AN ABSTRACT OF THE THESIS OF

Camie L. Meller for the degree of Master of Science in Animal Sciences presented on August 16, 2004.
Title: The Effect of Rubberized Flooring on Asian Elephant Behavior in Captivity

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Candace C. Croney

An experiment was designed to determine the effects of a poured rubber flooring substrate on the behavior of captive Asian elephants. Additionally, room utilization was evaluated in a series of seven rooms used for indoor housing. These seven rooms were divided into two observation areas, the Front observation area which consisted of three rooms, the viewing room, the middle room and the dead-end room, and the Back observation area which consisted of four rooms, labeled room 1, 2, 3 and 4.

Three separate phases of the study were conducted. Phase I ("Baseline Phase") consisted of examining elephant behavior on old concrete floors, except for the viewing room in the Front observation area, which had old rubberized flooring.

Phase II ("Choice Phase"), was conducted only in the Back observation area and consisted of observing elephant behavior when a choice of two flooring substrates was available. New rubberized flooring was installed in rooms 1 and 4 and rooms 2 and 3 remained concrete. Phase III ("Final Phase") of the study,

consisted of observing elephant behavior when all rooms in both observation areas, Front and Back, were poured with new rubberized flooring.

Subjects for this study were six elephants at the Oregon Zoo who were observed using closed-circuit, real-time video cameras during the hours of 11:00 to 14:00 and 18:00 to 06:00 for a total of fifteen hours per observation day. Three observation days were recorded for each phase of the study in each of two observation areas. Observed behaviors were assigned single letter or single number codes. Video-recorded behaviors were reviewed and coded. Focal point sampling (observing one individual's behavior for a specified amount of time at specific points in time) was conducted on each of the six subjects. Five continuous minutes of behavior as well as room location were recorded for each individual subject on the hour and on the half hour of each fifteen-hour observation day.

Room use in both of the observation areas remained relatively stable throughout the course of the study suggesting that flooring substrate did not affect room use choice. However, differences in behavior on the two flooring substrates, suggests that the rubber flooring may have provided a more comfortable surface to perform locomotion as well as standing resting behavior. There was a clear pattern of decreased discomfort behavior on the new rubber flooring. Both normal locomotion, as well as stereotypic locomotion increased on the new rubber flooring. In addition, resting behavior changed to more closely reflect the resting behavior of wild elephants, who typically sleep standing up and spend very little time in lateral recumbence (McKay, 1973). These results suggest that the new rubberized flooring may have provided a more comfortable surface for locomotion behavior as well as standing resting behavior and may be a beneficial addition to other animal facilities.

The Effect of Rubberized Flooring on Asian Elephant Behavior in Captivity

by
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Chapter 1: INTRODUCTION

Humans and elephants share a long history of association. Asian elephants have been captured, tamed and trained as beasts of burden in Asia for thousands of years (Hart, 1994; Sukumar *et al.*, 1997; Clutton-Brock, 1999). African elephants were used historically for military purposes (Iversen, 1995) and have been hunted for years for their ivory tusks (Sukumar, 1989; Kemf & Santiapillai, 2000). Both Asian and African elephants were used for entertainment in ancient times in brutal amphitheater fights (Groning & Saller, 1998; Clutton-Brock, 1999). Conversely, elephants have also been the object of religious adoration in both the present and the past (Groning & Saller, 1998). Today, elephants are used in logging camps, religious ceremonies and for wildlife tourism in Asia as well as being kept in zoos and circuses all over the world (Krishnamurthy & Wemmer, 1995).

Recently, captive elephant management has become one of the most hotly debated issues in the international zoo community (Clubb & Mason, 2002; Csuti, 2001). Elephants are a notoriously difficult species to maintain in captivity and their care and management raise many controversial issues related to their welfare (Adams, 1981; Kurt & Hartl, 1995; Schwammer & Karapanou, 1997). The focus of this study is the issue of poor foot health in captive elephants and in particular the impact that flooring substrate can have upon it. While the long-term effects of softer, more yielding flooring substrates may not be determined for many years, the immediate effects on behavior can be evaluated at this time and are the focus of this study.

Chapter 2: LITERATURE REVIEW

2.1 The Role of Zoos in Asian Elephant Conservation

Wild populations of both Asian and African elephants are critically endangered. Estimates suggest that more than 100,000 Asian elephants may have existed at the beginning of the twentieth century, ranging from the Tigris-Euphrates river systems in the west, to China in the east (WCMC and WWF-International, 2001b). Today, wild Asian elephants can only be found in small, isolated pockets throughout most of their range due to the loss and fragmentation of their habitat, poaching for their ivory and meat, and capture (often illegal) for domestication (Sukumar, 1989; Kemf & Santiapillai, 2000). Recent estimates from the IUCN/SSC Asian Elephant Specialist Group, suggest that there are between 34,000 to 50,000 wild Asian elephants living in 13 countries (Kemf & Santiapillai, 2000; WCMC and WWF-international, 2001b). In addition, there are approximately 16,000 Asian elephants that are believed to be under the care of humans in Asia, which would represent nearly 30% of the entire Asian elephant population (Sukumar, 1989).

There are 1713 captive elephants, both Asian and African, in intensive captive facilities world-wide (Clubb & Mason, 2002). Zoos account for the majority of these at 64.6% (Clubb & Mason, 2002). Zoos thus represent the largest portion of the facilities world-wide that are involved in elephant-keeping, and therefore their role in maintaining, managing and preserving the population should be examined.

In the last century the role of zoos has shifted from that of menagerie-collections to institutions of education and conservation. Today, any elephant keeping institution in the U.S. that is accredited by or affiliated with the American Zoological and Aquarium Association (AZA), must comply with recommendations set forth in the AZA Standards for Elephant Management and Care (2001). This plan mandates that every institution should institute an educational program for zoo visitors. In addition, all institutions governed by this plan are asked to contribute in some way to elephant research activities as well as *in situ* conservation of elephants and their habitats.

There are some potential benefits of keeping elephants in zoos. In contrast to their natural environments, zoos offer a constant food source, freedom from predation and poaching, and medical care. Maintaining elephants in captivity also allows for enhancement of our knowledge of elephant biology through research studies. For instance, the discovery of infrasonic communication was first revealed through studies of zoo elephants (Smith & Hutchins, 2000). New techniques for DNA extraction from faeces and ivory, the assessment of reproductive state from faecal hormone metabolites, novel methods for monitoring movement patterns, and innovative methods of contraception (Smith & Hutchinson, 2000) have all been brought about by zoo elephant research and are likely to aid in wild elephant conservation programs.

Another benefit of elephant keeping is that the presence of elephants in zoos may encourage public interest that can translate into conservation efforts (Olson, 1998). Elephants are said to be a "flagship species" due to the amount of public interest and support they generate (Sukumar *et al.*, 1997; Dorresteyn & Belterman, 1999). By concentrating on these so-called flagship species, many argue that public support for broader conservation efforts can be generated, hence protecting many other species that might otherwise be overlooked (Hutchins & Wemmer, 1991). Since visitors tend to spend longer in front of larger-bodied animals (Balmford, 2000), elephant exhibits may be important for generating this type of public interest in conservation.

However, despite these benefits, the merits of elephant keeping continue to be a hotly debated issue, primarily because many welfare issues are raised as a result of maintaining them in captivity. In order to evaluate whether the benefits of elephant keeping are outweighed by the potential harms, it is important to review what is known about welfare in context to captive wild animals in general, and to captive elephants in particular.

2.2 Welfare and Captive Wildlife

The term welfare, which is often used interchangeably with the term well-being (as is the case in this paper), can be described as "a state in which an animal is existing within a range of acceptable environmental specifications" (Ewing, Lay, & Von Borell, 1999). Hurnik *et al.* (1995) describes the term well-being as "a condition in which physical and psychological harmony exists between the organisms and its surroundings." In other words, welfare refers to a general state in which all of an organism's needs, both physical and psychological, are being met in its environment.

Captive environments can sometimes fall short of meeting an organism's needs. These needs can include but are not limited to, safe and sanitary living conditions, proper nutrition, freedom from injury and disease, medical attention when necessary, adequate space, proper social grouping if applicable, appropriate lighting, temperature and humidity, appropriate care and consideration during handling, and the ability to perform species-specific behavior.

Captivity can be detrimental to the health of wild animals for a number of reasons. For instance, illness in captive wildlife can be difficult to detect due to the adaptive nature of wild animals to avoid showing signs of illness in order to survive. This poses a challenge to animal caretakers to properly detect and diagnose serious illness successfully. Therefore, many captive animal programs have established preventative medicine programs that include quarantine, routine health monitoring and maintenance, nutrition, enclosure design, pest control, and sanitation (Hinshaw, Amand & Tinkelman, 1996).

Another problem with illness in captive wild animals is that diagnosis and treatment often require physical and chemical restraint, procedures that can be stressful to healthy animals and deleterious to sick or injured animals (Hinshaw, Amand & Tinkelman, 1996). Quarantine of newly arriving animals also poses the problem of social isolation, which can be a psychologically stressful event, (Hinshaw, Amand & Tinkelman, 1996). Many facilities, choose to place one or two conspecific individuals in quarantine with the newly arriving animal to provide companionship without risking the entire resident group (Hinshaw, Amand & Tinkelman, 1996).

Climate can also be a problem for captive wild animals if the captive environment differs significantly from that of the native environment. Some species are hardy and adapt relatively well, whereas others may not fare as well. In the latter case, animal facilities must create an artificial climate that is suitable for the well-being of the particular species.

Surplus animals can also pose a problem in captive wild animal facilities. Surplus animals, are defined by Graham (1996) as "individuals that do not contribute to the zoo's overall breeding management program." In natural ecosystems, breeding produces excess numbers of animals to ensure survival of the species. In captivity, with improved husbandry and without the threat of predation, starvation or natural catastrophe, survival can be much greater than in the wild. The carrying capacity of most zoos, however, remains limited and excess animals must be dealt with. Suitable options for placement include other accredited zoos, acceptable foreign zoos, and in some cases reintroduction to the wild (Graham, 1996). Generally unacceptable options for placement include the exotic pet trade, roadside "zoos," the fur trade, hunting preserves, and the entertainment industry (Graham, 1996). Euthanasia, though controversial, is another method of dealing with surplus animals, and is preferable to those options listed prior that offer no guarantee of humane treatment or adequate welfare (Graham, 1996).

Captivity can also have a huge impact on the behavior of wild animals. The conditions of captivity often do not mirror the environmental pressures and conditions of nature. In the wild, animals spend a great deal of time and energy involved in food acquisition behavior. With readily available and easily accessible food sources in captivity, the energy and time required to acquire food is greatly reduced. Many animals are highly motivated to perform appetitive behaviors such as foraging and hunting and without the proper stimuli they often begin performing stereotypic behavior. Stereotypic behavior is described as repetitive, invariant behavior that serves no goal or function (Odberg, 1978) and while it is common in captive species, it is rarely observed in the wild.

Other effects of captivity on the behavior of captive animals include changes in maternal behavior, reproductive behavior, learning capacity as well as genetic changes due to artificial selection, natural selection in captivity or relaxation of selection (Carlstead, 1996).

Elephants living in captivity face many of these welfare issues in addition to some that are specific to their species such as handling methods, chaining, and the lack of relatedness or stability within female social groups (Clubb & Mason, 2002, Csuti *et al.*, 2001). While all of these issues are noteworthy, foot health, is arguably the most wide-spread and serious welfare concern of captive elephants (Csuti *et al.*, 2001; Schmidt, 1986).

2.3 Welfare Issues related to Captive Elephant Foot Health

Fowler (2001) estimates that 50% of captive elephants will suffer from foot problems at some point in their life and that untreatable foot infections and arthritis are the major reasons for euthanization. The results of another report by Mikota *et al.* (1994) suggest that the incidence of foot problem may be even higher.

There are some reports of foot problems in wild elephants and elephants kept in extensive conditions such as timber camps, however, these are generally related to injuries such as cuts, snare wounds and fractures (Bengis *et al.*, 1991; Chandrasekharan *et al.*, 1995; Keet *et al.*, 1997; Fowler, 2001). Captive elephants on the other hand, suffer from a range of foot disorders and diseases. Abscessation of the sole or toenails, cracking of the sole or toenails, overgrowth of the cuticle, toenails or sole, foot rot and softening and degeneration of the sole and skin of the foot are just of few of the many serious ailments that can affect an elephant's foot. The causes of these problems are multiple and may be attributed to many different aspects of the captive environment (summarized by Clubb & Mason, 2002) and are detailed in the following sections.

2.3.1 Unhygienic Conditions

Captive elephants' feet are routinely exposed to their own urine and faeces, especially under conditions of confinement when they are unable to escape areas of contamination (Roocroft & Oosterhuis, 2001). These unhygienic conditions often cause skin irritations and ammonia burns and even more serious, are ideal for bacterial colonization which can lead to foot rot (Hughes & Southhard, 2001; Schmidt, 1986; Chandrasekharan *et al.*, 1995; Boardman *et al.*, 2001). Elephants in captivity are often seen throwing dirt or sand on their legs and feet to dry themselves (Hughes & Southhard, 2001). In the wild, elephants take daily trips to water holes for bathing which keep feet relatively clean (Roocroft & Oosterhuis, 2001). Many facilities try to substitute for this natural behavioral ritual by scrubbing feet and legs on a daily basis (Roocroft & Oosterhuis, 2001).

Efforts to minimize contact with excrement and excessive moisture have been shown to decrease the incidence of foot disease. Hughes & Southhard (2001) reported a decline in foot rot and abscesses when they stopped chaining at night and allowed the elephant to move to an area that was free from excrement. Moist and unhygienic conditions have also been implicated in foot disease and lameness in domesticated large animal species, such as dairy cattle (Wells *et al.*, 1995; Ward, 2001). Cattle that were housed in stalls designed to discourage them from defecating in the cubicle had a lower incidence of lameness (Ward, 2001).

2.3.2 Confinement

Chaining of elephants is common in the U.S. and Europe. Chaining permits routine maintenance such as foot care and washing, and is often used for indoor, overnight housing to prohibit aggression between herd members. Chaining involves placing a metal cuff around one or two ankles, usually a front and back ankle on opposite sides. The elephant can stand up and lie down. However, only a limited range of movement is typically allowed while chained. Elephants are the only zoo species managed this way, which raises concern for many reasons. Elephants chained for extended periods of time overnight are not able to escape the damp and unhygienic conditions that result from a build up of urine and faeces as discussed in the previous section and are said to experience a higher incidence of foot problems compared to those that are not restrained in this manner (e.g. Galloway, 1991; Roocroft & Oosterhuis, 2001). Chaining does not allow for exercise and the lack thereof can lead to obesity, arthritis and other joint problems, all of which have been associated with chaining (Kurt & Hartl, 1995). These will be discussed in a later section.

The question of whether or not chaining is even necessary is debatable. Brockett *et al.*, (1999) conducted a study on the nocturnal behavior of a group of unchained female African elephants. They collected data on activity budgets, social proximity and space utilization as well as all-occurrence data on social and non-social behaviors. They found that subjects spent half of their time within one body length of another animal and utilized all three available enclosures. Their findings suggested that the lack of restraints was an effective strategy for this elephant group. The high activity levels observed during many of the early evening hours suggested that zoos could permit increased activity and social interactions by extending the hours when elephants are unchained.

2.3.3 Climate

Climate can also have an effect on elephant foot health. Zoo elephants are often maintained in colder (and in the case of African elephants, wetter) conditions than those of their native environment (Clubb & Mason, 2002). Although wild elephants occasionally experience cold weather, they do not generally experience snow or ice. While elephants are commonly considered to be hardy animals, extremely cold weather conditions can prove fatal to them. Due to their large size, they require a long period of time to warm up once their body temperature has cooled (Poole & Taylor, 1999). Elephant facilities in more temperate climates are colder and wetter and have outdoor enclosures that are often muddy and wet. For this reason, zoo elephants in much colder climates are often confined indoors for up to 18 hours a day during the winter (Clubb & Mason, 2002). Indoor housing can increase their exposure to urine and faeces in damp and unhygienic conditions, which have been implicated in foot health. Although the effects of climate on captive elephant welfare have not been extensively studied, evidence from livestock research suggests climate may play a significant role in foot health. Cows, for instance, have a higher incidence of foot infection during the colder, wetter seasons (e.g. Huang *et al.*, 1995; Bergsten & Frank, 1996; Vaarst *et al.*, 1998; Rodriguez-Lainz *et al.*, 1999).

2.3.4 Inadequate or Improper Foot Care

Wild elephants are on their feet and active for 68 to 93% of their waking hours (McKay, 1973; Wyat & Eltringham, 1974; Sale *et al.*, 1992; Sivaganesan & Johnsingh, 1995). This constant movement naturally wears down the footpad and nails which grow continuously. Less movement correlates to less wear on the footpads and nails, which means that elephant care staff must trim the feet.

Regular foot care if improperly performed can be extremely detrimental to elephant foot health. Over-trimming of the footpad, which is a common problem, can cause pain when walking (Clubb & Mason, 2002). Excessive nail trimming can lead to weakening and cracking of the nail, which can then develop into an abscess (Clubb & Mason, 2002).

2.3.5 Lack of Exercise

Another welfare issue related to foot health is lack of exercise. The elephant's foot is remarkably adapted to support its tremendous weight. Each foot has an approximate slipper area of 16.4 cm^2, which equals a pressure of 0.91 kgf/cm^2. While bearing weight, the circumference of an elephant's foot increases six to ten centimeters. This compression and relaxation of the footpad serves as an important function in pumping venous blood from the foot back to the central venous system. Lack of exercise therefore, can have serious consequences on the foot health of an elephant (Fowler, 2001).

2.3.6 Excessive Body Weight

Lack of exercise can also lead to obesity. Zoo elephants are between 31 and 72% heavier than their native counterparts (Kurt & Kumarasinghe, 1998). This excess weight exerts additional pressure on the footpad and has been reported to worsen foot and joint problems (Hardjanti, 1997; Roocroft & Oosterhuis, 2001; Rutkowski *et al.*, 2001; Sadler, 2001; West, 2001). Studies on livestock species that also suffer from foot ailments such as dairy cattle have shown a positive correlation between weight and incidence of foot problems (e.g. Wells *et al.*, 1993; Vaarst *et al.*, 1998).

2.3.7 Inadequate Enclosure Space

Enclosure size can also have a profound effect on elephant foot health. Wild elephants roam over considerable distances each day, 1 to 7 km for family groups (Easa, 1992; Reimers *et al.*, 2001) and 1 to 28 km for solitary males (Sale *et al.*, 1992; Reimers *et al.*, 2001; Douglas-Hamilton, 1998). This daily travel, searching for food and water, and engaging in social activity, wears down the pads and nails of their feet (Douglas-Hamilton, 1998; Easa, 1992; Nowak, 1995; Reimers *et al.*, 2001; Sale *et al.*, 1992; Wyat & Eltringham, 1974). With less space for available travel, captive elephants are far less active than their native counterparts. In addition, the availability of resources nearby does not require travel over significant distances. Therefore, captive elephants have no incentive to exercise. As discussed earlier, lack of exercise can lead to obesity and inadequate foot and nail wear, both of which have been implicated as causal agents in the development of foot problems in captive elephants.

2.3.8 Stereotypic Behavior

Stereotypic behavior may intensify foot problems in captive elephants. Stereotypic behavior is defined as repetitive, unvarying behavior with no obvious goal or function (Keiper, 1969; Odberg, 1978; Mason, 1991a & 1991b). Many zoo elephants perform stereotypic behaviors such as weaving or swaying. This type of movement does not wear down the footpad and nails naturally, but rather exerts abnormal pressure on the lateral toes of the front feet and can cause nail cracks (Roocroft & Oosterhuis, 2001). In addition more serious problems such as abscesses may develop due to the disruption of the blood supply to the feet, which may then become infected if they rupture (Boardman *et al.*, 2001; Roocroft & Oosterhuis 2001).

2.3.9 Joint Problems

Joint problems also contribute to foot problems in captive elephants. While joint problems alone constitute a significant health problem, they may also contribute to the development of abnormal gaits and even lameness, which in turn can affect the development of foot problems (Roocroft & Oosterhuis, 2001).

2.3.10 Diet

Diet is also thought to affect the development of foot ailments in captive elephants. Malnutrition, or poor assimilation of nutrients can cause slow nail and pad growth, brittle nails, excessively thin footpads and soft nails (Buckley, 2001). The vitamin biotin (a B-complex vitamin) is given as a supplement by many zoos in hopes of improving foot health (e.g. Sampson, 2001; Seidon 2001). No formal studies have ever been conducted to determine whether or not captive elephants are actually deficient in this nutrient, as levels in wild elephant populations have never been measured nor have trials been done on captive elephants to assess the effectiveness of supplements. A study on horses however, suggests that biotin supplements may be an effective strategy. Sadler (2001) reported a significant increase in hoof strength and a reduction in cracking after eight to fifteen months of oral biotin supplements. In addition, a reversal was reported in most cases once the supplements were ceased. Several other trace elements have been implicated in foot health, such as zinc, selenium, and arsenic, though formal studies have not been carried out to establish their efficacy (Clubb & Mason, 2002).

2.3.11 Stress

It is widely known that chronic stress, both physical and psychological, can cause immunosuppression by reducing the efficacy of antibody responses and cell-mediated immunity (e.g. Broom, 1991; Wiepkema, 1993; Toates, 1995; Schedlowski & Schmidt, 1996; Tuchscherer & Manteuffel, 2000). Stress may play a role in foot health by increasing susceptibility to disease (e.g. Broom, 1991; Dorskind & Horseman, 2001) and decreasing immune function to fight off developing foot infections.

2.3.12 Flooring Substrate

The extent to which each of the previously discussed factors contributes to the development of foot problems in captive elephants is yet to be determined. Prolonged periods of contact with concrete flooring have been implicated by zookeepers, veterinarians and curators as one of the primary causal agents of elephant foot problems (Csuti, 2001). Ninety-one percent of North American zoos have concrete flooring (Dimeo-Ediger, 2001), presumably for reasons of practicality and durability. These hard, unyielding surfaces can cause the soles to crack and abscesses to form in the nails or on the pad of the foot (Buckley, 2001; Roocroft & Oosterhuis, 2001). Furthermore, the middle nail of the rear foot is prone to cracking if elephants have to routinely get up and down on hard surfaces (Roocroft & Oosterhuis, 2001). Anecdotal evidence suggests that elephants maintained on natural substrates have less incidence of foot problems (Gage, 2001). For instance, one individual elephant at the Milwaukee Zoo had drastically decreased bruising of the soles of the feet when the substrate was switched from rock to a sand-clay mixture (Sorensen, 2001). Similar findings in livestock species have also indicated a link between flooring substrates and incidence of foot problems, in that hard substrates such as concrete are associated with higher levels of lameness (Bergsten & Frank, 1996; Vokey *et al.*, 2001). Dairy cows have benefited from the use of rubber mats, which have been shown to significantly reduce the incidence of lameness and foot problems (e.g. Bergsten & Frank, 1996; Vokey *et al.*, 2001).

In response to this issue, some facilities throughout the world have begun to build new elephant enclosures or change existing elephant exhibits to include natural substrates and surfaces that are softer and more insulated for walking and lying (Clubb & Mason 2002, Schwammer, 2001). However these substrates have not been evaluated in a scientific study to determine their effect on foot health and behavior of elephants. While the long-term effects on foot health of softer, more yielding surfaces may not be determined for years, the immediate effects of flooring surface on elephant behavior can be evaluated immediately. Therefore, the first objective of this study was to initiate a scientific study to evaluate the impact of a new flooring surface on the behavior of captive elephants. The second objective was to evaluate the elephants' use of this new rubberized flooring substrate versus the old flooring substrate by comparing room use within each observation area.

2.4 Flooring Preference Studies

In addition to determining the impacts of environmental factors on animal welfare it is also important to determine what features of the captive environment, animals choose to use or perhaps prefer. One scientific means of assessing animals' preferences is to provide them with choices and then evaluate the amount of time they spend using each option. Assuming they will spend more time using the preferred option, preference between the given options can be determined. While this assumption is a good basis for preference testing, it is not always valid. To begin with, what an animal does or how it behaves does not always correlate precisely with its preference. For example, an animal may "prefer" to spend time in a particular setting, but perhaps due to fear, need for social companionship, temperature, etc. it may choose to remain in an unpreferred area. Novelty of a given option may result in an animal spending more time for a given choice, regardless of the degree of preference the animal may have for the particular option. If the animal is fearful of a given choice it may spend considerably less time with that given option. In addition, animals' preferences for a particular option do not always correspond to what is good welfare for the animal. For instance, many animals such as companion animals, are highly motivated to eat foods that are very high in fat and therefore not always good for their health.

The word preference, then, involves making an inference about the mental state of a non-human animal and for that reason will not be used in this study to mean an actual mental state. Rather, it will be used to convey a behavioral choice by the subjects to use one flooring option more than another.

Much of the current information on flooring preferences in animals has been gathered from research conducted on farm animals. Ponies have been shown to prefer bedded stall surfaces (wood shavings or straw) to unbedded concrete stall surfaces (Hunter & Houpt, 1989), spending significantly more time on the bedded surface and never lying on the unbedded areas. Dairy cows too have been found to prefer softer and/or more insulating surfaces such as sawdust or sand, and have reduced incidences and severity of leg injuries when housed on these softer surfaces (Tucker *et al.*, 2002; Natzke *et al.*, 1982). Exposure to unpreferred surfaces or flooring substrates can cause reduced lying times, which is an important behavior for dairy cows (Tucker *et al.*, 2002). Dawkins (1976, 1983) and Petherick *et al.* (1990) found that previous experience influences behavioral response to new surfaces, suggesting that familiarity plays a role in preference determination.

Fraser (1985) studied the preferences of pigs for bedded versus unbedded areas in relation to temperature. This study found that when it was cold, pigs preferred the bedded areas, whereas when it was hot, they preferred the concrete areas, presumably for their cooling effect. These results indicated that the animals' preference for a bedded versus concrete flooring depended strongly on temperature.

When conducting preference studies it is important to keep in mind that many factors may influence an animals' choice to use a particular object or area. There are numerous environmental variables such as temperature or familiarity, as discussed above, which may influence an animal's choice. The variables that may have impacted preference in this study are discussed in Chapter 6.

Chapter 3: MATERIALS AND METHODS

3.1 Animal Subjects

Six elephants at the Oregon Zoo were observed for this case study. The male subjects were two adult bull elephants, Packy and Rama, both born in captivity and maintained individually. At the time of this study, Packy was 48 years, and weighed 6010 kg. Rama (Packy's offspring) was 20 years, and weighed 3107 kg. The female subjects were maintained as a herd but observed as individual subjects. Pet (the matriarch) who was wild-born, was 48 years old and weighed 3398 kg. Sung-Surin or "Shine" (Pet's offspring) was 25 years, 3744 kg. and was born in captivity. Rose Tu was nine years, weighed 1350 kg and was also captive-born, while Chendra was eight years, 630 kg in weight and was a wild-born orphan.

3.2 Facility and Procedures

Elephants at the Oregon Zoo had two outdoor yards (Figure 1), the front yard (650 $m^{2)}$ and the back yard (3035 m^2). Substrate for the outdoor yards was 91 cm of sand filled over the existing natural substrate (dirt and soil). Indoor housing consisted of a multi-room barn (Figure 1), of which, seven rooms were used in this study (Figure 2).

Figure 1 – Diagram of the Oregon Zoo's elephant exhibit

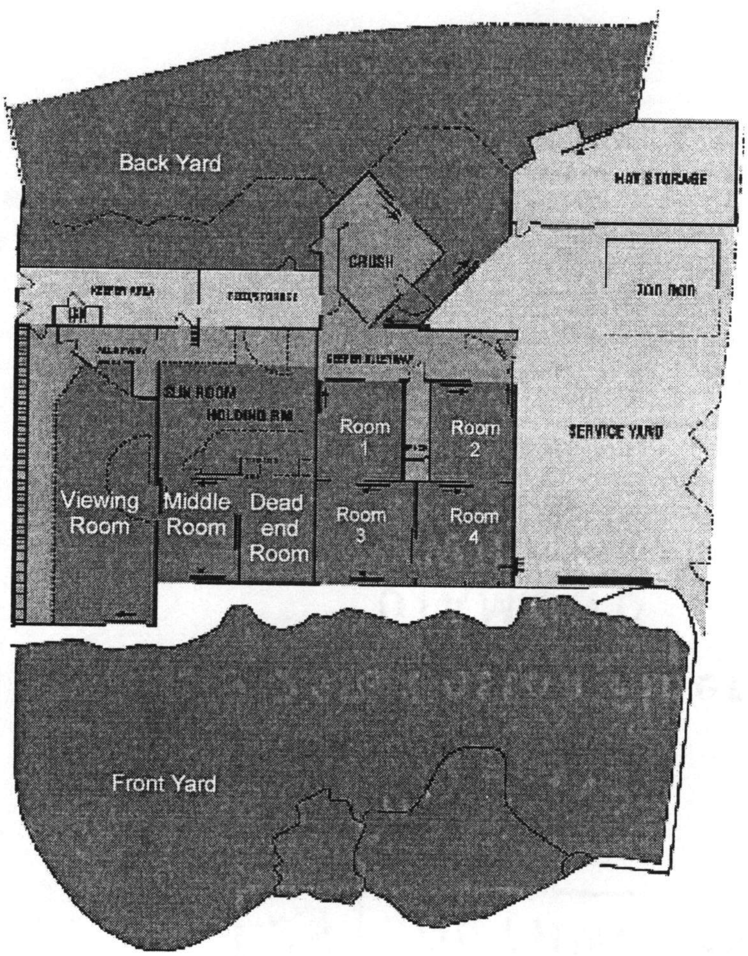
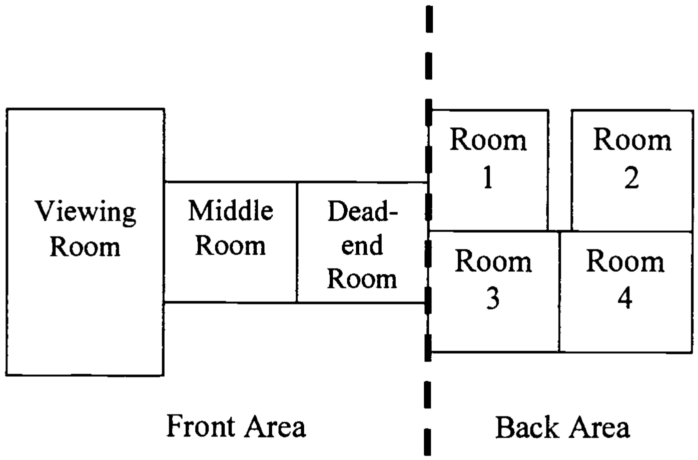


Figure 2 – Seven rooms of the elephant barn used for this study



Typically, for indoor housing the barn is divided into the "Back" area with access to rooms 1, 2, 3 and 4 and the "Front" area with access to the viewing room, middle room and dead-end room (Figure 2). Usually, elephants are housed in both of the outdoor yards while the remaining male or female herd is housed in one of the indoor areas in the barn, depending on the rotation schedule, so that the remaining area is free for maintenance tasks such as cleaning and food preparation.

For the current study, the seven rooms in the barn used for housing were divided into two observation areas. The "Front observation area" consisted of the viewing room (15.6 m x 6 m), middle room (6.3 m x 4.5 m) and dead-end room (6.3 m x 5.3 m) (Figure 2). The "Back observation area" consisted of rooms 1 and 2 (6 m x 4.8 m) and rooms 3 and 4 (6 m x 5.7 m) (Figure 2). Six of the seven rooms used for observation (middle room, dead-end room, room 1, 2, 3 and 4) had existing concrete floors prior to the commencement of this study. The viewing room of the "Front observation area" had an existing, older and deteriorated version of rubberized flooring that needed to be replaced (Figure 2).

During observation periods one male elephant or the female herd of elephants was placed in a single observation area with access to all rooms in the defined observation area for the defined observational period. Subjects were fed consistently at 11:00, 18:00, and 24:00 hours throughout the course of the study in addition to their other scheduled feedings that were not part of the observational periods. Water was provided *ad libitum* in all rooms throughout the course of the study.

Staff maintained free contact [direct handling of an elephant when the handler and elephant share the same unrestricted space (Clubb & Mason, 2002)] with the female group and protected contact [handling of an elephant when the handler and the elephant do not share the same unrestricted space, typically through a protective barrier of some type (Clubb & Mason, 2002)] with both of the bull elephants.

3.3 Phases of the Study

Closed circuit video cameras were used to record elephant behavior at three stages of this project: Phase I ("Baseline Phase") consisted of examining elephant behavior on old concrete floors, except for the viewing room in the Front observation area, which had old rubberized flooring. Phase II ("Choice Phase"), was conducted only in the Back observation area and consisted of observing elephant behavior when two of the rooms, rooms 1 and 4 were poured with the new rubberized flooring and the other two rooms, rooms 2 and 3, remained old concrete flooring. A Choice phase evaluation was not performed on the Front observation area due to the differences in room size as well as the fact that the viewing room had existing old rubber flooring. Phase III ("Final Phase") of the study, consisted of observing elephant behavior when all rooms in both observation areas were poured with new rubberized flooring.

3.4 Flooring Substrate and Installation

The rubberized flooring substrate used for this study was developed by Intracor/Familian International, Inc. (Portland, Oregon, USA) to be a seamless, cushioned, non-porous, non-toxic, non-skid substrate that would be durable enough to withstand the weight of Asian elephants. Before installation began, the floor was cleaned, dried and then primed. A mixture of rubber granules and Playflex 8805®, an aromatic urethane binder was troweled onto the floor from 0.95 to 2.54 cm thick to give slope to the drains and then left to cure overnight. Two coats of Gymflex 8881®, a 100% urethane-based material, was mixed with rubber dust and then poured and spread at 0.32 cm thickness onto the rubber base for strength and left to cure overnight. Next, an elastomeric polyurethane base coat was applied by roller at approximately 1 L per 1.8 m^2. A sand aggregate was then sprinkled on the wet surface to add traction and this was left to cure. Finally, the loose aggregate was removed from the surface and a single component aliphatic top coat was rolled onto the surface at approximately 1 L per 1.8 m^2 and left to cure.

3.5 Video Recording Schedule

In order to accommodate the husbandry duties of the elephant keeper staff and in an effort to disrupt the normal daily routine as minimally as possible, elephants were videotaped for three hours during the day (11:00 to 14:00 hours) and twelve hours at night (18:00 to 06:00 hours). Forty-five hours (3 days each consisting of 15 hours) of data were collected from each observation area during each of the three observation phases ("Baseline, Choice, and Final") for a total of 135 hours of videotaped behavior per individual for the entire duration of the study. Trained research volunteers, recruited from the Zoo's intern program as well as the Oregon State University Animal Behavior Group were used to code the videotapes. Each observer was required to pass an index of concordance, inter-observer reliability test (Martin & Bateson, 1994) at 80% or above, before being allowed to code data for this study.

3.6 Sampling Scheme

Videotaped behaviors were sampled by coding for five continuous minutes at the beginning of each hour and each half hour for each individual subject using the software program JWatcher ™ (Version 0.9, Built 2000-11-09,Copyright © 2000, Daniel T. Blumstein, Christopher S. Evans and Janice C. Daniel). Observations were made only when the subjects were in sight, the keepers were not present, and the subjects had full access to all rooms in the observation area.

The behaviors focused on for this study were locomotion, resting behavior, discomfort behavior (lifting of a foot for purposes other than locomotion), exploratory behavior, foraging behavior and stereotypic behavior. Locomotion behavior included walking, turning and backing up. Resting behaviors included kneeling, resting while standing, and resting while lying down. (See Appendix A for a complete ethogram of observed behaviors.)

3.7 Statistical Analysis

Behavioral data were evaluated by comparing the behaviors observed at Baseline (old flooring) to those observed in the Final phase (all floors were coated with rubber Natural Path Elephant Flooring). Behavioral data were presented as the percent of observation time, using each subject as its own control, as well as evaluating the four female subjects as a group. Two-tailed, paired t-tests were used to compare differences in behavior for the female group between the Baseline (control) and Final (treatment) phases.

One-way analysis of variance (ANOVA) tests in addition to post-hoc Bonferroni tests were performed on the room use data for the female group (Graphpad Prism version 4.0, Graphpad Software, San Diego, CA, USA). These tests were performed in order to evaluate differences in room utilization in each observation area between the Baseline and Final phases of the study and to determine whether there were differences in room use within each observation area. A two-tailed, paired t-test was also used to compare the difference in overall use of rubber-floored rooms versus concrete-floored rooms in the Back observation area during the Choice phase for the female group. The males were tested as individuals and therefore not included in the group analyses, however, the behavioral results and room use data for both male subjects were compared to the results of the female group.

Chapter 4: RESULTS

4.1 Behavioral Data for the Back Observation Area

Separate activity budgets were created for daytime (11:00 to 14:00 hours), and nighttime (18:00 to 06:00 hours) observation periods comparing Baseline (control) to Final (treatment) and are shown in Tables 1 and 2. The four female subjects were tested as a group and as such were represented as a group. Male subjects were tested as individuals and represented as individuals and therefore not included in the means.

Table 1 – Activity Budgets for all six subjects in the Back observation area during the daytime observation period

Percent of observation time

	Locomotion		Resting		Discomfort		Exploratory		Foraging		Stereotypic	
	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final
Chendra	10.2%	9.5%	12.6%	30.9%	0.0%	0.0%	7.1%	2.1%	47.5%	32.6%	21.4%	23.3%
Rose Tu	4.1%	11.6%	47.8%	59.4%	0.2%	0.0%	15.7%	3.7%	30.6%	23.9%	0.0%	0.0%
Shine	9.4%	9.4%	32.7%	53.4%	0.1%	0.1%	5.9%	3.5%	22.3%	25.6%	26.7%	5.6%
Pet	0.9%	4.3%	61.3%	65.4%	0.6%	0.0%	5.1%	0.4%	31.7%	29.3%	0.0%	0.0%
Females mean	6.1%	8.7%	38.6%	52.3%	0.2%	0.0%	8.5%	2.4%	33.0%	27.8%	12.0%	7.2%
SEM	2.2%	1.6%	10.5%	7.5%	0.1%	0.0%	2.5%	0.8%	5.3%	1.9%	7.0%	5.5%
paired t-test	0.269		0.035		0.264		0.062		0.268		0.445	

	Locomotion		Resting		Discomfort		Exploratory		Foraging		Stereotypic	
	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final
Male 1 (Rama)	8.7%	15.4%	9.6%	1.9%	1.4%	1.0%	11.9%	10.5%	21.9%	8.0%	45.4%	62.3%
Male 2 (Packy)	4.0%	9.1%	17.0%	32.2%	1.1%	4.5%	13.1%	11.8%	8.7%	8.1%	55.3%	28.9%

Table 2 – Activity Budgets for all six subjects in the Back observation area during the nighttime observation period

Percent of observation time

	Locomotion		Resting		Discomfort		Exploratory		Foraging		Stereotypic	
	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final
Chendra	10.6%	5.9%	57.6%	64.0%	0.1%	0.0%	3.5%	2.4%	22.6%	25.8%	3.9%	1.1%
Rose Tu	5.3%	4.5%	65.6%	67.4%	0.5%	0.1%	6.8%	4.7%	19.7%	21.9%	0.0%	0.0%
Shine	5.4%	7.4%	67.0%	51.1%	0.1%	0.0%	3.3%	3.1%	19.8%	22.6%	0.9%	12.9%
Pet	2.3%	1.8%	68.1%	71.8%	0.8%	0.7%	4.8%	0.9%	22.3%	24.3%	0.0%	0.0%
mean	5.9%	4.9%	64.6%	63.6%	0.4%	0.2%	4.6%	2.8%	21.1%	23.7%	1.2%	3.5%
SEM	1.7%	1.2%	2.4%	4.4%	0.2%	0.2%	0.8%	0.8%	0.8%	0.9%	0.9%	3.1%
paired t-test	0.531		0.852		0.148		0.112		0.003		0.537	

	Locomotion		Resting		Discomfort		Exploratory		Foraging		Stereotypic	
	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final
Male 1 (Rama)	6.8%	12.6%	33.6%	18.6%	0.7%	0.5%	5.4%	7.2%	24.9%	2.0%	28.3%	58.7%
Male 2 (Packy)	5.7%	5.6%	37.4%	36.2%	0.9%	2.3%	10.9%	11.1%	16.4%	19.8%	28.7%	22.7%

During the daytime observation period (Table 1), locomotion behavior increased from the Baseline phase to the Final phase for a majority of the subjects (four out of six). The other two subjects, Chendra and Shine, maintained approximately the same degree of locomotion behavior in both phases. During the nighttime (Table 2), there was no distinct pattern of change for locomotion behavior. Two subjects showed an increase in locomotion, three showed a decrease and one showed no change.

The category of resting behavior was subdivided into lying rest and standing rest for the daytime and nighttime observation periods (Table 3). Standing rest increased during the daytime for a majority of the subjects (five out of six). For the four females, the increase in standing resting behavior was significant ($p < 0.05$) and changed from 38.6% during the Baseline phase to 52.3% in the Final phase. The male subject Packy, also showed a similar pattern of change (17.0% during Baseline phase to 32.2% during the Final phase). The sixth subject, Rama (male), however, showed a decrease in standing resting behavior from 9.6% to 1.9%. Lying rest was not observed in any of the six subjects during the daytime observation period. During the nighttime observation period (Table 3) there were no discernable trends in resting behavior.

Table 3 – Resting behavior for all six subjects in the Back observation area during the daytime and nighttime observation periods

Resting behavior in the Back observation area

	Day		Night			
	Standing rest		Standing rest		Lying rest	
	Baseline	Final	Baseline	Final	Baseline	Final
Chendra	12.6%	30.9%	31.5%	34.9%	26.1%	29.1%
Rose Tu	47.8%	59.4%	43.9%	42.5%	21.7%	24.9%
Shine	32.7%	53.4%	46.4%	38.0%	20.6%	13.1%
Pet	61.3%	65.4%	55.7%	71.8%	12.5%	0.0%
Females mean	38.6%	52.3%	44.4%	46.8%	20.2%	16.8%
SEM	8.5%	6.1%	4.1%	6.9%	2.3%	5.3%
paired t-test	0.04		0.11		0.44	
Male 1 (Rama)	9.6%	1.9%	11.1%	10.1%	22.5%	8.6%
Male 2 (Packy)	17.0%	32.2%	37.4%	36.2%	0.0%	0.0%

Discomfort behavior was observed in all six subjects in at least one phase of the study, but all occurrences were observed at very low levels. In both the daytime (Table 1) and nighttime (Table 2) observation periods, discomfort behavior decreased for a majority of the subjects. Only one subject, Packy, showed an increase in discomfort behavior (3.4% increase during the daytime and 1.5% increase during the nighttime).

All six subjects showed a decrease in exploratory behavior during the daytime (Table 1). There was no pattern of change during the nighttime observation period for exploratory behavior (Table 2). Three subjects showed a decrease, one showed an increase and two showed no change from the Baseline to the Final phase.

Foraging behavior remained relatively constant during the daytime observation period (Table 1). At night (Table 2), the female group showed a very slight increase in foraging behavior from 21.1% to 23.7%, however the increase was statistically significant ($p < 0.05$). One of the males, Packy, also showed a slight increase in foraging behavior from 16.4% in the Baseline phase to 19.8% in the Final phase. The other male, Rama, however demonstrated the opposite pattern, which was a drastic decrease in foraging behavior from 24.9% in the Baseline phase to 2% in the Final phase.

There were no distinct patterns of change for Stereotypic behavior. Only four of the six studied subjects were observed performing stereotypic behavior. Of those four subjects, two showed a decrease in stereotypic behavior during the daytime (Table 1), while one showed an increase and the fourth showed no change. During the nighttime observation period (Table 2), two of the four subjects showed a decrease in stereotypic activity while the other two showed an increase.

4.2 Behavioral Data for the Front Observation Area

Separate activity budgets were created for daytime (11:00 to 14:00 hours), and for nighttime (18:00 to 06:00 hours) observation periods comparing Baseline (control) to Final (treatment) and are shown in Tables 4 and 5. The four female subjects were tested as a group and as such were represented as a group. Male subjects were tested as individuals and therefore not included in the means.

Table 4 – Activity budgets for all six subjects in the Front observation area during the daytime observation period

Percent of observation time

	Locomotion		Resting		Discomfort		Exploratory		Foraging		Stereotypic	
	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final
Chendra	18.8%	11.8%	11.5%	48.0%	0.0%	0.0%	3.2%	0.2%	25.1%	26.7%	37.2%	12.7%
Rose Tu	19.6%	11.8%	37.5%	63.2%	0.1%	0.0%	8.4%	0.4%	27.3%	24.4%	0.0%	0.0%
Shine	20.9%	14.2%	30.3%	6.8%	0.3%	0.1%	4.7%	0.8%	26.7%	23.1%	10.5%	53.8%
Pet	4.0%	4.2%	38.7%	63.0%	1.0%	0.0%	11.6%	0.3%	40.3%	32.5%	0.0%	0.0%
Females mean	15.8%	10.5%	29.5%	45.2%	0.3%	0.0%	7.0%	0.4%	29.9%	26.7%	11.9%	16.6%
SEM	4.0%	2.2%	6.3%	13.3%	0.2%	0.0%	1.9%	0.1%	3.5%	2.1%	8.8%	12.7%
paired t-test	0.064		0.323		0.273		0.042		0.195		0.761	

	Locomotion		Resting		Discomfort		Exploratory		Foraging		Stereotypic	
	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final
Male 1 (Rama)	17.9%	23.0%	17.8%	4.7%	0.6%	0.4%	7.6%	9.3%	22.2%	5.5%	33.6%	56.7%
Male 2 (Packy)	29.5%	4.3%	19.4%	16.3%	2.3%	2.1%	3.9%	1.7%	14.5%	25.3%	30.3%	50.2%

Table 5 – Activity budgets for all six subjects in the Front observation area during the nighttime observation period

Percent of observation time

	Locomotion		Resting		Discomfort		Exploratory		Foraging		Stereotypic	
	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final
Chendra	9.4%	8.2%	44.8%	44.2%	0.0%	0.0%	2.0%	0.8%	30.3%	19.8%	12.9%	26.4%
Rose Tu	8.0%	5.9%	57.1%	71.9%	0.2%	0.0%	2.4%	0.1%	28.5%	20.4%	0.0%	0.0%
Shine	11.1%	7.5%	35.4%	42.1%	0.8%	0.0%	3.9%	2.0%	32.3%	22.3%	6.4%	24.7%
Pet	1.9%	2.2%	54.4%	72.7%	3.1%	0.1%	7.6%	1.0%	30.3%	23.6%	0.0%	0.0%
Females mean	7.6%	5.9%	47.9%	57.7%	1.0%	0.0%	4.0%	1.0%	30.3%	21.5%	4.8%	12.8%
SEM	2.0%	1.3%	4.9%	8.4%	0.7%	0.0%	1.3%	0.4%	0.8%	0.9%	3.1%	7.4%
paired t-test	0.126		0.104		0.241		0.087		0.002		0.189	

	Locomotion		Resting		Discomfort		Exploratory		Foraging		Stereotypic	
	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final
Male 1 (Rama)	6.7%	9.7%	48.8%	30.2%	0.3%	0.7%	2.9%	3.3%	15.5%	3.7%	25.7%	52.1%
Male 2 (Packy)	6.9%	12.8%	47.2%	25.4%	1.1%	0.6%	6.1%	1.9%	19.9%	19.7%	16.7%	39.4%

Locomotion behavior decreased for a majority of the subjects during the daytime observation period (four out of six) (Table 4). At night there was no pattern of change for locomotion behavior (Table 5). Three of the subjects showed an increase, and three of the subjects showed a decrease.

Resting behavior was again subdivided to evaluate both standing rest and lying rest during the daytime and nighttime observation periods (Table 6).

Table 6 – Resting behavior for all six subjects in the Front observation area during the daytime and nighttime observation periods

Resting behavior in the Front observation area

	Day		Night			
	Standing rest		Standing rest		Lying rest	
	Baseline	Final	Baseline	Final	Baseline	Final
Chendra	11.5%	48.0%	9.9%	26.8%	34.9%	17.4%
Rose Tu	37.5%	63.2%	19.5%	55.5%	37.6%	16.3%
Shine	30.3%	6.8%	18.0%	29.7%	17.3%	12.5%
Pet	38.7%	63.0%	42.1%	71.0%	12.3%	1.7%
Females mean	29.5%	45.2%	22.4%	45.7%	25.5%	12.0%
SEM	5.1%	10.9%	5.6%	8.7%	5.1%	2.9%
paired t-test	0.32		0.02		0.03	
Male 1 (Rama)	17.8%	4.7%	14.0%	20.2%	34.8%	10.1%
Male 2 (Packy)	19.4%	16.3%	29.6%	25.4%	17.5%	0.0%

Standing rest increased for three of the four females drastically during the daytime observation period (Table 6), consistent with the daytime increase in standing rest in the Back observation area. One female, Shine, however, showed the opposite pattern with a drastic decrease in standing rest. For the males, Rama also showed a decrease, while Packy maintained approximately the same level of standing resting behavior. As in the Back observation area, lying rest was not observed during the daytime observation period.

At night, there were some significant changes in resting behavior (Table 6). The overall pattern was an increase in standing rest and decrease in lying rest. In the female group, standing rest increased from 22.4% to 45.7% (p-value < 0.05). Rama also reflected this pattern, with a change of 14.0% to 20.2% in standing rest. The second male, Packy, showed no change in standing rest. Alternatively, lying rest decreased significantly in the female group from 25.5% to

12.0% (p-value < 0.05). Both males also showed a marked decrease in lying resting behavior as well.

Discomfort behavior was observed at very low levels in the Front observation area consistent with the Back observation area. All subjects showed a decrease in discomfort behavior during the daytime and nighttime observation periods (Tables 4 and 5), apart from Rama, who showed a very slight increase of 0.3% to 0.7% during the night.

Exploratory behavior in the Front observation area showed a decreasing trend during both the daytime and nighttime observation periods (Tables 4 and 5). The females showed a significant decrease in exploratory behavior during the daytime from 7.0% to 0.4% (p-value < 0.05). The male, Packy, also followed this trend, while the other male, Rama, showed an increase in exploratory behavior. During the nighttime observation period, the results were identical.

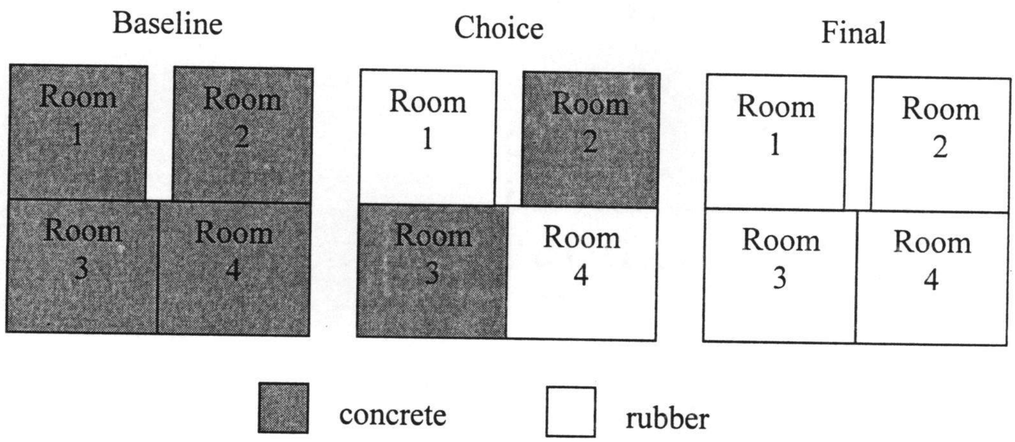
There were no distinct trends for foraging behavior during the daytime (Table 4). At night however, there was a significant decrease in foraging behavior (Table 5). For the females, time spent foraging decreased from 30.3% in the baseline phase to 21.5% in the final phase (p-value < 0.05). Rama also reflected this trend, while the other male, Packy, did not show a change.

For stereotypic behavior there were no statistically significant differences, however, there was a clear pattern of increase. Three of the four subjects that were observed performing stereotypic behavior showed a daytime increase in stereotypic behavior (Table 4) and all four of these subjects showed a nighttime increase (Table 5).

4.3 Room Utilization in the Back observation area

Room utilization was evaluated in the Back observation area (Figure 3) during all three phases of the study (Baseline phase = concrete in all four rooms, Choice phase = concrete in rooms 2 and 3, and Natural Path Elephant Flooring in rooms 1 and 4, Final phase = Natural Path Elephant Flooring in all four rooms).

Figure 3 – Diagram of the Back observation area during each of the three phases of the study

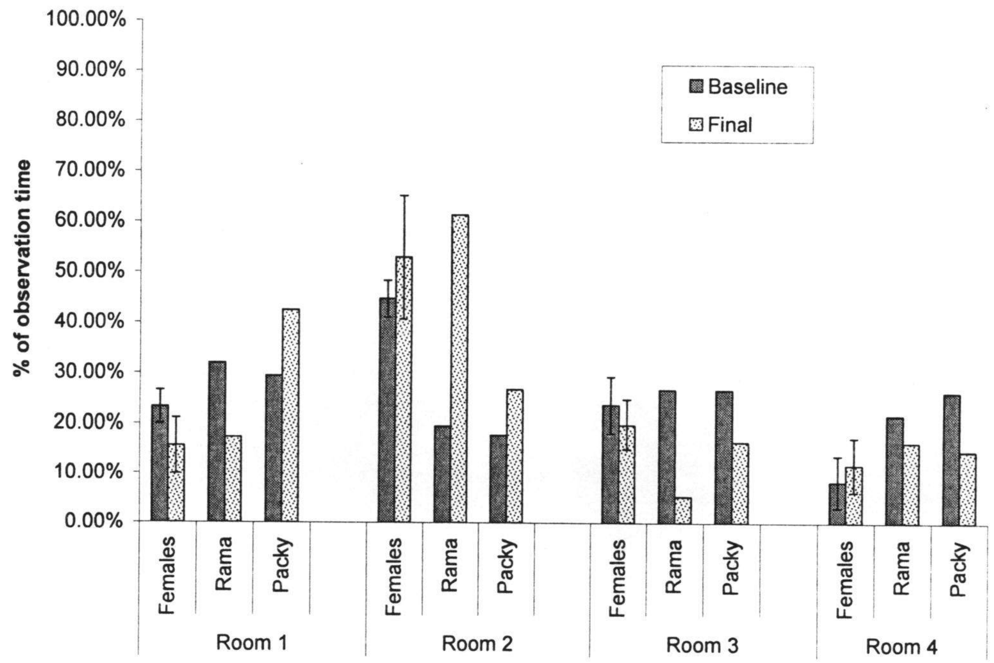


The average amount of time spent in each of the four accessible rooms in the back observation area during each of the three phases of the study are illustrated in Figures 4 and 5. The Baseline phase was compared to Final phase and the Choice phase was evaluated separately. (The four females were represented as a group and the two males were represented separately.)

For the female group, room 2 was consistently used most during the day in both the Baseline and Final phases (Figure 4). In the Baseline phase, day usage of room 2 was significantly greater than room usage of all three other accessible rooms (room 2 use greater than room 1: $p < 0.05$, room 2 use greater than room 3: p-value < 0.005, room 2 use greater than room 4: p-value < 0.001). In the Final phase, day usage of room 2 was again greater than room usage of all other rooms, (room 2 use greater than room 1: $p < 0.05$, room 2 use greater than room 4: $p < 0.05$, room 2 use greater than room 3 but not significant).

The males, Rama and Packy, did not show a strong preference for any of the four rooms during the Baseline phase (Figure 4). In the Final phase, however, Rama spent the most time in room 2, while Packy spent the most time in room 1.

Figure 4 – Room use in the Back observation area during the daytime observation period

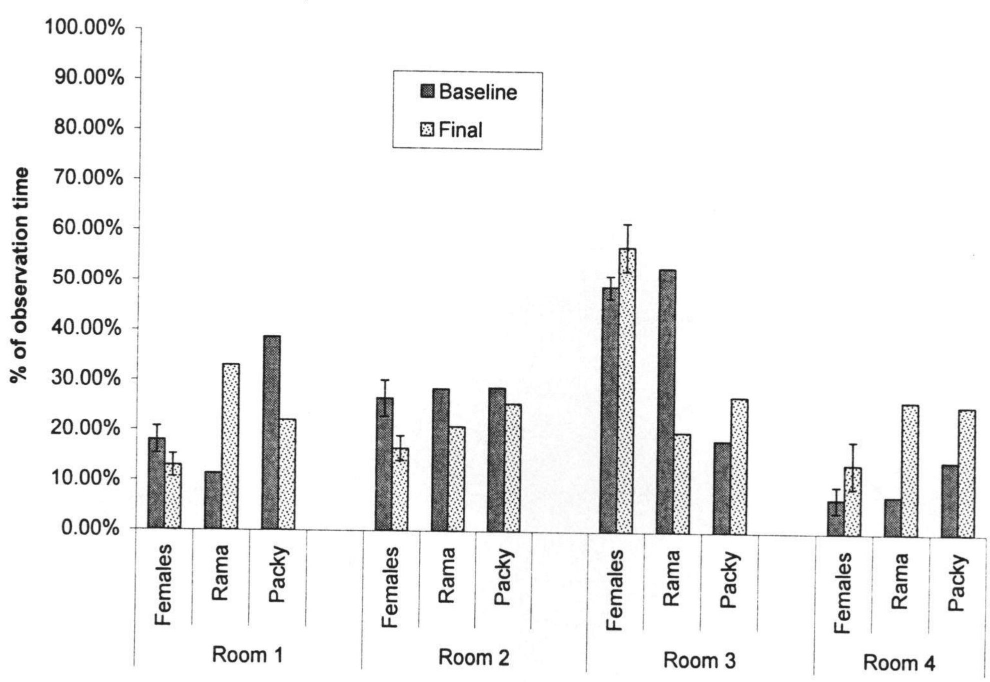


At night the female group consistently spent the most time in room 3 during both the Baseline and Final phases (Figure 5). In the Baseline phase, room

3 was used significantly more than all other accessible rooms (room 3 use greater than room 1: $p < 0.001$, room 3 use greater than room 2: $p < 0.001$, room 3 use greater than room 4: $p < 0.001$). In the Final phase, use of room 3 remained significantly higher than all three other rooms (room 3 use greater than room 1: $p < 0.001$, room 3 use greater than room 2: $p < 0.001$, room 3 use greater than room 4: $p < 0.001$).

At night, Rama showed a strong preference for room 3 during the Baseline phase, and a slight preference for room 1 during the Final phase (Figure 5). Packy showed a preference for room 1 during the Baseline phase at night and no preference during the Final phase at night (Figure 5).

Figure 5 - Room use in the Back observation area during the nighttime observation period



During the Choice phase of the study when subjects were allowed access to all four rooms in the Back observation area, two with concrete flooring (rooms 2 and 3) and two with Natural Path Elephant Flooring (rooms 1 and 4), the females used room 2 significantly more during the daytime (room 2 use greater than room 1: $p < 0.01$, room 2 use greater than room 3: $p < 0.001$, room 2 use greater than room 4: $p < 0.001$) (Figure 6). At night, they used rooms 2 and 3, the concrete floored rooms, more than the two rooms with rubberized flooring (rooms 1 and 4) but these differences were not statistically significant (Figure 7). Both males (Rama and Packy) used room 1 (rubber) more than the other three rooms during the daytime observation period of the Choice phase. At night, during the Choice phase, both males showed a preference for room 2 (concrete).

Figure 6 – Room use in the Back observation area during the daytime observation periods of the Choice Phase

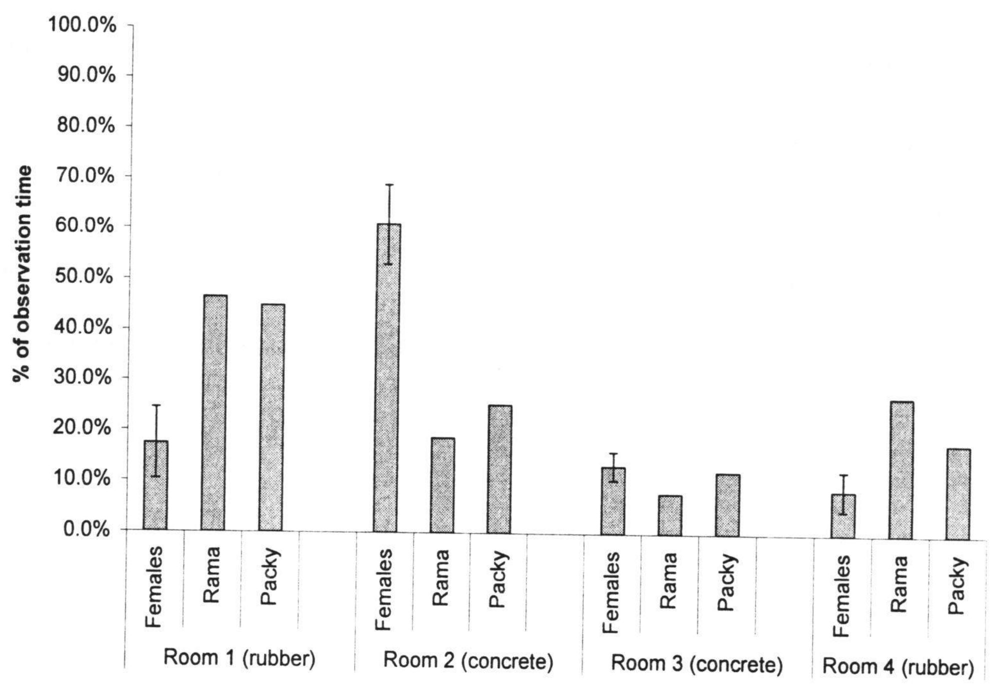
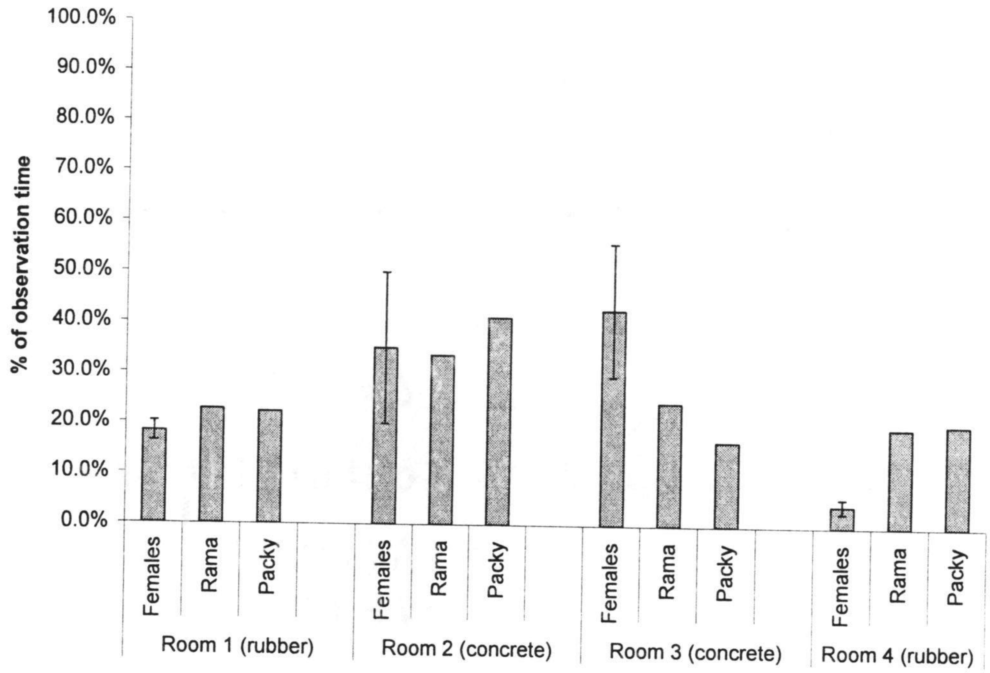


Figure 7 – Room use in the Back observation area during the nighttime observation periods of the Choice Phase



When overall use of concrete versus rubber flooring was evaluated, a two-tailed, paired t-test revealed significantly higher use of concrete flooring compared to rubber flooring for the female group during the daytime ($p < 0.05$) and night time ($p < 0.005$) observation periods (Table 7). The males on the other hand, showed a strong preference for rubber-floored rooms during the day and a slight preference for concrete-floored rooms at night (Table 7).

Table 7 – Use of concrete versus rubber flooring during the Choice phase

Day

	Rubber floor	Concrete floor
Chendra	25.8%	74.2%
Rose Tu	42.7%	57.3%
Shine	27.2%	72.8%
Pet	7.9%	92.1%
Females mean =	25.9%	74.1%
SEM =	7.1%	7.1%
paired t-test =	$p < 0.05$	
Rama	73.6%	26.4%
Packy	62.7%	37.3%

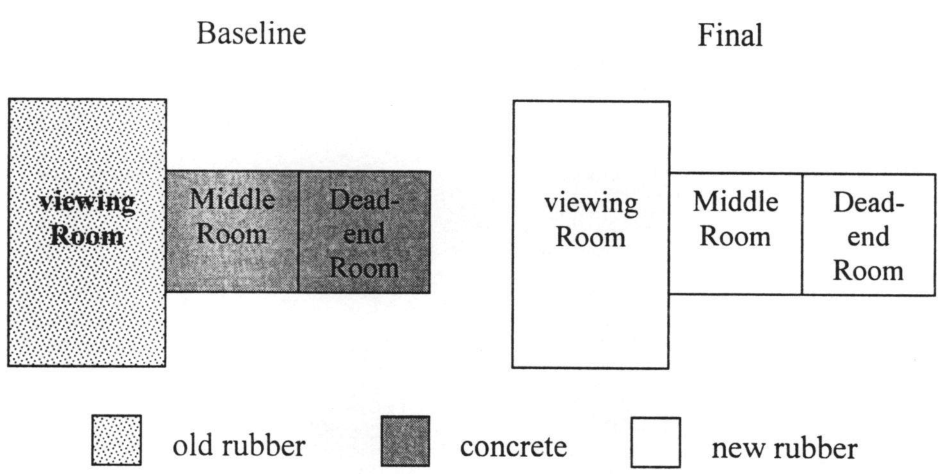
Night

	Rubber floor	Concrete floor
Chendra	20.1%	79.9%
Rose Tu	25.1%	74.9%
Shine	28.5%	71.5%
Pet	16.3%	83.7%
Females mean =	22.5%	77.5%
SEM =	2.7%	2.7%
paired t-test =	$p < 0.005$	
Rama	42.2%	57.8%
Packy	42.4%	57.6%

4.4 Room utilization in the Front observation area

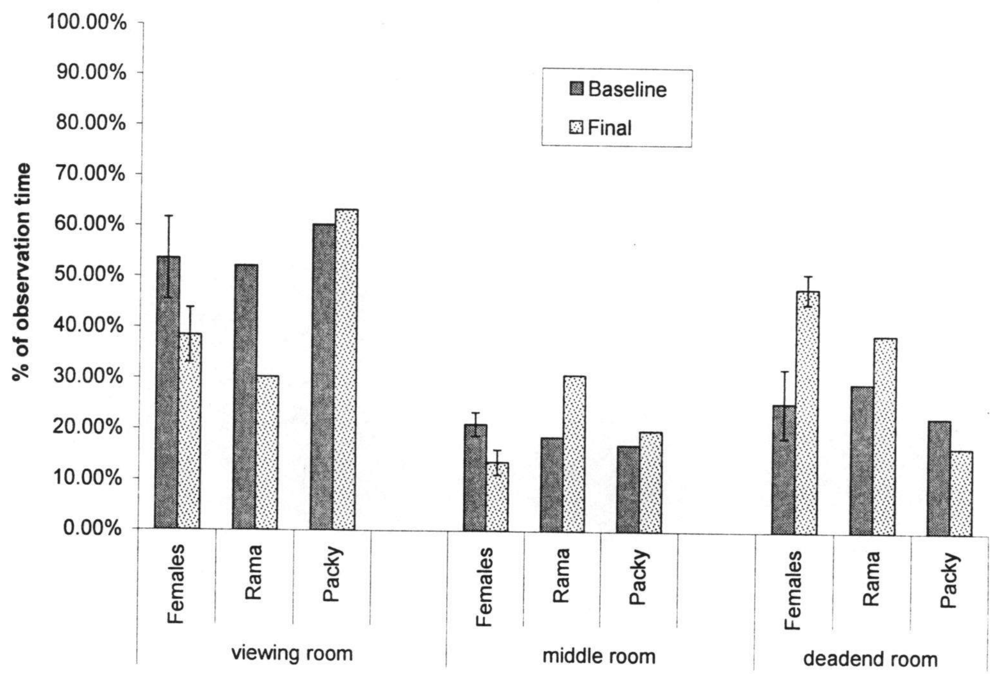
Room utilization in the Front observation area was evaluated by comparing room use in the Baseline phase to that of room use in the Final phase (Figure 8). A Choice phase evaluation was not performed on the Front observation area due to the differences in room size as well as the fact that the viewing room had existing old rubber flooring.

Figure 8 – Diagram of the Front observation area



The percent of time each subject spent in each of the three accessible rooms in the Front observation area during each of the two evaluated phases for this area of the study are illustrated in Figures 9 and 10.

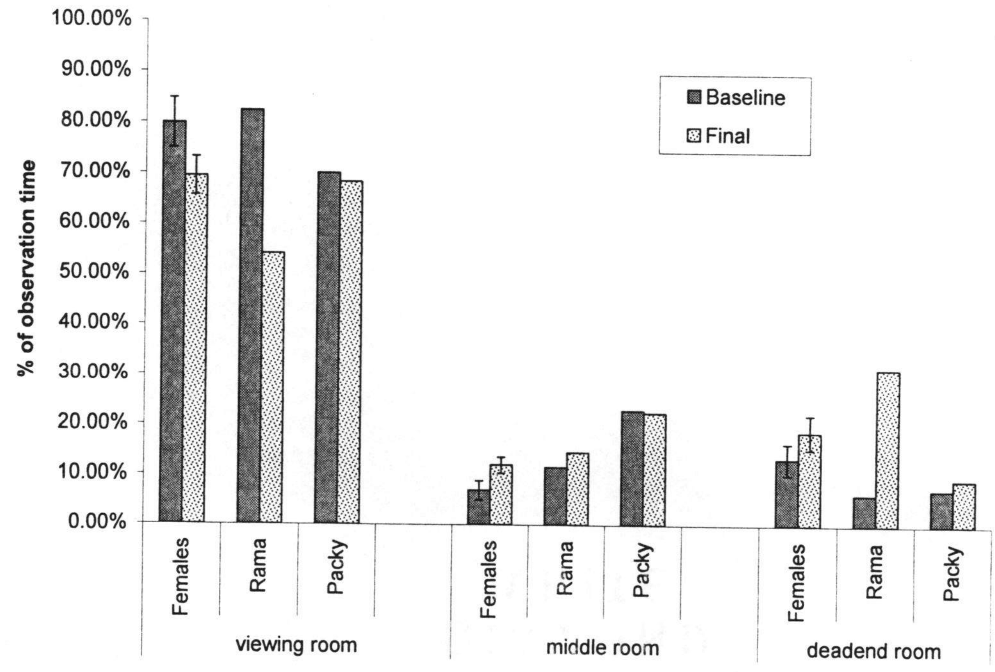
Figure 9 – Room use in the Front observation area during the daytime observation period



During the daytime, the females used the viewing room and the dead-end room the most (Figure 9). In the Baseline phase, day usage of the viewing room was significantly higher than that of the other two rooms in the Front observation area for the females (viewing room use greater than middle room use: $p < 0.05$, viewing room use greater than dead-end room use: $p < 0.05$). In the Final phase, day usage of both the viewing room and the dead-end room were significantly higher than that of the middle room for the females (viewing room use greater than middle room use: $p < 0.01$, dead-end room use greater than middle room use: $p < 0.001$). Both males, Rama and Packy, showed a strong preference for the viewing room in both the Baseline and Final phases during the day.

Night usage of the viewing room (Figure 10), in both the Baseline and Final phases, remained significantly higher than that of the middle room (Baseline and Final: $p < 0.001$) and that of the dead-end room (Baseline and Final: $p < 0.001$) for the female group. The viewing room also remained the preferred room at night for both males as well in the Baseline and Final phases.

Figure 10 – Room use in the Front observation area during the nighttime observation period



Chapter 5: Discussion

5.1 Discussion of Behavioral Data

The first objective of this study was to investigate any behavioral changes that occurred as a result of the new rubberized flooring by comparing the Baseline phase (old flooring) to the Final phase (new rubberized flooring). There were in fact several changes in the behavior of the elephants between the two phases.

With the installation of softer flooring it was expected that locomotion behavior might increase. This expectation was met to some extent. There was an increase in locomotion during the daytime in the Back observation area. Four of the six subjects (two males and two females) showed an increase in locomotion in the Final phase of the study as compared to the Baseline phase. The other two subjects showed no change. Most noteworthy was the increase in locomotion behavior for the female subject Pet, the oldest subject tested at 48 years of age, who was known to have chronically poor foot health. While there were no overall patterns of increased locomotion behavior in the Front observation area, Pet showed slight increases in locomotion in both the day and nighttime observation periods in this area compared to her baseline locomotion activity. This implies that the new rubberized Natural Path Elephant Flooring may have provided a more comfortable surface for her to walk and move on. The rubber flooring may have provided a more yielding surface for her feet as well as her arthritic joints.

Contrary to expectation, there was decreased locomotion behavior during the daytime observation period in the Front observation area. Three of the four females as well as one of the males showed decreased locomotion behavior in the Final phase as compared to the Baseline phase. Although, locomotion did not increase, all four of these subjects, showed increases in other categories of behavior such as abnormal locomotion behavior and increased standing resting behavior that further imply that the new rubber flooring was more comfortable for movement as well as long periods of standing, and are discussed in the following sections.

Unexpectedly, there was a trend for increased stereotypic behavior in the Front observation area. Four of the six subjects, Chendra and Shine (females), as well as the two males, Rama and Packy, were observed performing stereotypic behavior. Of these four individuals, three showed an increase in stereotypic behavior during the daytime and all four showed an increase during the night. There are at least two possible explanations for this observed trend in stereotypic behavior. The first explanation may be that the environmental change of the new flooring substrate may have been a stressful or aversive event. One theory for the causation of stereotypic behavior is that it functions as a coping method for stressful conditions (Odberg, 1978). It is possible that the installation of new flooring and the disruption of their environment from this process may have contributed to the observed increase in stereotypic behavior. In addition the odor from the new flooring may have been aversive to the elephants and may also have contributed to the observed increase in stereotypic behavior.

During the installation, and for several days following, there was a strong rubber odor in each of the rooms of the elephant barn. Efforts were made to properly ventilate the areas prior to testing. However, it is possible that the elephants were able to detect lingering odor that was undetectable to humans. Moreover, the fact that their trunks routinely scan or drag along the ground from which the odor emanated would have facilitated their detection of any residual odor.

A second explanation for the increase in stereotypic behavior is the possibility that the new rubberized flooring afforded the elephants a more comfortable surface for the performance of stereotypic locomotion behavior that was already present prior to the addition of the new flooring. Four of the six subjects tested in this study performed stereotypic behavior prior to the installation of the new rubberized flooring and only those same four individuals were observed performing stereotypic behavior after the installation of the new flooring. The stereotypic behaviors that were performed in each of the four individuals were abnormal locomotion behaviors that included swaying on all four feet and pacing. Prior to the installation of the new rubberized flooring in the Front observation area, only the viewing room had rubber flooring. After the installation there was a much larger, continuous space, of softer, more yielding flooring that may have provided a more comfortable surface for the abnormal locomotion behaviors that were already a part of these four individual elephants' behavioral repertoires.

If comfort was indeed a factor in the behavioral change of increased stereotypic locomotion behavior then it would make sense that this change should have occurred in both observation areas, which was not the case. Stereotypic behavior increased in the Front observation area and showed no pattern of change in the Back observation area. However, in the Back observation area, normal locomotion behavior increased. In both observation areas, there were patterns of increased gross motor movement, normal locomotion behavior in the Back observation area and stereotypic locomotion behavior in the Front observation area. These patterns provide a strong case for the argument that rubberized flooring was indeed a more comfortable surface for gross motor movement.

Another unexpected behavioral change was the change in the type of resting behavior that was performed. In the Front observation area during the nighttime observation period, lying rest decreased for all six subjects while standing rest increased for five out of the six subjects. Standing rest also increased for five out of the six subjects during the daytime in the Back observation area. While most elephants do lie down at some point during the night, elephants in the wild typically rest and sleep in a standing position (McKay, 1973, Tobler, 1992). McKay (1973) reported that Asian elephants in Ceylon were infrequently observed lying down to rest, at only 3.4 to 4.8 hours per day. This may suggest that standing sleep/rest is more common than lying sleep/rest for wild Asian elephants. If standing is the typical position of sleep preferred by wild Asian elephants, then it would appear that the elephants in this study began performing resting behavior that was more similar to that of wild Asian elephants. The new rubberized flooring may have provided a more comfortable surface for standing resting behavior by alleviating pressure on the feet and joints while resting in the standing position.

It was expected that with the installation of rubberized flooring, discomfort behavior would decrease. Discomfort behavior was described as lifting one foot fully off of the ground for reasons other than locomotion, such as shifting weight from a particular foot to relieve pressure. In both observation areas during both the daytime and nighttime observation periods, discomfort behavior decreased in a majority of the subjects. It is quite plausible again that the new rubber Natural Path Elephant Flooring provided a more comfortable surface for the elephants to stand on. The softer flooring may have relieved pressure on the feet and joints, therefore decreasing the need to shift weight from a particular foot.

Exploratory behavior was categorized as any behavior that involved using the trunk or foot to touch/explore any surrounding feature excluding self and conspecifics. The environmental change of new flooring was expected to cause an increase in exploratory behavior. However, this was not the case. In both observation areas, during both the nighttime and daytime observation periods this behavior decreased in a majority of the animals. One possible explanation for this observation is that there may have been a lingering odor from the rubber substrate that comprised the new Natural Path Elephant Flooring. As stated previously, there was a strong rubber odor in each of the rooms of the elephant barn during the installation process and for several days following. The elephant's trunk is its olfactory organ and rests close to the ground. If an unpleasant or aversive odor from the new rubber flooring was detectable, it makes sense that the elephants would avoid or decrease behaviors, such as exploration that would increase contact between the trunk and the floor. Foraging behavior was not expected to change from the Baseline to the Final phases of the study. However, foraging is another behavior that requires the trunk to be in close contact with the ground. Elephants use their trunks while foraging to grasp food and place it in their mouth. The elephants in this study were always fed by scattering food on the floor, which required them to pick the food up off of the floor. In the Final phase of the study, this required close contact between the trunk and the new rubber flooring. As with exploratory behavior, foraging behavior also decreased in the Final phase as compared to the Baseline phase but only in the Front observation area.

In the Back observation area, foraging behavior remained relatively constant for both the daytime and nighttime observation periods. The female group did show an increase in foraging behavior at night that was statistically significant, however, the increase was very slight, 21.1% to 23.7%. Final phase testing in the Back observation area was the last to be completed, hence giving this area longer to ventilate. If the odor had dissipated to a greater degree in the Back observation area by the time Final phase testing was conducted in this area, then it might not have been an influencing factor. If odor was not a factor, it then makes sense that foraging activity would remain constant between the Baseline and Final phases of the study, as was the case in Back observation area.

5.2 Discussion of Room Utilization Data

The second objective of this study was to evaluate the elephants' use of the new rubberized flooring substrate versus the old flooring substrate by comparing room use. It was expected that the animals might have preferences for particular rooms prior to the study, particularly in the Front observation area. It was also expected that rooms with rubberized flooring would be preferred to rooms with concrete flooring and that room preferences may change with flooring substrate changes. Despite expected room biases and possible flooring substrate biases, it was necessary to determine whether or not behavior on the new flooring substrate differed from behavior during the baseline phase. Changes in behavior could then be used to determine whether or not the new rubber flooring had a negative or positive effect on their behavior.

Room use in both of the observation areas remained relatively stable throughout the course of the study. In the Front observation area, the viewing room was used most during the day and night in the Baseline as well as the Final phase of the study. There are several reasons why this room may have been the preferred room. To begin with, the viewing room was the largest of the three rooms in the Front observation area and had a higher ceiling than the other two rooms. The larger room provided more space for activity and could more easily accommodate the four females than any of the smaller rooms. It also provided more space for normal locomotion as well as stereotypic locomotion. The taller ceiling also gave the viewing room better lighting compared to the smaller, middle and dead-end rooms, which may have been preferable to the animals.

Another reason the viewing room may have been so attractive to the animals in this study is the fact that it had an existing rubber floor. This existing rubber floor was comprised of an older version of the Natural Path Elephant Flooring substrate that was used in this study. This old flooring may have also provided a more comfortable surface for movement, making it the preferred room at Baseline. Other factors such as increased airflow or proximity to the elephant care staff may also have contributed to the preference of the viewing room, however these variables were not measured in this study.

In the Final phase of the study, when all three rooms in the Front observation area were installed with new rubber flooring, the females shared their preference of the viewing room with the dead-end room as well during the day. At night, the viewing room remained the most used. Rama also increased his use of the dead-end room during the daytime observation period as well as his use of the middle room in the Final phase. At night all six subjects retained a very strong preference for the viewing room in the Final phase. This implies that the animals had strong room preferences prior to the study and while a slightly increased use of the other two available rooms was achieved once the entire area had been installed with rubberized flooring, the overall preference for the viewing room remained strong.

The many differences in the rooms of the Front observation area made it difficult to determine whether or not the new rubberized flooring had any effect on preference. In the Back observation area, however, the four rooms were very similar in size, shape, lighting, etc. and all had concrete floors prior to the study. This area provided much better conditions for testing room preference before and after the installation of the new Natural Path Elephant Flooring.

In the Back observation area, preferences remained relatively stable as in the Front observation. The females and Packy preferred the same rooms in the Final phase as they did in the Baseline phase. The females appeared to have a very strong preference for room 2 during the daytime and room 3 during the nighttime. Packy showed a preference only for room 1; at night during the Baseline phase, and during the day in the Final phase. Rama was the only subject that had different preferences in the Final phase compared to the Baseline phase. In the Baseline phase, he showed a preference for room 3 at night but no strong preferences during the day. In the Final phase, he showed a preference for room 2 during the day and room 1 during the night.

When the subjects were given a choice between flooring substrates, the females showed a preference for concrete-floored rooms during the day as well as the night. The concrete-floored rooms were rooms 2 and 3. The females also preferred rooms 2 and 3 during the Baseline phase as well as in the Final phase during the day and night. It seems clear that the female elephants in this study had strong preferences for rooms 2 and 3 prior to testing. The installation of rubber floors in rooms 1 and 4 during the Choice phase did not affect their preferences for rooms 2 and 3. Once all four rooms had been installed with new rubberized flooring their preferences remained unchanged.

Despite the argument above, the fact that the females showed a preference for concrete-floored rooms during the Choice phase should be addressed. One possibility is that concrete was indeed the preferred substrate due to its cooling effects. This study was conducted during the summer months, and temperatures in the barn may have been high enough to warrant thermoregulation behavior, such as choosing to be in a concrete-floored room versus a rubber-floored room. However, because the elephants' preferences for rooms 2 and 3 were constant throughout the course of the study, it is more likely that their choice to spend more time in these rooms had to do with a variable other than flooring substrate. In addition, when concrete flooring was available in the Front observation area during the Baseline phase, those rooms (middle room and dead-end room) were not used in preference to the rubber-floored viewing room.

The males on the other hand, spent more time in the rubber-floored rooms during the day and more time in the concrete-floored rooms at night during the Choice phase. The rubber-floored rooms were rooms 1 and 4. Prior to the installation of any rubber flooring in the four rooms of the Back observation area (Baseline), Packy showed a preference for room 1 at night. Once rooms 1 and 4 received rubber flooring in the Choice phase, he preferred room 1 during the day and room 2, a concrete-floored room at night. Once all the rooms had received rubber floors in the Final phase, his only preference was again for room 1 during the day. Apart from his nighttime use of room 2 in the Choice phase, this elephant consistently preferred room 1, during the Baseline, Choice and Final phases of the study. Consistent with the results of the female group, the installation of rubber flooring did not appear to affect initial room preferences.

Rama was the only subject whose room preferences changed between phases of the study. Prior to installation of any rubberized flooring, Rama showed a preference for room 1 during the day and room 3 at night. Once rooms 1 and 4 received rubberized floors in the Choice phase, he again preferred room 1 (rubber) during the day, but spent more time in room 2 (concrete) at night rather than room 4, his original nighttime preference in the Baseline phase. Once all the rooms were installed with rubberized flooring, he preferred room 2 during the day and room 3 at night. There was no clear pattern of preference for this individual, neither for rooms nor for flooring substrate. Although his room preferences changed during each phase, they did not appear to change in relation to flooring substrate. This individual subject did not likely possess strong room preferences prior to the study. Moreover, the environmental change of flooring substrate did not contribute to the development of strong preferences either.

Taken together, these results suggest that a majority of the elephants had strong room preferences in both observation areas prior to the study, and these preferences most likely did not change as a result of flooring substrate. The consistency of room preference regardless of flooring substrate, shown by the elephant subjects in this study, may indicate that familiarity with the rooms influenced their room choices. Prior experience has been shown to influence behavioral response in preference testing (Dawkins, 1976 and 1983, Petherick *et al.*, 1990). In this case, the elephants used in this study were familiar with each of the rooms used for testing and most had preferences for particular rooms. This prior experience may explain why they continued, for the most part, using the same rooms throughout the course of the study.

Chapter 6: PITFALLS AND LIMITATIONS OF THE STUDY

There are several limitations of this particular study as well as some limitations that interested parties should be aware of. To begin with, this study had a very small sample size and is considered a case study rather than a large study with a randomly sampled group of subjects. Therefore, the results of this study cannot be widely extrapolated to captive elephants in general. Instead, it provides an example of the behavioral response to a change in flooring for one group of captive Asian elephants for other institutions to consider when contemplating flooring for their elephant facilities.

Secondly, the complex social structure of elephants makes it difficult to test subjects independently. The AZA does not recommend that female elephants be maintained in isolation (AZA, 2001). Therefore when evaluating behavioral response and room utilization in this study, the female subjects were placed in the observation areas as a group and observed as individuals. This could have been problematic if the females behaved differently from the males who were placed in the observation areas alone during the observation times. However, because the males consistently performed similarly to the females throughout the course of the study, and had similar room preference patterns to the overall group preferences, this issue is of less concern.

The odor of the rubberized flooring used in this study which may have been present during testing, likely affected the elephants' behavior, although the extent of its effects are unknown. Had this odor been detectable to humans, the rooms could have been ventilated more thoroughly, and an additional period of testing could have been performed once the odor had dissipated to minimize its influence on observed behaviors.

A problem relevant to behavioral studies in general is the possibility of observer error. The large amount of video that was generated in this study required the use of several trained observers and any time human accuracy must be relied upon there is always the chance for error to be introduced. To account for this, each observer was required to pass an index of concordance test of inter-observer reliability with 80% agreement or higher (Martin & Bateson, 1994).

Finally, a major limitation on accurately interpreting the elephants' flooring preferences was the likelihood that there were pre-existing preferences for certain rooms regardless of flooring. Such preferences may have been based on previous experience, lighting, temperature, proximity to keepers, proximity to other preferred areas, etc. Therefore future investigations should carefully examine, and if possible, attempt to control for as many of these factors as is possible.

Chapter 7: CONCLUSIONS AND RECOMMENDATIONS

The first objective of this study was to evaluate the impact of a new rubber flooring substrate on the behavior of captive elephants by comparing behavior in the Baseline phase to behavior in the Final phase. The second objective was to evaluate the elephants' use of this new flooring substrate by determining how they spent their time in each of the studied areas, and on each of the flooring surfaces.

The results of the behavioral data revealed a pattern of increased gross motor movement on the new rubberized flooring that included both normal locomotion and stereotypic locomotion behavior. Resting behavior also showed a pattern of change. Elephants spent more time performing standing rest and less time lying in recumbent rest, a pattern that more closely reflects the resting behavior of wild elephants. Additionally, behavioral data revealed an overall decrease in discomfort behavior. Taken together, these results suggest that the new rubberized flooring provided a more comfortable surface for the feet and joints for locomotion activity as well as during extended periods of standing rest.

Further behavioral analysis revealed a decrease in activities that required the trunk to be in close contact with the new rubber flooring, exploratory and foraging behavior. Given the fact that the new flooring gave off a potent rubber odor during installation and for several days following, it was most likely the odor that contributed to the decrease in these behaviors. Once the smell dissipated, it is likely that these behaviors returned to the Baseline levels, however, because odor was not measured in this study, this was not tested.

It is the author's opinion that the rubberized flooring tested in this study (Natural Path Elephant Flooring) would be a good recommendation to other elephant-keeping institutions for promoting locomotion behavior as well as providing a softer, more yielding surface for standing rest. However, since the softer flooring also appeared to facilitate abnormal locomotion behavior as well, care should be taken to adequately enrich the captive environment of the newly floored area. Secondly, because odor may have contributed to a decrease in exploratory and foraging behavior in this study, it would be advisable for other institutions to allow ample time for ventilation as well as fans or other means of ventilation after installation to ensure that the rubber odor is no longer detectable to the animals. If this study were to be repeated, odor should be included as a variable. Additionally, temperature and climate should be included as variables to account for thermoregulatory behavior. For warmer climates or seasons it may be advisable to leave some areas partially concrete to provide a cool surface during the warmer seasons.

Elephants' unique anatomy, enormous size, impressive strength, and length of life, require that they maintain healthy feet and joints in order to live to their full life expectancy. Therefore, every effort should be made to determine the impact that environmental conditions have on foot health in order to create captive conditions that promote healthy feet. Future studies should investigate the effects of moisture, confinement, diet, exercise and weight on foot health. Furthermore, studies that look at the long-term effects of housing elephants on different flooring substrates should be initiated. Lastly, whenever it is feasible, scientific studies should be implemented at elephant facilities as environmental conditions are altered so that the merits of these changes can be shared with the elephant-keeping community.

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APPENDICES

Appendix A: ETHOGRAM OF ELEPHANT BEHAVIORS

Room Occupation	**Description**
room 1	Back room observation area
room 2	Back room observation area
room 3	Back room observation area
room 4	Back room observation area
front room	Front room observation area
middle room	Front room observation area
dead-end room	Front room observation area
Primary Behaviors	**Description**
lie	lateral recumbence
shake	any shaking of body or head to remove matter
*stereotypy	any repetitive, invariant activity that does not appear to serve any obvious goal or function
*aggression	any forceful contact directed at conspecific
back up	using at least two feet to move body backward (excludes movement of one step with one foot)
*environmental interaction	trunk touching and exploring of any surrounding feature excluding self and conspecifics
forage/eat	any trunk manipulation used to transfer food to mouth as well as any ingestion of food
*social interaction	any nonagonistic touching or contact of conspecific
kneel	lowering front of body onto front knees
foot lift	lifts one foot fully off of the ground for reason other than locomotion
pawing	using foot to touch, scrape, or push at any surrounding feature excluding self and conspecific
other	any other behavior not listed in ethogram
throw on top of self	throwing hay, dirt, mud or faeces on top of self
stationary/no activity	standing still, performing no obvious activity
turn	using at least two feet to turn body (excludes movement of one step with one foot)
unable to determine	room occupation is known, behavior is undeterminable due to angle or lighting of camera or position of subject
walk	movement that transports the body forward at a normal pace
drink	filling trunk with water and transporting it to mouth
head-butt	uses head to push at object or feature (excluding conspecifics)

**Modifier	Description
Chendra	Modifies an aggression or social interaction; describes the subject initializing an aggressive or social interaction
Shine	Modifies an aggression or social interaction; describes the subject initializing an aggressive or social interaction
Pet	Modifies an aggression or social interaction; describes the subject initializing an aggressive or social interaction
Rose Tu	Modifies an aggression or social interaction; describes the subject initializing an aggressive or social interaction
wall	Modifies an environmental interaction; describes the feature involved in the interaction
ground	Modifies an environmental interaction; describes the feature involved in the interaction
faeces	Modifies an environmental interaction; describes the feature involved in the interaction
head bob	Modifies a stereotypy; repetitively bobbing head up and down
pace	Modifies a stereotypy; locomotors over same path repetitively
structure/object	Modifies a stereotypy; any surrounding feature excluding wall, ground, faeces, self and conspecifics
sway	Modifies a stereotypy; repetitively swinging trunk or body from side to side

* Denotes a primary behavior that was further described with a modifier.

* * A modifier further described a primary behavior, for example, stereotypic behavior was a primary behavior that was observed in this study. This primary behavior could be further identified with a modifier that described the specific stereotypie that was observed such as pacing or swaying. Social behavior was another primary behavior that was observed in this study and modifiers were used to identify the initiating subject.

Appendix B: SUMMARY OF BEHAVIOR DATA

All recorded behaviors in the Back observation area (rooms 1, 2, 3 and 4) for each subject are shown in the following tables. Behaviors in bold denote behaviors that were analyzed for this study.

Chendra

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
locomotion backup	**17**	**1.9%**	**11**	**1.1%**	**54**	**1.0%**	**29**	**0.4%**
locomotion turn	**27**	**1.1%**	**27**	**1.3%**	**109**	**1.2%**	**86**	**1.0%**
locomotion walk	**46**	**7.2%**	**51**	**7.1%**	**248**	**8.5%**	**132**	**4.5%**
explore ground	**10**	**1.9%**	**4**	**0.6%**	**27**	**1.4%**	**9**	**1.4%**
explore other	**12**	**4.9%**	**13**	**1.5%**	**54**	**2.0%**	**6**	**1.0%**
explore pawing	**4**	**0.3%**	**1**	**0.0%**	**16**	**0.1%**	**5**	**0.1%**
forage	**45**	**47.5%**	**40**	**32.6%**	**159**	**22.6%**	**135**	**25.8%**
resting standing	**29**	**12.6%**	**49**	**30.9%**	**191**	**31.5%**	**117**	**34.9%**
resting lying	**0**	**0.0%**	**0**	**0.0%**	**22**	**26.1%**	**21**	**29.1%**
resting kneel	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
discomfort lift foot	**1**	**0.0%**	**0**	**0.0%**	**3**	**0.1%**	**0**	**0.0%**
Stereotypic behavior	**11**	**21.4%**	**22**	**23.3%**	**14**	**3.9%**	**4**	**1.1%**
aggression	0	0.0%	0	0.0%	15	0.6%	0	0.0%
social interaction	1	0.1%	3	1.1%	10	0.5%	4	0.2%
other	2	0.9%	0	0.0%	2	0.1%	2	0.2%
throw hay/dirt on self	0	0.0%	0	0.0%	0	0.0%	3	0.1%
Shake	0	0.0%	0	0.0%	0	0.0%	0	0.0%
drink	1	0.3%	3	0.5%	9	0.5%	5	0.2%

Rose Tu

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
locomotion backup	**12**	**0.7%**	**28**	**2.5%**	**44**	**0.9%**	**52**	**1.2%**
locomotion turn	**15**	**0.5%**	**31**	**1.3%**	**65**	**0.8%**	**70**	**0.8%**
locomotion walk	**30**	**3.0%**	**64**	**7.9%**	**127**	**3.5%**	**89**	**2.6%**
explore ground	**6**	**0.7%**	**7**	**1.3%**	**31**	**1.5%**	**9**	**1.4%**
explore other	**54**	**14.9%**	**20**	**2.2%**	**72**	**5.1%**	**44**	**3.2%**
explore pawing	**4**	**0.2%**	**5**	**0.2%**	**10**	**0.3%**	**6**	**0.2%**
forage	**54**	**30.6%**	**31**	**23.9%**	**149**	**19.7%**	**104**	**21.9%**
resting standing	**28**	**47.8%**	**67**	**59.4%**	**134**	**43.9%**	**118**	**42.5%**
resting lying	**0**	**0.0%**	**0**	**0.0%**	**16**	**21.7%**	**20**	**24.9%**
resting kneel	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
discomfort lift foot	**8**	**0.2%**	**1**	**0.0%**	**25**	**0.5%**	**4**	**0.1%**
Stereotypic behavior	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
aggression	0	0.0%	0	0.0%	3	0.3%	0	0.0%
social interaction	5	0.5%	5	0.7%	23	1.1%	14	0.6%
other	3	0.9%	0	0.0%	4	0.2%	2	0.2%
throw hay/dirt on self	0	0.0%	0	0.0%	13	0.2%	4	0.1%
Shake	0	0.0%	0	0.0%	0	0.0%	0	0.0%
drink	1	0.2%	7	0.7%	6	0.2%	8	0.5%

Shine

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
locomotion backup	**39**	**3.0%**	**34**	**2.5%**	**78**	**1.5%**	**87**	**2.3%**
locomotion turn	**50**	**1.8%**	**46**	**2.1%**	**100**	**1.1%**	**116**	**1.3%**
locomotion walk	**47**	**4.6%**	**48**	**4.8%**	**123**	**2.8%**	**122**	**3.8%**
explore ground	**7**	**1.0%**	**5**	**0.6%**	**29**	**1.2%**	**5**	**0.2%**
explore other	**33**	**4.9%**	**18**	**2.8%**	**48**	**2.0%**	**51**	**2.9%**
explore pawing	**3**	**0.1%**	**3**	**0.1%**	**1**	**0.0%**	**1**	**0.0%**
forage	**64**	**22.3%**	**45**	**25.6%**	**127**	**19.8%**	**132**	**22.6%**
resting standing	**65**	**32.7%**	**73**	**53.4%**	**169**	**46.4%**	**182**	**38.0%**
resting lying	**0**	**0.0%**	**0**	**0.0%**	**15**	**20.6%**	**11**	**13.1%**
resting kneel	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
discomfort lift foot	**7**	**0.1%**	**5**	**0.1%**	**9**	**0.1%**	**3**	**0.0%**
Stereotypic behavior	**12**	**26.7%**	**1**	**5.6%**	**5**	**0.9%**	**22**	**12.9%**
aggression	0	0.0%	0	0.0%	5	0.1%	0	0.0%
social interaction	11	1.3%	6	2.2%	19	0.8%	11	0.4%
other	0	0.0%	0	0.0%	3	0.5%	1	0.1%
throw hay/dirt on self	0	0.0%	0	0.0%	2	0.1%	5	0.3%
Shake	0	0.0%	0	0.0%	0	0.0%	1	0.0%
drink	5	1.4%	2	0.2%	15	2.0%	29	2.1%

Pet

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
locomotion backup	**0**	**0.0%**	**13**	**1.1%**	**9**	**0.1%**	**13**	**0.4%**
locomotion turn	**6**	**0.2%**	**16**	**0.6%**	**36**	**1.0%**	**33**	**0.5%**
locomotion walk	**16**	**0.7%**	**17**	**2.6%**	**41**	**1.2%**	**41**	**0.9%**
explore ground	**11**	**1.3%**	**0**	**0.0%**	**15**	**0.5%**	**0**	**0.0%**
explore other	**26**	**3.8%**	**4**	**0.4%**	**52**	**3.6%**	**21**	**0.9%**
explore pawing	**1**	**0.0%**	**0**	**0.0%**	**9**	**0.7%**	**0**	**0.0%**
forage	**30**	**31.7%**	**29**	**29.3%**	**112**	**22.3%**	**91**	**24.3%**
resting standing	**43**	**61.3%**	**30**	**65.4%**	**121**	**55.7%**	**96**	**71.8%**
resting lying	**0**	**0.0%**	**0**	**0.0%**	**10**	**12.5%**	**0**	**0.0%**
resting kneel	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
discomfort lift foot	**15**	**0.6%**	**1**	**0.0%**	**56**	**0.8%**	**28**	**0.7%**
Stereotypic behavior	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
aggression	0	0.0%	0	0.0%	1	0.0%	0	0.0%
social interaction	2	0.2%	1	0.2%	16	0.9%	3	0.1%
other	0	0.0%	0	0.0%	2	0.2%	0	0.0%
throw hay/dirt on self	0	0.0%	0	0.0%	9	0.1%	0	0.0%
Shake	0	0.0%	0	0.0%	0	0.0%	0	0.0%
drink	1	0.2%	3	0.3%	3	0.5%	6	0.4%

Rama

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
locomotion backup	**12**	**2.7%**	**36**	**6.0%**	**59**	**2.1%**	**116**	**3.4%**
locomotion turn	**4**	**0.6%**	**3**	**0.3%**	**30**	**1.0%**	**10**	**0.2%**
locomotion walk	**27**	**5.5%**	**51**	**9.1%**	**83**	**3.7%**	**189**	**9.1%**
explore ground	**2**	**1.0%**	**2**	**0.7%**	**5**	**0.4%**	**4**	**0.3%**
explore other	**27**	**10.9%**	**50**	**9.9%**	**50**	**5.0%**	**160**	**7.0%**
explore pawing	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
forage	**20**	**21.9%**	**9**	**8.0%**	**90**	**24.9%**	**23**	**2.0%**
resting standing	**15**	**9.6%**	**12**	**1.9%**	**64**	**11.1%**	**42**	**10.1%**
resting lying	**0**	**0.0%**	**0**	**0.0%**	**17**	**22.5%**	**7**	**8.6%**
resting kneel	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
discomfort lift foot	**17**	**1.4%**	**11**	**1.0%**	**56**	**0.7%**	**27**	**0.5%**
Stereotypic behavior	**34**	**45.4%**	**70**	**62.3%**	**87**	**28.3%**	**321**	**58.7%**
aggression	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
social interaction	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
throw hay/dirt on self	0	0.0%	0	0.0%	2	0.2%	1	0.2%
Shake	0	0.0%	0	0.0%	0	0.0%	0	0.0%
drink	4	1.1%	4	0.9%	0	0.0%	4	0.2%

Packy

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
locomotion backup	**6**	**0.8%**	**8**	**1.1%**	**13**	**0.4%**	**24**	**0.8%**
locomotion turn	**8**	**2.3%**	**30**	**2.8%**	**32**	**1.6%**	**64**	**2.2%**
locomotion walk	**11**	**0.9%**	**25**	**5.2%**	**47**	**3.7%**	**52**	**2.6%**
explore ground	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
explore other	**31**	**13.1%**	**21**	**11.8%**	**48**	**10.9%**	**78**	**11.1%**
explore pawing	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
forage	**8**	**8.7%**	**7**	**8.1%**	**26**	**16.4%**	**43**	**19.8%**
resting standing	**39**	**17.0%**	**51**	**32.2%**	**108**	**37.4%**	**149**	**36.2%**
resting lying	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
resting kneel	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
discomfort lift foot	**6**	**1.1%**	**13**	**4.5%**	**22**	**0.9%**	**21**	**2.3%**
Stereotypic behavior	**14**	**55.3%**	**15**	**28.9%**	**24**	**28.7%**	**35**	**22.7%**
aggression	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
social interaction	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
other	1	0.9%	0	0.0%	2	0.0%	2	0.0%
throw hay/dirt on self	0	0.0%	0	0.0%	1	0.0%	0	0.0%
Shake	0	0.0%	0	0.0%	0	0.0%	0	0.0%
drink	0	0.0%	7	5.5%	0	0.0%	8	2.1%

All recorded behaviors in the Front observation area (viewing room, middle room and dead-end room) for each subject are shown in the following tables. Behaviors in bold denote behaviors that were analyzed for this study.

Chendra

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
locomotion backup	**9**	**0.8%**	**10**	**1.7%**	**23**	**0.4%**	**13**	**0.5%**
locomotion turn	**38**	**3.0%**	**17**	**0.7%**	**92**	**1.2%**	**52**	**0.7%**
locomotion walk	**80**	**15.0%**	**38**	**9.4%**	**161**	**7.8%**	**132**	**7.0%**
explore ground	**8**	**1.2%**	**0**	**0.0%**	**18**	**0.9%**	**9**	**0.4%**
explore other	**12**	**1.7%**	**0**	**0.0%**	**20**	**0.9%**	**7**	**0.2%**
explore pawing	**9**	**0.2%**	**6**	**0.2%**	**10**	**0.2%**	**12**	**0.1%**
forage	**49**	**25.1%**	**33**	**26.7%**	**175**	**30.3%**	**121**	**19.8%**
rest standing	**37**	**11.5%**	**30**	**48.0%**	**63**	**9.9%**	**98**	**26.8%**
rest lying	**0**	**0.0%**	**0**	**0.0%**	**25**	**34.9%**	**12**	**17.4%**
rest kneel	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
discomfort lift foot	**1**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
Stereotypic behavior	**21**	**37.2%**	**4**	**12.7%**	**19**	**12.9%**	**46**	**26.4%**
aggression	0	0.0%	0	0.0%	0	0.0%	2	0.2%
social interaction	10	3.0%	3	0.7%	7	0.4%	4	0.4%
other	3	1.1%	0	0.0%	1	0.2%	0	0.0%
throw hay/dirt on self	0	0.0%	0	0.0%	0	0.0%	1	0.1%
Shake	2	0.1%	0	0.0%	1	0.0%	0	0.0%
drink	0	0.0%	0.00%	0.0%	0	0.0%	0.00%	0.0%

Rose Tu

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
locomotion backup	**40**	**5.2%**	**21**	**2.1%**	**59**	**0.9%**	**36**	**0.9%**
locomotion turn	**48**	**2.6%**	**18**	**0.9%**	**103**	**1.6%**	**43**	**0.5%**
locomotion walk	**74**	**11.9%**	**40**	**8.8%**	**165**	**5.5%**	**113**	**4.5%**
explore ground	**22**	**3.4%**	**0**	**0.0%**	**27**	**1.7%**	**1**	**0.0%**
explore other	**14**	**4.9%**	**2**	**0.3%**	**15**	**0.5%**	**2**	**0.0%**
explore pawing	**2**	**0.1%**	**3**	**0.1%**	**10**	**0.1%**	**4**	**0.1%**
forage	**58**	**27.3%**	**35**	**24.4%**	**198**	**28.5%**	**108**	**20.4%**
rest standing	**79**	**37.5%**	**33**	**63.2%**	**101**	**19.5%**	**104**	**55.5%**
rest lying	**0**	**0.0%**	**0**	**0.0%**	**24**	**37.6%**	**13**	**16.3%**
rest kneel	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**1**	**0.0%**
discomfort lift foot	**2**	**0.1%**	**0**	**0.0%**	**14**	**0.2%**	**0**	**0.0%**
Stereotypic behavior	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
aggression	0	0.0%	0	0.0%	0	0.0%	3	0.1%
social interaction	30	5.8%	0	0.0%	63	3.2%	11	1.3%
other	1	1.3%	0	0.0%	2	0.4%	2	0.2%
throw hay/dirt on self	0	0.0%	1	0.1%	1	0.0%	7	0.1%
Shake	0	0.0%	0	0.0%	0	0.0%	1	0.0%
drink	0	0.0%	0	0.0%	1	0.1%	0	0.0%

Shine

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
locomotion backup	**71**	**8.2%**	**25**	**4.3%**	**83**	**2.9%**	**63**	**1.7%**
locomotion turn	**54**	**2.9%**	**16**	**1.3%**	**129**	**2.1%**	**68**	**1.3%**
locomotion walk	**70**	**9.8%**	**40**	**8.6%**	**148**	**6.1%**	**114**	**4.5%**
explore ground	**27**	**2.6%**	**1**	**0.4%**	**26**	**2.0%**	**9**	**0.4%**
explore other	**17**	**2.1%**	**1**	**0.1%**	**31**	**1.8%**	**19**	**1.4%**
explore pawing	**0**	**0.0%**	**7**	**0.4%**	**6**	**0.1%**	**20**	**0.2%**
forage	**51**	**26.7%**	**39**	**23.1%**	**220**	**32.3%**	**132**	**22.3%**
rest standing	**95**	**30.3%**	**29**	**6.8%**	**125**	**18.0%**	**106**	**29.7%**
rest lying	**0**	**0.0%**	**0**	**0.0%**	**8**	**17.3%**	**7**	**12.5%**
rest kneel	**0**	**0.0%**	**0**	**0.0%**	**1**	**0.0%**	**0**	**0.0%**
discomfort lift foot	**8**	**0.3%**	**2**	**0.1%**	**33**	**0.8%**	**0**	**0.0%**
Stereotypic behavior	**11**	**10.5%**	**7**	**53.8%**	**10**	**6.4%**	**31**	**24.7%**
aggression	0	0.0%	1	0.1%	0	0.0%	0	0.0%
social interaction	40	6.6%	4	1.1%	62	9.2%	10	0.7%
other	0	0.0%	0	0.0%	5	0.8%	2	0.4%
throw hay/dirt on self	0	0.0%	0	0.0%	0	0.0%	9	0.2%
Shake	0	0.0%	0	0.0%	1	0.0%	2	0.1%
drink	1	0.1%	0	0.0%	2	0.2%	0	0.0%

Pet

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
locomotion backup	**5**	**0.3%**	**0**	**0.0%**	**7**	**0.2%**	**7**	**0.2%**
locomotion turn	**7**	**0.2%**	**11**	**0.9%**	**27**	**0.5%**	**11**	**0.1%**
locomotion walk	**29**	**3.5%**	**35**	**3.3%**	**30**	**1.2%**	**66**	**1.8%**
explore ground	**29**	**9.7%**	**1**	**0.1%**	**36**	**6.6%**	**18**	**0.9%**
explore other	**8**	**1.9%**	**1**	**0.1%**	**6**	**0.3%**	**2**	**0.1%**
explore pawing	**0**	**0.0%**	**3**	**0.1%**	**9**	**0.7%**	**4**	**0.0%**
forage	**43**	**40.3%**	**42**	**32.5%**	**90**	**30.3%**	**83**	**23.6%**
rest standing	**55**	**38.7%**	**19**	**63.0%**	**123**	**42.1%**	**65**	**71.0%**
rest lying	**0**	**0.0%**	**0**	**0.0%**	**5**	**12.3%**	**1**	**1.7%**
rest kneel	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
discomfort lift foot	**12**	**1.0%**	**0**	**0.0%**	**73**	**3.1%**	**3**	**0.1%**
Stereotypic behavior	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
aggression	0	0.0%	0	0.0%	0	0.0%	0	0.0%
social interaction	16	4.4%	0	0.0%	15	1.6%	8	0.3%
other	0	0.0%	0	0.0%	20	1.1%	0	0.0%
throw hay/dirt on self	0	0.0%	0	0.0%	4	0.0%	11	0.2%
Shake	0	0.0%	0	0.0%	0	0.0%	0	0.0%
drink	0	0.0%	0	0.0%	0	0.0%	0	0.0%

Rama

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
locomotion backup	**31**	**7.9%**	**32**	**5.2%**	**37**	**2.2%**	**101**	**3.8%**
locomotion turn	**9**	**0.8%**	**8**	**0.5%**	**26**	**1.0%**	**13**	**0.2%**
locomotion walk	**36**	**9.2%**	**73**	**17.3%**	**51**	**3.5%**	**123**	**5.8%**
explore ground	**8**	**2.8%**	**7**	**1.0%**	**8**	**0.4%**	**6**	**0.3%**
explore other	**19**	**4.7%**	**31**	**8.3%**	**24**	**2.5%**	**62**	**3.0%**
explore pawing	**0**	**0.0%**	**0**	**0.0%**	**1**	**0.0%**	**2**	**0.0%**
forage	**26**	**22.2%**	**8**	**5.5%**	**36**	**15.5%**	**11**	**3.7%**
rest standing	**21**	**17.8%**	**19**	**4.7%**	**62**	**14.0%**	**72**	**20.2%**
rest lying	**0**	**0.0%**	**0**	**0.0%**	**24**	**34.8%**	**8**	**10.1%**
rest kneel	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
discomfort lift foot	**6**	**0.6%**	**7**	**0.4%**	**11**	**0.3%**	**26**	**0.7%**
Stereotypic behavior	**32**	**33.6%**	**71**	**56.7%**	**66**	**25.7%**	**218**	**52.1%**
aggression	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
social interaction	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
other	0	0.0%	0	0.0%	0	0.0%	0	0.0%
throw hay/dirt on self	1	0.4%	0	0.0%	0	0.0%	3	0.1%
Shake	0	0.0%	0	0.0%	0	0.0%	0	0.0%
drink	0	0.0%	1	0.3%	0	0.0%	0	0.0%

Packy

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
locomotion backup	**13**	**2.1%**	**5**	**1.3%**	**11**	**0.2%**	**39**	**2.3%**
locomotion turn	**47**	**10.0%**	**17**	**1.8%**	**38**	**2.4%**	**75**	**2.7%**
locomotion walk	**68**	**17.4%**	**9**	**1.2%**	**53**	**4.3%**	**78**	**7.8%**
explore ground	**3**	**0.4%**	**0**	**0.0%**	**10**	**0.8%**	**0**	**0.0%**
explore other	**10**	**3.5%**	**6**	**1.7%**	**13**	**5.2%**	**14**	**1.9%**
explore pawing	**0**	**0.0%**	**0**	**0.0%**	**2**	**0.0%**	**0**	**0.0%**
forage	**6**	**14.5%**	**20**	**25.3%**	**43**	**19.9%**	**29**	**19.7%**
rest standing	**33**	**19.4%**	**31**	**16.3%**	**73**	**29.6%**	**114**	**25.4%**
rest lying	**0**	**0.0%**	**0**	**0.0%**	**6**	**17.5%**	**0**	**0.0%**
rest kneel	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
discomfort lift foot	**12**	**2.3%**	**20**	**2.1%**	**93**	**1.1%**	**42**	**0.6%**
Stereotypic behavior	**9**	**30.3%**	**16**	**50.2%**	**6**	**16.7%**	**29**	**39.4%**
aggression	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
social interaction	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
other	1	0.1%	0	0.0%	7	2.1%	1	0.1%
throw hay/dirt on self	0	0.0%	0	0.0%	1	0.1%	1	0.0%
Shake	0	0.0%	0	0.0%	0	0.0%	0	0.0%
drink	0	0.0%	0	0.0%	0	0.0%	0	0.0%

Appendix C: SUMMARY OF ROOM USE DATA

Room Use in the Back observation area (rooms 1, 2, 3 and 4) for each subject is shown in the following tables.

Chendra

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
Room 1	6	26.16%	9	31.79%	15	13.96%	11	7.60%
Room 2	10	36.53%	8	20.83%	28	23.29%	22	22.42%
Room 3	12	14.89%	34	30.89%	68	48.81%	40	43.32%
Room 4	12	22.42%	29	16.49%	38	14.39%	26	26.66%

Rose Tu

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
Room 1	4	19.17%	6	12.60%	15	15.70%	10	12.71%
Room 2	10	43.05%	17	56.31%	30	23.94%	15	14.50%
Room 3	11	36.77%	14	25.14%	50	54.60%	48	59.38%
Room 4	2	1.01%	5	5.95%	10	5.75%	13	13.42%

Shine

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
Room 1	6	31.16%	2	6.25%	23	25.83%	10	12.45%
Room 2	12	45.19%	14	54.35%	25	21.47%	18	17.97%
Room 3	10	13.78%	6	14.90%	42	48.79%	56	59.68%
Room 4	4	9.87%	7	24.50%	6	3.90%	15	9.90%

Pet

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
Room 1	3	16.67%	3	11.23%	14	16.42%	13	18.79%
Room 2	10	54.10%	16	80.41%	31	37.24%	9	10.93%
Room 3	6	29.23%	3	8.36%	32	43.44%	45	65.59%
Room 4	0	0.00%	0	0.00%	3	2.90%	4	4.69%

Packy

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
Room 1	5	29.41%	10	42.53%	33	38.61%	20	22.05%
Room 2	3	17.65%	11	26.80%	36	28.69%	38	25.51%
Room 3	54	26.68%	22	16.23%	102	18.27%	78	27.03%
Room 4	52	26.26%	17	14.44%	90	14.43%	60	25.40%

Rama

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
Room 1	9	32.01%	8	17.21%	11	11.33%	46	33.03%
Room 2	7	19.54%	22	61.33%	30	28.42%	57	20.79%
Room 3	9	26.76%	10	5.32%	45	52.86%	53	19.91%
Room 4	7	21.70%	7	16.14%	8	7.40%	40	26.27%

Room Use in the Front observation area (viewing room, middle room, and dead-end room) for each subject is shown in the following tables.

Chendra

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
viewing room	24	58.85%	11	39.76%	91	71.45%	91	77.74%
middle room	29	22.24%	18	12.94%	85	10.38%	69	7.26%
deadend room	19	18.91%	15	47.30%	52	18.17%	34	15.01%

Rose Tu

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
viewing room	13	41.91%	7	40.02%	61	77.78%	52	68.66%
middle room	19	26.53%	7	12.01%	21	8.31%	22	13.22%
deadend room	15	31.56%	11	47.98%	16	13.91%	18	18.12%

Shine

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
viewing room	12	39.27%	6	24.01%	59	76.12%	48	59.45%
middle room	11	19.93%	9	20.51%	26	7.38%	24	12.30%
deadend room	12	40.80%	10	55.48%	21	16.49%	31	28.25%

Pet

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
viewing room	15	74.19%	6	50.00%	64	94.08%	52	71.88%
middle room	4	15.51%	2	8.94%	2	1.50%	13	14.92%
deadend room	2	10.30%	6	41.06%	3	4.41%	9	13.19%

Rama

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
viewing room	12	52.06%	14	30.23%	63	82.38%	53	54.12%
middle room	10	18.55%	25	30.85%	18	11.52%	43	14.54%
deadend room	10	29.38%	19	38.92%	9	6.10%	41	31.34%

Packy

	Day				Night			
	Baseline		Final		Baseline		Final	
	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time	frequency	% of observation time
viewing room	14	60.26%	12	63.26%	43	70.05%	56	68.36%
middle room	16	17.09%	8	19.92%	24	22.84%	26	22.43%
deadend room	13	22.66%	7	16.83%	10	7.11%	13	9.22%