight rise in temperature occurred approximately 20 minutes before departure, though measured less than a single degree and was within normal body temperature range. Overall, body temperature maintained a 1.8°F range between 96.8°F to 98.6°F.

Hawthorn Corporation (No.1)

The Hawthorn Corporation is based in Richmond, IL, where it leases several elephant (and cat) acts to a variety of organizations, including circuses, carnivals, fairs, and even business conventions. The company owns approximately 25 elephants that make up four different acts that are leased out and travel by truck. A second elephant act (Hawthorn Corporation No. 2) was surveyed during cold weather and is reported in the cold weather section of this article. Each act has one head handler and several grooms that travel as a unit. Typically an act will leave the headquarters in Illinois for a destination somewhere in North America and remain there for a week or more as part of the event. Upon the contract for that event being completed, the act will make a trip to another show or event. An act may maintain this routine for several months. Trips may last for several days during which the driver and grooms will stop at truck stops and sleep in either travel trailers or compartments within the truck. During this time, the elephants are kept in the trailer.

The elephant area of the truck surveyed had a total of 5 vents of various sizes, comprising a total area of 5.2 x 8.04 ft (Figure 15). There was also a rather unique intake vent in the front that channeled air through the storage area via a duct and with a blower. Each vent was covered with expanded metal. There were four entrance/exit doors in the elephant compartment, two on the passenger side, and two on the driver side. This particular unit transported two Asian elephants, one facing the direction of travel and the other facing away from the direction of travel. The total area provided to the two elephants was

approximately 1892.7 cubic ft, consisting of the entire trailer, except for a small area over the fifth wheel that was used for storage/living quarters and a rear portion used for storage. The walls of the truck were insulated.

Fort Worth, TX, to Houston, TX. During the trip from Fort Worth, TX, to Houston, TX, (Figure 16), one environmental logger was placed in the midsection of the trailer, approximately 4.0 ft from the floor. The handler broke the trip into two legs to ensure that all circus supplies (primarily water) would be set up by the time the elephants arrived at the final destination.

During the portion of the trip when the animals were in the truck, internal temperature reached a maximum of 96°F at 7/11/01 20:15. At this time the elephants were being loaded for the second leg of the trip and both external and internal temperatures were falling, typical at that time of day. The highest recorded temperature (107°F) inside the vehicle throughout the survey period occurred at 7/11/01 18:23; however, at this time, the elephants were outside under large trees. During travel, a slight temperature buildup occurred and the external temperature typically read 1 to 5°F less than the internal logger. A much larger difference of 15°F was detected during the period when the maximum temperature was recorded; however, as already mentioned, the elephants were not in the trailer.

Relative humidity tended to be inversely proportional to external temperature, reaching a high of 100% approximately six hours after loading and maintaining that

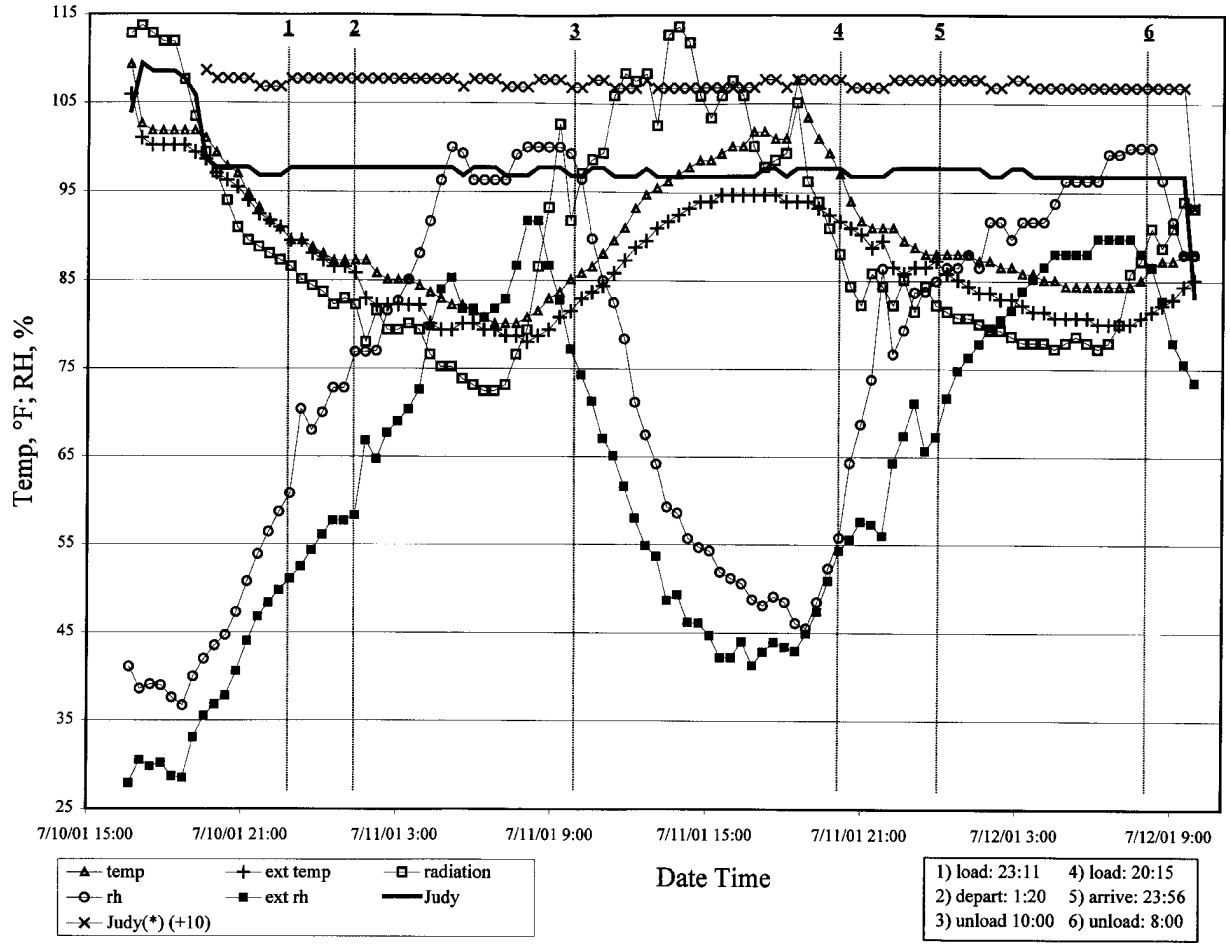


Figure 16. Hawthorn Corporation (No. 1): trip from Fort Worth, TX to Houston, TX. Ten degrees were added to each of Judy's body temperature readings to avoid superimposition of data.

level until the elephants were unloaded at 7/11/01 10:00. After this first unloading, internal relative humidity followed a trend similar to external relative humidity. The external and internal measures later equalized. When the elephants were loaded that evening for the second leg of the trip, internal relative humidity experienced a sharp rise to approximately 80%. During this time, both internal and external relative humidity rose steadily with the internal measuring 7–10% above the external.

Tests for the presence of noxious gases were made immediately before the animals were unloaded after the first leg of the trip at 7/11/01 10:00. A sample was not taken after this survey's final unloading. Within our range of detection, no ammonia or carbon monoxide was detected.

To collect body temperature data, six body temperature loggers were fed to the two elephants at the same time several hours before departure. All body temperature loggers were recovered, although only two were downloadable. Both functional loggers were from the same elephant, Judy. The loggers were fed at the same time though recorded different ranges of temperatures, most likely a reflection of different set points for each logger. Nonetheless, the loggers' recordings maintained individual ranges of 0.9°C.

Houston (North), TX, to Houston (South), TX. During the trip from Houston (North), TX, to Houston (South), TX, (Figure 17), the environmental loggers were placed in the same position as during the previous jump.

The elephants were loaded at 7/17/01 22:45 when

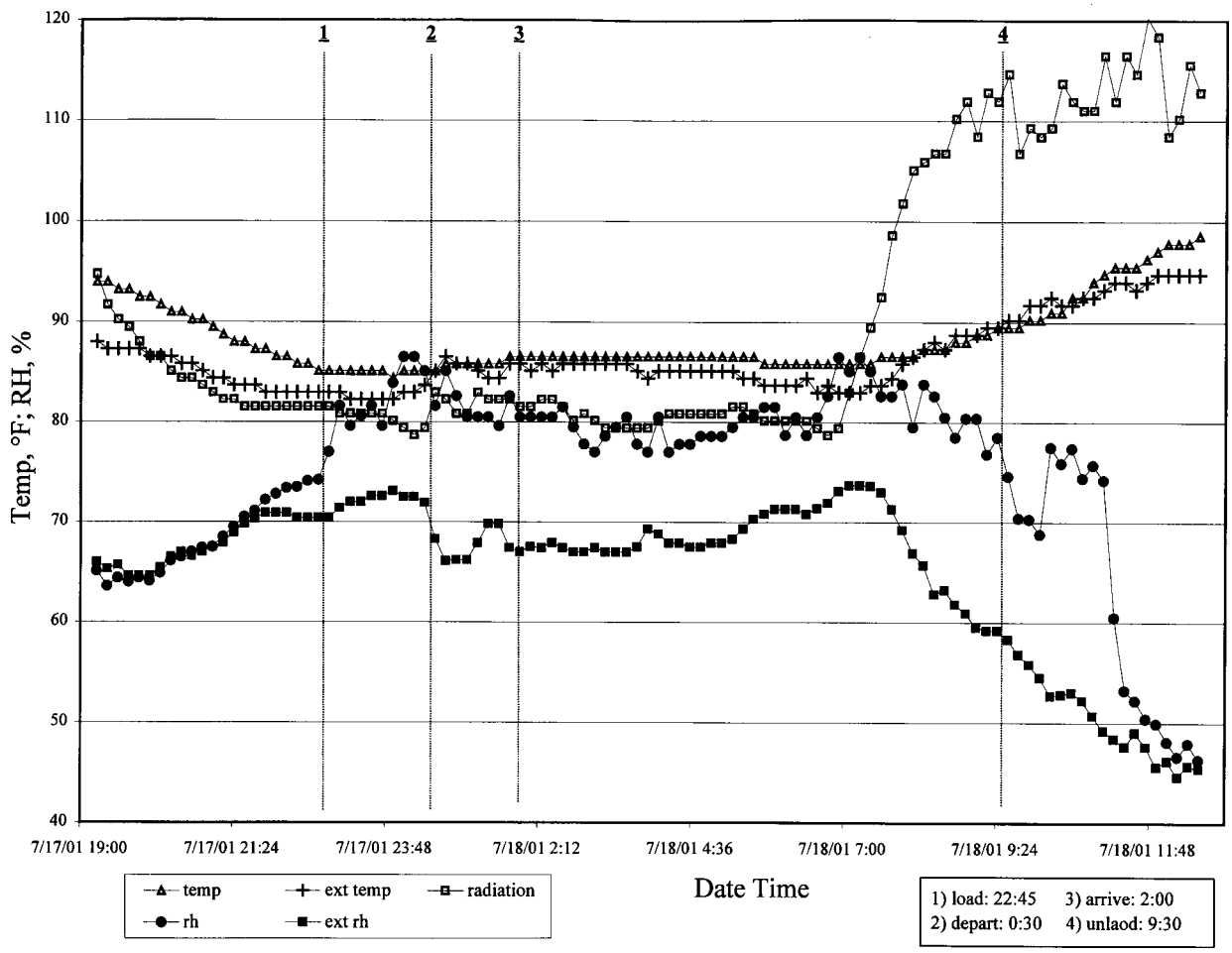


Figure 17. Hawthorn Corporation: trip from Houston, TX (North), to Houston, TX (South).

internal temperature was at 83°F and reached a maximum of 90°F at 7/18/01 9:30 whereupon the elephants were unloaded. Except for the last five hours before unloading, the entire trip occurred in the absence of daylight. Radiation reached a high of 112°F while the elephants were in the trailer. This increase occurred with a concurrent change in external and internal temperature, though the internal temperature was maintained at a reasonable level. During travel, a slight temperature buildup occurred and the external temperature typically read 1°F to 3°F less than the internal logger. Internal temperature throughout the trip (loading to unloading) was fairly steady and was maintained within a 5°F range.

Relative humidity tended to be inversely proportional to external temperature, though the changes throughout the trip were much less than seen during the Fort Worth, TX, to Houston, TX, trip, most likely a result of the short duration. While the animals were in the trailer, internal relative humidity ranged 77% to 85%, with the external measure reading approximately 10% under the internal.

Samples for ammonia and carbon monoxide were not taken during this trip because the researchers were not present at the time the truck arrived.

To collect body temperature, three loggers were fed to Debbie

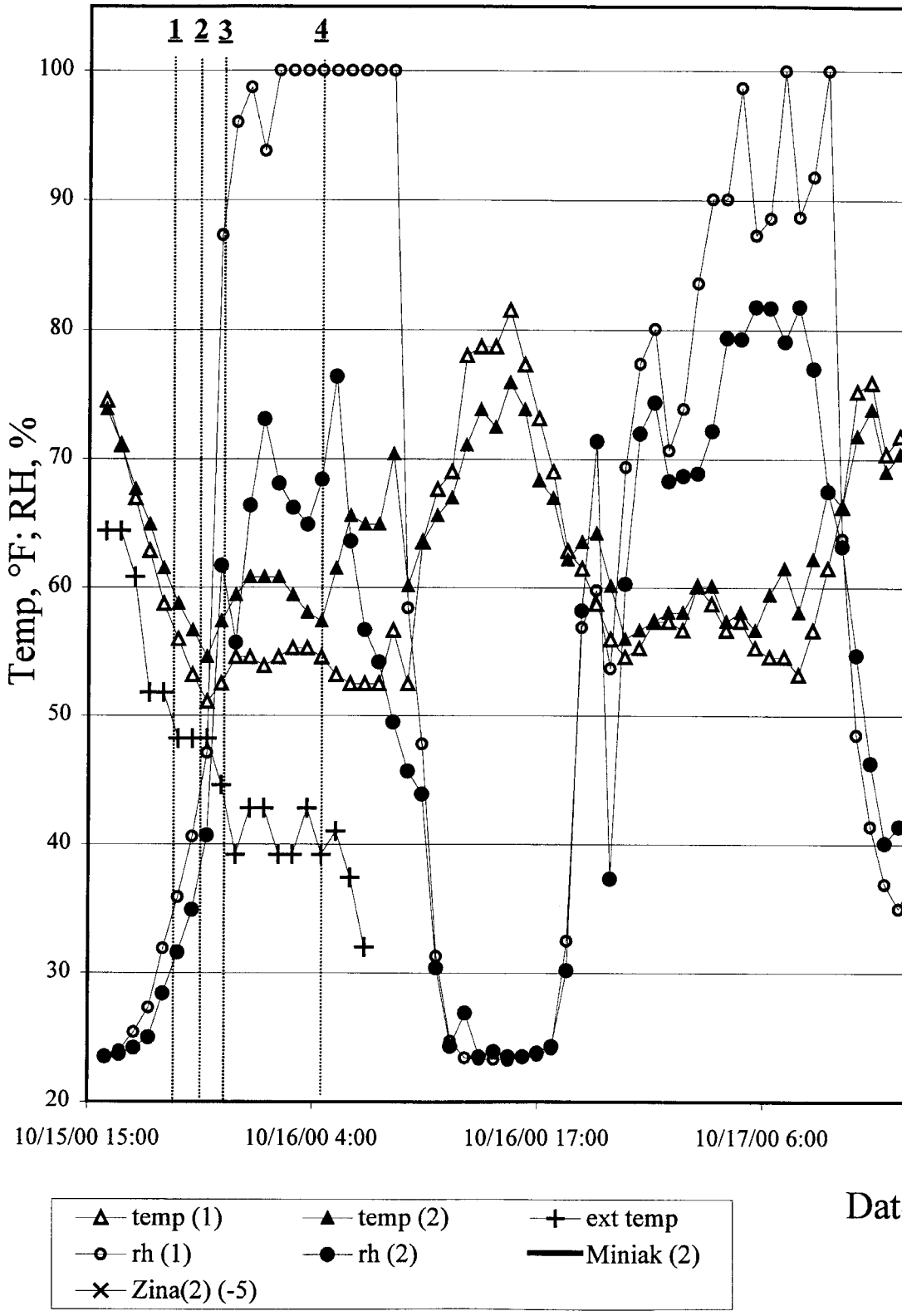
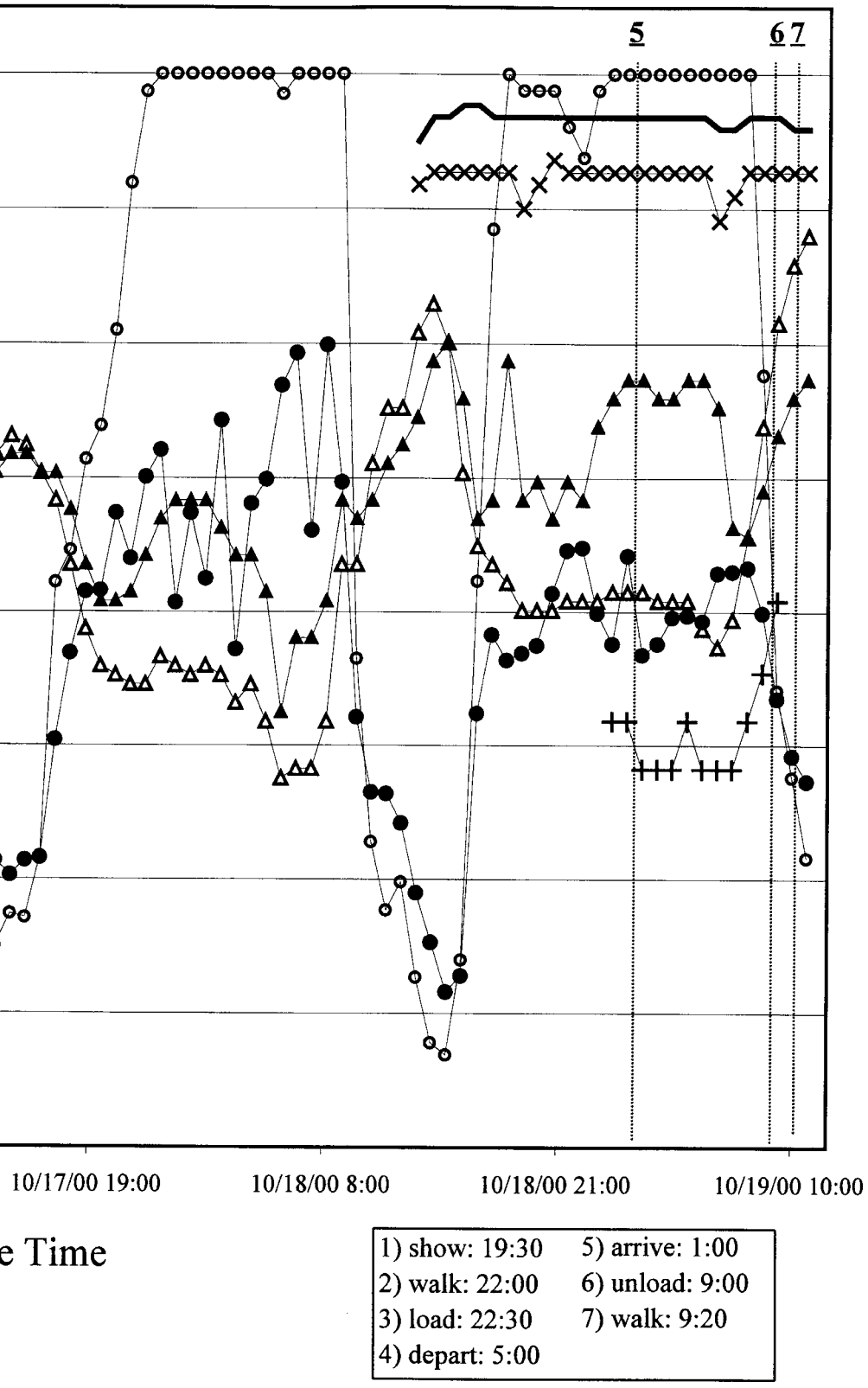


Figure 18. Ringling Blue: trip from Denver, CO, to Cleveland, OH. Five degrees were subtracted from each of Zina's body temperature readings to avoid superimposition of data.



and one to Judy. Although all four loggers were recovered, they were slightly damaged (chewed) and body temperature data could not be downloaded.

Cold Weather

Ringling Blue

Descriptions of the railcars Ringling Blue used to transport elephants as well as an overall synopsis of travel procedure are detailed in the Ringling Blue hot weather section of this report.

Denver, CO, to Cleveland, OH. Due to the long duration of travel, the figures for the Denver, CO, to Cleveland, OH, trip (Figure 18) are divided across two pages. During the trip, two environmental loggers were mounted in the full car (1), and one each in the alpaca (2) and baby (3) cars. The environmental loggers in the full (1) and alpaca cars (2) were positioned in approximately the same places as during the hot weather trials, although no probes were used. The environmental logger in the baby car (3) was mounted 6' from the floor approximately 2' from the door. Unfortunately, the environmental logger recording external measures malfunctioned, and we were unable to obtain these for comparison. Using databases from the National Weather Service, we have provided external temperature conditions during the periods before departure from Denver, CO, and upon arrival in Cleveland, OH (NOAA 2001). Between this period we are unsure of the circus' route and thus cannot provide further descriptions of external temperature.

Internal environmental loggers recorded very different readings indicating that variations in temperature and humidity existed between cars and areas

within the car. A major difference can be attributed to the presence of heating units in the two half cars (2, 3), whereas the third car (1) that transported five adult elephants did not have a heater. During travel, the units' thermostats were set to maintain a temperature between 65°F to 75°F. Styrofoam or wood was used to cover windows. Vents in the roof of the car were not covered and the fans were not turned on.

Preloading internal temperature decreased until the elephants were loaded, whereupon all cars experienced a sudden rise in temperature, though much smaller in the juvenile car (3), which is not shown in Figure 18. The sudden rise the juvenile car (3) experienced at 10/16/00 0:50 was most likely due to the heater being activated. During the trip, the juvenile car maintained a temperature range between 52°F and 77°F. All cars maintained a temperature range between 44.6°F to 80.6°F.

Though exterior temperatures were not measured by our environmental loggers, measurements between 33°F and 42°F were reported for the Denver area after loading and before departure (NOAA 2001). Temperatures between 48°F and 61°F were reported around the time of arrival and before unloading in Cleveland, OH (NOAA 2001). The full car (1) was able to maintain a minimum internal temperature 16.2°F above these external temperatures indicating the elephants' ability to warm their own environment adequately despite the lack of a heating unit. During the afternoon, for each day of the trip, the environmental logger in the full car (1) recorded the highest temperature of the three elephant cars while the reverse trend occurred at night. This trend is most likely due to reduced use of the heating units during the day in the two half cars (2, 3). During the daytime, temperatures would be high enough to not activate the heaters, and thus heat came primarily from the elephants themselves. The car with the most and largest animals (1) experienced the highest temperature. At night, when external temperatures were lowest, the half cars (2, 3) with heaters had higher temperatures than the full car (1) with only the elephants themselves generating heat.

Temperature for the most part was maintained above 52°F in all cars except for a dip in temperature at 10/18/00 4:30 measured in all elephant cars. The juvenile car (3) experienced a sharp rise in temperature with the activation of the heating unit at 10/18/00 5:30. The alpaca car (2) experienced a similar rise, though the temperature fell several degrees lower before rising. The full car (1) reached the lowest point for the entire trip at 10/18/00 6:10 and took several hours to come within range of the other cars, illustrating the effects of the absence of a heating unit. The sudden increase in temperature for the full car was most likely due to the rising sun that likely occurred at this time.

Relative humidity in the full car (1) was typically much higher than the other cars during non-afternoon times, often maintaining levels at 100%. High humidity is common when ventilation is reduced to lessen the loss of body heat produced by the animals.

Tests for the presence of noxious gases were not made during this trip.

Two sets of eight body temperature loggers were administered to four elephants in this trip, though none were recovered from the first set ingested before departure. Four body temperature loggers from the second set, ingested at 10/18/00 13:00, as shown by the sudden appearance of body temperature in Figure 18, were recovered from three elephants and showed a temperature range of: 94.1°F to 98.6°F. The minimum in this case, the sudden dip in Zina(2) at 10/19/00 6:00, spanned 1 hour and was most likely a result of drinking water.

Chicago, IL, to Savannah, GA. During the Chicago, IL, to Savannah, GA, trip (Figure 19), one environmental logger was placed in the car transporting five adults (1), and a second in the alpaca car (2), each approximately 5' high and in the car's midsection. Differences in temperatures similar to the Denver, CO, to Cleveland, OH, trip were seen between the full (1) and half car (2). Environmental loggers in the alpaca car (2) recorded higher temperatures than the full car (1) in the non-afternoon hours for the first leg of the trip, indicating the significant effect of the heating units. The readings equalized after approximately 11/28/00 10:00 for several hours then divided again with the full car (1) reading between 10.0°F to 15°F below the alpaca car (2). At one point (11/27/00 8:30), the difference was 20°F below the heated alpaca car (2) and several other times reached near freezing temperatures.

Internal relative humidity of the full car (1) tended to be significantly higher than the alpaca car (2) during

non-afternoon times. During these times, relative humidity in the full car (1) registered 100% contrasting the alpaca car (2) that remained below 75% for most of the trip. A sudden drop in external relative humidity occurred at approximately 8:20 on both 11/28/00 and 11/29/00. The rise in humidity is timed with a corresponding rise in solar radiation and due to the sun "burning off" humidity from the previous night.

Tests for the presence of noxious gases were made at 11/28/00 10:00 and upon unloading. No ammonia or carbon monoxide were detected by our instruments.

Body temperature was observed using a total of 12 body temperature loggers administered sequentially in three sets of four during the trip. The date and time that each body temperature logger suddenly appears is when the logger was ingested. Using this method resulted in a near continuous measurement of body temperature, though not for the same elephant. During this trip, evidence suggested that the body temperature loggers' position in the animal was related to the degree of drinking related drops occurring in the recorded body temperature. For instance, the large dip in body temperature for Miniak(2) at 11/27/00 20:40 occurred just after the body temperature logger was ingested, thus the logger would still be in the stomach and highly influenced by drinking cold water. In comparison, Jewel(1), a body temperature logger administered in the first set, was still in the elephant and experienced a smaller dip at the same time, indicating the logger may have been in the cecum or transverse colon, an area close to the stomach.

Excluding what appear to be drinking related dips, body temperature ranged from 95.9°F to 99.5°F. Note that five degrees were subtracted off of Miniak's temperatures in Figure 19 so that her temperature would not

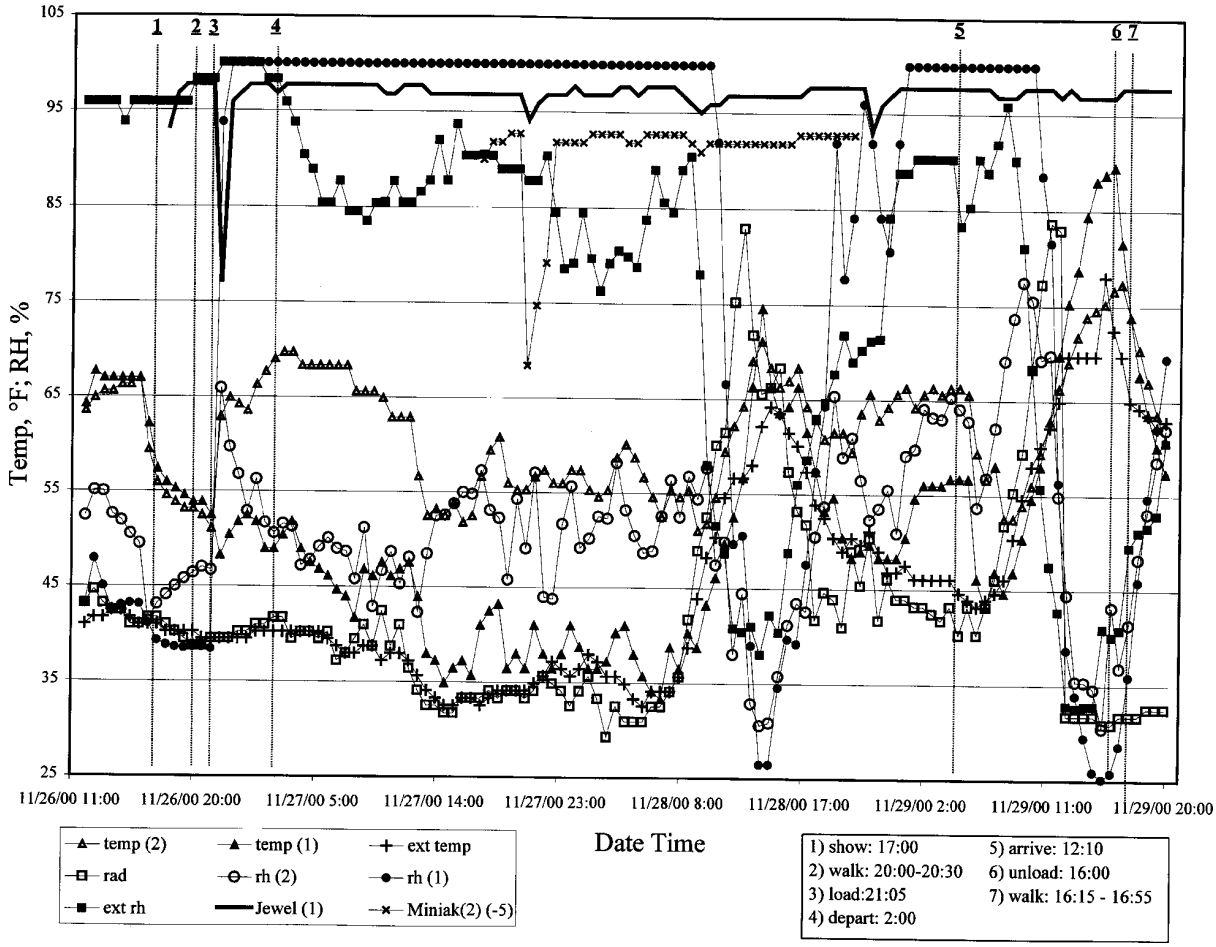


Figure 19. Ringling Blue: trip from Chicago, IL, to Savannah, GA. Five degrees were subtracted from each of Miniak's body temperature readings to avoid superimposition of data. The items "temp (1)" and "temp (2)" are the internal temperatures for cars No. 1 and No. 2.

be plotted on top of Jewel's. The maximum was short lived, occurring in Zina(2) at 11/29/00 16:55 for one measurement. The maximum also appears to be activity related having occurred within a half-hour after unloading and walking to the arena. Body temperature was not influenced by changes in the internal temperature of the railcar despite near-freezing temperatures.

Hawthorn Corporation (No. 2)

Richmond, IL, to Nashville, TN . Two Asian and two African elephants were transported using an 18-wheel truck (Figure 20). The elephant area of the truck had a total of six vents covered with bars, and as a cold weather adaptation, were also covered with styrofoam. Two small panels were cut into the trailer's base along the side to allow access for the animals to be watered and fed while in the truck. There was one entrance/exit door in the middle of the elephant compartment. The four animals were positioned with the forward two facing the direction of travel and the rear two facing away from the direction of travel. This arrangement allowed for easy feeding and watering using the access panels, as well as removal of feces through the entrance/exit door. The forward wall was a steel sheet held in place by small sections of sheet metal welded to the wall leaving a gap between the sheet and the trailer wall. The rear wall was of the same design except the gap existed only at the top. The total area provided to the four elephants was 2,228 cubic ft, consisting of the entire trailer except for the space over the fifth wheel that was used for storage/ living quarters and a rear portion used for storage. The walls of the truck were insulated.

Three environmental loggers were placed in the mid-section of the truck; one (1) 2' 6" from the floor and two more approximately 7' 7" from the floor (1*, 1+). Loggers 1* and 1+ had similar readings during the trip so only 1* is plotted in Figure 21. During the trip, external temperatures below freezing were recorded during the first 10 hours of transit. Despite this low temperature, the presence of the animals had a significant effect on internal temperature inside the trailer shown by the dramatic rise in temperature in the two-hour period following the elephants being loaded

Once traveling began, the interior temperature recorded by the environmental logger closest to the floor (1) began to fall probably reflecting air leaking in at floor level. The loggers level with the elephant's heads maintained a fairly stable temperature of approximately 70°F during the same period. Several other differences were noted between environmental loggers and appear

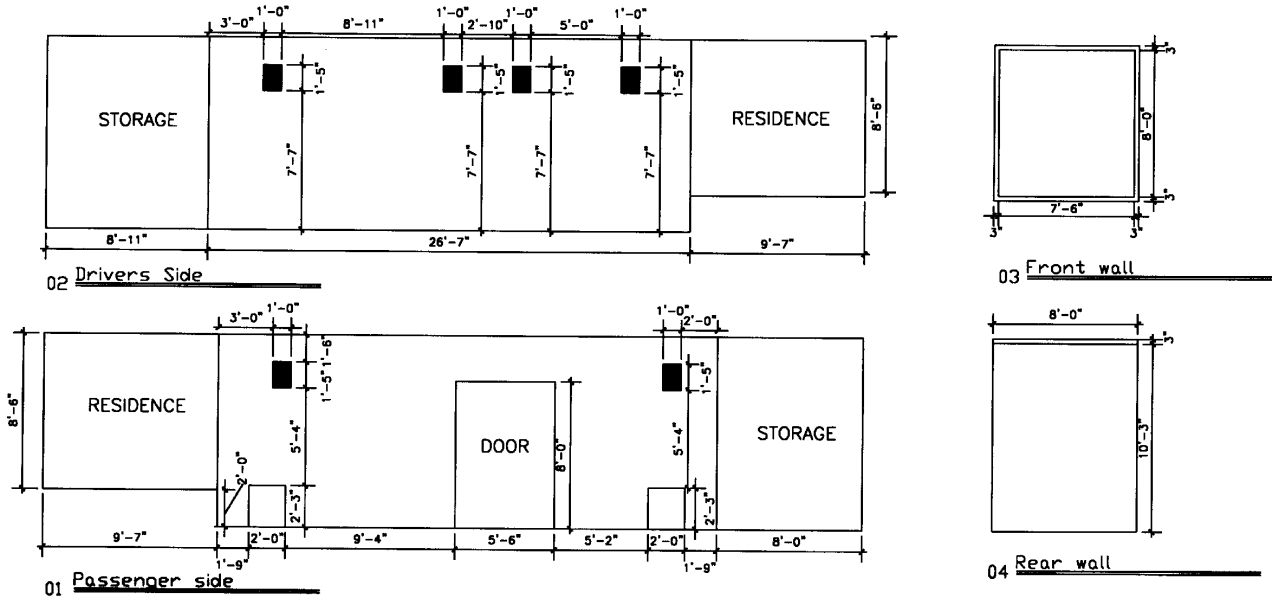


Figure 20. Hawthorn Corporation (No. 2): structural diagram of insulated trailer. The darkened rectangles represent windows.

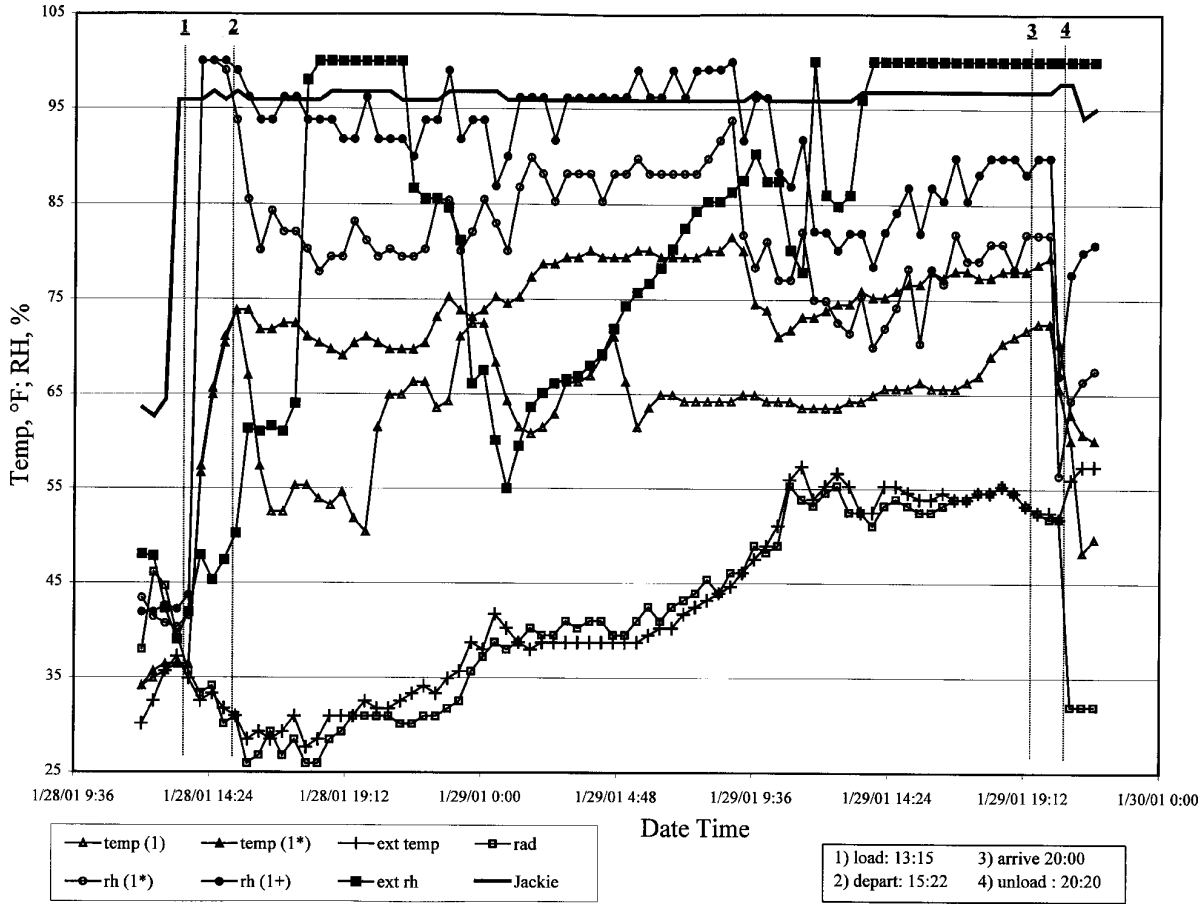


Figure 21. Hawthorn Corporation (No. 2): trip from Richmond, IL, to Nashville, TN.

related to the position of the loggers and the opening and closing of access panels.

At all times during transit, a significant difference was maintained between internal and external temperatures. Internal temperature during the overnight stop (midnight to 0900) did become relatively warm and appeared to match the slight rise in external temperature that occurred after 1/29/01 05:00. The heat produced by the presence of the elephants was enough to maintain an adequate temperature under these conditions.

During the first day of the trip, relative humidity was high with two environmental loggers averaging above 90 % and a third at 80 %. On the second day, the handler opened the vents before departure, and relative humidity decreased 5% to 10 % from the previous day. External relative humidity was variable throughout the trip, with rain and sleet occurring through most of the second day. Considering the moderate internal temperature, the high relative humidity should not be a factor in assessing comfort.

Tests for the presence of noxious gases were made on 1/29/00 0:40 and immediately before unloading. Within our range of detection, no ammonia or carbon monoxide was detected.

After the elephants were unloaded and the elephants staff began to clean out the elephant area of the trailer, the researcher could smell ammonia, but not until the top layers of hay and shavings were removed.

To collect body temperature data, eight body temperature loggers were fed to the four elephants at one time before departure. Body temperature loggers were recovered from two of the four elephants. Recorded body temperatures ranged from 95°F to 99.5°F. For almost the entire trip, Joy's temperature was approxi-

mately 1.8°F above Jackie's, though neither body temperature logger detected deviations greater than a single degree. Despite the difference, both body temperature loggers were within the normal body temperature range for an elephant.

Carson and Barnes

Descriptions of the trucks Carson and Barnes used to transport elephants as well as an overall synopsis of travel procedure are detailed in the Carson and Barnes hot weather section of this report.

Rockdale, TX to Tomball, TX. One trip from Rockdale, TX, to Tomball, TX, (Figure 22) was surveyed with Carson and Barnes during which environmental data were collected. Descriptions of the transport vehicles are included in the hot weather section.

Two environmental loggers were mounted in truck 55; one on the front wall and a second on the rear. Another environmental logger was mounted on the rear wall of truck 56. Two and four elephants were transported in the trucks, respectively.

Due to cold, wet conditions, the elephants had been loaded the previous night at 22:00 and the doors were kept closed. Figure 22 shows that even in non-insulated trailers, the presence of elephants will increase temperature within the trailer 10 or more degrees. Immediately before leaving, the trainers closed several vents which most likely was responsible for the internal temperature increase seen after departure. During the pre-departure period, the internal temperatures were 4.9 to 15°F greater than the external temperature. Once actual travel began,

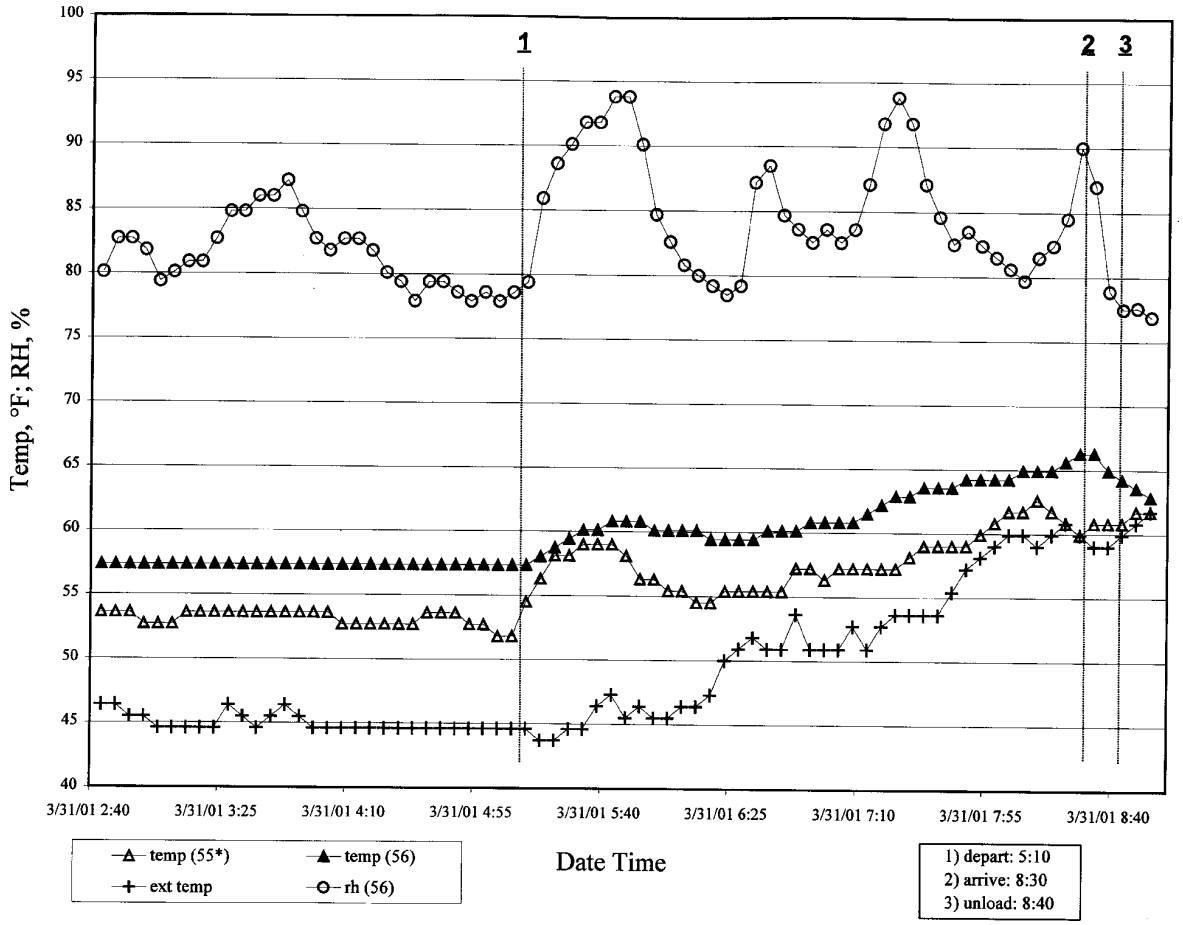


Figure 22. Carson and Barnes: trip from Rockdale, TX to Tomball, TX. Due to rainy weather, the elephants were loaded in the trailer shortly after midnight.

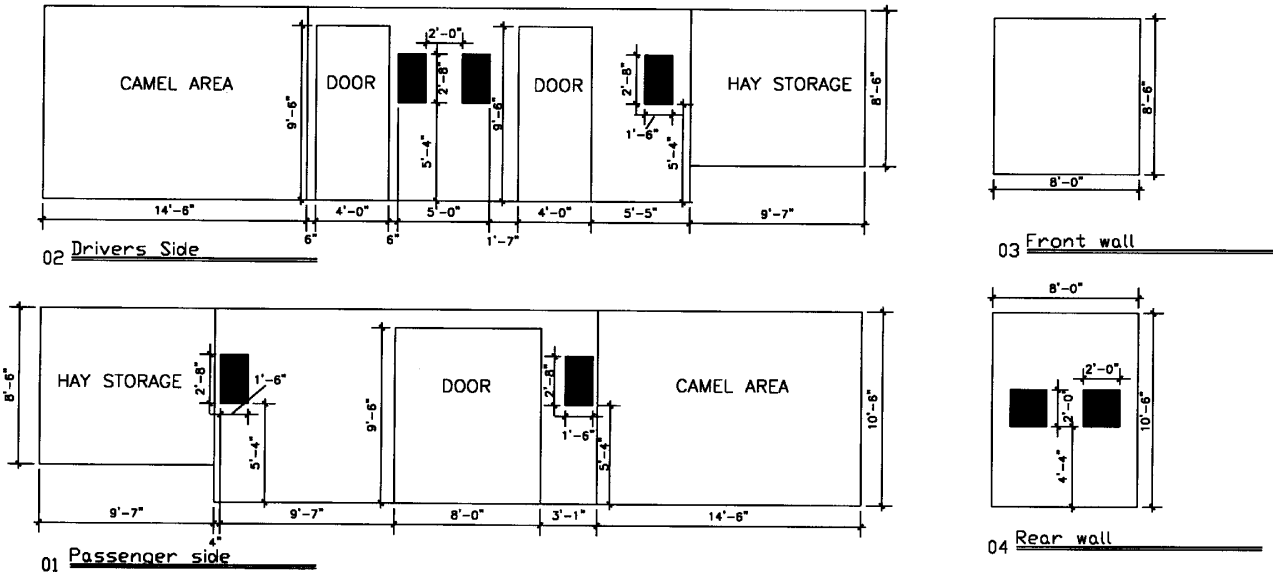


Figure 23. Trucks & Humps: structural diagram of trailer. The darkened rectangles represent windows.

this difference gradually decreased as more vents were opened until unloading, when external temperature rose above the internal temperature.

As with the departure-timed rise in internal temperature, internal relative humidity also experienced a sudden rise of 15% at this time though it returned to pre-travel levels within an hour. Three other travel-related peaks were detected: 3/31/01: 6:30, 8:13, and 7:08. Throughout travel, relative humidity remained above 79%.

Tests for the presence of noxious gases and body temperature collections were not performed during this survey.

Trunks and Humps

Trunks and Humps is equipped to transport three elephants and two camels in a single 18-wheel truck/trailer (Figure 23). A wall of expanded metal completely separated the elephant compartment from the camels in the rear, with another wall that separated the elephants from hay storage located over the fifth wheel. The elephant compartment has three vents on each side of the trailer. Two additional vents were at the rear of the trailer in the camel compartment. Both sets of vents were covered with expanded metal. The trailer had two small doorways on one side and a larger doorway on the opposite side of the elephant compartment. Steel beams could be placed across the doors so that the doorways could remain open during travel. The elephant compartment measured 1766 cubic ft.

Two trips of Trumps and Humps were surveyed. However, temperature during travel was relatively mild during the second trip, thus we are only reporting the first, Cut 'n' Shoot, TX to College Station, TX (Figure 24).

Cut 'N' Shoot, TX to College Station, TX. Two environmental loggers were mounted in the one trailer, one on the forward expanded metal sheet (1) and the second on the rear (2). The environmental loggers were mounted 9' 4" and 3' 6" from the floor, respectively.

During this trip, the three elephants had been loaded the previous day at approximately 17:00, and an electric heater turned on which ran all night until just before departure. The heater maintained a temperature of 75°F during this period, 30.1°F above the external temperature. Upon being turned off, the internal temperature fell approximately 20°F within a half hour. In the next hour during travel, the internal temperature continued to fall

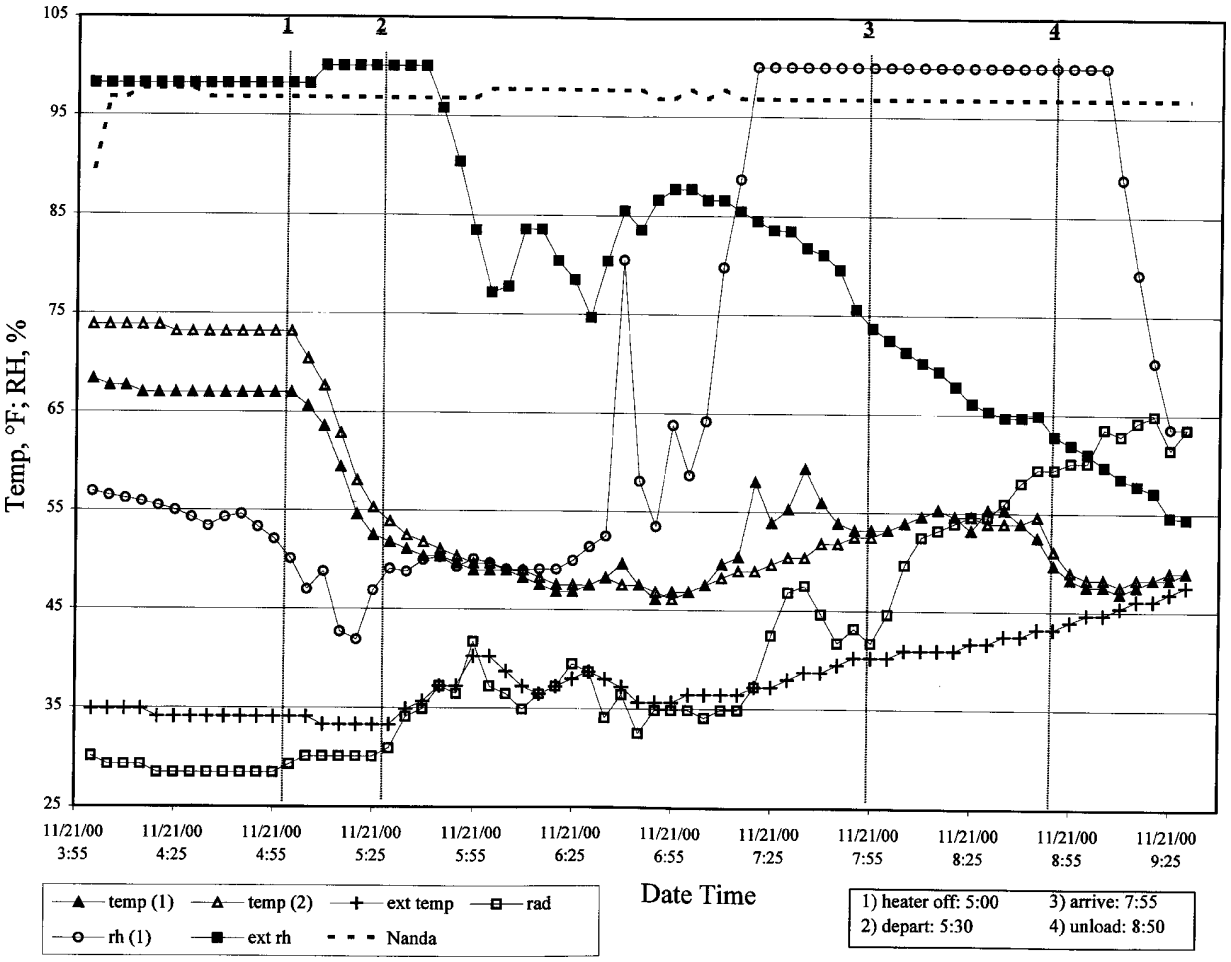


Figure 24. Trucks & Humps: trip from Cut n' Shoot, TX, to College Station, TX.

another 5°F during motion, and maintained a range of roughly 12°F above the external temperature.

The environmental loggers tended to measure equal temperatures except for a sudden rise of 10.1°F recorded by one environmental logger (1) during the stopped period (11/21/00 7:00-7:45). The other environmental logger (2) rose just a few degrees, similar to the external temperature. Though external temperature did not spike during this time, direct sunlight may be a factor in this deviation, as a similar rise in radiation occurred. Other changes in radiation did not appear to correlate with changes in internal temperature, thus radiation was not a significant factor during this trip. The similar slopes of the internal and external measures during the stopped period indicate that the elephants can sufficiently warm an uninsulated trailer above the external temperature despite near freezing conditions.

Relative humidity during the trip tended to be strongly influenced by the motion of the trailer. Both environmental loggers measured a rise in relative humidity immediately following departure (one much more dramatically than the other) and then again during the stopped period.

Tests for the presence of noxious gases were made upon arrival. Within our range of detection, no ammonia or carbon monoxide was detected.

Four body temperature loggers were administered to the three elephants transported. Two body temperature loggers were found from a single elephant, Nanda. A third non-functioning logger that had separated from its

epoxy coat and nylon flag was found approximately four months after it was ingested. A passage time of four months suggests that the body temperature logger was retained in the cecum. Body temperature proved to be relatively stable remaining between 96.8°F and 98.6°F during transportation.

Discussion

The internal and external environmental temperatures of the transport vehicles observed during transport were all within a range of temperatures not considered unusual for non-circus populations of Asian elephants. Asian elephants in their native habitat experience temperatures ranging from below 32°F to 104°F (Sukumar 1989) where African elephants historically ranged from hot deserts to regions where snow is common (Schlitter, personal communication). Elephants in zoological parks in North America commonly experience temperatures from below freezing to above 100°F. Thus, the temperatures observed during transport were within the range that healthy elephants have the physiological and behavioral ability with which to cope.

As seen in surveys of transport conditions in livestock, interior temperatures were strongly influenced by exterior conditions. Results of the present study indicate that during relatively hot weather, the temperature within the transport vehicles was generally maintained below 100.4°F. Measurements greater than this value did occur, but they were short-lived and variable among environmental loggers within the same vehicle. This suggests that those occurrences were related to equipment malfunctions, rather than hazardous conditions.

The circuses surveyed during hot weather used several methods to avoid relatively hot temperatures during the summer touring season. The two circuses surveyed that travel over rail lines, Ringling Blue and Ringling Red, typically have trips that might span days. These circuses may experience periods where environmental conditions reach extreme temperatures. Both circuses respond to this challenge by using railcars outfitted with insulated walls, high capacity ventilation fans, and other structural and environmental enhancements that effectively maintained internal temperatures below or within a relatively safe range of the external temperature. During Ringling Red's trip from San Antonio, TX, to College Station, TX, (Figure 3), internal temperatures did not exceed the external temperature despite external temperatures above 98.6°F. During the Lafayette, LA to San Antonio, TX (Figure 2) trip, internal temperatures were only several degrees above the external temperature during similar extremely high external temperatures.

The other circus and exhibitors surveyed did not have the structural and environmental enhancements (e.g., high capacity ventilation fans) that Ringling's units possessed. Instead, these groups avoided high daytime temperatures by traveling late at night (i.e., Clyde Beatty, Circus Vargas) or in the early morning (i.e., Carson and Barnes). This method proved extremely effective; the highest external temperature measured in all surveys for these three latter circuses while the animals were in the transport vehicles was 87.1°F, though it was often below 80.1°F. Since these circuses avoided high external temperatures and solar radiation, their ability to maintain low internal temperatures and prevent a buildup of temperature inside the vehicle was dependent on adequate ventilation achieved through vents in the sides of the trailers. This objective was also met with success as demonstrated during Clyde Beatty's trip from Staten Island, NY, to Forest Park, NY, (Figure 12). The difference between internal temperatures and external temperatures reached a maximum of 7°F, a value typical of the other circuses that traveled during periods of low external temperatures.

Other methods were used by individual circuses in an attempt to reduce the internal temperature of the transport vehicle. For instance, Ringling Red ran a soaker hose connected to a fire hydrant over the entire length of the elephant cars several hours prior to loading for their trip from Lafayette, LA to San Antonio, TX (Figure 2), during which the internal temperature fell 14° F. Though this change was substantial, the effect was short-lived and was not a viable alternative to cool the railcar during hot weather conditions during travel.

Internal temperatures sometimes did change over a rather brief period of time. Though changes were within ranges easily tolerated by healthy elephants, a temperature telemetry device with high and low temperature

alarms to alert handlers of the temperature conditions inside the transport vehicle could prove invaluable. For instance, during Circus Vargas's trip from Santa Barbara, CA, to San Luis Obispo, CA, (Figure 14), a temperature increase of 25.2°F occurred over a 90-minutes period the morning after travel, most likely a result of rising external temperature and radiation. However, the elephant was removed before the temperature became a concern.

During cold weather transport, internal temperature of the transport vehicle was generally kept above 50°F, though lesser values did occur. Internal temperature exceeded the external reading 5.4°F to 39.6°F. This value was dependent on the type of procedures used to maintain the internal temperature. For instance, before Humps and Trumps departed from Cut 'n' Shoot, TX, to College Station, TX, (Figure 24), an electric heater was used to keep the pre-departure internal temperature at roughly 64.9°F while the external temperature was 36.9F, a difference of 28.1°F. In comparison, Carson and Barnes did not use an electric heater in their uninsulated trailer during their trip from Rockdale, TX, to Tomball, TX, (Figure 22), but reduced ventilation and relied on heat production from the elephants as the sole heat source. During the pre-transport period, both Carson and Barnes' trailers maintained an internal temperature between 51.8°F and 62.6°F during which the external temperature was 45.0°F. In both situations, the measures taken were successful in moderating the temperature within the vehicle despite relatively cold exterior temperatures.

Relying solely on the heat produced from the elephants in the transport vehicles to maintain an adequate internal temperature proved particularly effective with the Hawthorn Corporation during the Richmond, IL, to Nashville, TN, trip (Figure 21). Separate environmental loggers recorded internal temperatures of 55.0°F and 64.9°F while the external temperature was below freezing (27.1°F). Though variable between the different environmental loggers within the trailer, this was the largest difference between the external and internal temperatures recorded, and was partially the result of the insulated trailer used by Hawthorn Corporation. The relatively dense travel conditions—520 cu ft per elephant for Hawthorn Corporation as compared to Carson and Barnes's density of 900 cu ft and Ringling Blue's 1,200 cu ft per elephant—undoubtedly also contributed to the difference between external and internal temperatures.

Ringling Blue had distinct differences in exterior and interior temperatures between their three cars used to transport elephants, most likely due to the presence of a thermostat-controlled heating unit in car 2, which held three adult elephants, and car 3, which held three juveniles. Particularly during the trip from Chicago, IL, to Savannah, GA, (Figure 19), car 2's minimum temperature during transport was 50.9°F. Comparatively, temperatures in car 1, where five adult elephants were held, reached 32.5°F several times, matching the external temperature during this cool period. Temperatures of this range are common in the natural habitat of Asian (Sukumar 1989) and African (Schlitter, personal communication). However, with the potential for the temperature of the railcar to reach such low values, the installation of a heating unit in car No. 1 may warrant consideration even though no shivering or decrease in body temperature was observed in the elephants.

No carbon monoxide or ammonia gases were detected for any of the surveys except for an isolated incident when the plastic collection tube fell directly into a pile of feces. The lack of a buildup of both gases during transit was most likely a result of high ventilation. The removal of feces during longer trips as well as the use of hay and sawdust to lessen the spread of urine undoubtedly had a positive effect on reducing ammonia. The absence of ammonia can also be attributed to insufficient time for urine to breakdown to ammonia.

Body temperature was possibly the most difficult measurement to obtain as each stage of the process presented several obstacles. Having the elephant ingest the body temperature logger without chewing it proved to be difficult in itself, as was retrieving the logger. In one case, it was discovered that one elephant was eating the feces of another which had been fed a body temperature logger. The logger was not found. Passage time averaged three days, though times were extremely variable ranging from 12 hours to over four months. Longer durations may be due to a minor stenosis or the body temperature logger being retained in the cecum (Schmidt, personal communication). The cecum is an area not

subject to peristalsis.

Recorded body temperature for hot weather and cold weather trials averaged 97.2°F and 97.3°F, respectively. Body temperature ranged from 95°F to 98.6°F, similar to the reported basal body temperature of 95°F to 98.6°F for an elephant (AAZK 1997). Often, within three hours after the body temperature loggers were ingested, a sudden decline of 5.0 to 15°F from regular body temperature would occur followed by a slow return to normal temperature, e.g., Misore's body temperature before the last show in Figure 5. Those drops resulted from the animals drinking cold water while the body temperature logger was still in the stomach of the animal. Occasionally, drops were seen later than the first few hours after the body temperature logger was ingested. These later dips were usually much less than the initial dips, indicating that the body temperature logger was possibly entering the intestine, or in the transverse colon or cecum. The transverse colon and cecum are areas close to the stomach and could be affected by the animal taking in water (Hauk, personal communication).

Elevation in body temperature of two to three degrees is not considered a problem in elephants or most other mammals. Body temperature fluctuations within a range of 2.7°F were seen throughout the study at various points. These fluctuations occurred during periods of increased activity (i.e., walking to the train) as would be expected. The lack of a larger increase in body temperature in the elephants clearly indicated that they could easily cope with daily environmental temperatures that approach 100°F in the shade as well as travel related activity. Additionally, we think that the exercise and stimulation the elephants receive during the walk is very beneficial for the overall health of the animals.

Body temperatures as high as 103.3°F and 105°F were observed in horses transported for 24 hours under

hot conditions without water (Friend et al. 1998). These temperatures were substantially greater than 100.8°F, the high end of normal body temperature range for a horse (Anderson 1984). Horses may experience a 3.6°F body temperature increase during moderate exercise. In comparison, the highest body temperature recorded during this study was only 0.9°F above the normal body temperature range in an elephant (Mary) during Ringling Red's trip from San Antonio, TX to College Station, TX. Previous to the walk to the train, Mary's body temperature was 97.7°F; thus the respective rise to 99.5°F from this elephant's baseline was only 1.8°F. In addition to being minor, the most extreme fluctuations were less than an hour in duration and associated with increased physical activity rather than changes in environmental conditions and dehydration as seen in horse transport by Friend et al. (1998).

The relatively small increases in body temperature seen in the present study suggest that transport during the extreme temperatures experienced during this study did not affect ability to thermoregulate. Lastly, our procedure for collecting body temperature provided continuous readings throughout the transport session versus periodic measurements during travel or at the trip's conclusion as done in other studies (e.g., Friend et al. 1998; Stull and Rodiek 2000). Thus, the lack of substantial fluctuations in the present study applies to particular events during transport (e.g. loading, changes in environmental temperature) as well as the body temperature upon arrival.

Conclusions

These data indicate that the transport of circus elephants, even during relatively extreme environmental conditions is not inherently stressful. The circuses and exhibitors surveyed used a variety of strategies and equipment to maintain environmental conditions within ranges with which the elephants could cope. There was no evidence of hyper- or hypo-thermia in the elephants even during the most extreme climatic conditions. The interior of the transport vehicles was effectively maintained at temperatures within the temperature range to which Asian and African elephants have historically experienced (Schlitter, personal communication) despite extreme external conditions. Ammonia and carbon monoxide were below detectable concentrations even during winter conditions when ventilation in the trailers was greatly reduced. However, it is important that transport of elephants during extreme weather conditions be attempted by only experienced handlers and that conditions within transport vehicles be carefully monitored so that environmental conditions stay within a range suitable for the age and condition of the elephants being transported.

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