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DEFENDANT'S EXHIBIT DX300a Case 1:03-cv-2006-EGS

FELD 0002210

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Cooperating Circuses/Owners

Carson and Barnes

Ringling Brothers, Barnum and Bailey (Red Unit)

Larry Carden (traveling with Ringling Red)

Clyde Beatty – Cole Brothers

Ringling Brothers, Barnum and Bailey (Blue Unit)

Circus Vargus

Hawthorn Corporation (two units)

Trunks and Humps

Objectives

1. Characterize the environment within truck and rail cars that are typically used for transporting circus elephants during hot and cold climatic conditions.

2. Characterize the reaction of circus elephants to transport in trucks and rail cars during hot and cold conditions.

Introduction

Transportation of livestock has occurred for over 3500 years (Cregier, 1982). Contemporarily, animals are transported for a variety of reasons including for agriculture, athletic events, and entertainment. A vast amount of research has demonstrated that transportation negatively affects animals and severely compromises welfare. Broom (1998) defines the term welfare as the state of an animal as it works to maintain homeostasis within its environment. Research of animal transportation has largely focused on livestock species in which transport is essential for moving animals from the producer to slaughter facilities, between units in a production system, etc. No work has been published investigating the transportation of elephants used by circuses and other exhibitor groups, both of which undergo quite rigorous and lengthy travel schedules through extreme weather conditions. Thus, the effects of transport on circus elephants and the conditions experienced by these animals are relatively unknown. However, growing public concern over the lifestyle of circus animals has generated a need for investigation into the management practices of circuses and animal exhibitors.

Research has shown that livestock species are negatively affected by transport through a variety of means that suggest compromised welfare of these animals (e.g., Eicher, 2000; Swanson and Morrow-Tesch, 2000; Zanella, 2000). Transportation of healthy horses for 24 hr resulted in weight loss and raised body temperature, among other factors indicating compromised welfare (Friend et al., 1998; Stull and Rodiek, 2000). Swine transported for 16- and 24-hr periods suffered weight loss, raised cortisol concentrations, and had indications of muscle fatigue (Brown et al., 1999). Research by Knowles et al. (1995) demonstrated that sheep undergoing transport for periods of three, nine, 15-, 18- and 24-h experienced increased plasma cortisol and heart rates, though apparently adapted after nine hours of transport. Knowles et al. (1999) also found that transported cattle for 14-, 21-, 26-, and 31-h suffered from weight loss, increased plasma cortisol concentrations, as well as increased concentrations of plasma creatine kinase. Increased plasma creatine kinase (CK) suggests that tissue damage occurred during travel. Transport of steers for 24-h compromised immune function and resulted in elevated plasma cortisol and plasma glucose concentrations (Tarrant et al., 1992).

Though transported livestock are generally believed to suffer from compromised welfare, the sources of these effects are complex. An understanding of these stress-producing elements or stressors would allow transporters to eliminate or reduce the stress placed on the animal.

Density

Density is considered one of the most important factors when transporting livestock. Density was determined to be proportional to the total number and severity of injuries horses received and the time to regain balance once they fell during a 30-min transit session (Collins et al., 2000). Indication of muscle fatigue was seen in lambs transported at high density (Knowles et al., 1998). General fatigue was also seen in sheep during the post transport period (Cockram et al., 1996). Cattle transported at comparatively high densities had elevated plasma cortisol and glucose, as well as elevated concentrations of plasma CK, thought to be a result of the animals' inability to adopt a preferred orientation and/or adjust to changes in the vehicle's motion (Tarrant et al., 1992). Eldridge and Windfield (1988b) determined that high density conditions significantly increased the general occurrence of injuries in transported cattle. Additionally, high densities are associated with increased loss of balance, considered the major risk for injury in cattle transport (Tarrant, 1990; Tarrant and Grandin, 1993). Investigations of densities in swine transport revealed that select tissues had elevated pH during the highest treatment density indicating muscle fatigue (Lambooy and Engel, 1991). This fatigue is most likely a result of laying pigs being disturbed by those attempting to lie or pigs not being able to lie at all (Lamboy and Engel, 1991; Warriss, 1998).

Duration of Transport

The duration that horses and livestock are transported has become an increasingly important topic as the number of processing and slaughtering plants has decreased. Transporters are forced to make longer trips during which animals are typically not provided water and/or food during transit. Particularly during hot weather and longer trips, access to water is essential to maximize the body's cooling efforts. Friend et al. (1998, 2000) determined that healthy horses transported during hot, humid conditions (>90°F) for longer than 24 hr without access to water showed signs of extreme dehydration. Friend also found that that providing horses with water during the trip delayed the onset of dehydration indefinitely, although fatigue became limiting factor after 28 hours. Lambs undergoing trips greater than 15 hr benefited from a two-hour stop during which they received food and water. In trips longer than 24 hr, an eight-hour rest before 10 additional hours of transport proved beneficial to the lambs (Knowles et al., 1996). Knowles et al. (1999) transported cattle for 31 hr with water provided at 14 h and found the trips not extremely physically demanding, though signs of fatigue were evident after 24 hr. However, the researchers observed that many animals (42%) did not drink when offered water. External temperature during the trip was moderately warm with a high of 84.2°C. The researchers also suggested that

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towards the end of the journey, additional fatigue may have been caused by sleep deprivation as the animals had to remain awake to maintain balance. The density of the animals transported in the trailer most likely made lying down difficult as discussed above. Hoffman et al. (1998) observed a proportional increase in the severity of bruises in beef cows with varying transport distances. It was concluded that this was most likely due to fatigue from withholding food, among other factors. Brown et al. (1999) determined that pigs transported at a low stocking density with access to food and water did not show elevated plasma cortisol, CK or other signs of stress despite a 24-hour transit time.

Unfamiliar Animals

Individual livestock typically develop relationships over time with herdmates that reflect that particular specie's social organization (Craig, 1986). Mixing unfamiliar animals during transport where these relationships have not developed is considered a major stressor in the transport of horses (Grandin et al., 1999; Friend, 2000), calves (Trunkfield and Broom. 1990), and swine (Kilgour and Dalton, 1984). Kenny and Tarrant (1987) found that incidences of fighting and elevated plasma CK cortisol increased in young bulls when reorganized in unfamiliar groups and transported for one hour. Mixing conspecifics reared in isolation will generally increase this problem (Trunkfield and Broom, 1990).

Noxious Gases

Concentrations of noxious gases in transportation situations and the resulting effects are not well researched, though a six-day exposure to constant concentrations of ammonia in swine production systems was shown to compromise immune resistance in a rate proportional to exposure (Urbain et al., 1994). Animals were noticed to be lethargic within two days of 50-ppm exposure. Swine on a restricted diet avoided food when subjected to short bursts of ammonia indicating that the gas's presence may interfere with the expression of feeding activity (Jones et al., 1997).

Specific Events

In addition to certain characteristics of transport increasing fatigue or other measures of stress, specific events can also be stressful. Waran and Cuddeford (1995) investigated loading in horses and concluded that multiple evasive behaviors during loading of yearlings suggested a clear desire not to enter the trailer. The behavior was most probably related to a horse's fear of dark, closed areas (Cregier, 1982). Knowles (1998) suggested that the first few hours of sheep transport were the most stressful as demonstrated by a sharp rise in heart rate and cortisol concentrations during the first four hours of transport. Tennessen et al. (1984) found the loading process in steer transportation to be the most stressful component of transport as suggested by increased heart rates. Kent and Ewbanks (1983) reported elevated cortisol concentrations of six-month-old calves immediately after loading and again before departure. Tarant (1990), in a review of cattle transport, suggests that loading in particular is stressful, though she advised that similar results of similar investigations were variable. The variability may be a result of the overall stresses imposed by transport rather than loading procedures alone (Kent and Ewbanks, 1983; Tarrant, 1990). Loading was found to be the most stressful and physically demanding event in swine transport (Augustini and Fischer, 1982) when substantially increased heart rates and rectal temperatures were recorded. In general, livestock, with the exception of horses, are usually herded onto transport vehicles using a dog or person as a driver, a process that inevitably will cause a fear response.

Environmental Characteristics

The environmental characteristics in the transport vehicle can be the most important factor in assessing conditions that will affect welfare. Temperature extremes can impose their own stresses such as hypo- and hyperthermia associated with impaired thermoregulation and increased sweating. Increased sweating will speed the onset of dehydration or potentially exacerbate the aforementioned factors. For instance, consider a group of cattle transported in highly dense numbers during hot weather. In addition to the stressors associated with high density, the animals will have reduced ability to dissipate heat to the surrounding air as a result of the decreased space provided for each animal. In certain trailers, where ventilation is solely through vents in the side of the trailer, animals in high density conditions will be pushed against the sides and cover the vent holes, reducing ventilation rates (Randall, 1993). Conditions that cause the animals to be more active, such as mixing unfamiliar conspecifics (Kenny and Tarrant, 1987), will worsen conditions through increased heat production and water loss associated with physical activity. Additional water loss through excessive urination and highly liquid feces, observed in calf transport (Kent and Ewbanks, 1983), is likely to be a debilitating factor as well. Increased defecation will make the trailer floor slippery, compounding problems. Similar results would be expected with other livestock. Rare cases of large numbers of livestock deaths associated with high external temperatures have been reported (Knowles, 1998).

Habituation

Despite the stressors and rigors associated with transport, research has shown that animals can be habituated to the process. Often this is not practical in a production situation, particularly when animals that are brought to slaughter might spend their entire or a large part of their life in a range setting without any exposure to humans or confinement. However animals transported for other reasons, such as horses used in athletic events and circus animals, undergo regular and routine transportation.

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 in travel and recommended acclimating animals to stressors early in life to reduce the stress response during exposure as an adult. The capacity to adapt is dependent on a variety of factors, such as the fearfulness of the individual and the species as a whole, and the nature of previous experiences. Waran and Cuddeford (1995) studied the effects of loading on several groups of horses, each with a different level of experience ranging from yearlings with no experience to adult mares with numerous experiences. The yearling group took significantly more time to load and displayed the most struggle through a multitude of evasive maneuvers. This distinctly contrasted with the other groups; researchers observed cases of older individual horses pulling the handler into the trailer at times, indicating willingness to load. Knowles et al. (1995) observed that after transporting sheep for nine hours in a 24-hr journey, measurements of cortisol, glucose, and heart rate had returned to pre-transport levels indicating that the animals no longer perceived transport as stressful. Similar decreases in heart rate were reported by Tennessen et al. (1984) after loading steers in preparation for transport.

Tarrant (1990) suggested that cattle almost always exhibit signs of stress through altered behavioral and physiological parameters when being transported. However, in the absence of poor conditions, cattle will adapt to the journey and avoid distress, a state characterized by the development of radical behavioral changes and pathological disorders. Other evidence of habituation to transport in cattle has been observed by Eldridge and Winfield (1988a) and reviewed by Trunkfield and Broom (1990). Crookshank et al. (1979) noted increased habituation in calves during handling, an effect possibly due to the young age of the animals. Additionally, Friend (1991) suggested in a review of animal adaptation that after an initial response, often characterized by hyperactivity, escape attempts, and other behavioral signs of acute stress, the animals may adapt and as a result cease exhibiting signs of stress.

Summary

In summary, livestock transport is generally considered a stressful process. A better understanding of the factors which cause the stress can allow for improved travel methods. Some of the factors that have been identified are travel density, trip duration, access to food and water, mixture of unfamiliar animals, concentration of noxious gases, specific events such as loading, and high environmental temperatures. Lastly, adaptation to travel can reduce the stresses imposed on the animal during transit.

Relevancy and Background of Methods

In the following sections, the relevancy of certain factors to animal welfare is considered. These factors include environmental conditions, physiological, psychological, and behavioral elements. Environmental conditions can provide information as to whether the animal's environment compromises welfare from a causal perspective. For example, welfare can be assumed to be compromised in animals being transported where ammonia concentrations exceed an amount regarded as safe. The latter three factors can indicate compromised welfare by providing a partial picture of an animal's internal state. For instance, extreme fluctuations in body temperature indicate the animal is not successfully coping with temperature loads and potentially suffering.

Environmental Conditions

Determining environmental temperature and humidity within the transport vehicle during transport is important to insure that interior temperatures do not become extreme or dangerous. Maintaining numerous mammals in a small, enclosed space with inadequate ventilation while external temperatures reach critically high levels could create an excessive temperature buildup inside the vehicle. Conversely, extreme cold temperatures can create an environment where animals can suffer from excessive discomfort or worse, hypothermia and/or frostbite. Maintaining animals at extreme temperatures to which they are not adapted can have severe, if not fatal, effects. Thus, the internal temperature of the transport vehicle can provide crucial information in regards to the quality of transport.

Instrumenting transport vehicles with equipment to record temperature and humidity parameters can verify the temperature inside the vehicle and whether the conditions are hazardous. A set of continuous readings can suggest correlations with ambient parameters as well as specific events during transport. Furthermore, information regarding attempts by transport personnel to maintain interior conditions within certain ranges, i.e., insulation, ventilation fans, can potentially be evaluated. If successful, certain procedures can benefit any industry that transports animals under similar conditions.

A series of three articles (Baker et al.,1996; Hoxey et al., 1996; Kettlewell et al., 2000) investigated the ventilation, heat production, aerodynamic characteristics, and effects of a forced ventilation system involved in transporting broilers by truck and attempted to correlate these parameters with indicators of welfare and stress. Results showed that: interior temperatures were affected by vehicular speed, ventilation was affected by a variety of factors including structural design and position, among other details which potentially provide a model for improved transport of broilers. Randall (1993) and Schrama et al. (1996) reviewed comparative research for livestock and suggested environmental parameters and other details necessary for comfortable and safe travel of livestock. Similarly, Hahn (1999) reviewed efforts to define appropriate thermal heat loads for cattle and their effects on measures of animal health and productivity. He recommends that the response of these measures during heat loads can be used to establish management strategies to effectively deal with high temperatures.

Noxious Gases

Exposure to noxious gases is another critical concern during transport (Randall, 1993). With proper ventilation and/or containment of the gases in question, problems can be eliminated. Concentrations of ammonia under 25 ppm should be maintained; exposure to greater concentrations can elicit irritation and in larger quantities are associated with breathing difficulties (CDC, 2001). In transportation, the principle source of ammonia is from urine, where urea will degrade to ammonia over time. In terms of carbon monoxide, concentrations of 25 ppm are the maximum level of safe exposure; effects include headache, nausea, and dizziness (CDC, 2001). The principal source of carbon monoxide during transportation is from vehicular emissions.

Body Temperature

Proper thermoregulation is essential to homeotherms, a class of animals that must maintain a constant body temperature in the face of changing external and internal conditions. Under ideal functioning, the body's temperature is maintained at a specific level in thermal equilibrium where heat production is balanced with heat loss (Bligh, 1973; Schrama et al., 1996). If environmental temperatures exceed body temperature (warmer environments) or if heat production from the body exceeds the organism's ability to dissipate heat to the environment, heat will be stored in the animal's body, raising body temperature. The animal, in an attempt to prevent elevated body temperature, maximizes heat loss through processes such as perspiration, panting, or other species-specific methods (Bligh, 1973). If possible, the animal can also decrease its own heat production through reduced activity and feed intake. The animal may also move to a cooler environment to minimize heat flow to the organism from the environment.

Contrasting this, in conditions where the environmental temperature is less than body temperature (colder environments), the surrounding environment will act as a sink and draw heat from the body (Bligh, 1973), lowering the body temperature of the animal. In response, the animal alters its behavior by moving to a warmer environment in an effort to reduce heat loss from the body. If this proves ineffective, the animal increases heat production through increased activity, metabolic rate, shivering, or other physiological and physical responses depending on the severity of the difference.

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 range (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 under such extreme conditions. Thus, fluctuations in body temperature in response to environmental temperatures can be used to indicate heat or cold stress (Schrama et al., 1996) and impacts on animal welfare. Raised body temperature or fever indicates other ailments.

Fluctuations in body temperature can be used to determine acceptable temperature ranges during transportation. 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 where a maximum of 95°F was reached. Tennnessen et al. (1984) detected significantly raised body temperatures in bulls transported for two hours where external temperature reached a maximum of 82.4°F. Under simulated conditions, Lambooy et al. (1981) used heat production and environmental temperatures to determine acceptable temperature ranges in swine transport. Becker et al. (1985) correlated increased body temperature and concentrations of serum cortisol with increased heat exposure. Augustini and Fischer (1996) also found body temperature as a useful indicator of stressful conditions in transported swine.

Cortisol

Cortisol, classified as a glucocorticoid, is a hormone that has a variety of effects on the body's metabolic functions including gluconeogenesis and the breakdown of proteins, carbohydrates and fats. Cortisol is released from the adrenal cortex in a series of processes that begins with stimulation of the hypothalamus to release corticotropin-releasing hormone (CRH) which acts upon the anterior pituitary (AP) gland to cleave proopiomelanocortin (POMC). Adrenocorticotropic hormone (ACTH), a product of cleaving POMC, is released from the AP and activates the adrenal cortex to release cortisol which then binds to target tissues within several hours (Norris, 1980; Guyton, 1991). This series of glands, responses, and hormones is often referred to as the hypothalamic pituitary adrenal (HPA) axis or system.

The role of cortisol in the stress response was first described by Selye's (1936) General Adaption Syndrome (GAS) which involved the release of ACTH and resulting elevated plasma cortisol concentrations in response to stressors imposed on the animal.

Since then, knowledge of cortisol and the processes that affect it has grown tremendously though questions remain in interpreting fluctuations in concentrations. For instance, Moberg (1987) cites the difficulty in interpreting varying levels of cortisol concentrations and their inconsistency with other stress indicators. Furthermore, the activation of the adrenal cortex, a system that has evolved to aid organisms to adjust to stressors, may falsely imply the animal was affected negatively by the stimulus.

Nonetheless, cortisol concentrations remains a powerful tool in determining stimuli/situations that an animal perceives as stressful and is widely used in behavioral research (e.g., Becker et al., 1985; Dathe et al., 1992). Cortisol is generally considered an indicator of psychological stress (Mason, 1971; Dantzer and Mormede, 1983), though it can be used to detect stress in a broad range of situations because the psychological component is often present (Dantzer and Mormede, 1983). For instance, the presence of a dominant pig in the pen of a subordinate raised cortisol concentrations significantly whether fighting occurred or not (Arnone and Dantzer, 1980).

Cortisol has been used to indicate the affect of stressors that are applied or perceived over various durations, from a few seconds (Lay et al., 1992), several hours (Becker, 1985), and days (Dathe et al., 1992). Exposures to acute heat and cold temperatures have been shown to elevate cortisol concentrations (Alvarez and Johnson, 1973; Blatchford et al., 1978), illustrating the diverse range of stimuli to which the hypothalamic pituitary axis is capable of reacting.

Cortisol has been used to measure stress during transport in horses (Friend et al., 1998), sheep (Knowles, 1998), cattle (Crookshank et al., 1979), and swine (Brown et al., 1999). In a study (Kenny and Tarrant, 1987) examining a variety of factors affecting hour long transportation sessions in young bulls, cortisol was found to be a superior physiological measure of stress during transport compared with non-esterified fatty acids (NEFA), plasma CK, and glucose. However, the researchers suggested that during longer trips cortisol concentrations measured towards the conclusion of the journey might be reduced as the animals adapted to transport. This scenario could falsely imply the animal was not affected by travel as earlier events could have been very stressful.

Direct and Video Observations

Direct and video observations can provide valuable information in determining an animal's perception of its environment and whether its behavioral needs are satisfied. However, Duncan (1981) recommends caution in behavioral observations, mainly regarding attempts by humans to distinguish normal behaviors in non-human animals. Friend (1991) reviewed several vital concepts regarding normal behaviors that are important to consider when conducting such observations. Firstly, the absence of grooming and other self-maintenance behaviors indicate a stressful environment. Secondly, exploratory behavior is normally exhibited only when an animal is in an environment perceived as safe. Lastly, failure to participate in group herd behaviors and/or altered eating patterns may indicate the animal is under stress.

The occurrence of stereotypic behavior can also be useful when considering an animal's internal state. Stereotypic behavior is defined as a repetitive action that occurs relatively unchanging over time and without apparent function (Dantzer, 1986). Typically performed in animals in confinement, stereotypies are believed to suggest that the animal exhibiting the behavior finds its current environment stressful (Mendl, 1991). The actions may be a means for the animal to provide itself stimulation in a "dull" environment or to dissipate tension or frustration caused by the environment's inadequacies (Dantzer, 1986; Dantzer and Mormede, 1981). Often the stereotypic behavior itself may result in secondary problems such as foot injuries from excessive pacing.

Though stereotypic behavior normally infers a poor environment, the potential causes and effects of the behavior must be considered before accurate conclusions regarding impacts on welfare can be drawn. For instance, animals using stereotypic behavior as release of anticipation may not suffer from compromised welfare if the "built-up emotion" is released within an appropriate amount of time, indicated by the halting of the behavior. Stereotypic behaviors that develop in a lacking or stressful environment may also persist after the stressor is removed (Mason, 1991).

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, one or more vehicles (either truck or railcar) were instrumented 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 levels of ammonia and carbon monoxide.

The researchers measured body temperature continuously during transport by using ingested temperature loggers as an indication of the elephants' physiological response. To estimate the psychological response of elephants to transport, blood was collected before and after transport to determine cortisol concentrations. This measure was collected only during hot weather surveys because obtaining blood samples from elephants via venipuncture during cold weather is extremely difficult. During cold weather, elephants will typically direct blood away from their peripheral veins in an attempt to conserve body heat. Direct and/or video observations of the animals during transport were also gathered when possible.

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" wide) that insulated the logger from the wall. The environmental loggers were factory tested and found to be accurate within ± 1.8°F. Spreading the environmental loggers over multiple sites in the transport unit (when possible) 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, the loggers were generally in an area behind the elephant and significantly in front of other elephants was sought to place the environmental loggers. The environmental loggers recorded temperature and relative humidity in the vehicle at 5-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 and then sealed with duct tape. 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, i.e. 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 –1000 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 h 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) encased in a biologically inert epoxy (EPO-TEK T905, Epoxy Technologies, Bourne, MA) to record continuos body temperature by having the animal ingest the unit. These particular loggers are referred to as body temperature loggers in this report. 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. When the epoxy potting process was completed, the logger was 0.8" wide and 0.50" thick. The end of a ripstop nylon ribbon approximately 0.75" in width and 6" long was embedded in the epoxy to make the body temperature loggers more visible during recovery. Each recorded temperature reading was time/date stamped, allowing fluctuations in body temperature to be correlated with transportation events (i.e. loading) and/or changes in environmental parameters. A similar procedure using a transmitter encased in a plastic shell approximately twice the size as that used in the present study was used by Dr. Michael Schmidt (personal communication) and was found to be safe and accurate. In our own test of 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 min during which four readings were made with a 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.

The normal Asian Elephant body temperature is 95°F to 98.6°F (AAZK, 1992), though several ranges have been reported (Benedict, 1936; Altevogt, 1990), that have slightly higher 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).

Cortisol

When possible trips during the hot weather surveys, circus personnel took blood samples from the elephants for plasma cortisol analysis. Pre-transport samples for the Carson and Barnes circus were taken an hour before and then immediately before loading. Post transport samples were taken immediately after unloading and then again an hour later. During trips for Ringling Red and Ringling Blue, the first sample was taken immediately before the animals were led to the train and the second immediately after loading. The third sample was taken after the walk to the animal compound and the fourth an hour after that. During the trip for Ringling Blue, an early sample was taken approximately four hours before the one-hour pre-shipment sample.

To serve as a comparison and demonstrate fluctuations in cortisol in response to a positive stimulus, blood samples were taken an hour before, a half-hour before, immediately after, and a half-hour after being brought to their exercise pen were they were turned loose and provided watermelons.

At each sampling, approximately 5 ml of blood were collected using a vacutainer containing lithium-heparin. The samples were placed on ice until the samples were centrifuged, the plasma collected, and frozen. Cortisol concentrations were determined using a cortisol assay kit (DPC, Los Angeles, CA). To control for diurnal effects, a second set of control blood samples was obtained from each of the elephants in the study. The goal was to collect control blood samples at the same time of day as the samples obtained during transport but during days when the elephants were idle.

Direct and Video Observation

Video footage were made of the animals whenever possible during transport. This record allowed the researchers to determine whether the animals were performing abnormal behaviors, principally weaving, the most commonly observed stereotypic behavior in circus elephants when not being transported (Friend, 1999). Weaving was defined as a continous shifting of the animal's weight from either side to side or to-and-fro for a period greater than 30 seconds, a definition adapted from Schmid (1995). If steps were taken in this described fashion repeatedly, this was also considered weaving. Animals were also observed for the occurrence of normal behaviors that are commonly seen when not being transported or in a natural setting, i.e. throwing hay on their backs, drinking, and eating. Video data were collected by mounting a video camera (Panasonic WV-BP312 CCTV, Seacaucus, NJ) with a light source in the vehicle. The video was recorded on a time-lapse video recorder (Panasonic VHS AG-1070, Seacaucus, NJ) and analyzed for the percentage of time spent weaving, laying down, and standing using Etholog (Etholog 2.2, Sao Paolo, SP, Brazil), a software program for the timing of behavior observation sessions (Ottoni, 2000).

Direct observations were also made by the researcher whenever possible. The researcher rode in the actual elephant compartment of the transport vehicle during transport when possible.

Statistical Analysis

Results from blood collection were divided into two categories: short (Carson and Barnes) and long trips (Ringling Red, Ringling Blue). For short trips, sources of variation between sample times were tested by analysis of variance using the general linear model repeated measures procedures of SAS (SAS, 1999) where sample time was the independent variable and cortisol concentration was the dependent variable. Repeated measures procedures are required when successive samples are taken from the same animal during the same test period. Tukey's test, a statistical test that minimizes both Type I and Type II errors, was used to detect significant differences between each sampling time if the sample time variable was found significant ($\alpha < .05$). Comparisons with controls were not possible due to an unsuccessful attempt to get accurate control samples.

During longer trips, a student's t-test was used to detect significant differences between means of control and transport cortisol concentrations for each sampling time. Use of ANOVA repeated measures was considered for long trip analysis, but rejected because only two means (transport and control means for each sample time) were to be compared during each of the five sample times instead of five means as in the short trip analysis. Thus, under these conditions, ANOVA did not provide any statistical benefit and a student's t-test was used.

Transport Vehicle Descriptions

To determine ventilation and design characteristics of each vehicle, elevations detailing overall dimensions, windows, doors, ventilation equipment (i.e. fans), and other particulars were developed for each vehicle using computer aided design software (AutoCad, 1997).

Results

General

A plot of the environmental and body temperature data is provided for each trip that a circus made which we surveyed. The legend codes for each parameter displayed, which vehicle the environmental logger was recording in, and whether a probe recorded the measure or not. 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 vehicle "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 (i.e. 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 in sequential time frames during the course of the trip are labeled (i.e. Miniak(1), Miniak(2), etc.).

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 that is 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 ground 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 acts and equipment are transported over land using a variety of trucks, trailers, and recreational vehicles.

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. Each vent had an exterior cover that prevented sun and rain from entering into the car through the vent. The entire area provided to the elephants was approximately 6593 cubic ft. The ceiling of the railcar was rounded (the height provided was the highest point in the car). Twelve drains were spread equidistantly along the floor of 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.

The railcars' interior reached a maximum of 99.5°F though never exceeded the external temperature more than 5.04°F. This variation tended to be greatest during the period after loading (#2) and before departure (#3). Comparison of the stationary (#1 -

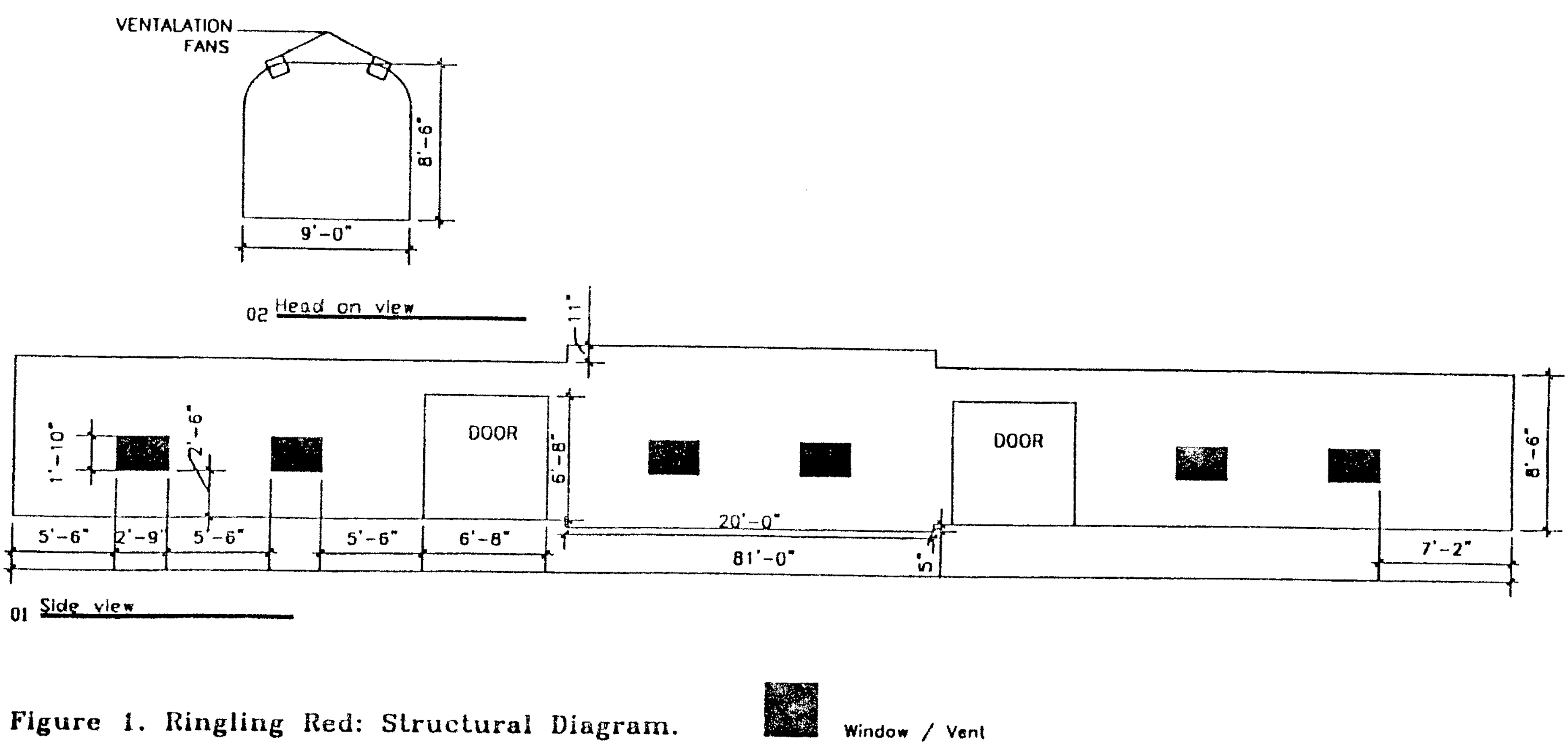

Figure 1. Ringling Red: Structural Diagram.

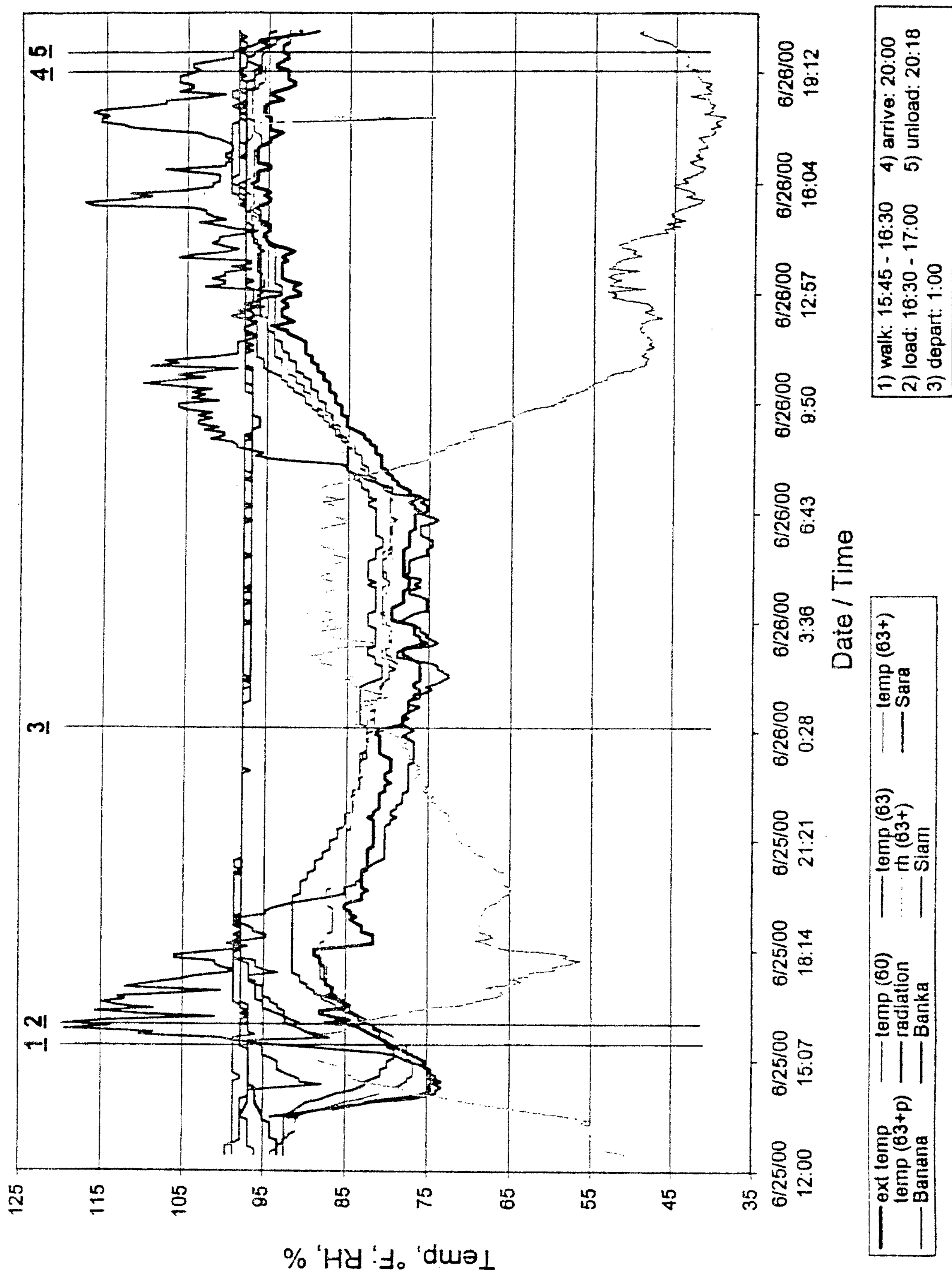

Figure 2. Ringling Red: Lafayette, LA, to San Antonio, TX.

#3) and non-stationary (#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, though the dip spanned less than 10 minutes. 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 running cool water over the roof of the stockcars for several hours utilizing a large soaker hose. 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 pre-watering temperature by loading time because the hose had to be turned off prior to loading the elephants. 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 concentration was 17 ppm, but the plastic collection tube had fallen directly into a pile of feces. There was no detectable ammonia once the problem had been corrected. No carbon monoxide was detected.

Of eight body temperature loggers given to elephants, four were recovered. Body temperatures were maintained fairly stable between 95.9 °F and 98.6°F with individual loggers for each elephant reading within a 1.9°F temperature range. A large dip in temperature coinciding with watering sessions occurred in Siam's body temperature at 14:27 and 15:52 6/25/00. A similar dip occurred in Banka's body temperature during the same periods.

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

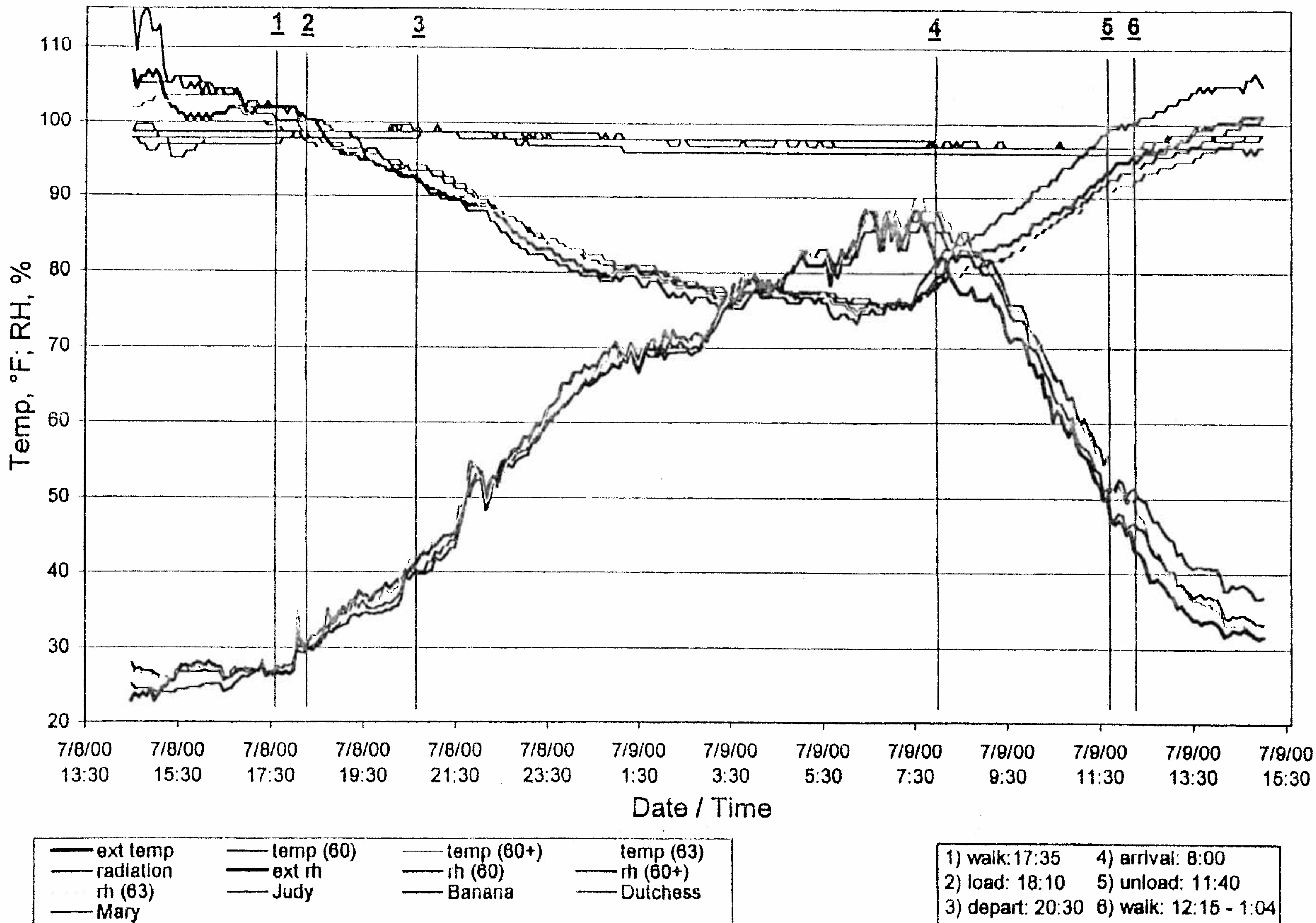

Figure 3. Ringling Red: San Antonio, TX, to College Station, TX.

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 in the travel description, 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 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 identical to the Red unit, typically walking their elephants on a Sunday night, after the last show, from the venue to the train.

Ringling Blue transported 10 Asian elephants and a variety of other hoofstock utilizing 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 many times to remove feces, spread fresh bedding, 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 raised ceiling or dropped floor (Figure 4). 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 5), 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

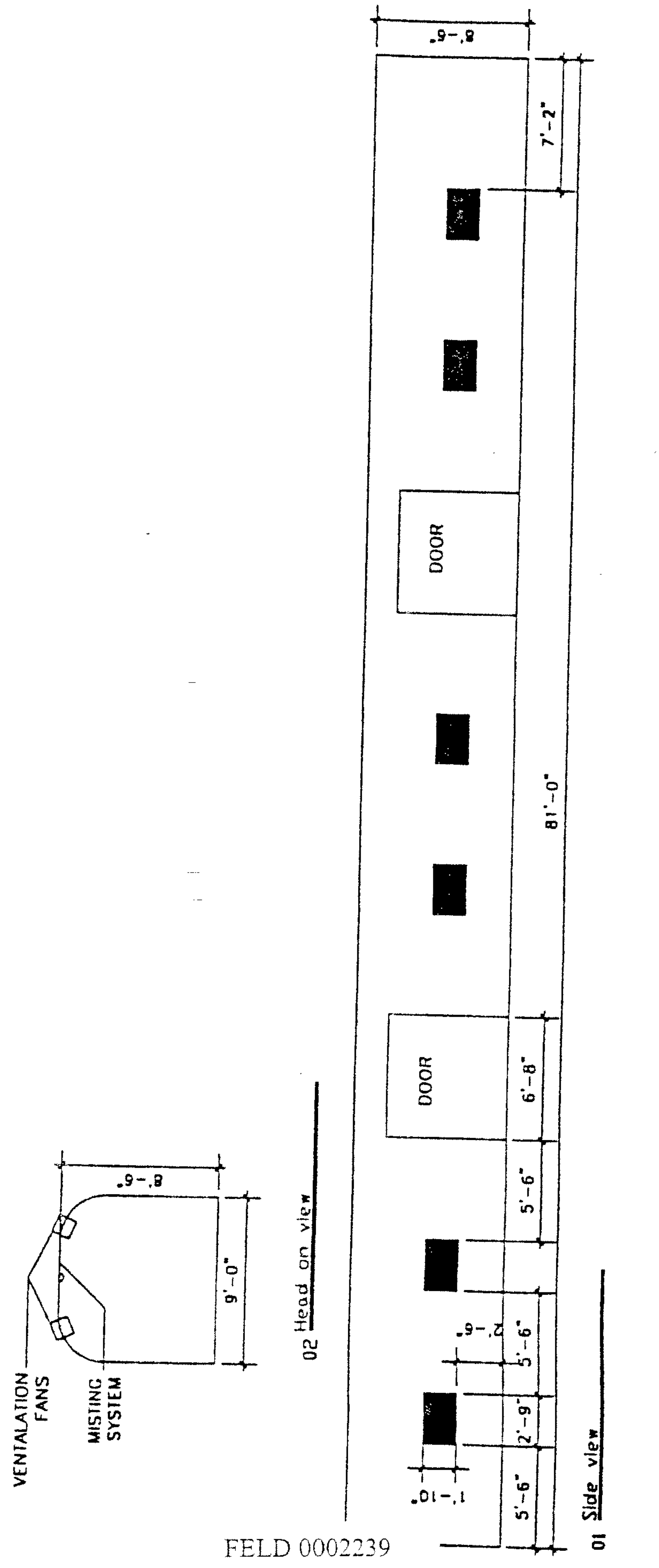

Figure 4. Ringling Blue: Structural Diagram.

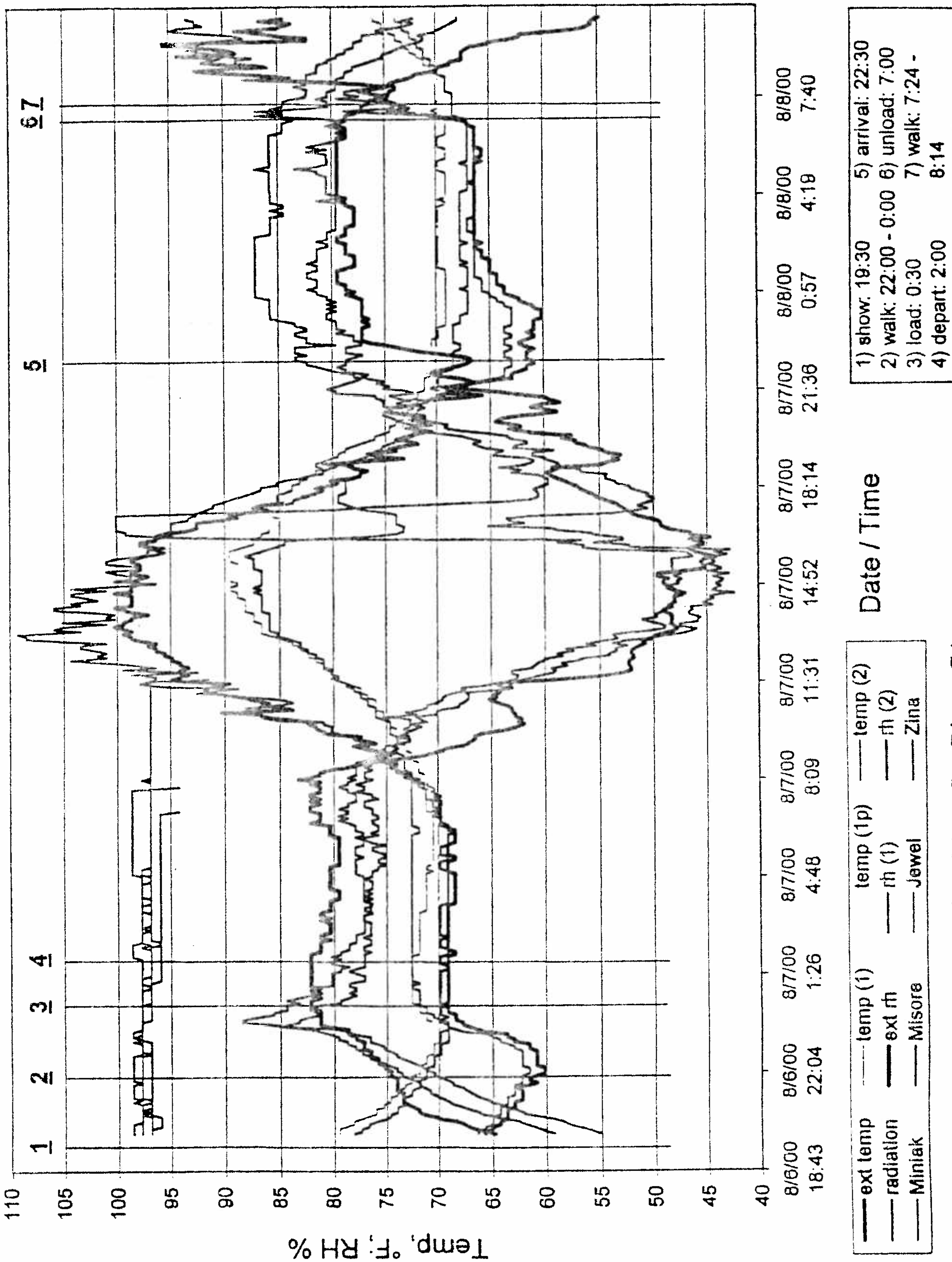

Figure 5. Ringling Blue: Los Angeles, CA, to San Diego, CA.

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.

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 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, 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 6), 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 environmental loggers (1+ and 1*) recorded a temperature in excess of 95°F and then another peak of 104°F and 97.7°F approximately a half-hour later. 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, we don't believe the temperature spikes to be 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 upon arrival. Within our range of detection, no ammonia or carbon monoxide was detected.

In regards 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

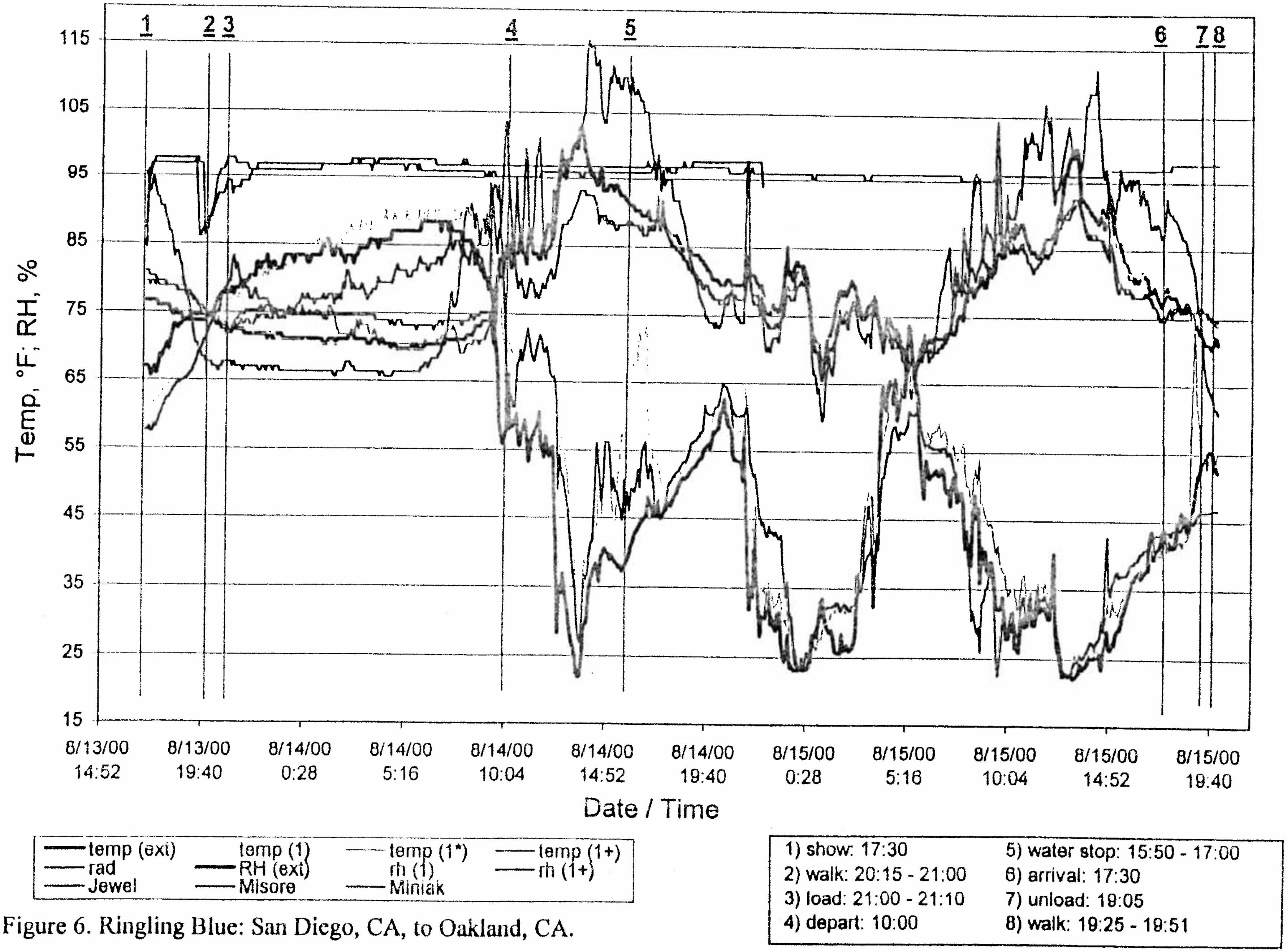

Figure 6. Ringling Blue: San Diego, CA, to Oakland, CA.

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 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 recovered body temperature loggers as a group recorded a minimum and maximum of 1.94°F and 98.6°F, respectively. 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 that 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 prior to the times shown in the figure.

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 location two days in a row.

Carson and Barnes transported 14 Asian and 2 African elephants using five trucks (not including an additional trailer that was modified to transport a baby elephant and its aunt). Typically three elephants are transported in each trailer. Rear and forward portions of each trailer served as either a storage compartment or residence for several of the staff (Figures 7,8). The drawings provided do not include trailers with forward compartments. 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. 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

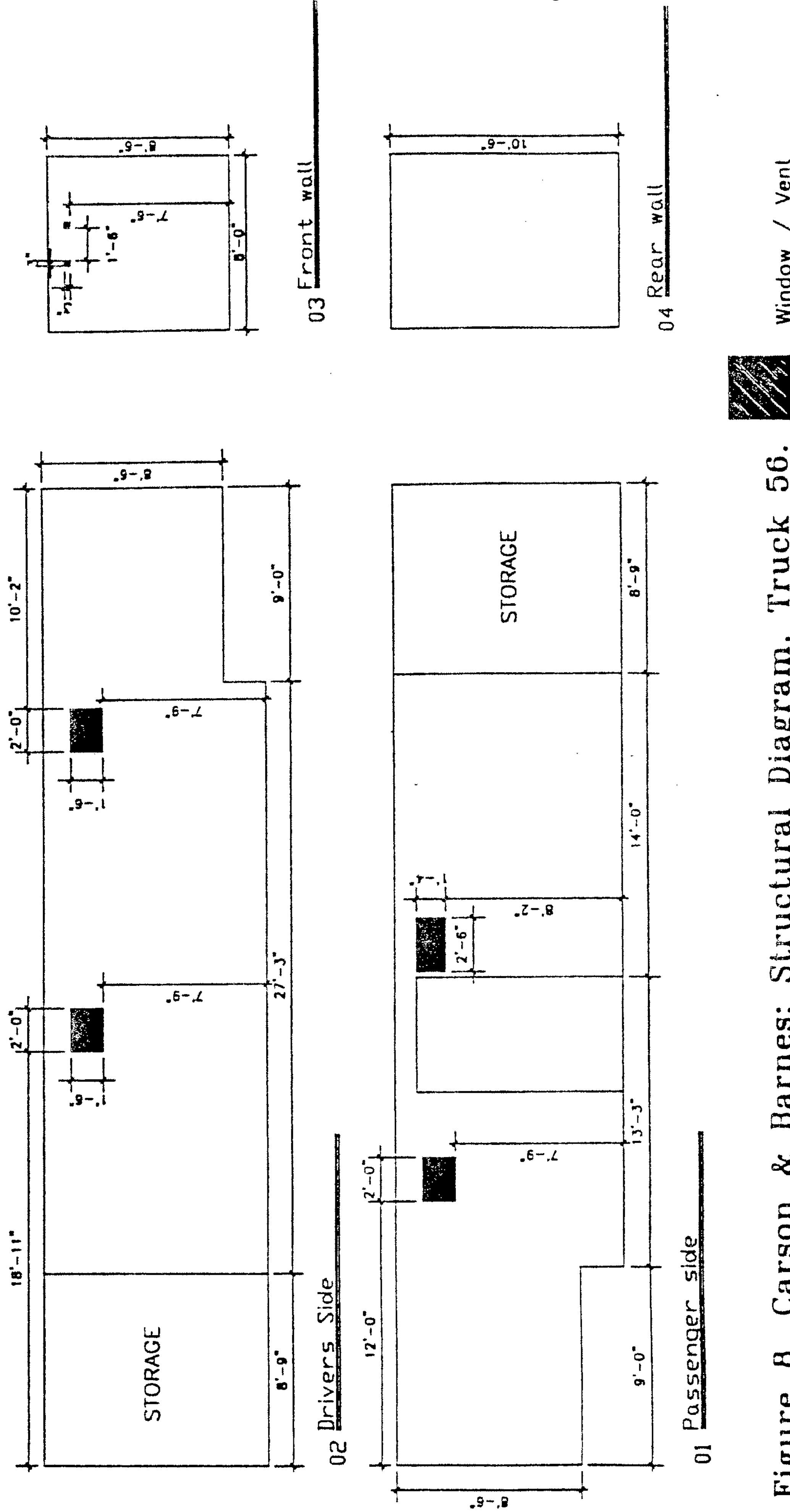

Figure 8. Carson & Barnes: Structural Diagram, Truck 56.

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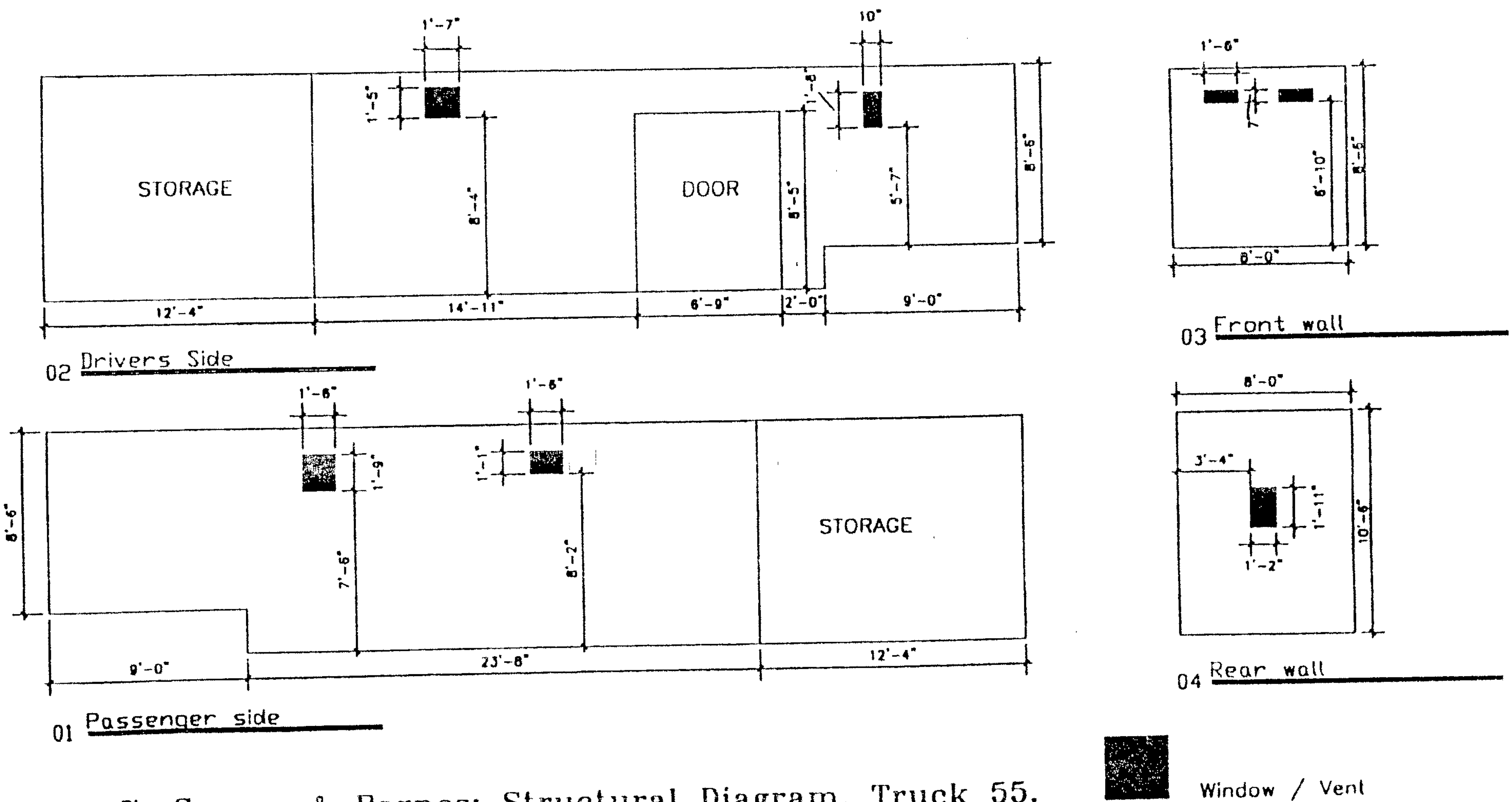

Figure 7. Carson & Barnes: Structural Diagram, Truck 55.

ventilation while also 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 2860 cubic ft. Drains were strategically located in the floor of the trailer. The trailers were uninsulated and had walls constructed of wood and metal with rubber surfaced floors.

Fort Dix, NJ, to Williamstown, NJ. During the Fort Dix, NJ, to Williamstown, NJ, trip (Figure 9), 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 humidities at this low temperature are 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 was maintained between 96.8°F and 97.7°F. The minor fluctuations did not appear to be related to transportation events.

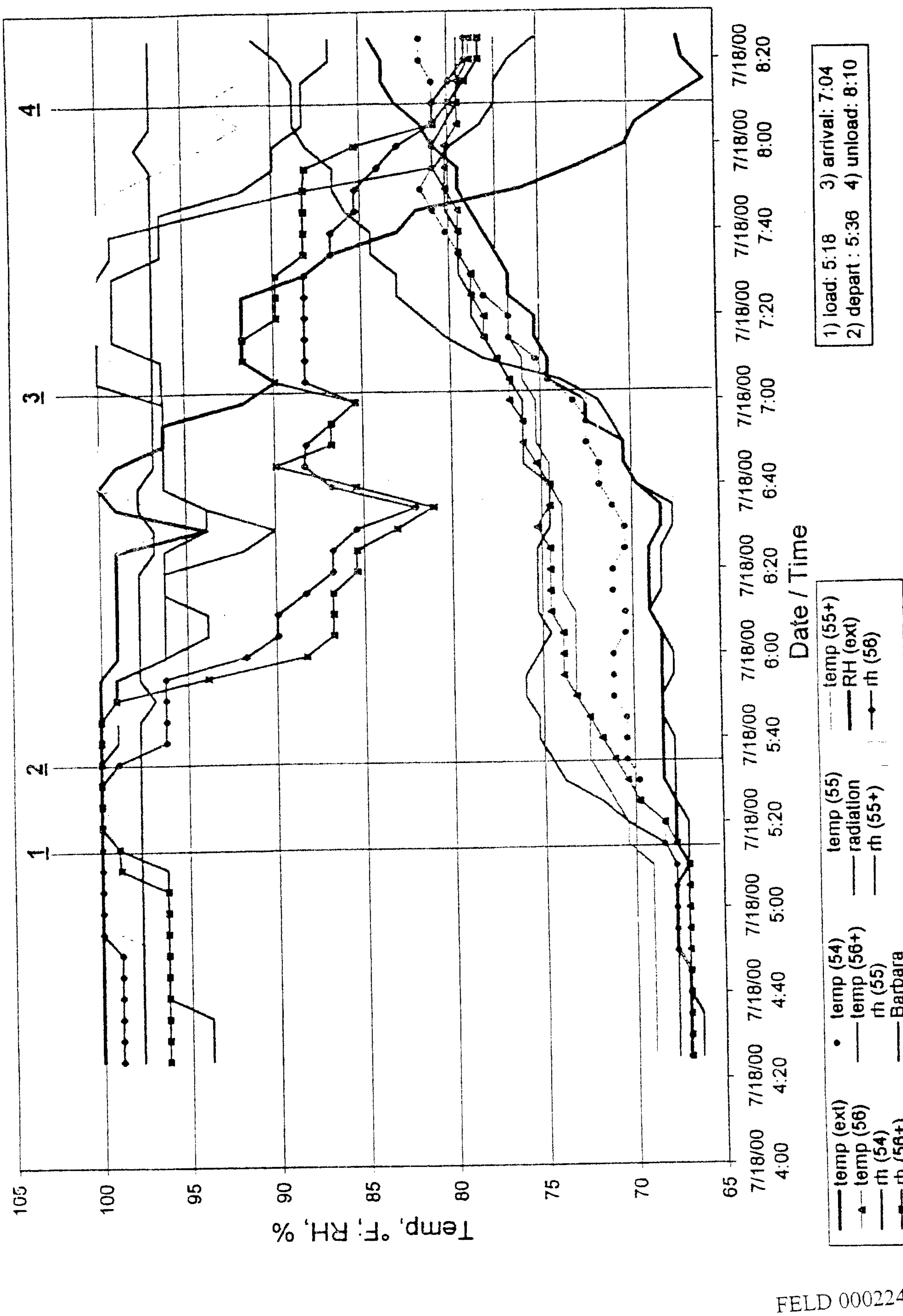

Figure 9. Carson and Barnes: Fort Dix, NJ, to Williamstown, NJ.

Williamstown, NJ, to Chester, PA. During the Willimstown, NJ, to Chester, PA, trip (Figure 10), the environmental loggers were positioned in the same places as during the Fort Dix, NJ to Williamstown, NJ, trip.

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 chewed by the elephants. 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 11) 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 we believe to be a malfunction and is 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.

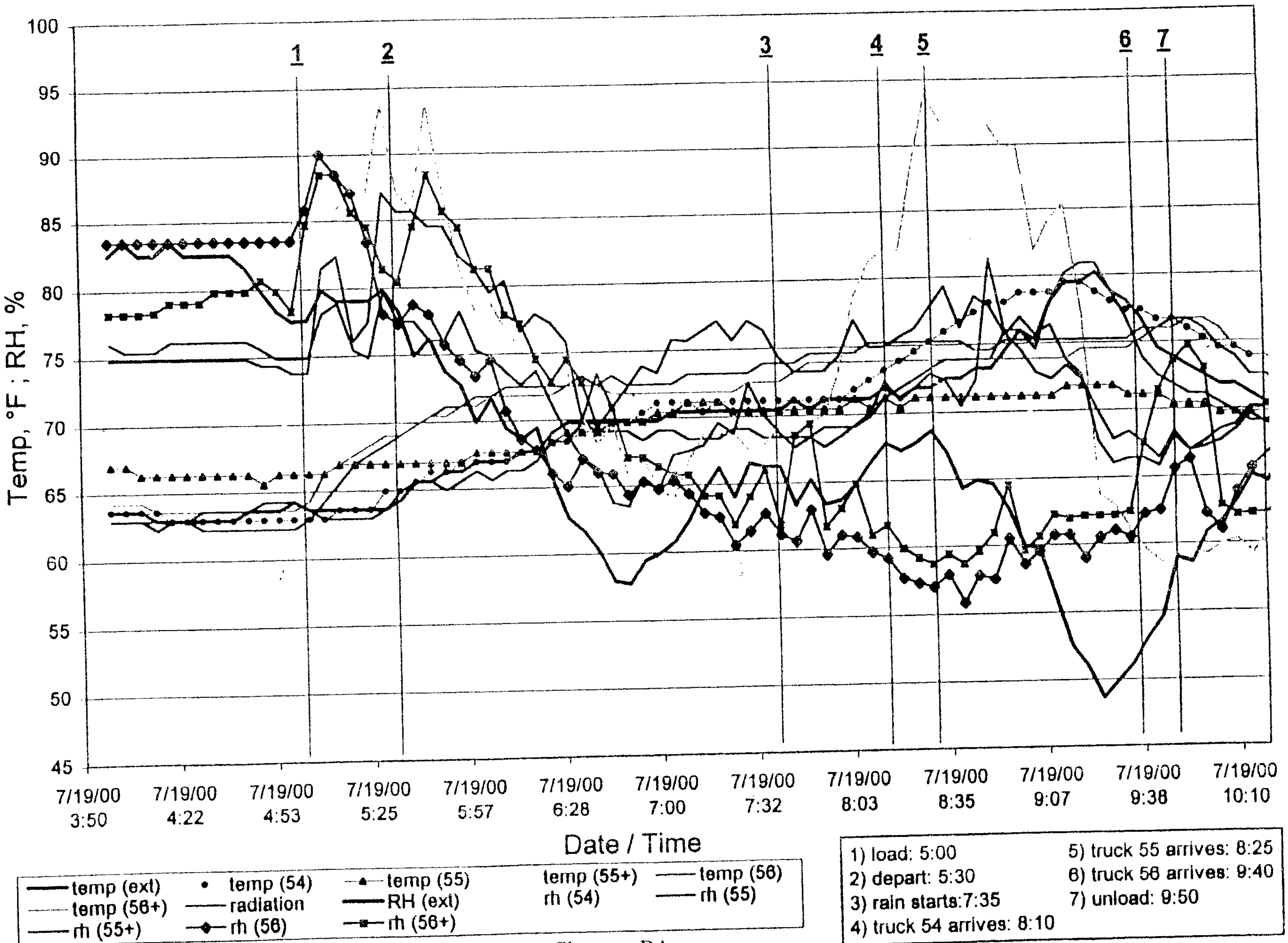

Figure 10. Carson and Barnes: Williamstown, NJ, to Chester, PA.

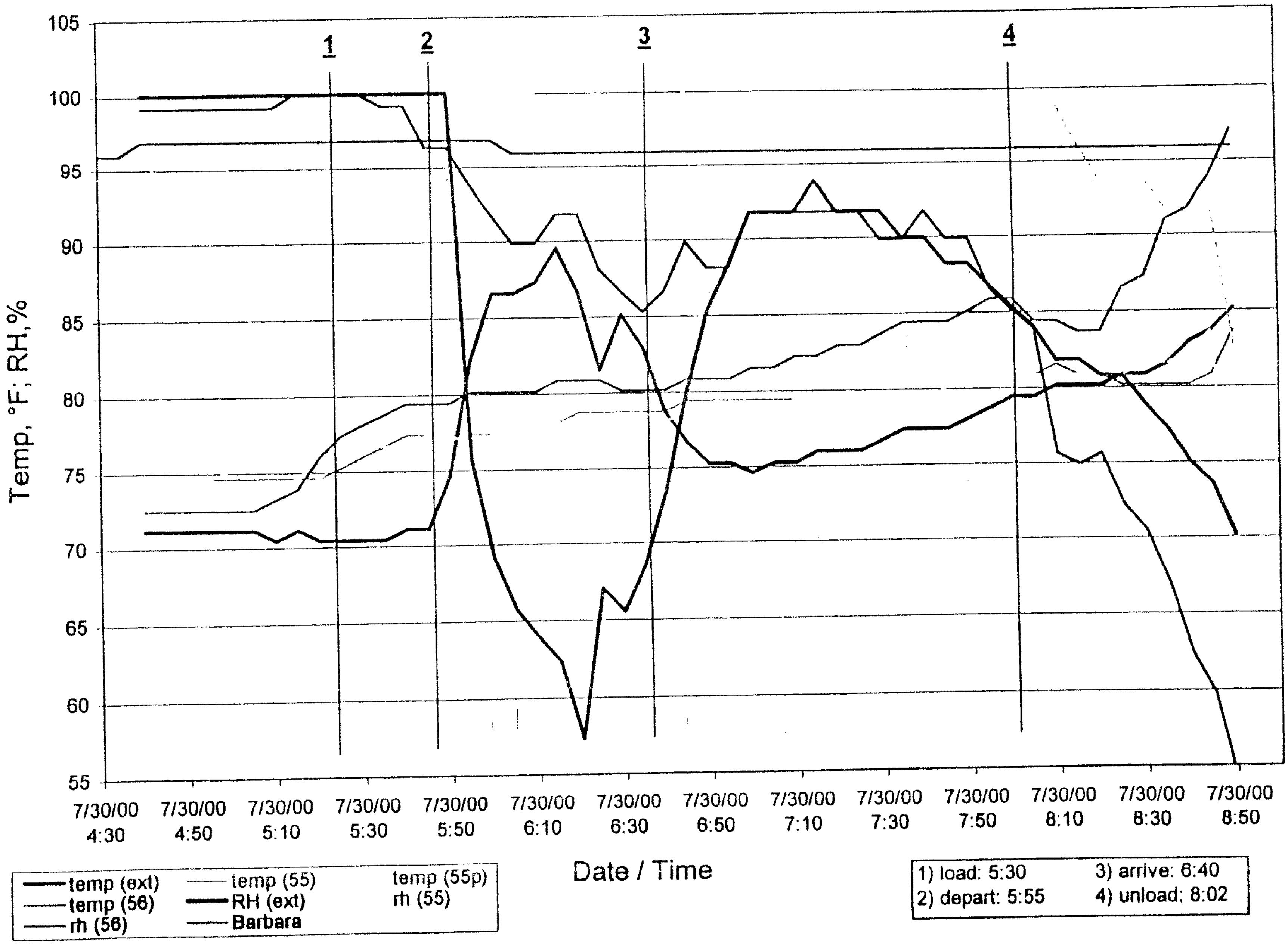

Figure 11. Carson and Barnes: Poquonson, VA, to Smithfield, VA.

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.

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 seen with Carson and Barnes, Clyde Beatty essentially avoids hot daytime temperatures by traveling during the night.

Clyde Beatty transports four Asian elephants in two semi-trailers (2 elephants/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 (Figures 12,13). 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. 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 throughout the floor of the elephant compartment. The trailers were uninsulated with

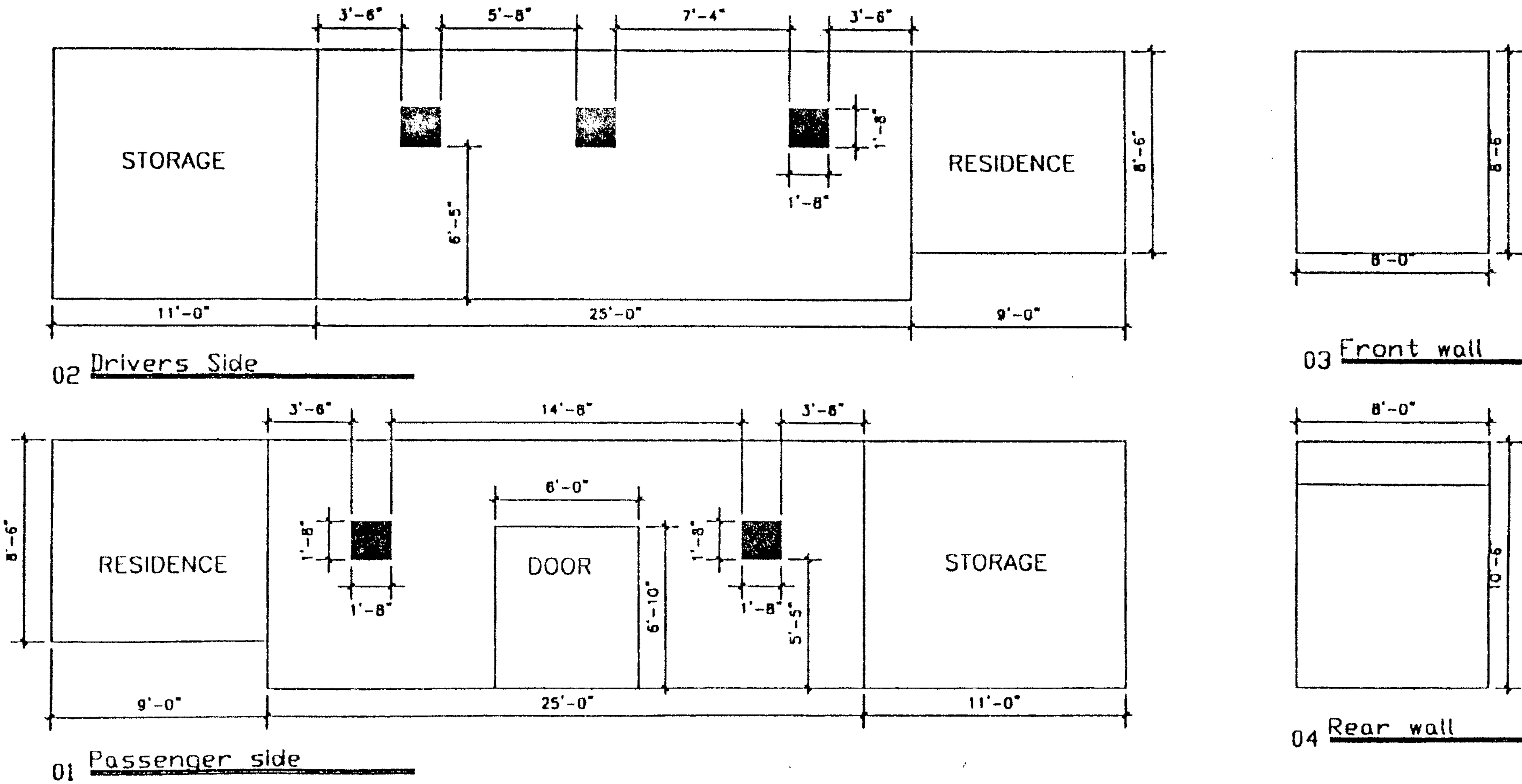

Figure 12. Clyde Beatty-Cole Bros: Structural Diagram, Truck 60. Window / Vent

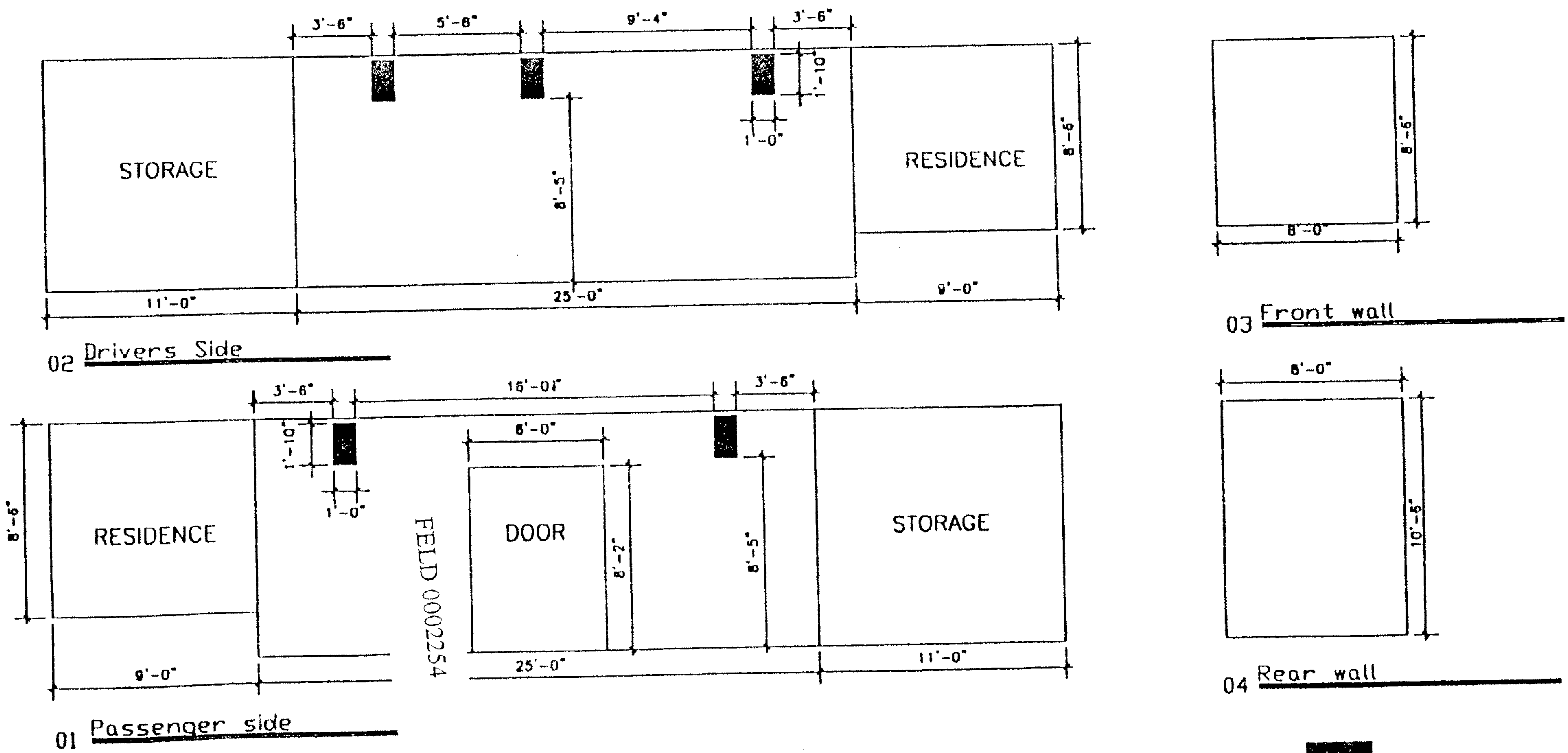

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Figure 13. Clyde Beatty-Cole Bros: Structural Diagram, Truck 62.

walls of steel and wood. 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 14), six environmental loggers (4 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 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 ft. 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 temperature 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%.

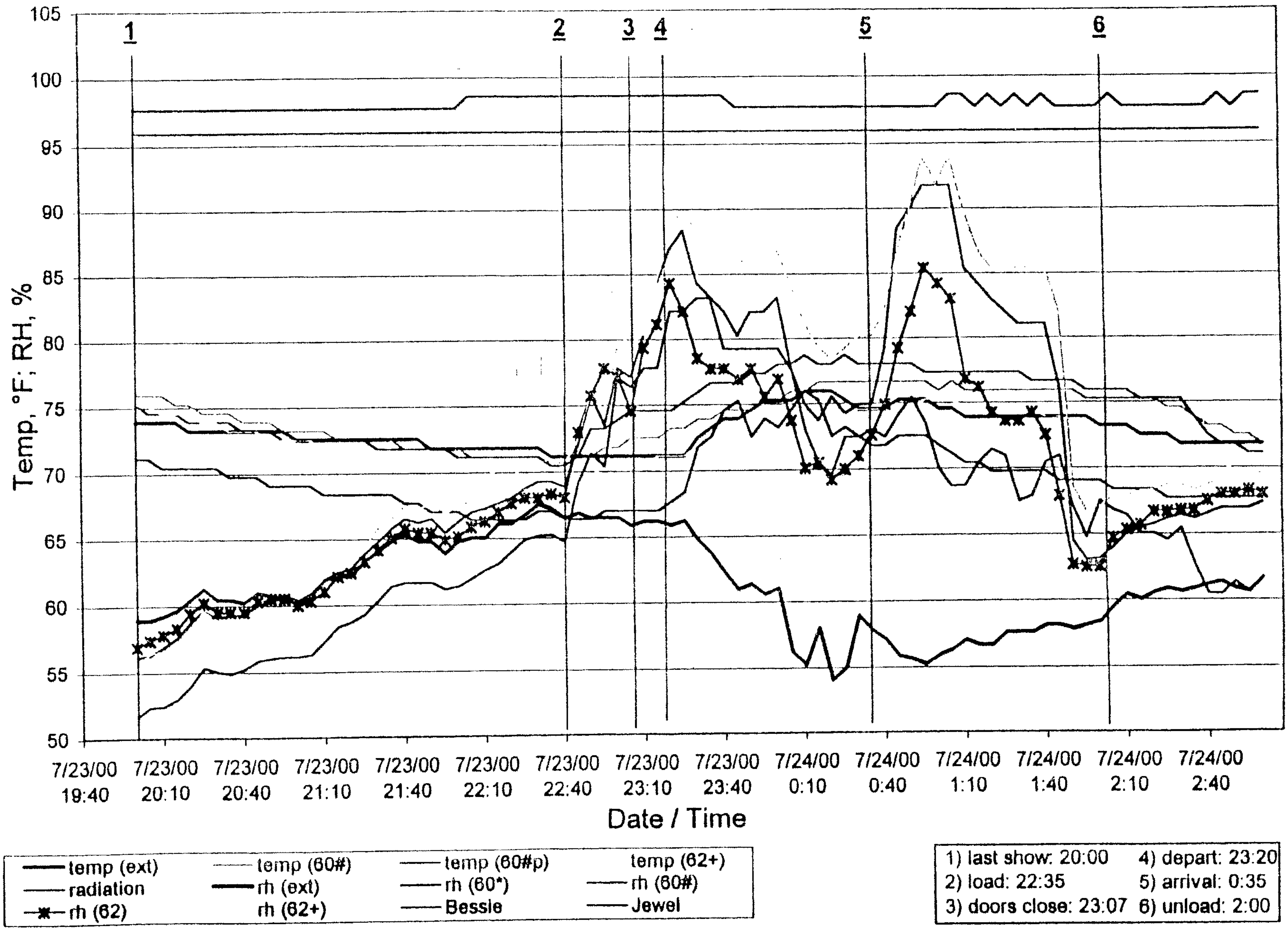

Figure 14. Clyde Beatty: Brooklyn, NY, to Staten Island, NY.

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 cracked 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 15), 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 remained above the internal readings during the entire transport period. Additionally, internal relative humidity was above 85% for the preponderance of the trip.

The high humidities 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.

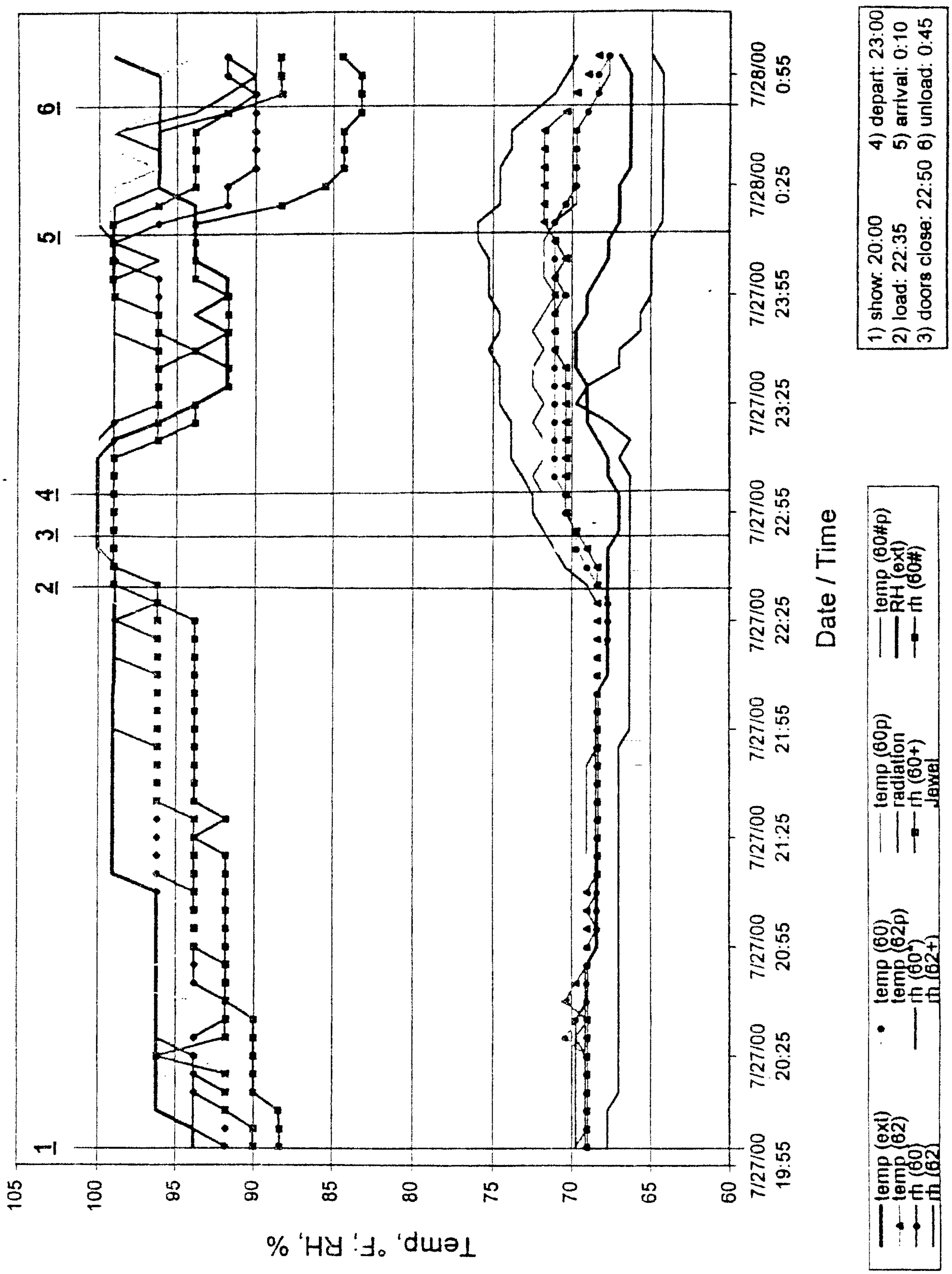

Figure 15. Clyde Beatty: Staten Island, NY, to Forest Park, NY.

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's petting zoo (Figure 16). 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 1547 cubic ft. The truck was uninsulated and had wooden sidewalls and floor.

One environmental logger was used to record interior enviromental 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 one trip, Santa Barbara, CA, to San Luis Obispo, CA (Figure 17), 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 not significantly different from the temperature in the elephant compartment. Beginning 8/14/00 7:00, internal temperature did begin 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 does highlight the

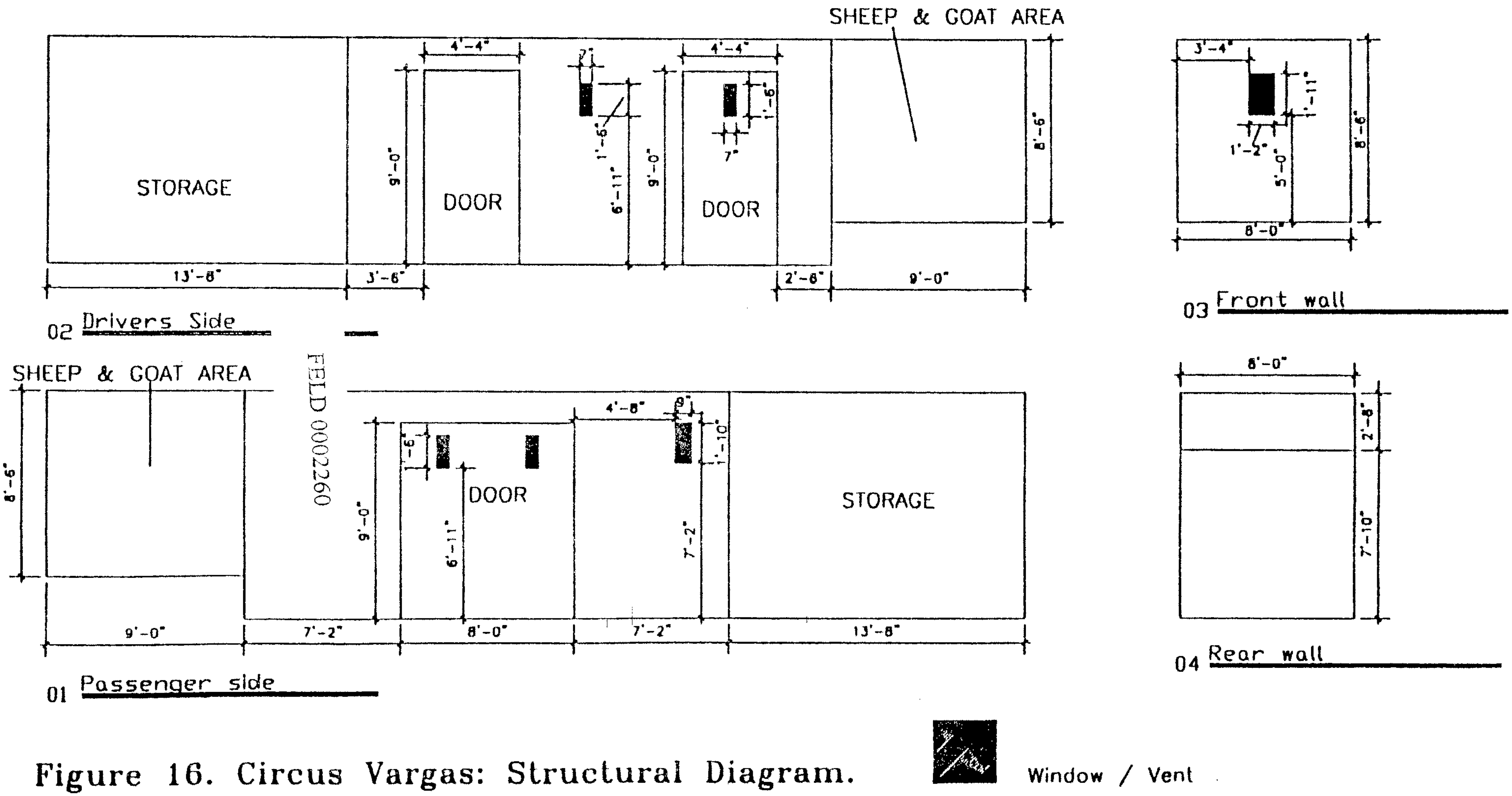

Figure 16. Circus Vargas: Structural Diagram.

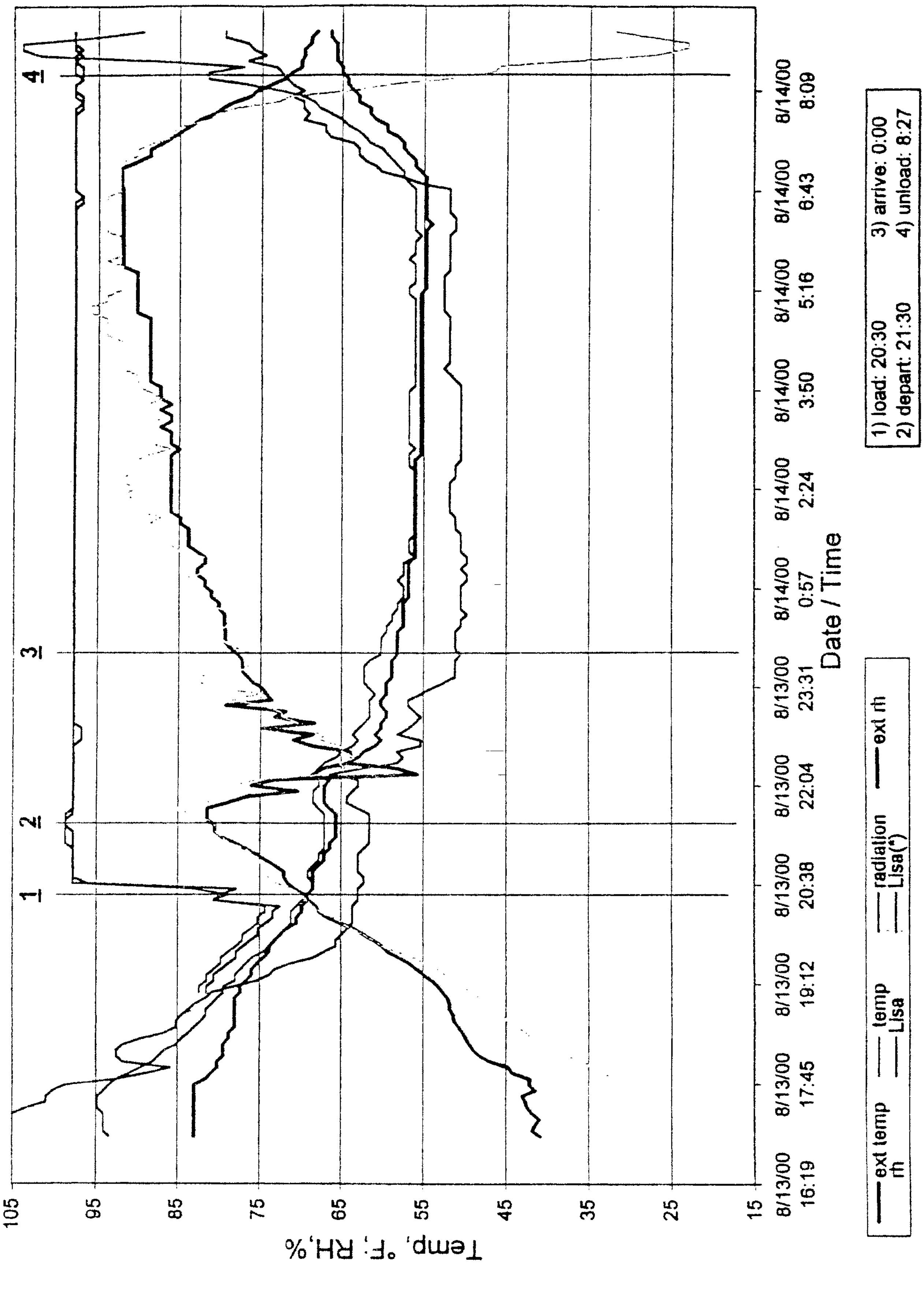

Figure 17. Circus Vargas: Santa Barbara, CA, to San Luis Obispo, CA.

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 peeking 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 lay 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 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 (#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 twenty-five elephants that make up four different acts that are leased out and travel by truck. A second elephant act (Hawthorn Corporation #2) was surveyed during cold weather and is reported in the cold weather section of this report. Each act has one head handler and several grooms that travel as a unit. Typically an act will leave headquarters in Illinois for a destination somewhere in North America and remain there for a week or more as part of the 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 had a total of 5 vents of various sizes, comprising a total area of 5.2 X 8.04 ft (Figure 18). 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, 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 19), 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 insure 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 where 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 temperature 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

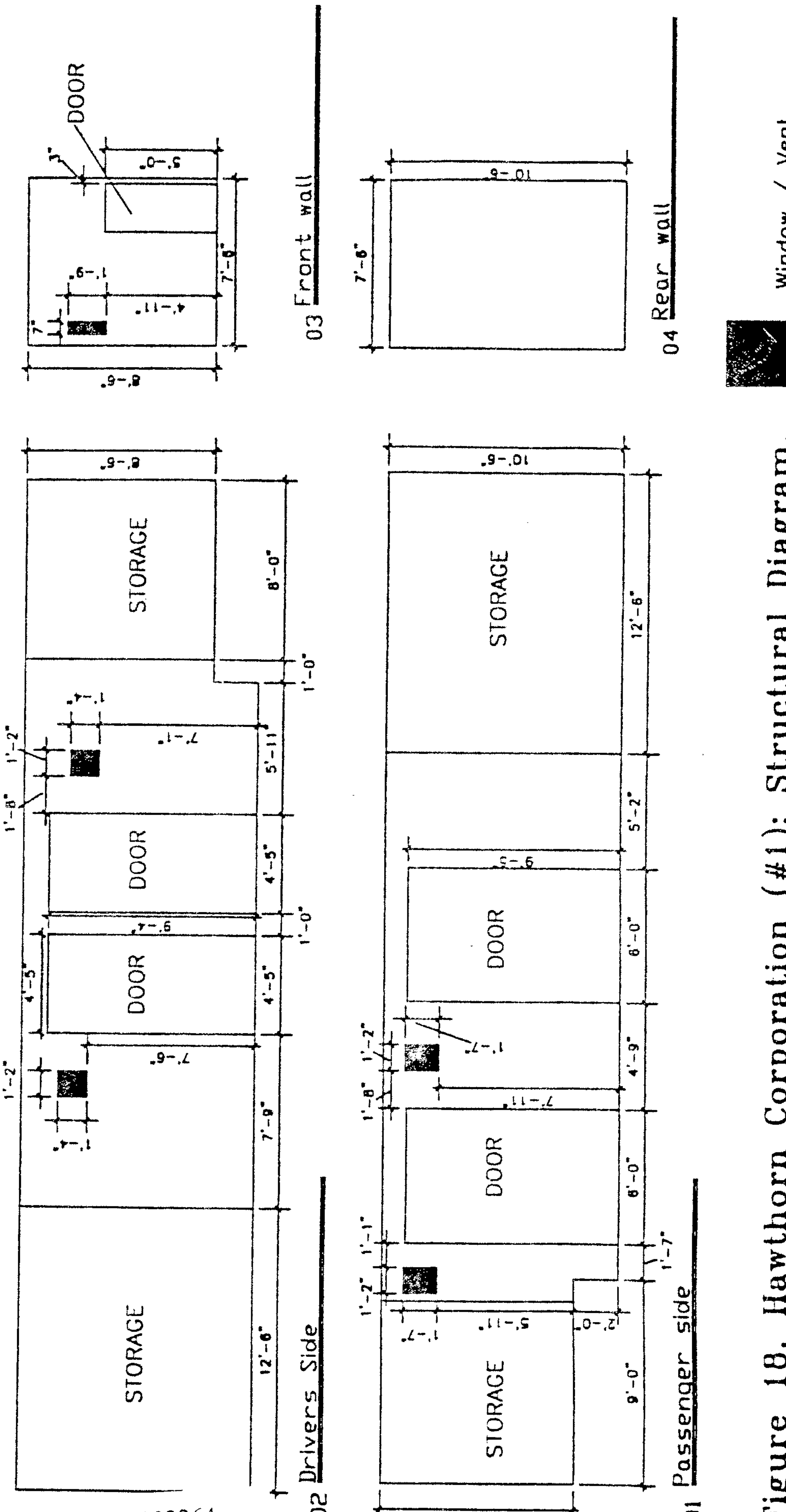

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Figure 18. Hawthorn Corporation (#1): Structural Diagram.

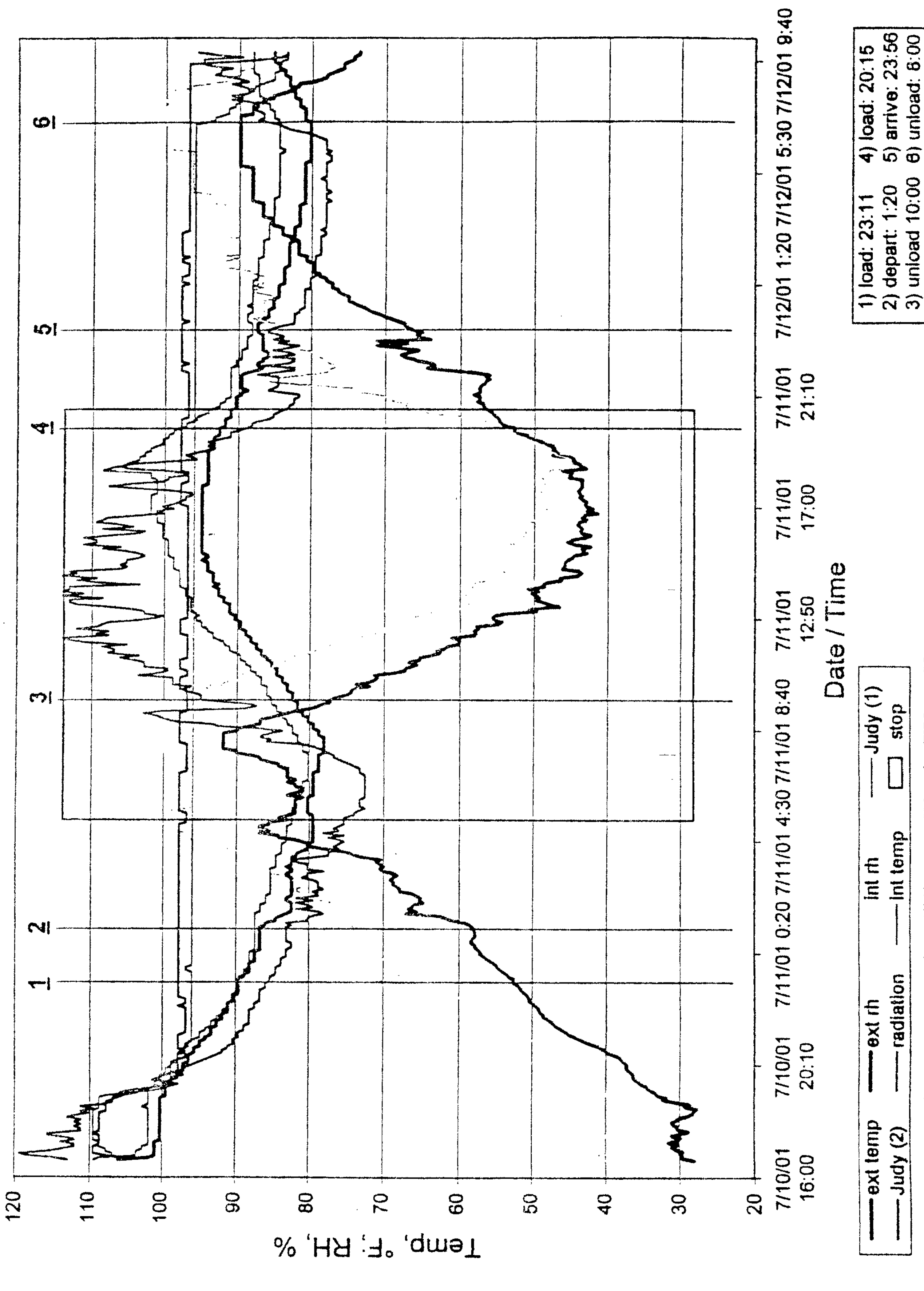

Figure 19. Hawthorn Corporation (#1): Fort Worth, TX, to Houston,

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temperature buildup occurred and the external temperature typically read 1°F 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 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 measure 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 but most had been chewed on and only two could be downloaded. Both functional loggers were from the same elephant, Judy. The loggers were fed at the same time but recorded slightly different temperatures, most likely a reflection of different set points for each logger. Nonetheless, the loggers' recordings maintained individual ranges of 0.9°F.

Houston (North), TX, to Houston (South), TX. During the trip from Houston (North), TX, to Houston (South), TX (Figure 20), 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 internal temperature was at 83°F and reached a maximum of 90°F at 7/18/01 9:30 whereupon the elephants were

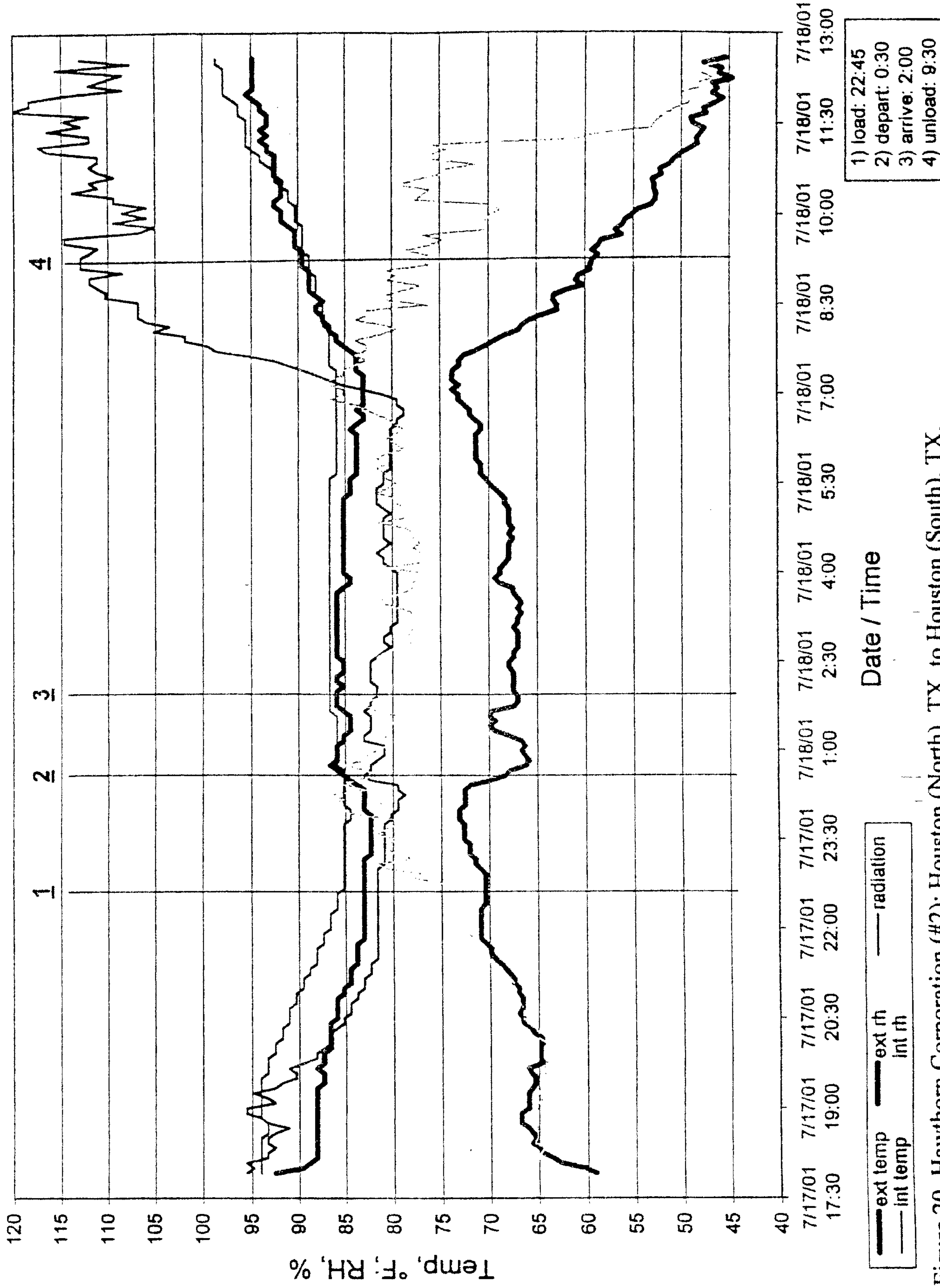


Figure 20. Hawthorn Corporation (#2): Houston (North), TX, to Houston (South), TX.

unloaded. Except for the last five hours before unloading, the entire trip occurred in the absence of daylight. Radiation did reach a high of 112°F while the elephants where in the trailer. This increase did occur 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.

To collect body temperature, three loggers were fed to Debbie and one to Judy. Although all four loggers where recovered, they were slightly damaged (chewed) and body temperature data could not be unloaded.

Cortisol Concentrations

Results for cortisol concentrations collected from Carson and Barnes for controls and during the trips from Fort Dix, NJ to Williamstown, NJ, and Williamstown, NJ, to Chester, PA, are displayed in Figures 21,22, and 23, respectively.

Due to unplanned changes in the arrival times during transit for the short trip blood collections, control samples taken the day before transit are not accurate comparisons for transport. They are included as an indication of the trends associated with baseline readings. Additionally, the first set of samples during the Fort Dix, NJ, to Williamstown, NJ, trip were not collected.

A significant difference was found between the first and second ($p=.015$) and the first and third samples ($p=.028$) of the Williamstown, NJ, to Chester, PA. trip. The

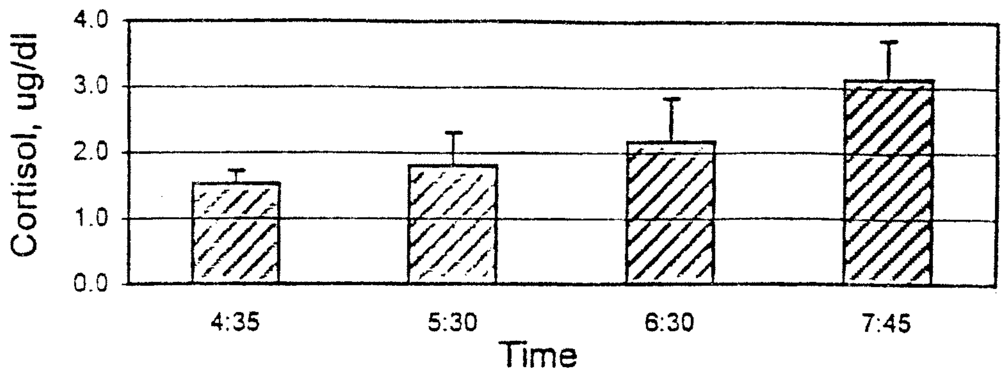


Figure 21. Carson and Barnes: Quasi-control cortisol concentrations for short trips displayed in Figures 22 and 23.

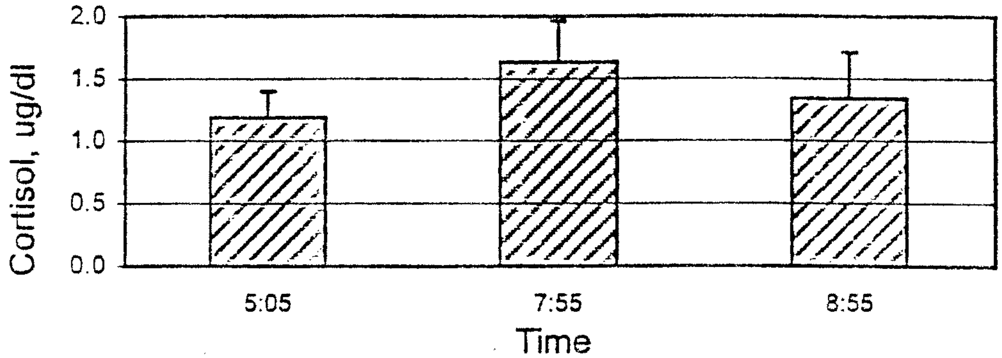


Figure 22. Carson and Barnes: Fort Dix, NJ, to Williamstown, NJ: Transport Cortisol Concentrations. Transport occurred between 5:05 and 7:55 on the same day.

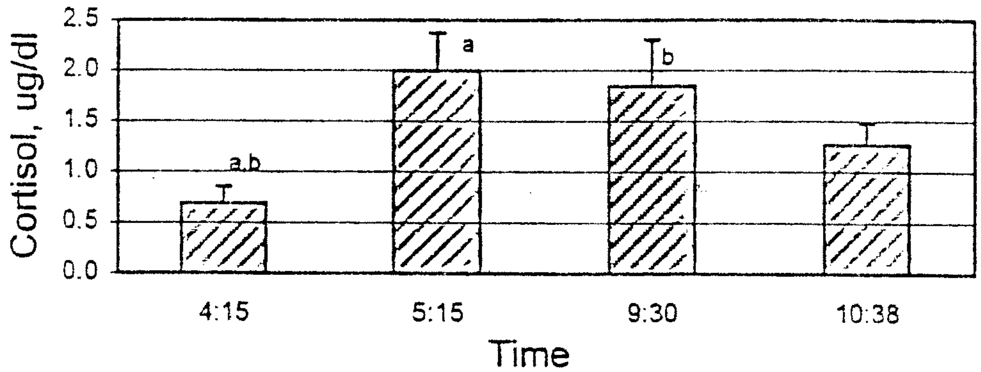


Figure 23. Carson and Barnes: Williamstown, NJ, to Chester, PA: Transport Cortisol Concentrations. Significant differences are indicated by [a](p=0.015) and [b](p=0.028). Transport occurred between 5:15 and 9:30 on the same day.

relative changes of these increases are 190% and 184%, respectively. Though the first set of samples were not collected for the Fort Dix, NJ, to Williamstown, NJ, trip (Figure 22), the second and third samples collected during this trip were considerably lower in comparison to the Williamstown, NJ to Chester, PA, trip where significance was found. All other tests for both short and long trips failed to indicate statistical differences in cortisol concentrations between sample times.

The greatest mean concentrations of cortisol were detected for two separate elephants during the third and fourth samples of the short trip control collections (Figure 21) suggesting the significant changes in Figure 22 may not be biologically significant.

The long trip analysis, which constitutes two trips, one from Ringling Red and another from Ringling Blue, are displayed in Figures 24 and 25, respectively. There was a trend for the difference between mean transport and control concentrations to gradually increase with each successive sampling time. The largest difference between control and transport samples was seen during the last sample for Ringling Blue when an increase of 271% occurred between the control and transport. The difference, like all others during the long trips, was not statistically significant as a result of high variation. When a positive stimulus was applied to the elephants in the form of being brought to an exercise pen, individual cortisol concentrations for three elephants rose 157.7%, 73.4%, and 31.0% after being brought to the exercise pen (Figure 26).

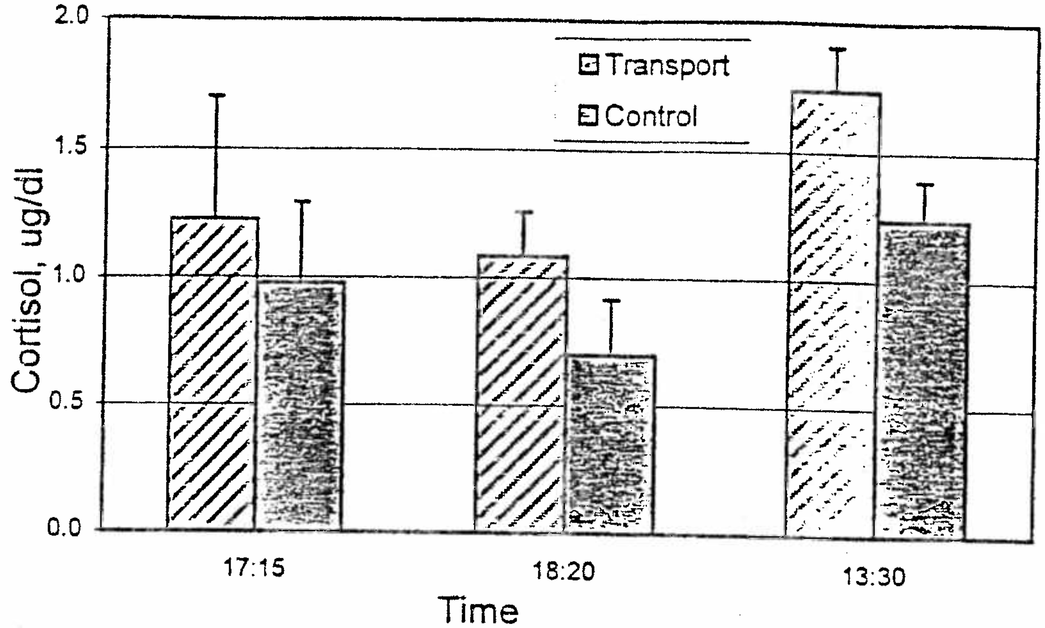


Figure 24. Ringling Red: Transport/Control cortisol concentrations for long trips. Transport occurred between 18:20 (7/8) and 13:30 (7/9).

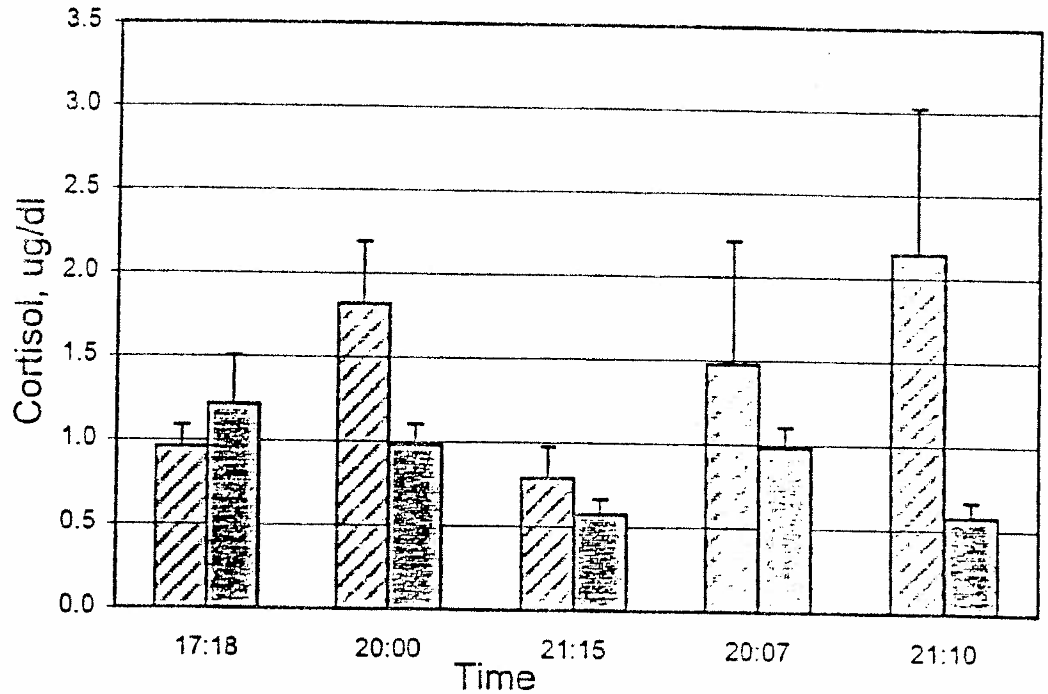


Figure 25. Ringling Blue: Transport/control cortisol concentrations for long trips. Transport occurred between 21:15 (8/13) and 20:07 (8/15).

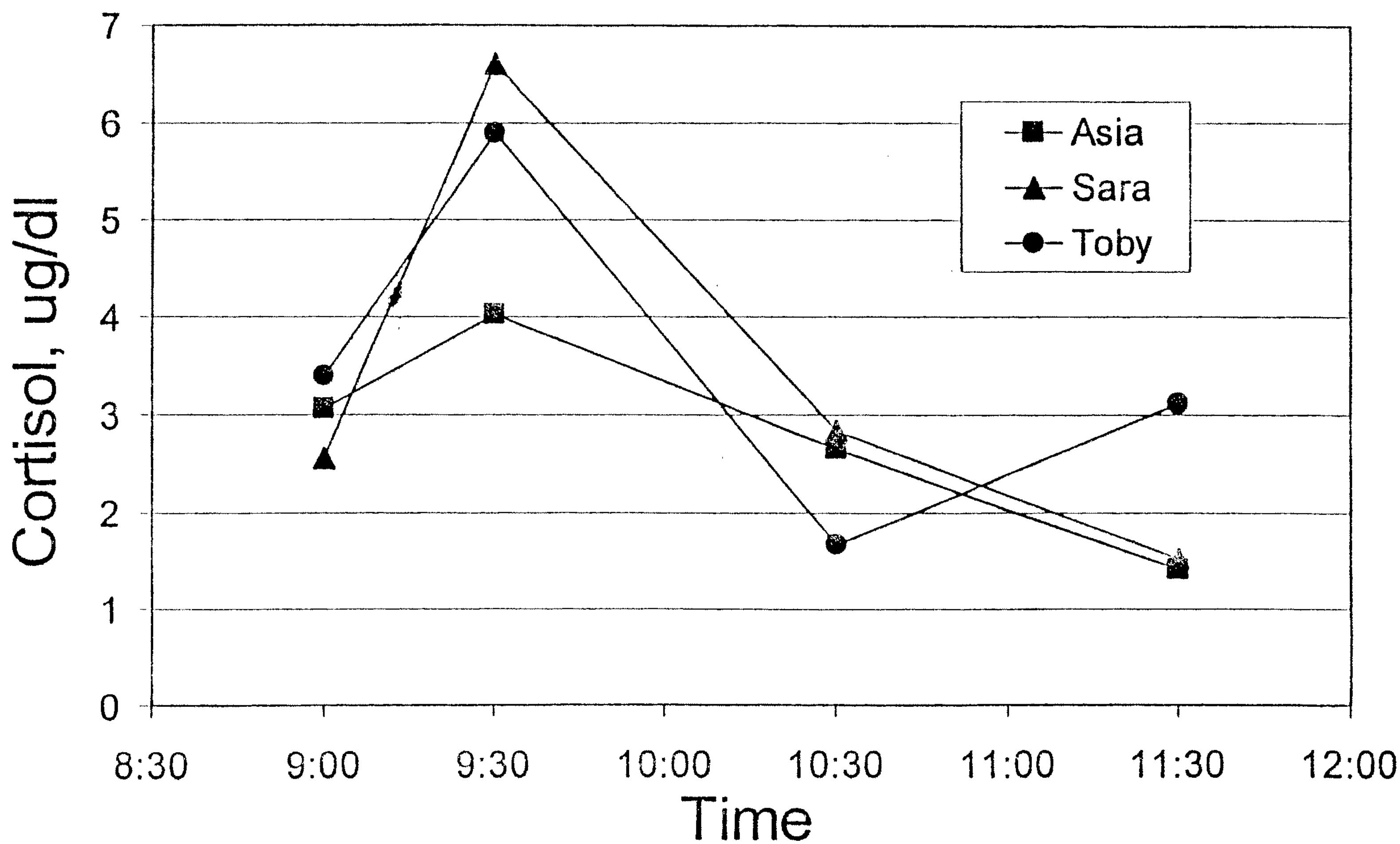


Figure 26. Ringling Red: Novel Stimulus.

Direct and Video Observations

General Loading and Unloading. Though direct/video observations could only be obtained from a few of the circuses that participated, we were able to view the loading/unloading at least once (usually more) for each circus (including circuses that participated in only cold weather trials). In all instances, the animals appeared to load easily and voluntarily with little direction from circus staff, indicating the process caused little, if any, stress on the elephants.

Ringling Blue. Ringling's Blue unit provided several opportunities for both direct and video observations. Two trips were recorded using a time lapse video recorder during which the entire forward side of the elephant was in view. A researcher who traveled in the juvenile car with the handler observed a third trip. The handler proved to be an extremely important aspect of travel and performed a variety of tasks that enhanced the quality of travel during these comparatively long trips.

Analysis of the time lapse video revealed that the elephant that was taped spent 40% of its time weaving throughout the trips. Frequent explorations were made with its trunk. The animal would often stop weaving when the handler passed, when feed and water were provided, or while eating and drinking. The observed elephant did not lay down though appeared to be asleep when standing for several hours, an observation also noted by Tobler et al. (1992).

During the third trip (which the researcher traveled on), the train was in motion for less than six hours, though several observations were immediately apparent. Firstly, the handlers would quickly remove feces and urine and pile it at the door. At certain locations the feces and urine were shoveled out the door. Circus staffs were adamant to insure that feces were not put out at improper locations, i.e. a roadway. Sawdust was usually laid down to lessen the spread of urine although several times the handler was able to catch feces/urine in a shovel before it had touched the ground. These techniques substantially reduced the accumulation of feces and urine.

The presence of a handler allowed for constant monitoring of the animals for signs of fatigue, sickness and general health as well as making adjustments in the railcar environment by controlling the fans, misting system, and position of the doors.

Upon arrival and waiting for the animals to be unloaded at approximately 11:00, an obvious temperature difference between the interior and exterior temperature could be detected by simply walking between the two areas. Even though the train wasn't moving, the fans in the roof created an extremely high ventilation rate, pulling in air through the entrance/exit doors.

Clyde Beatty. Two trips were surveyed with Clyde Beatty – Cole Bros., one of which was observed by a researcher traveling in the rear loft of one of the trailers. A video recorder videotaped the elephants in the other trailer during the same trip in real time.

During the trip in which the researcher traveled in the loft, only the backs of the elephants could be seen. The elephants performed weaving for approximately 70% of the time they were standing in the trailer. The elephants did not seem to change activity when the truck was in motion or not, although they did sometimes become suddenly still as the truck slowed to break, possibly to brace themselves. This observation was extremely variable. Though the elephant's fronts (and mouths) could not be seen, the animals could be heard eating through most of the trip and seen throwing hay on their backs, a typical elephant behavior. Lastly, the elephants were not observed to lose footing or be thrown off balance as the truck moved.

Analysis of the recorded video revealed that the elephants spent a considerable amount of time weaving. An exact amount was difficult to formulate, as the elephants' motion often seemed to be caused by the trucks' motion and not necessarily the elephants themselves. Though a rough estimate, the elephants weaved 80% of the time in the truck. As noticed by the researcher traveling in the loft, the elephants would occasionally cease movement as the truck slowed.

Hawthorn Corporation (#1). A single elephant was videotaped on each of the two trips surveyed with Hawthorn Corporation (#1). The video camera was placed in the midsection of the truck providing a full view of one animals's back and side. During the second trip (Houston North to Houston South), our video cable became disconnected and thus we were not able to analyze the video from the second trip.

During the first jump (Ft. Worth to Hosuton), the recorded elephant was observed to throw hay on its back several times and maintain it there for the entire trip. Weaving was observed to occur 49% of the time while traveling. The animal did not lay down.

Cold Weather

<u>*Ringling Blue*</u>

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 27), 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 thus 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). Dring transport between Denver and Cleveland, we are unsure of time that the circus passed

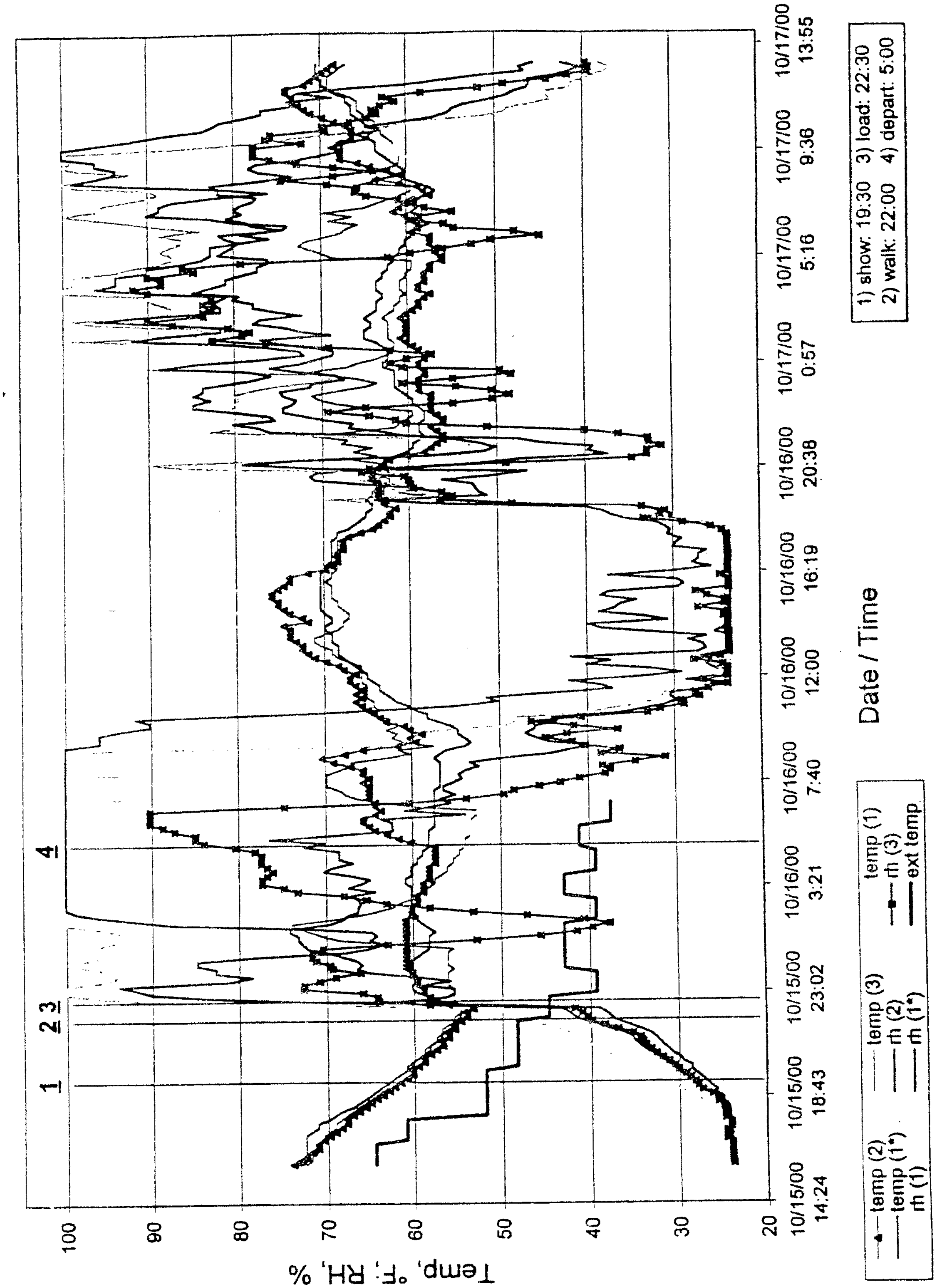


Figure 27. Ringling Blue: Denver, CO, to Cleveland, OH.

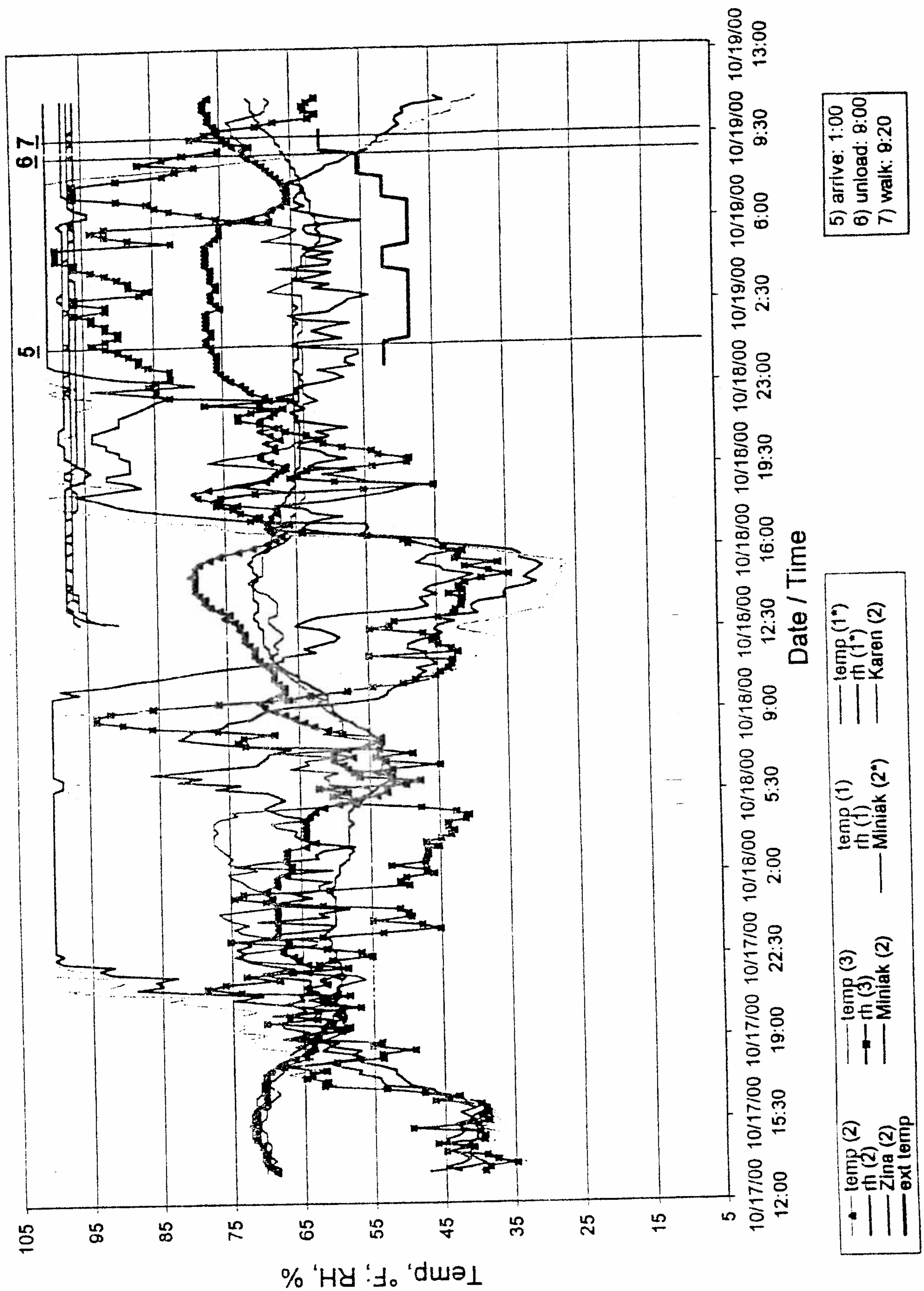


Figure 27. (continued).

weather reporting stations along the route and thus cannot provide further descriptions of external temperature using NOAA data.

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 full car (1) 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 all windows. The vents in the roof of the car were not covered and the fans were not turned on.

Pre-loading 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). 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 27, 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 h and was most likely influenced by the animal drinking water.

Chicago, IL, to Savannah, GA. During the Chicago, IL, to Savannah, GA, trip (Figure 28), one environmental logger was placed in the full car (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

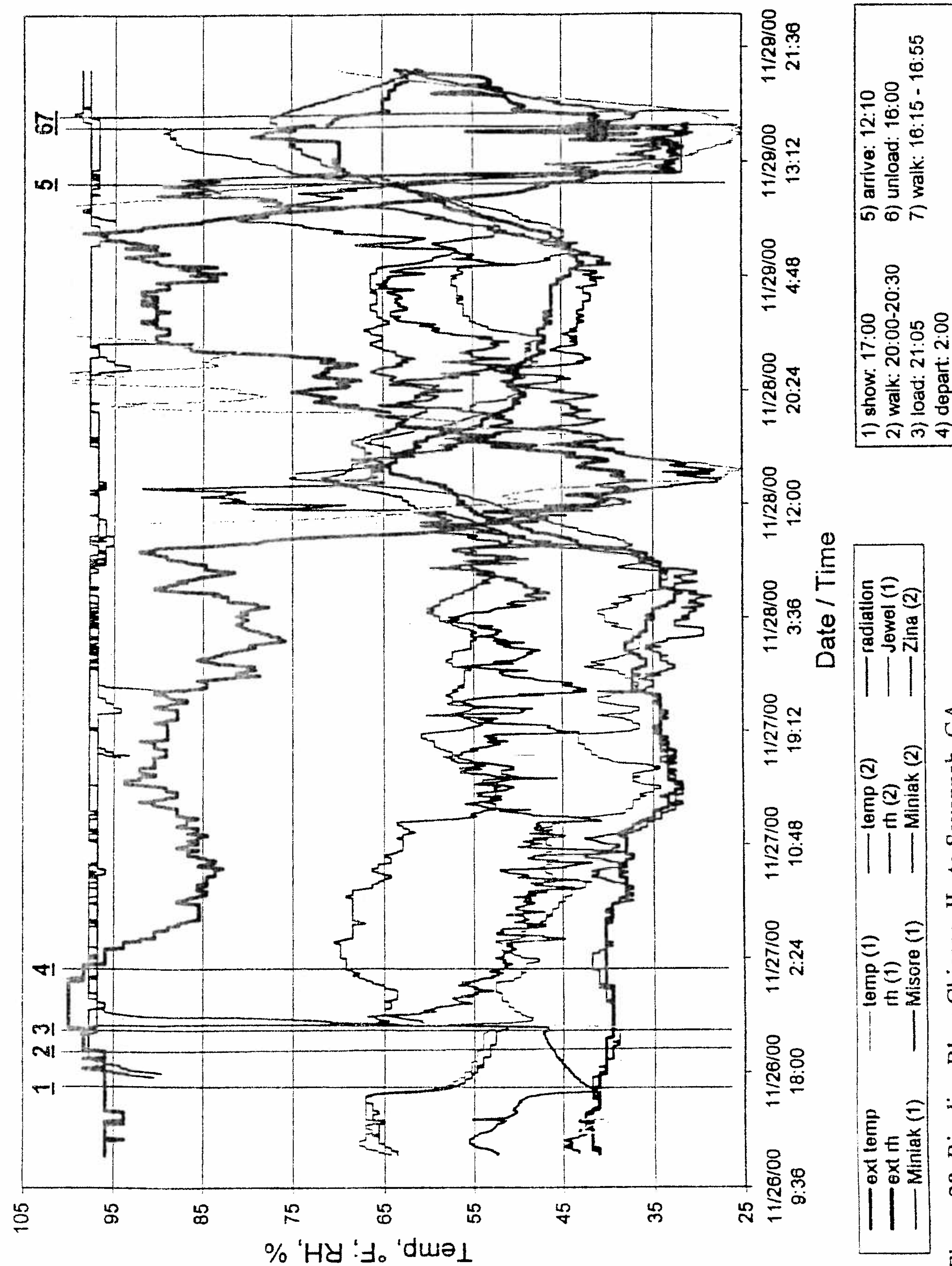


Figure 28. Ringling Blue: Chicago, IL, to Savannah, GA.

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. Within our range of detection, no ammonia or carbon monoxide was detected.

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 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 was seen suggesting that the body temperature loggers were influenced by the elephants' drinking water. 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's (1), a body temperature logger was administered in the first set, recorded 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. 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 (#2)

An overall synopsis of the travel procedures of the Hawthorn Corporation has already been described in Hawthorn Corporation (#1) of the hot weather section of this report. Truck design, number of elephants transported, and specific travel procedures for this particular unit of the Hawthorn Corporation are different from the unit already mentioned and are reported below.

The elephant area of the truck had a total of 6 vents covered with bars and as a cold weather adaptation, styrofoam as well (Figure 29). 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 two forward elephants facing the direction of travel and the rear elephants facing away from the direction of travel. Each set of elephants stood side by side. This arrangement allowed for easy feeding and watering utilizing 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 2228 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.

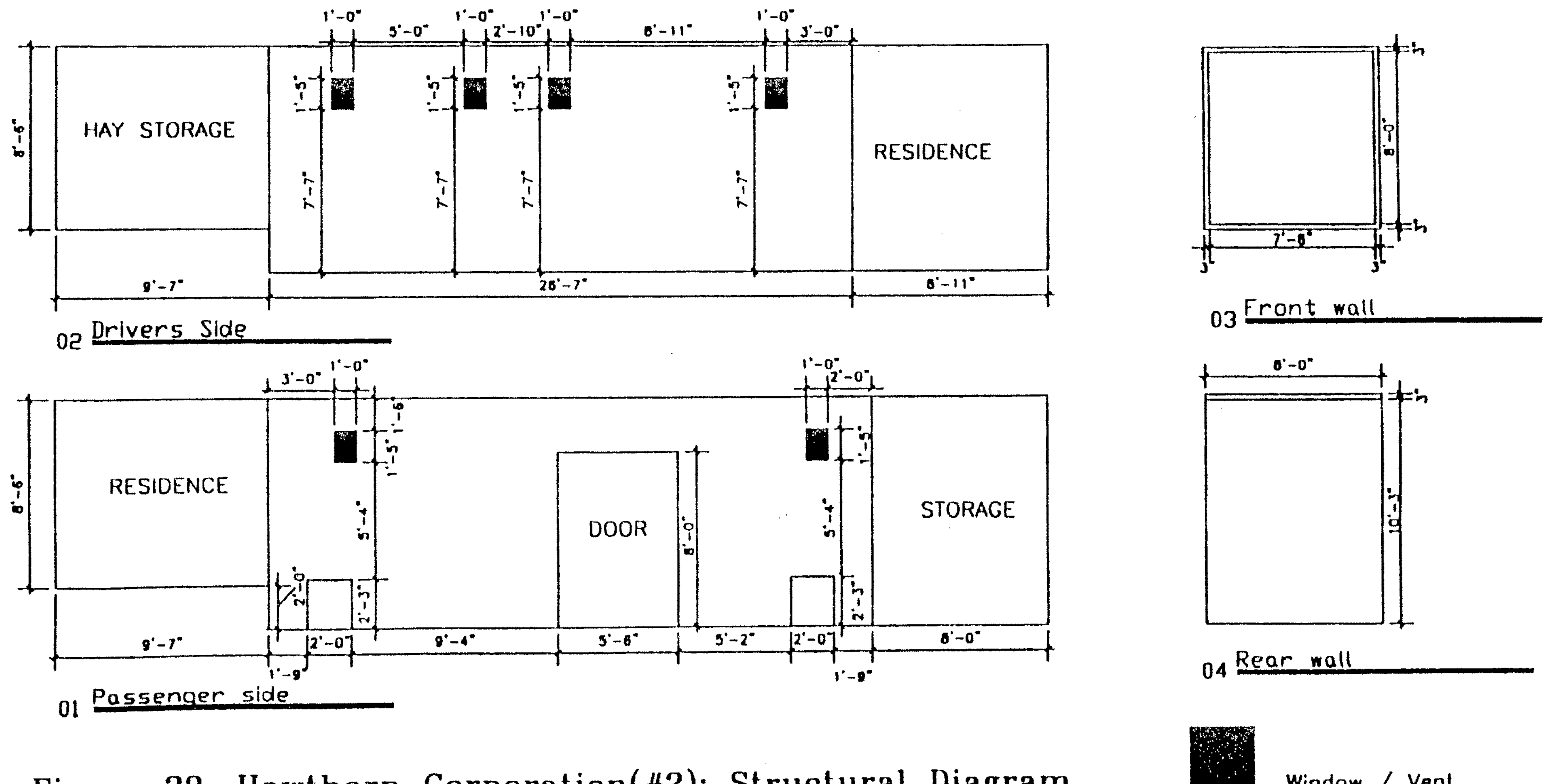


Figure 29. Hawthorn Corporation(#2): Structural Diagram.

Richmond, IL. to Nashville, TN. Three environmental loggers were placed in the midsection of the truck, one (1) 2' 6" from the floor and two more approximately 7' 7" from the floor (1*, 1+). On the particular trip surveyed, two Asian and two African elephants were transported using an 18-wheel truck from Richmond, IL, to Nashville, TN (Figure 30). 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. Throughout the trip, internal temperature reached a minimum of 48.0°F during a stop (not considering the first two hours) and was maintained approximately 20°F to 40°F above the exterior temperature with large variations between environmental loggers.

Once actual traveling began, the interior temperature recorded by environmental logger (1) began to fall until the truck stopped despite a stable exterior temperature during the same period. The other internal environmental loggers maintained a fairly stable temperature during the same period. Several other differences were noted between environmental loggers and appear related to environmental logger position indicating different trends within the same trailer. The opening and closing of access panels may have affected the trends as well. Particularly during stops, trends between measures were inconsistent. During the first stop, environmental logger 1 recorded a rising internal temperature while the environmental loggers 1* and 1+ remained stable. Contrasting this, during the second and third stops, environmental logger 1 recorded a decrease while the two environmental loggers mounted higher (1* and 1+) tended to record stable temperatures. The higher environmental loggers (1* and 2+) read internal temperature within approximately 5.4°F of each other, while the lower (1) typically read 10.1°F to 15°F less than the others.

At all times during transit, a significant difference was recorded between internal and external temperatures. Internal temperature during the overnight stop did rise, but the measure never approached body temperature and appeared to match the slight rise in

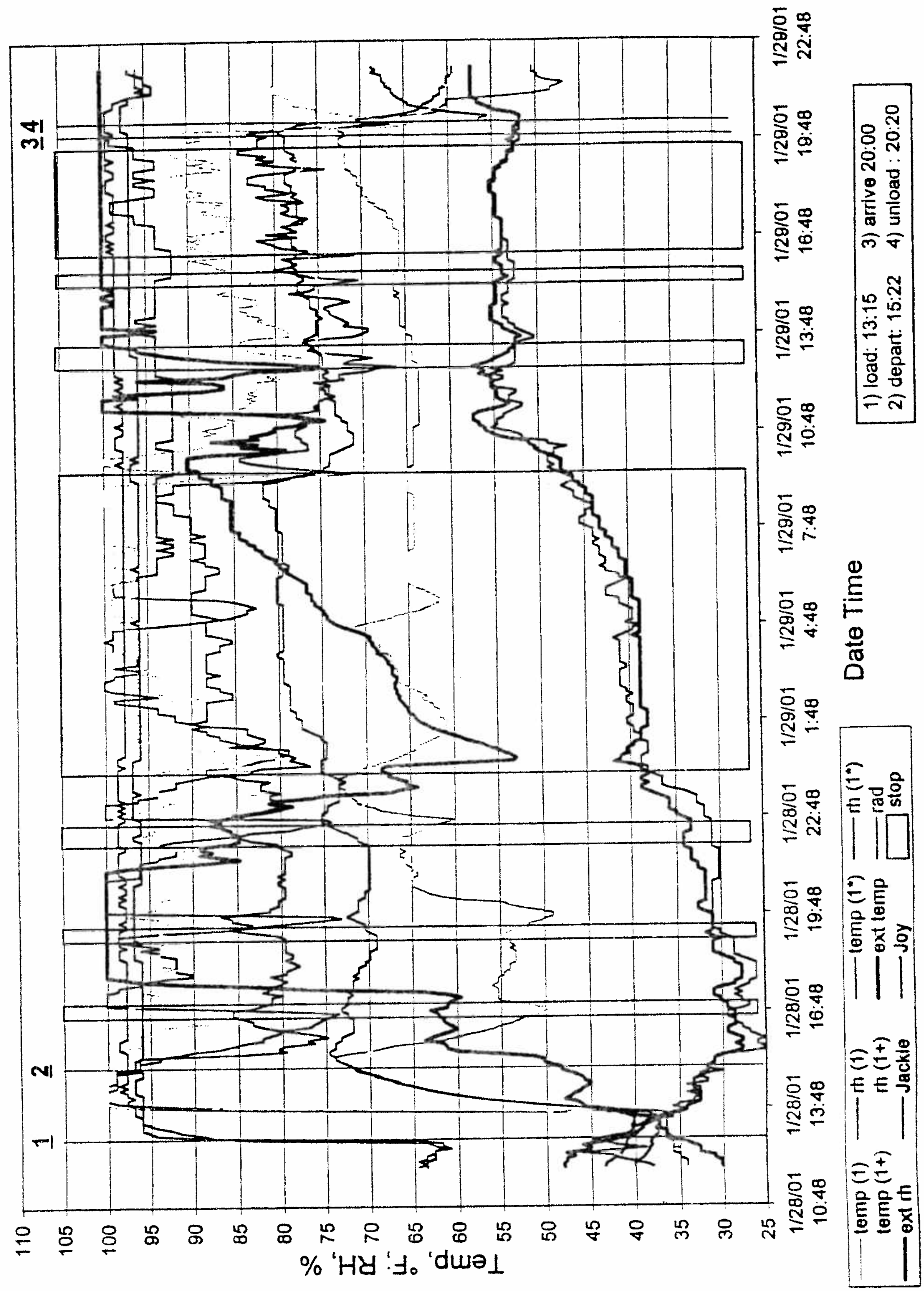


Figure 30. Hawthorn Corporation: Richmond, IL, to Nashville, TN.

external temperature that occurred after 1/29/01 5:00. This observation suggests that 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. We believe that opening the vents was the primary factor in the lower relative humidities seen on the second day of the trip. 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, however, 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 temperature ranged from 95°F to 99.5°F. For almost the entire trip, Joy's temperature was approximately 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 31) 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 put on the rear wall of truck 56. Two and four elephants were transported in the trucks, respectively.

We were unable to collect data for external relative humidity or internal relative humidity for more than one truck.

Due to cold, wet conditions, the elephants had been loaded the previous night at 22:00 and the doors were kept closed. 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°F to 15°F greater than the external temperature. Once actual travel began, this difference gradually decreased to nothing until unloading when external temperature rose above the internal temperature.

As with the departure-timed rise in internal temperature, internal RH 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 32). A wall of expanded metal completely separated the elephant compartment from the camels in the rear; another wall 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

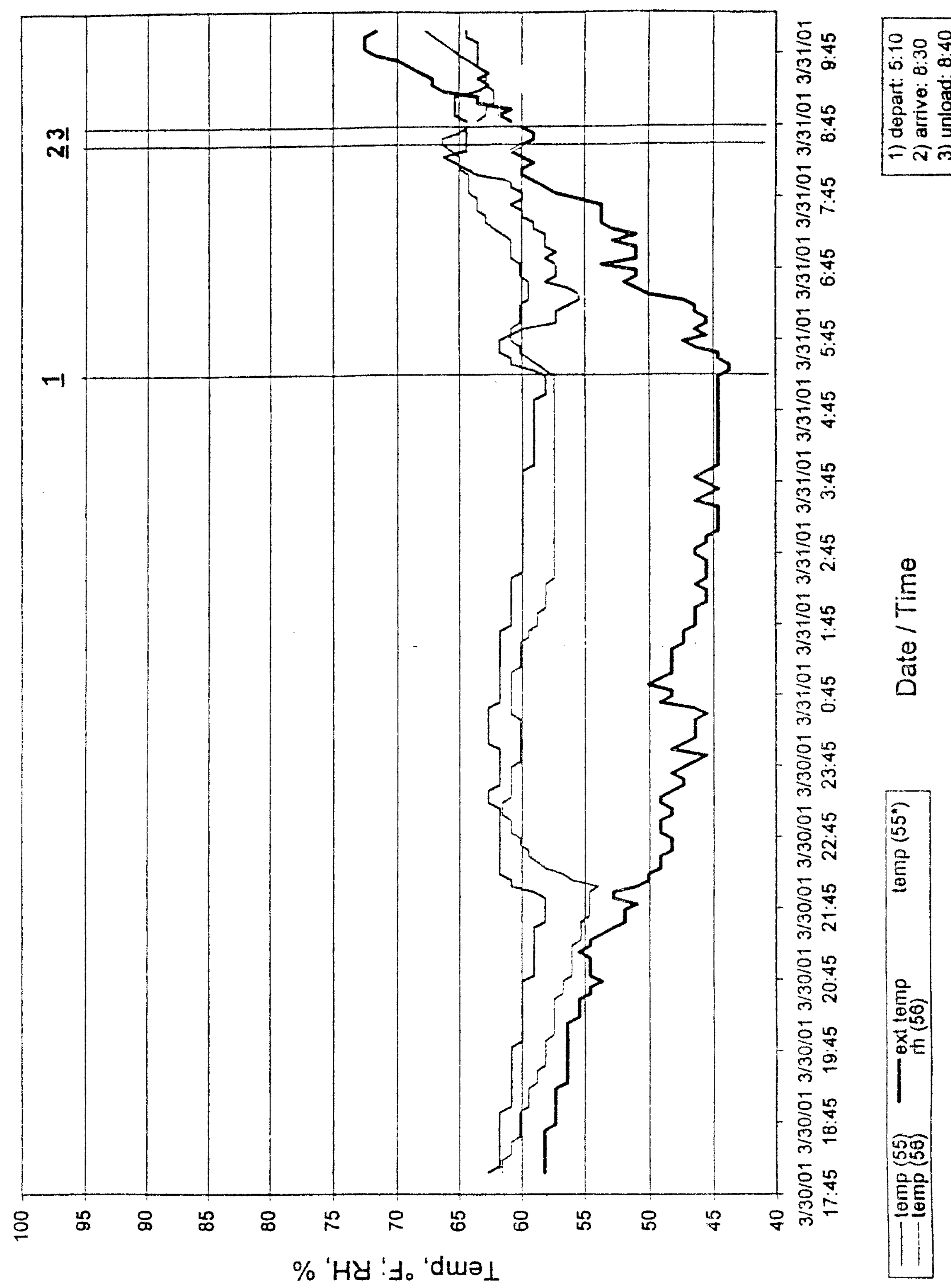
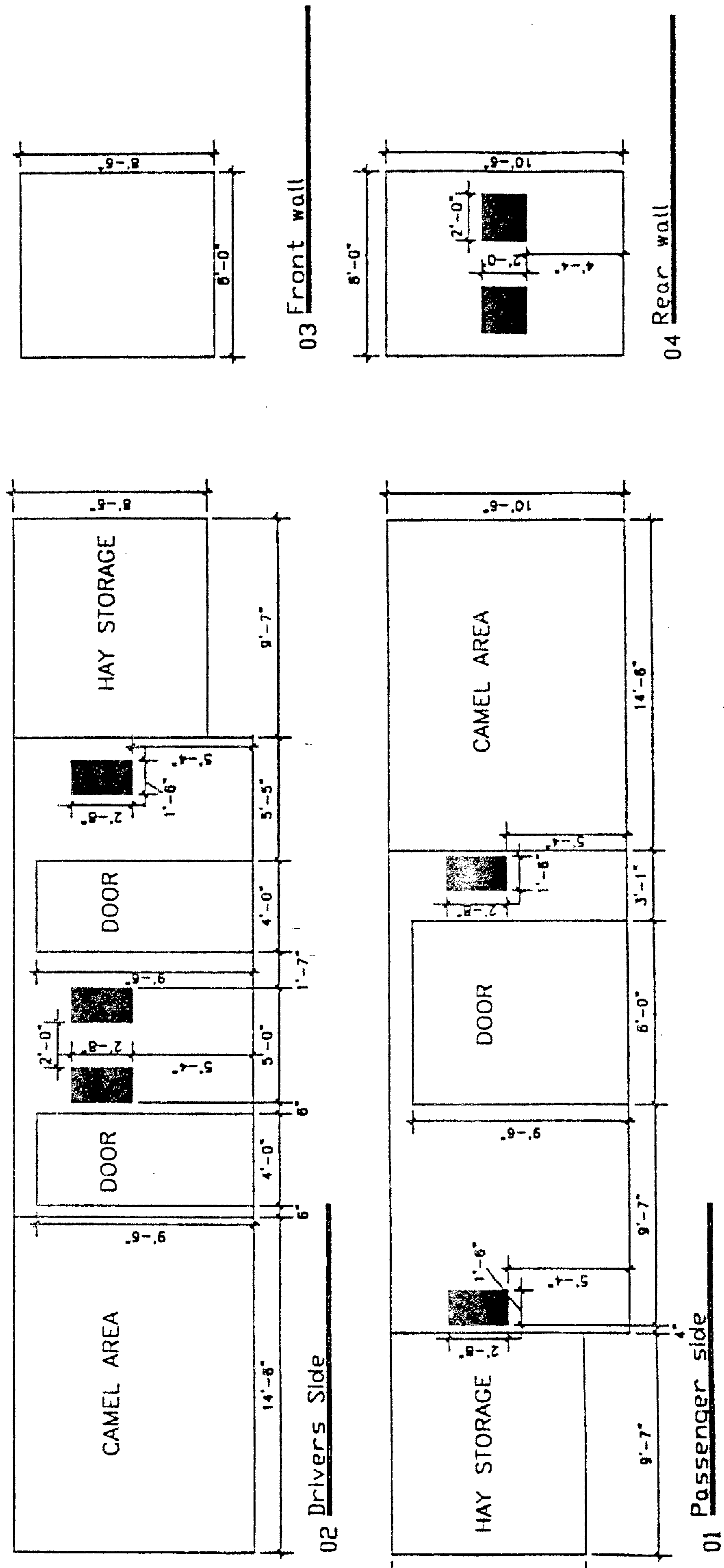


Figure 31. Carson and Barnes: Rockdale, TX, to Tomball, TX.



Window / Vent

Figure 32. Trunks & Humps: Structural Diagram.

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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 33).

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 another 5°F, but maintained a differential 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) while 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

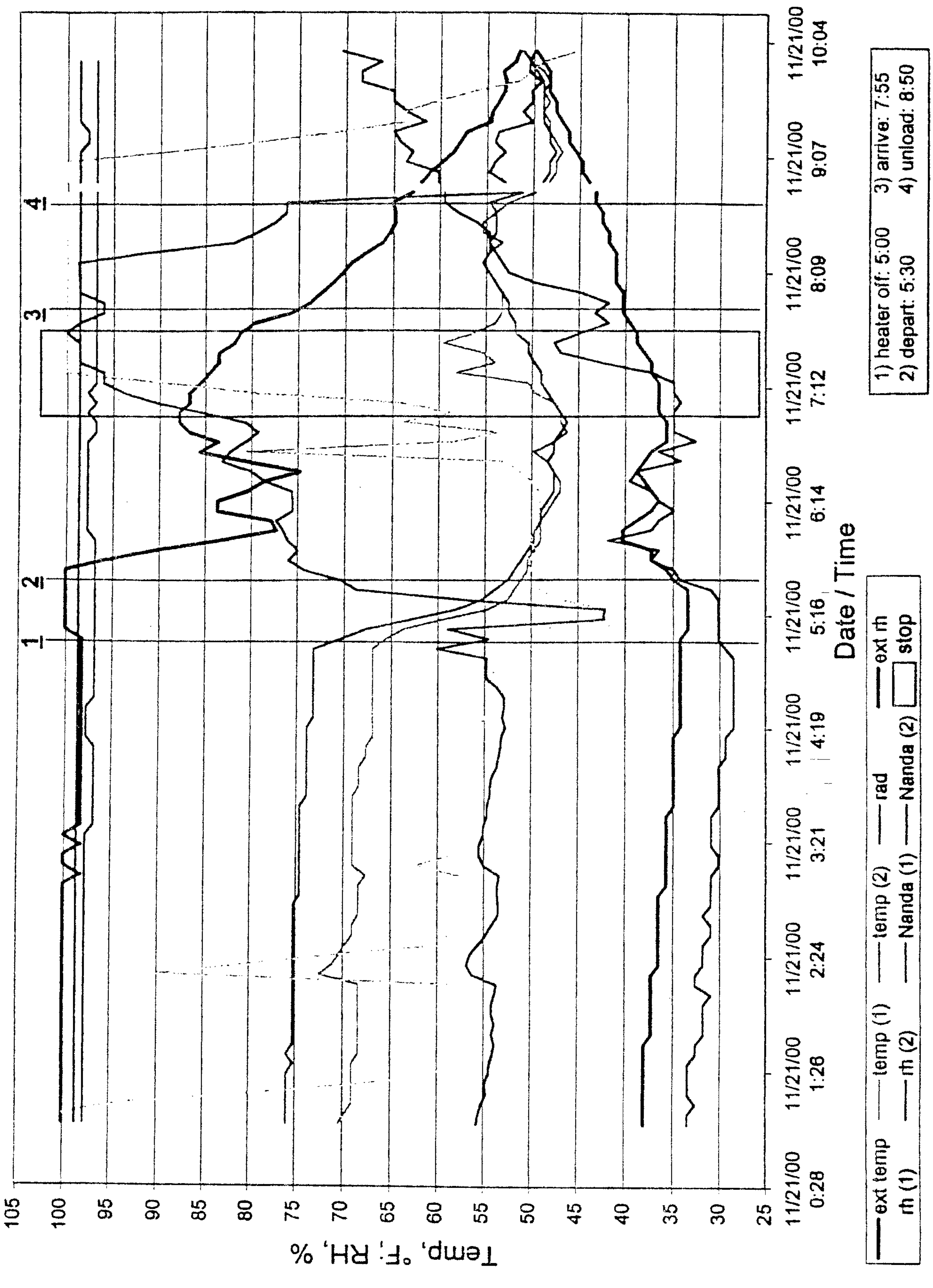

Figure 33. Trunks and Humps: Cut 'n' Shoot, TX, to College Station, TX.

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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 RH immediately following departure (one much more dramatically than the other) and then again when the truck was stopped.

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 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.

Direct and Video Observations

Ringling Blue. During the Chicago, IL, to Savannah, GA, trip, a researcher traveled in the stock car with the three juvenile elephants and a handler for the entire duration of the trip. The majority of the trip was spent with these animals, although the trainers did walk the researcher to the different cars so that all animals could be observed.

The trip occurred over three days of which the first half experienced relatively cold weather. The researcher traveled in the same stockcar as during the hot weather trip. As with shorter trips, the handler would frequently remove feces, and feed and water the animals. During this trip, elephants in all cars were observed laying down and resting, including the adults. The juveniles were positioned side to side parallel to the direction to travel and thus where not able to lie down at the same time, but would "take turns".

Of the three juvenile elephants which the researcher spent the preponderance of time during the trip observing, one elephant weaved nearly 80% of the time while standing. Despite this near constant motion while standing, she did lay down and rested during the trip for several hours each night.

Hawthorn Corporation #2. During this trip, the researcher did not travel in the elephant trailer as in previous instances but in the cab of the truck. As seen in Figure 30, stops were made frequently to allow for feeding of the animals and staff breaks. The researcher was not able to see the animals in the trailer, though the head manager did not believe that the elephants could lie down during transit due to lack of room. For this reason, he would take a minimum of breaks to reach the destination as soon as possible.

During stops, the animals would be provided water and/or feed using a bucket slid in through the access panels on the side. The morning after the overnight stop, feces and urine that had collected at the rear of the animals were shoveled out through the entrance/exit doors. This procedure most likely had a large impact on the absence of ammonia when the air was sampled.

Discussion

Extreme environmental temperatures can result in harmful effects on animals being transported if precautions are not taken to insure that conditions inside the transport vehicle are kept within a safe range. Animals that respond poorly to transport or find the transport environment inadequate or stressful will suffer from compromised welfare if their response or the environment does not change. The present project was undertaken to survey the environmental conditions that circus and other performing elephants experience while being transported during relatively extreme temperatures, evaluate methods to maintain appropriate conditions within the transport vehicle, and characterize the response of the elephants to transport. Measurements of interior and exterior temperature and relative humidity data, as well as concentrations of noxious gases during transit, were obtained to fulfill the first two objectives. Measurements of body temperature, direct and video observations, and plasma cortisol concentrations were collected to accomplish the third objective. Although our findings lead to the formation of new questions and suggest areas for additional research, the results suggest overall positive transport conditions.

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). Elephants in zoological parks of the northern United States commonly experience temperatures as low as 38°F (Keele, personal communication). Thus, the temperatures observed during transport were within the range that 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 suggesting that these occurrences were related to equipment malfunctions, such as spray from an elephant creating a short, rather than hazardous conditions. As demonstrated in a survey of Ringling Blue's trip from San Diego, CA to Oakland, CA, two separate temperature spikes were recorded at approximately 8/15/00 8:15 and 9:25, the second of which reached a maximum of 104.2°F. The lack of a correlating fluctuation in the external temperature or the third environmental logger measuring interior temperature suggests that the cause of the temperature spikes were not related to external conditions and not an accurate description of the overall environment within the railcar.

The circuses surveyed during hot weather utilized 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 utilizing railcars outfitted with insulated walls, high capacity ventilation fans, and other structural and environmental enhancements that can effectively maintain 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 Ringlings' 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 15). 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 elephant cars several hours prior to loading for their trip from Lafayette, LA, to San Antonio, TX (Figure 2), successfully lowering the internal temperature 14°F. Though this change was substantial, the effect was short-lived and thus not a viable alternative to cool the railcar during hot weather conditions unless performed throughout travel. Hence, this is not a feasible option.

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 17), a temperature increase of 25.2°F occurred over a 90-min period the morning after travel, most likely a result of rising external temperature and radiation. Though the elephant was removed before the temperature the temperature became a concern, a warning device would alert the handlers to extremes in temperature within the trailers could be very useful.

During cold weather transport, internal temperature of the transport vehicle was generally kept above 77°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 trailer and the procedures used to control the internal temperature. For instance, before Humps and Trumps departed from Cut 'n' Shoot, TX, to College Station, TX (Figure 33) an electric heater was utilized 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 31), 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 Chicago, IL, to Nashville, TN, trip (Figure 30). 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, this was the largest difference between the external and internal temperatures recorded and a likely result of the insulated trailer used by Hawthorn Corporation. The dense travel conditions, 15.7 cubic meters per elephant for Hawthorn Corporation as compared to Carson and Barnes's density of 27.0 cubic m 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 28), car 2's minimum temperature during transport was 50.9°F. Comparatively, temperatures in car 1, where five elephants were held, reached 32.5°F several times, equaling the external temperature during this cool period. The elephants did not seem to be adversely affected as indicated by stable body temperatures. Temperatures of this range are also common in the natural habitat of Asian elephants (Sukumar, 1989). However, with the potential for the temperature of the railcar to reach such low values, the installation of a heating unit in car 1 may warrant consideration.

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 buildup of both gases during transit was most likely avoided due to high ventilation, particularly during the summer when fans are used in Ringlings' units which travel over several days. 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.

The third objective of our study was an attempt to characterize the response of the elephants using physiological and behavior parameters. In contrast to the environmental conditions discussed above, the collected physiological and behavioral data provide a view of the internal state of the animal.

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. Our original estimate of a five-day passage time proved close to the actual average of three days, though times were extremely variable ranging from 12 hours to over four months. The four-month duration occurred when the logger became separated from the epoxy encasement and nylon flag possibly resulting in the body temperature logger being retained in the cecum. The cecum is an area not subject to peristalsis. In a study using ingested loggers to determine body temperature in elephants, loggers were commonly found in this area during extended passage times (Schmidt, personal communication).

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). Temporary drops in temperature were recorded, but appear to be a result of drinking water. Often, within three hours after the body temperature loggers were ingested, a sudden decline of 5.0°F to 15°F from regular body temperature would occur followed by a slow return to normal temperature, e.g., Misore and Jewel's body temperature before the last show in Figure 6. These drops result from the animals drinking cold water while the body temperature logger was still in the stomach of the animal before entering the small intestine. Occasionally, drops are seen later than the first few hours after the body temperature logger was ingested. These later dips were usually much less than the early 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. This raised temperature was at times sustained during certain 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 indicates that they can 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.

Tennesenn et al. (1984) observed an average rise of 0.9°F in rectal temperature of steers transported for a two-hour session. They concluded this and other statistically detectable variations in physiological measures to be slight, indicating a relatively stress free response to transit. The researchers noted that transportation with familiar pen-mates and other efforts to minimize stress during transport had a large impact on this result. Friend et al. (1998) attempted to characterize physiological parameters of horses during relatively long transit distances under hot conditions with a maximum of 95.0°F and found body temperature to be a useful indicator. Of 20 horses that were transported for 24 h with limited access to water, one animal that received water every five hours recorded an elevated rectal temperature of 105.1°F while another horse not provided water had a slight fever of 103.3°F. These temperatures are 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 temperature increase with moderate exercise (Friend, unpublished data). However, the decision was made not to transport these animals further based on the rise in body temperature and a visual evaluation of the animal.

In comparison, the highest body temperature recorded during our survey was only 0.9°F above the normal body temperature range in an elephant (Mary) in 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 particular 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 as seen by Friend et al. (1998). The relatively small increases seen in the present study suggest that transport during extreme temperatures 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.

Due to the loggers' accuracy range of ±1.8°F, the body temperature loggers may not have been reporting the true body temperature at that time. As noted earlier, reports of body temperature ranges vary widely in reported literature, particularly in terms of a lower value. However, for the purpose of detecting effective thermoregulation, our primary interest, the occurrence of fluctuations in body temperature for a particular elephants is more important than achieving an overall accurate temperature. Based on the manufacturer's reported precision (± 0.9°F) and our own tests, we feel that body temperature fluctuations in this study were detected with confidence.

Direct and video observations provide a second important parameter to indicate an animal's internal state. As described in Friend et al. (1991), the performance of certain abnormal and normal behaviors can be used to suggest the status of the animal's welfare. The stereotypic behavior of weaving, considered an abnormal behavior, was observed in several elephants during transit. However, a definitive conclusion regarding their cause is difficult given the speculation for the underlying reasons behind stereotypic behavior. Normal behaviors, i.e. eating and exploration, were also displayed at the same time as the abnormal behaviors, further impeding conclusions.

Stereotypic behavior has several potential functions that serve the animal exhibiting them. The behaviors may function to help animals cope with little or no variation in their environment by increasing physical and sensory stimulation (Friend and Dellmeier, 1986; Friend, 1991). They may also serve as a replacement for species-specific behaviors, such as foraging, which cannot be performed under the current given environment (Gruber et al., 2000). In both these cases, stereotypic behavior may help the animal deal with situations it finds as "boring". Stereotypic behavior has also been shown to serve as a release of tension or anxiety (Dantzer and Mormede, 1983). Despite the prevalence of stereotypic behavior in restrictive agricultural environments, no published research exists reporting occurrences of the behavior in transported livestock. This observation suggests that the causes of weaving in elephants during travel might be different from the causes that are seen in agriculture, i.e., a poor environment.

Weaving in elephants has been shown to reflect the occurrence of arousal in response to a positive event. Friend (1999) reported weaving in circus elephants to significantly increase immediately before receiving water and hay. The behavior may have been a means of releasing excitement in response to the prospect of the respective stimuli. Weaving in this circumstance should not be interpreted as an indication of a poor environment because watering and performing are not events that would be considered stressful stimuli. Benedict (1936) observed that elephants tended to begin weaving when excited, though did not explain his rational or observations.

Cronin et al (1986) suggested a neurological basis for the cause of stereotypic behavior for animals in an impoverished environment and reported the release of endorphins, an endogenous hormone with effects similar to morphine with the occurrence of stereotypic behavior. In his study, tethered sows reduced or eliminated the stereotypic behavior when an opiate antagonist was administered to prevent the binding of endorphins. Hence, the performance of stereotypic behavior may not reflect problems with the present environment.

The performance of stereotypic behavior in impoverished environments has been shown to lower cortisol concentrations (Dantzer and Mormede, 1981) and reduce the effects of a low stimulus environment on the health of the animals in it (Wiepkema et al., 1987). Thus, though the environments where the behavior is being performed may be inadequate, stereotypic behavior may help to reduce the impact of those inadequacies and eliminate a state of compromised welfare. In circumstances where stereotypies are indicative of a positive stimulus, the behavior may be a release of excitement or anticipation in response to the stimulus. In both circumstances of negative and positive environments, the performance of stereotypic behavior, barring that the behaviors do not cause secondary problems, i.e., foot injuries from excessive pacing, does not indicate a state of compromised welfare.

During this study, weaving was observed in both short and long trips during direct and video observations. All observed animals, whether weavers or not, exhibited some or all of the general normal behaviors described in Friend (1991) including grooming and self-maintenance, exploratory behavior, regular eating, and participation in herd behaviors. For instance, as an example of a maintenance behavior seen in transit, elephants would typically throw hay on their backs. This behavior was also commonly seen during non-transport times in the animal compounds. During travel, elephants would also use their trunk to explore the walls of the train in the area that they were held. During trips in which the elephants were fed and watered, the animals were observed to readily eat and drink, suggesting they maintained a feeling of security.

These results make interpretation of elephants' behavior during transport complicated. The performance of normal behaviors suggests the animal is not afraid or insecure in the transport environment. During short trips where weaving was exhibited, the brief period of several hours the animals were in the restricted transport environment contrasts the long-term impoverished conditions in agriculture which are related to stereotypic behavior. During longer trips where the restricted environment was imposed for a longer period of time, the observed stereotypic behavior was likely related to a barren environment. The animals still maintained elements of a normal behavior routine in addition to stereotypic behavior. Lastly, the proposed release of endorphins in response to weaving may have an addictive quality causing the animal to weave despite the removal of the stressor, i.e., transport before the animal had adapted. Thus, though stereotypic behavior often implies negative connotations, the incidence of stereotypic behavior in transported elephants does not indicate a state of compromised welfare.

Plasma cortisol concentrations were the third parameter examined to provide an indication of the animals' internal state. Significant differences between cortisol concentrations in response to treatments are typically used in stress research to indicate a perceived stress to the treatment or stressor (Dantzer and Mormede, 1983). Conclusions of this nature must be carefully made and take into account several details.

Heightened cortisol concentrations do not invariably indicate compromised welfare. The hypothalamic pituitary adrenal axis is an evolved system that aids the animal in coping with stressors and other changes to its environment. Activation of this axis is not necessarily synonymous with a harmful stimulus being applied to the animal (Moberg, 1987). The activation of the adrenal cortex functions in an effort to allow the animal to cope with the stressor before a state of compromised welfare is reached. Thus, though fluctuations in cortisol can prove an accurate indicator of compromised welfare, the connection between altered cortisol concentrations and reduced welfare must first be established (Moberg, 1987). Otherwise, false conclusions regarding the impact of stimuli on welfare are possible.

Mendl (1991) theorized whether a definitive point existed at which cortisol concentrations compromised welfare when that point was surpassed. He suggests that such a point does exist if the criterion used in establishing that point is grounded in reliable evidence, such as the animal's reproductive fitness or other long term indicators of health. Moberg (1987) advised a similar examination of long-term measurements of welfare and suggested evidence of compromised immune function as a viable possibility to indicate compromised welfare.

Additionally, although cortisol generally increases with the onset of a negative stimulus, evidence in this study from blood collected during application of a positive stimulus (free time in an exercise pen) suggests that cortisol may rise in situations perceived as exciting or enjoyable. Researchers can use cortisol as an accurate indicator of compromised welfare only when these guidelines and considerations are taken into account.

The results of the present study found a trend towards increasing cortisol concentrations immediately before transport and after. Significant differences between two sets of sample times were detected during Carson and Barnes's trip from Williamstown, NJ, to Chester, NJ (Figure 23) with increases of 190% and 160% between samples one and two and one and three, respectively. Though not significant, the mean difference for the final collection during long trip transport for Ringling Blue was 274% greater than the control value.

Fluctuations of cortisol concentrations in response to transport have varied widely in published research. Kenny and Tarrant (1987) found a 1010% increase in plasma cortisol in young bulls in response to being transported for one hour. During transport, significant increases in pushing and headbutting, principal causes of bruising, was observed as well. Kent and Ewbanks (1983) transported calves for 6 hours and determined serum cortisol had risen over 695% after two hours of transit. The relatively large increases in cortisol were likely related to the animal's youth and lack of transport experience. In comparison, during the short trips surveyed of Carson and Barnes in the present study where trip duration was typically two to three hours, the largest increase during transport was 190% and occurred prior to loading.

Much smaller increases in cortisol fluctuations have been reported in transported livestock though the lower concentrations are most likely a result of the samples being taken 12 or more hours after the start of transport. Using this method of sampling later in the transport session, any elevations in cortisol that occurred in response to the first hours of transit would have cleared the blood by the time of the first sample. Also, the initial drain of cortisol during the beginning of transport may have depleted the animal's storage of cortisol, an effect termed exhaustion (Selye, 1973). The first few hours of transport is considered the most stressful period of transport as a whole in unacclimated animals (Tarrant, 1990). Thus, studies that base their conclusions in regards to cortisol concentrations on data collected during the latter part or at the conclusion of transport may be overlooking the most critical segment of travel and serve as poor comparisons for the present study. If accurate comparisons are to be made between transport, the length of the trip and the periods between sampling must be taken into account. For instance, Knowles et al. (1999) reported a 32% increase in plasma cortisol over a 31 h transport session of cattle. The first sample was taken after 14 h and showed an increase of 13% from the initial sample. Tarrant et al. (1992) reported a 46% increase in plasma cortisol concentrations of cattle transported for 24 h, though only two samples were taken, before and after travel.

Though not in response to travel, Dathe et al. (1992) reported an increase of 295% in an Asian elephant over a period of two days after introduction of the animal to an unfamiliar captive herd, an increase larger than any of the fluctuations that occurred in the present study.

Under alternative conditions, i.e. long term intensive confinement, the incidence of weaving and statistically significant elevated cortisol concentrations might be interpreted as indications of stress during transport. However, as discussed above, interpretations regarding the results of these tests must be considered carefully. The performance of weaving observed prior to watering and performances as reported in Friend (1999) suggests that the animals are aroused or stimulated by travel during short trips where confinement in the truck is limited to several hours. Similarly, though raised cortisol concentrations were observed, the lack of a precise cut off point makes interpretation difficult, particularly when the occurrence of much larger increases in comparative agriculture research and stress research in elephants is considered. Furthermore, the highest cortisol concentrations measured in this study occurred during the last two sample periods of the short trip control collection when the elephants were not transported. This observation suggests that the event of not being transported, or a break in the routine the circus elephants had become accustomed to, may have imposed more stress than being transported. Dantzer et al. (1980) reported a parallel finding when swine, trained to expect a routine food reward, no longer received the reward. Lastly, due to lack of accurate controls, we were unable to control for any effects imposed by diurnal rhythms.

Considering the ambiguity of the results for cortisol and behavior analysis, examination of long term indicators of fitness can provide important information regarding impacts on welfare (Moberg, 1987; Mendl, 1991) and the perception animals have to transport. Theoretically, if transportation were a significant stressor, reproductive fitness and the overall health of the animals would be severely affected considering the extensive travel done by circus elephants. However reproductive successes in the circus industry are considerably high, surpassing zoological parks in the percentage of young surviving their first year (Keele, 2000).

As additional evidence suggesting transport is not an inherently significant stressor to circus elephants, nearly all of the factors considered to negatively affect transported livestock were not present in the surveys of circus elephants made in this study. Moderate temperatures were seen throughout transport and the mixing of unfamiliar animals did not occur. Due to short trip duration, animals were not restricted from feed and water for extended periods of time, did not spend extensive times standing, were not exposed to noxious gases, and did not have to maintain their balance on wet, slippery floors. During longer trips, feed and water were provided at regular intervals and urine and feces were removed efficiently, eliminating problems associated with noxious gases or slippery floors. Animal density was low enough to allow animals to lie down and rest during longer trips with one exception, though elephants are able to sleep while standing (Benedict, 1936; Tobler, 1992) and thus were most likely not very affected in this case. Loading of animals, generally considered the most stressful event in livestock, seemed rather stress free during observations of elephant loading. With Clyde Beatty's elephants, the animals perform the entire loading process by themselves, running to and entering the trailers after a release command from the trainer.

Additionally, transport can occur essentially without stress if efforts are made to minimize stressors during transport (Tennesen et al., 1984) and animals are acclimated to the events which cannot be altered (Tarrant, 1992). The regular transport schedule that circus elephants undergo throughout the year, the willingness to load, and the occurrence of natural behaviors such as eating, drinking, and self and mutual grooming during transport suggest that the animals have become acclimated to the rigors of transport.

Conclusions

The results of this research do not indicate that transportation of circus elephants is inherently stressful. The lack of any evidence of hyper or hypothermia during travel, the absence of factors known to be stress-inducing in livestock transport, the comparative high reproductive successes of circus elephants, and the appearance that circus elephants are acclimated to transport indicate that the response of elephants to transport is minimal for the subjects in this study and not a detractor of animal welfare.

Literature Cited

AAZK. 1992. Biological Values for Selected Mammals. 3rd ed. American Association of Zoological Zookeepers, Topeka, KS.

Adams, D.B. 1994. Transportation of animals and welfare. Rev. Sci. Tech. 13:153-169.

Altevogt, R. 1990. Proboscideans. In: S. Parker (ed.) Grzimek's Encylcopedia of Mamamls. Vol.4, p 472. McGraw Hill Publishing Co., New York, NY.

Alvarez, M.B., and H.D. Johnson. 1973. Environmental heat exposure on cattle plasma catecholamine and glucocorticoids. J. Dairy Sci. 56:189-194.

Anderson, B.E. 1984. Temperature regulation and environmental physiology. In: M. Swenson (ed.) Dukes' Physiology of Domestic Animals. 10th ed. p 720. Cornell University Press, Ithaca, NY.

Arnone, M. and R. Dantzer. 1980. Does frustration induce aggression in pigs? Appl. Anim. Etho. 6:351-362.

Augustini, C. and K. Fischer. 1982. Physiological reaction of slaughter animals during transportation. In: Transport of Animals Intended for Breeding, Production, and Slaughter, Maritinus Nijhoff Pulishers, Brussels, Belgium. p 125.

Autocad for Windows LT 97. 1995. Autodesk Student Portfolio, New Milford, CT.

Baker, C.J., Dalley, S., Yang, A., Kettlewell, P., and R. Hoxey. 1996. An investigation of the aerodynamic and ventilation characteristics of poultry transport vehicles: Part 2, wind tunnel experiments. J. Agric. Engng. Res., 65:97-113.

Becker, B.A., Nienaber, J.A., Christenson, R.K., Manak, R.C., DeShazer, J.A., and G.L. Hahn. 1985. Peripheral concentrations of cortisol as an indicator of stress in the pig. Am. J. Vet. Res. 45:1034-1038.

Benedict, F.G. 1931. The Physiology of the Elephant. Carnegie Institute of Washington, New York, NY.

Blatchford, D., Holzbauer, M., Ingram, D.L., and D.F. Sharman. 1978. Responses of the pituitary-adrenal system of the pig to environmental changes and drugs. Brit. J. Pharmacology. 62: 241-54.

Bligh, J. 1973. Temperature Regulation in Mammals and Other Vertebrates. 1st ed. American Elsevier Publishing Company, New York, N Y.

Broom, D.M. 1986. Indicators of poor welfare. Br. Vet. J. 142:524-525.

Brown, S.N., Knowles, T.G., Edwards, J.E., and P.D. Warriss. 1999. Behavioral and physiological responses of pigs being transported for up to 24 hours followed by six hours recovery in lairage. Vet. Rec. 145: 421-426.

CDC. 2001. Centers for Disease Control, National Institute for Occupational Safety and Health (NIOSH). Available at: http://www.cdc.gov/niosh/npg/pgdstart.html#english. Accessed May 13, 2000.

Clark, D.K., Friend, T.H., and G. Dellmeier. 1993. The effect of orientation during trailer transport on heart rate, cortisol. and balance of in horses. Appl. Anim. Behav. Sci. 38:179-189.

Cockram, M.S., Kent, J.E., Waran, N.K., and P.J. Goddard. 1996. Effects of journey length. space allowance during transport, and lairage during and after road transport on the behavior of sheep. In: Proc. of the 30th Intl. Congress of the Intl. Soc. for Appl. Ethology. Ontario. Canada. p 82-94.

Collins, M.N.. Friend, T.H., Jousan, F.D., and S.C. Chen. 2000. Effects of density on displacement, falls, injuries, and orientation during horse transportation. Appl. Anim. Behav. Sci. 67: 169-179.

Craig, J.V. 1986. Measuring social behavior: Social dominance. J Anim Sci. 62:1120-1129.

Cregier, S.E. 1982. Reducing equine hauling stress: A review. J Equine Vet. Sci. 2:187-198.

Cronin, G.M.. Wiepkema, P.R., and J.M. van Ree. 1986. Endorphins implicated in stereotypies of tethered sows. Experientia. 42:198-199.

Crookshank. H.R., Elissalde, M.H., White, R.G., Clanton, D.C., and H.E. Smalley. 1979. Effect of transportation and handling of calves upon blood serum composition. J. Anim. Sci. 48:430-435.

Dantzer, R. 1986. Behavioral, physiological and functional aspects of stereotyped behavior: a review and a reinterpretation. J. Anim. Sci. 62:1776-1786.

Dantzer, R., and P. Mormede. 1981. Pituitary-adrenal consequences of adjunctive activities in pigs. Horm. Behav. 15:386-395.

Dantzer, R., and P. Mormede. 1983. Stress in farm animals: a need for reevaluation. J. Anim. Sci. 57:6-18.

Dantzer, R., Arnone, M., and P. Mormede. 1980. Effects of frustration on behavior and plasma corticosteroid levels in pigs. Physiol. Behav. 24:1-4.

Dathe, H.H., Kuckelkorn, B., and Dieter Minnemann. 1992. Salivary cortisol assessment for stress detection in the Asian Elephant (*Elephas maximus*): A pilot study. Zoo Biol. 11:285-289.

Duncan, I.J.H. 1981. Animal rights – animal welfare: A scientist's assessment. Poult. Sci. 60: 489–499.

Eicher, SD. 2000. Transportation of cattle in the dairy industry: Current research and future directions. In: Proc. of 2000 Am. Dairy Sci. Assoc. & Am. Soc. of Anim. Sci. Joint An. Meeting, July 24-28. Baltimore,MD. p 2.

Eldridge G.A. and C.G. Winfield. 1988a. Responses of cattle to different space allowances, pen sizes, and road conditions during transport. Aust. J. Exp. Agric. 28:155-159.

Eldridge G.A. and C.G. Winfield. 1988b. The behavior and bruising of cattle during transport at different space allowances. Aust. J. Exp. Agric. 28:695-8.

Friend, T.H. 1991. Behavioral aspects of stress. J. Dairy Sci. 74:292-303.

Friend, T.H. 1999. Behavior of picketed circus elephants. Appl. Anim. Behav. Sci. 62:73-88.

Friend, T.H. 2000. Dehydration, stress, and water consumption of horses during long-distance commercial transport. J. Anim. Sci. 78:2568-2580.

Friend, T.H. and G.R. Dellmeier. 1986. Recent developments in stress research. The Professional Animal Scientist. 2:1-6.

Friend, T.H., Martin, T.M., Householder, D.D., and D.M. Bushong. 1998. Stress response of horses during a long period of transport in a commmercial truck. J. Am. Vet. Med. Assoc. 212: 838-44.

Grandin, T. 1997. Assessment of stress during handling and transport. J. Anim. Sci. 75:249-257.

Grandin, T., McGee, K., and J.L.. Lanier. 1999. Prevalence of severe welfare problems in horses that arrive at slaughter plants. J. Am. Vet. Med. Assoc. 214:1531-1533.

Gruber, T.M.. Friend, T.H., Gardner, J.M., Packard, J.M., Beaver, B.M., and D. Bushong. 2000. Variation in stereotypic behavior related to restraint in circus elephants. Zoo Biol. 19:209-221.

Guyton, A.C. 1991. Textbook of Medical Physiology. 8th ed. W.B. Saunders Company, Philadelphia, PA.

Hahn, G.L. 1999. Dynamic responses of cattle to thermal heat loads. J. Anim. Sci. 77(Suppl. 2):11-20.

Hauk, D. Personal communication. Retired veterinarian, Tampa, FL. May 8, 2001.

Hoffman, D.E., Spire, M.F., Schwenke, J.R., and J.A. Unruh. 1998. Effect of source cattle and distance transported to a commercial slaughter facility on carcass bruises in mature beef cows. J. Am. Vet. Med. Assoc. 212:668-672.

Hoxey, R.P. Kettlewell, P.J., Meethan, A.M., Baker, C.J., and X. Yang. 1996. An investigation of the aerodynamic and ventilation characteristics of poultry transport vehicles: Part 1, full-scale measurements. J. Agric. Engng. Res. 65:77-83.

Jones, J.B., Wathes, C.M., and A.J.F. Webster. 1997. Behavioral responses of pigs to atmospheric ammonia. In: Proceedings of the Fifth International Symposium on Livestock Environment, Bloomington, MN. p 875-882.

Keele, M. 2000. Asian Elephant (*Elephs maximus)* North American Regional Studbook. American Zoo and Aquarium Association, Silver Spring, MD.

Keele, M. Personal communication. Elephant keeper, Portland, OR. May 9, 2001.

Kenny, F.J., and P.V. Tarrant. 1987. The reaction of young bulls to short-haul road transport. Appl. Anim. Behav. Sci. 17: 209-227.

Kent, J.E., and R. Ewbanks. 1983. The effect of road transportation on the blood constituents and behavior of calves. I. Six months old. Br. Vet. J. 139:228-235.

Kettlewell, P.J., Hoxey, R.P., and M.A. Mitchell. 2000. Heat produced by broiler chickens in a commercial transport vehicle. J. Agric. Engng. Res. 75:315-26.

Kilgour, R. and C. Dalton. 1984. Livestock and Behavior. p 181. Westview Press, Boulder, CO.

Knowles, T.G. 1998. A review of the road transport of slaughter sheep. Vet. Rec. 143:212-219.

Knowles, T.G., Brown, S.N., Warriss, P.D., Phillips, A.J., Dolan, S.K., Hunt P., Ford, J.E., Edwards, J.E., and P.E. Watkins. 1995. Effects on sheep of transport by road for up to 24 hours. Vet. Rec. 136:431-438.

Knowles, T.G., Warriss, P.D., Brown, S.N., and J.E. Edwards. 1998. Effect of stocking density on lambs being transported by road. Vet. Rec. 142: 503-509.

Knowles, T.G., Warriss, P.D., Brown, S.N., and J.E. Edwards. 1999. Effects on cattle of transportation by road for up to 31 hours. Vet. Rec. 145:557-582.

Knowles, T.G., Warriss, P.D., Brown, S.N., Kestin, S.C., Edwards, J.E., Perry, A.M., Watkins, P.E., and A.J. Philips. 1996. Effects of feeding, watering, and resting intervals on lambs transported by road and ferry to France. Vet. Rec. 139:335-339.

Lambooy, E. and B. Engel. 1991. Transport of slaughter pigs by truck over a long distance: some aspects of loading density and ventilation. Livest. Prod. Sci. 28:163-174.

Lambooy, E., Hel, W. van der, Hulsegge, B., and H.A. Brandsma. 1981. Effect of environmental temperature and air velocity two days pre-slaughtering on heat production, weight loss, and meat quality in non-fed pigs. In: Energy Metabolism in

Farm Animals: Effects of Housing, Stress and Disease (ed. Verstegen, M.W.A., and Henken, A.M.). Dordrecht, The Netherlands. p 164.

Lay, D.C., Friend, T.H., Bowers, C.L., Grissom, K.K., and O.C. Jenkins. 1992. A comparative physiological and behavioral study of freeze and hot-iron branding using dairy cows. J. Anim. Sci. 71:1121-1125.

Lay, D.C. Jr., Friend, T.H., Randel R.D., Jenkins, O.C., Neuendorff, D.A., Kapp, G.M., and D.M. Bushong. 1996. Adrenocorticotropic hormone dose response and some physiological effects of transportation on pregnant Brahman cattle. J Anim Sci. 74:1806-1811.

Mason, J.W. 1971. A re-evaluation of the concept of 'non-specificity' in stress theory. J. Psychiat. Res. 8:323-333.

Mason, G.J. 1993. Forms of stereotypic behavior. In: Stereotypic Animal Behavior: Fundamentals and Applications to Welfare (ed. Lawrence, A.B., and Rushen, J.) CAB International, Wallingford, Oxon, UK.

Mendl, M. 1991. Some problems with the concept of a cut-off point for determining when an animal's welfare is at risk. Appl. Anim. Behav. Sci. 31:139-146.

Moberg, G.P. 1987. Problems in defining stress and distress in animals . J. Am. Vet. Med. Assoc. 191:1207-11.

Mitchell, M.A. and P.J. Kettlewell. 1998. Physiological stress and welfare of broiler chickens in transit: solutions not problems! Poult Sci. 77:1803-1814.

NOAA. 2001. National Oceanographic and Atmospheric Administration virtual data systems. Available at: http://nndc.noaa.gov.

Norris, D.O. 1980. Vertebrate Endocrinology. 3rd ed. Academic Press, New York, NY.

Ottoni, E.B. 2000. EthoLog 2.2: A tool for the transcription and timing of behavior observation sessions. Behav. Res. Methods Instrum. Comput. 32: 446-449.

Randall, J.M. 1993. Environmental parameters necessary to define comfort for pigs, cattle, and sheep in livestock transporters. Anim. Prod. Sci. 57:299-307.

SAS. 1999. SAS User's Guide: Statistics (Version 8.01 Ed.). SAS Inst. Inc., Cary, NC.

Schmid, J. 1995. Keeping circus elephants temporarily in paddocks – the effects on behavior. Anim. Welfare. 4:87-101.

Schmidt, M. Personal Communication. ERGO, Portland, OR. November 3, 2000.

Schrama, J.W., van der Hel, W., Gorssen, J., Henken, A.M., Verstegen, M.W.A., and J.P.T.M. Noordhuizen. 1996. Vet. Quart. 18:90-5.

Selye, H. 1936. A syndrome produced by diverse nocous agents. Nature. 138:32.

Selye, H. 1973. The evolution of the stress concept. Am. Sci. 61:692-9.

Stull, C.L., and A.V. Rodiek. 2000. Physiological responses of horses to 24 hours of transportation using a commercial van during summer conditions. J. Anim. Sci. 78:1458-1466.

Swanson, J.C. and Morrow-Tesch, J. 2000. Cattle transport: Historical and future perspectives. In: Proc. of 2000 Am. Dairy Sci. Assoc. & Am. Soc. of Anim. Sci. Joint An. Meeting, July 24-28. Baltimore,MD. p 2.

Sukumar, R. 1989. The Asian Elephant: Ecology and Management. Cambridge University Press, New York NY.

Tarrant, P.V. 1990. Transportation of cattle by road. Appl. Anim. Behav. Sci. 28:153-170.

Tarrant, P. V., and T. Grandin. 1993. Cattle Transport. In: T. Grandin (ed.) Livestock Handling and Transport. p 109-116. Cab International, Wallingford, UK.

Tarrant, P.V., Kenny, F.J., Harrington, D., and M. Murphy. 1992. Long distance transportation of steers to slaughter: effect of stocking density on physiology, behavior, and carcass quality. Livest. Prod. Sci. 30:223-238.

Tennessen, T., Price, M.A. and R.T. Berg. 1984. Comparative responses of bulls and steers to transportation. Can. J. Anim. Sci. 64:333-338.

Tobler, I. 1992. Behavioral sleep in the Asian Elephant in captivity. Sleep. 15:1-12.

Trunkfield, H.R., and D.M. Broom. 1990. The welfare of calves during handling and transport. Appl. Anim. Behav. Sci. 28:135-152.

Urbain, B., Gustin, P., Provost, J.F., and M. Ansay. 1994. Quantitative Assessment of aerial ammnonia toxicity to the nasal mucosa by use of nasal lavage method in pigs. Am. J. Vet. Res. 55:1335-1340.

Waran, N.K., and D. Cuddeford. 1995. Effects of loading and transport on the heart rate and behavior of horses. Appl. Anim. Behav. Sci. 43:71-81.

Warriss, P.D. 1998. Choosing appropriate space allowances for slaughter pigs transported by road: a review. Vet. Rec. 142:449-454.

Wiepkema, P.R., Van Hellemond, K.K., Roessingh, P., and H. Romberg. 1987. Behavioral and abomasal damage in individual veal calves. Appl. Anim. Ethol. 18:257-267.

Zanella, A. J. 2000. Swine transportation: a critical review. In: Proc. of 2000 Am. Dairy Sci. Assoc. & Am. Soc. of Anim. Sci. Joint An. Meeting, July 24-28. Baltimore,MD. p 3.